OPPORTUNITIES FOR INTERVENTIONS TO IMPROVE ENVIRONMENTAL SUSTAINABILITY OF SMALLHOLDER BANANA PRODUCTION IN MWENSE ZAMBIA

By

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Opportunities for Interventions to Improve Environmental Sustainability of Smallholder Banana Production in Mwense Zambia

Van Hall Larenstein University of Applied Sciences

A Thesis Submitted to Van Hall Larenstein University of Applied Sciences as Partial Requirement for the Award of Master of Science Degree in Agricultural Production Chain Management – Horticulture Chains

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DEDICATION

This dissertation is dedicated to the small-scale farmers in Mwense district who have, despite enormous social, economic, and environmental challenges to modern agriculture, have relentlessly continued to play their role of contributing to global food production, to poverty alleviation and rural development. It is anticipated that this work will play a pivotal role in motivating policy makers, the donor community and extension providers to make informed decisions and in applying the proposed interventions to enhance production and performance of the banana sector in Zambia and globally.

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ABBREVIATIONS AND ACRONYMS

BBTD	Banana Bunch Top Disease
DOA	Department of Agriculture
FAO	Food and Agriculture Organisation
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FGD	Focus Group Discussion
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
IDC	Industrial Development Cooperation
ISO	International Organization for Standardization
LCA	Life circle assessment
MFC	Mununshi Fruit Company
MFNP	Ministry of Finance and National Planning
MOA	Ministry of Agriculture
OECD	Organisation for Economic Co-operation and Development
SA	Sustainability Assessment
SAEMETH-G	Sustainable Agri-Food Evaluation Methodology-Garden
SAFA	Sustainability Assessment of Food and Agriculture Systems
SAPs	Sustainable Agriculture Practices
SDGs	Sustainable Development Goals
SFPs	Sustainable Farming Practices
SI	Sustainable Intensification
SPSS	Statistical Package for Social Sciences
TOC	Theory of Change
TC	Tissue Culture
WCED	World Commission on Environment and Development
WFP	World Food Programme
ZARI	Zambia Agriculture Research Institute
ZIAMIS	Zambia Integrated Agriculture Management Information System

ABSTRACT

Banana (*Musa spp.)* have been recognised to play an indispensable role in meeting the ever-increasing food demands of the world populace and in improving the livelihoods of millions of smallholders. However, use of unsustainable farming practices especially among smallholders in rural domains has become both a local and global issue impacting negatively on rural livelihoods and future agricultural productivity. In Mwense, use of unsustainable production practices has been the leading cause of declining banana production among small-scale producers. Therefore, this study employed the concept of sustainability assessment to assess the environmental sustainability status of the current farming practices to develop tailor-made interventions targeting to enhance environmental sustainability of smallholder banana production. Data were collected through key informant interviews, focus group discussions, and a survey. Analysis of data was by use of both qualitative and quantitative analysis tools. Results describe the current state of farming practices among banana producers in Mwense. Land preparation is characterised by burning of residues, conventional tillage practices, and use of conservation tillage tools. Crop management is characterised by use of uncertified local varieties, irregular weeding of fields, non-implementation of integrated practices for weed, pest and disease control and improper application of chemical fertilizers. Postharvest management is characterised by poor cooling, storage, and transportation practices whereas quality control and produce certification is non-existent. The current farming practices have limited adherence to environmental sustainability standards due to poor crop management, fertilizer use, and postharvest handling practices. There is limited performance of the water conservation, soil conservation, land rehabilitation, and ecosystem conservation indicators of environmental sustainability among banana producers with an overall implementation status of 27%. The study argues that the environmental sustainability status of smallholder banana production in Mwense is lacking in resilience and stability to sustainably support future production and productivity, and to meet future livelihood needs of concerned households unless robust interventions to boost the sustainability performance of the production practices and to improve farmer's adoption of sustainable farming practices are implemented.

CHAPTER 1: INTRODUCTION

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1.1 Research Context

Agriculture is a fundamental source of income and livelihood for the world's poorest people in developing countries (George, 2020). On a global scale, the world's population is speedily expanding and based on the latest estimates, it is projected to reach 9.8 million by 2050 and 11.2 million by 2100 (Lampridi et al., 2019). Consequently, managing of agricultural production systems is key to ensuring sustained income, food security and livelihoods of the rural inhabitants. Of the total world populace currently projected at 7.7 billon, it is estimated that at least 927.6 million people, representing 11.9% of the world population, are severely food insecure (FAOSTAT, 2020). Additionally, the World Food Programme (WFP) estimates that 925 million people worldwide are hungry (Shal et al., 2021; Van Pham & Smith, 2014).

To fill this food insecurity and hunger gap, production of food ought to increase but in a sustainable way. Moreover, the management of agricultural production is critical to achievement of the Sustainable Development Goals (SDGs) related to eliminating hunger by 2030 and for providing enough food to humans (Van Pham & Smith, 2014). Therefore, understanding the agricultural production practices, especially among smallholder farmers, is crucial to getting an insight into which practices adversely impact the long-term production capability (Shal et al., 2021).

Sustainability in agriculture ecosystems entails satisfying the human need for food, safeguarding the environment, enhancing the economic well-being, and fostering social sustainability (Tanguay et al., 2010). A balanced agrarian ecosystem should provide copious services that are equitable, practical, and appropriate (Tanguay et al., 2010). The main goal of SDGs is that sustainable agriculture should fulfil the needs of people for an extended period, without damaging the environment and renewable resources, use minimal non-renewable resources, sustain, and improve both the economic wellbeing and value of life (DeClerck et al., 2016).

For a developing country like Zambia, agriculture is a key source of the required raw materials, exportable agricultural goods, livelihood to more than 70% of the rural population, and contributes to rural poverty reduction and employment of an estimated 1.5 million small-scale farmers (MFNP, 2022). In the ten-year period between 2011 and 2020, the agricultural sector growth averaged 0.4% while its share of GDP was 5.8% (MFNP, 2022). This slow growth of the sector has, however, been unable to keep step with the food needs of an increasing population. According to FAOSTAT data (2020), the prevalence of severe food insecurity is estimated at 23.2% of Zambia's population which has sharply increased from 12 million in 2010 to a projected 18 million in 2020, while national GDP has been increasing at an average of 6% (Zambia Statistics Agency, 2021). This population growth has translated into increasing demand for food. To satisfy this spiralling demand, agricultural productivity needs to improve.

Banana (*Musa spp.)* is a potential food crop in meeting the ever-increasing world's food requirements and in improving the livelihoods of millions of African farmers. Bananas have been acknowledged to be a leading fruit crop by volume and by value in the global market Woldu et al., (2015). As of 2020, a total of 119,833,677 metric tons of bananas were produced against an estimated 7.7 billion people worldwide. (FAOSTAT, 2020). Despite an increase in production, food insecurity has been on the rise on the global scale. Bananas have potential to contribute to reducing the prevalence of food insecurity among the severely food insecure people worldwide.

Bananas play a significant role to Zambia's agricultural sector and economy by improving income status of rural farmers and contributing to poverty reduction (Hichambwa, 2010). According to the Ministry of Agriculture (2020), bananas are grown both for income and for food and contribute 30% to the fruit subsector. Banana is the second most widespread fruit in Zambia after Mango and is consumed as a green fruit for dessert (MOA, 2020). The national food supply quantity of bananas currently stands at 0.28kg/capita/year as of 2019 (FAOSTAT, 2020). Bananas are consumed mostly for their health benefits. They are available throughout the year and are a source of carbohydrates, protein, and vitamins such as vitamin A, B, C, D and E, and thus are among the key fruit crops promoted under the crop diversification agenda of the Ministry of Agriculture in Zambia (MOA, 2020). At least 85% of total production is by smallholder farmers who are the main actors performing the production function in the banana value chain (MOA, 2020).

The banana value chain is among the key sub-sectors in Zambia with enormous potential to create jobs and boost economic development among the rural households (MOA, 2020). Consequently, smallholder banana production is a core function that must be maintained sustainably for the value chain to be sustainable. Agricultural production is the initial function that produces products and raw materials that feed into other functions and actors along the value chain. Thus, any disruption in production interrupts the normal product flow along the value chain which affects chain relationships and thus impacting on the overall value chain sustainability. Value chain sustainability is intricately linked, if not synonymous, to agricultural sustainability. In the recent past, there is a growing interest in sustainable agriculture as a pathway to a sustainable future and to sustainability of agricultural value chains. Therefore, agricultural sustainability is a growing concept among researchers and policy makers on a global scale (Neven, 2014).

Agricultural sustainability has over the years been understood and defined in diverse contexts, with extant literature suggesting no unanimous understanding. Nonetheless, agricultural sustainability falls within the broad concept of 'sustainable development' which was introduced by the 'Brundtland report' in the late 1980s. The WCED (1987) universally described sustainable development as an economically feasible, environmentally sound, and socially acceptable development that provides for the needs of the present without compromising future needs. Ever since, 'sustainability,' 'sustainable development' and 'sustainable intensification' have often been used as catchwords with different understandings to reduce the impacts of human activities on the environment. Moreover, climate change and related environmental changes are now the major sustainability challenges for humanity in the 21st century.

According to Goswami et al., (2017), emphasis is now placed on more ecological conscious agricultural practices and thus developing sustainable tailor-made interventions for agricultural systems has become crucial for targeted policy support by extension agencies. Henceforth, other than simply adding to the existing body of knowledge and to current debates on sustainability in scientific domains, the unique contribution and integral goal of this study is to suggest sustainable tailor-made interventions that enhance environmental sustainability of smallholder banana production and address environmental challenges faced by banana growers in the study expanse and globally. To achieve this, the study employed the concept of sustainability assessment on a set of selected sustainability indicators.

1.2 Research Commissioner

The Ministry of Agriculture in Luapula Province of Zambia commissioned this research to develop tailor-made interventions targeting to enhance the environmental sustainability of smallholder banana production in Mwense Zambia, which aims at curbing the declining trend in banana production in the target area.

1.3 Problem Statement

Unsustainable farming practices especially among smallholder farmers in rural domains has become both a local and global issue impacting negatively on rural livelihoods and future agricultural productivity. The current banana value chain in Mwense Zambia is no exception. Use of unsustainable production practices has been reported as the leading cause of declining banana production among small-scale producers. Recent statistics of the Ministry of Agriculture have revealed an appalling decrease in the area under cultivation and the number of small-scale farmers currently engaged in banana production. At national level, production quantity of bananas dropped by more than 20% from 900 tonnes in 2004 to 696 tonnes in 2020 whereas area harvested declined from 282ha to 154ha respectively (FAOSTAT, 2020).

At marketing level, there has been an observed decrease in quantity of bananas available on the local market despite the increasing demand locally and countrywide. This declining trend in banana production has forced traders to resort to importing bananas from outside sources despite the geographical and climatic advantage of the district that gives it an inherent potential to be the top producer of bananas in the region. The current trend in banana production has potential to threaten food security and household income of rural communities in addition to reducing employment opportunities. Furthermore, the overall sustainability performance of the banana value chain is potentially affected.

Granted, the private and public supporters of the value chain have demonstrated efforts to counteract the growing trend. However, such efforts have focused only on the economic sustainability dimension of the value chain, precisely improving productivity of bananas. However, agricultural sustainability should address the three basic pillars of sustainable development by concurrently promoting environmental, economic, and social issues related to agricultural practices (Van Pham & Smith, 2014).

Currently, there exists a knowledge gap on what environmental issues of sustainability are related to the declining trend in production and to sustainable production of bananas among small-scale producers. Although some sustainability studies have been reported in some parts of Africa, to the best knowledge of the author, there is no single sustainability assessment study conducted in Zambia to assess the environmental sustainability of banana production among small-scale producers despite the growing global concern to do so. This study sought to apply the concept of Sustainability Assessment (SA) to assess the environmental sustainability status of small-scale banana production in Mwense Zambia.

1.4 Research Objective

The main research objective of this study was to develop tailor-made interventions targeting to enhance the environmental sustainability of smallholder banana production in Mwense, Zambia.

1.5 Research Questions and Sub-questions

1. **What are the current farming practices among the smallholder banana producers in Mwense, Zambia?**

2. **What is the environmental sustainability status of farming practices among the smallholder banana producers in Mwense, Zambia?**

   2.1. Are the current farming practices following environmental sustainability standards?
   2.2. What is the performance of water management, soil conservation, land rehabilitation and ecosystem conservation indicators of sustainability among smallholder banana producers?
   2.3. What are the factors hindering the implementation of sustainable farming practices among smallholder banana producers?

CHAPTER 2: LITERATURE REVIEW

CHAPTER 2: LITERATURE REVIEW

This chapter covers a review of literature related to the study, provides definition of key concepts that were explored in the study, and present the design and operationalization of the conceptual framework that guided the study.

2.1 Banana Production and Cultivation System in Zambia

Bananas occupy about 4% of the cropped land and are mostly cultivated in wetlands (MOA, 2020). Bananas in Zambia are grown in a mixed farming system with other crops such as cassava, sweet potatoes, vegetables, sugar cane and rice. Wetlands are the most preferred ecologies for cultivation by small-scale farmers although they are also grown around homesteads as pockets of stools by rural households (MOA, 2020). Common cultivars of bananas include Grande Naine, Dwarf Cavendish, and Williams. The Zambia Agriculture Research Institute (ZARI) of the Zambian Ministry of Agriculture has developed high-yield disease-resistant varieties (Mansa 1 and Mansa 2). However, many farmers grow low-yield bananas because they are unable to access credit to buy high yield or tissue cultured varieties (such as Dwarf Cavendish and Giant Cavendish or Williams) (MOA, 2020).

Wanzala (2014) showed that banana growers have inadequate management skills to grow bananas, resulting in low production. The average size of a banana field for small-scale farmers is 0.5ha (MOA, 2020). Regrettably, there is no official data available from local statistical databases on banana production in Zambia. However, according to the 2020 FAOSTAT imputed data, Zambia's production of bananas has been declining in the last two decades as shown in figure 1, whereas its imports have been on the rise to meet national demand as shown in figure 2. According to the FAOSTAT (2020), Zambia's total import value of bananas increased from 751 tonnes in 2010 to 5,287 tonnes in 2020.

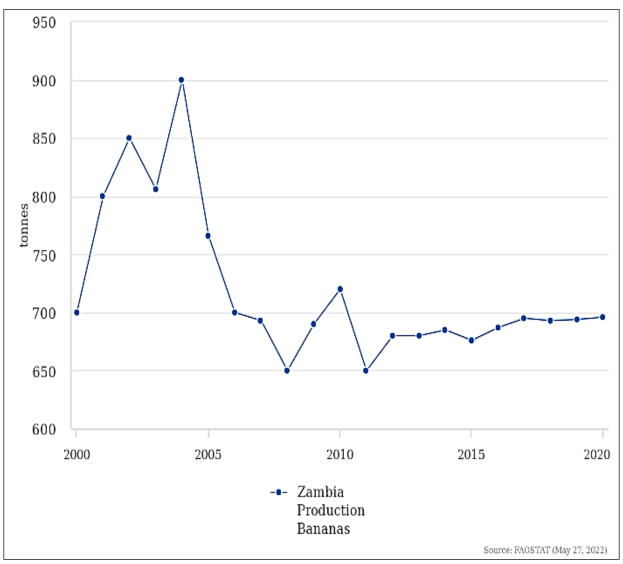


Figure 1. Zambia production quantity of Bananas

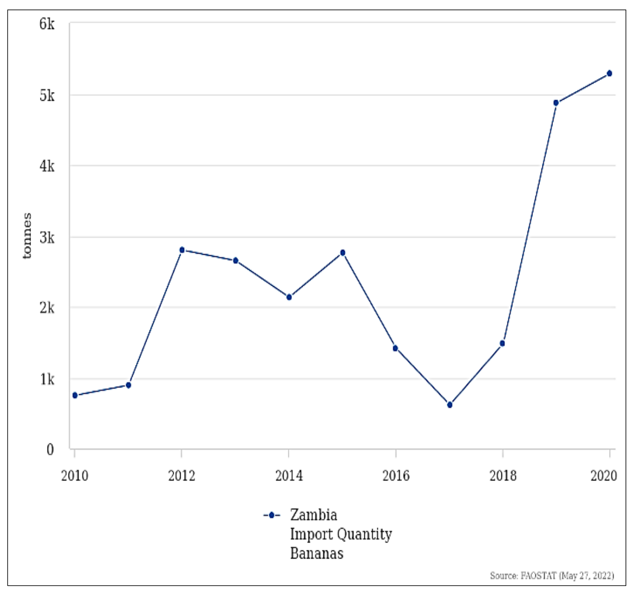


Figure 2. Zambia import quantity of Bananas

Source. FAOSTA (2022)

In Mwense district of Luapula province of Zambia, banana is a crop of major economic importance in the district, it being the most productive and the second most cultivated fruit crop next to Mango (MOA, 2020). According to the Ministry of Agriculture, current yield stands at 23.9ton/ha whereas total production volume stands at 9,631tonnes. The MOA further reports that production at small scale level has been decreasing since 2010 due to the outbreak of banana bunchy top disease (BBTD). On the other hand, production at large scale level has increased from 14.9tons in 1996 to 1,425tons in 2021 (accounting for 15% of total volume) following recapitalization of a commercial farm, the Mununshi Fruit Company (MFC), a subsidiary of the Industrial Development Corporation (IDC) owned by the Zambian Government (MOA, 2020). Table 1 shows the fruit crop production statistics for Mwense district. As mentioned earlier, it is however worth mentioning that the data stated above and shown in table 1 are not official data from statistical surveys or official database and their use henceforth is only indicative of the current production situation in the district. The author holds the view that these figures are not dependable as they are much higher than the national FAOSTAT imputed data and thus do not reflect the reality.

Table 1. Fruit crop production statistics for Mwense District

Crop	Cultivated area (Ha)	No. small scale farmers	No. of large-scale farmers	Production Qty-small scale (MT)	Production Qty - large scale (MT)	Total Production (MT)	Yield (Ton/ha)
Mango	1,712.0	66,000	-	14,980.0	-	4,980.0	8.8
Banana	403.0	1,500	1	8,206.0	1,485.0	9,691.0	23.9
Lemon	23.5	4,576	-	387.0	-	387.0	16.5
Orange	22.2	3,256	-	341.0	-	341.0	15.4
Mandarin	30.5	5,353	-	587.5	-	587.5	19.3

Source: 2020 District Annual Report, Ministry of Agriculture, Mwense.

2.2 Value Chain Sustainability

Value chain sustainability is an important value chain concept. Neven (2014) defines Value chain sustainability as value-adding activities that produce agricultural raw material and turn them into products that are sold to final consumers until final use and disposal in a manner that is profitable, provides broad based societal benefits, and preserves natural resources. Neven further argues that a value chain is economically sustainable if the required activities of each actor or support provider are commercially or financially viable; socially sustainable if it provides socially and culturally acceptable outcomes regarding the distribution of the benefits and costs associated with the increased value creation; and environmentally sustainable if value chain actors show little or no negative impact on the natural environment from their value-adding activities (Neven, 2014). This study adopted this understanding of value chain sustainability in the assessment of smallholder banana production in the banana value chain in Mwense.

2.3 Agricultural Production Systems and Practices

Literature differentiates between Agricultural Production Systems and Agricultural Production Practices. According to Walters et al, (2016), agricultural production systems consist of multidimensional elements that interact in intricate ways to affect production sustainability. Agricultural production practices, on the other hand, are defined as a collection of standards or principles applied during the farm production processes to get better agricultural products, or simply put, practices or farming activities conducted in agriculture to facilitate farming (Walters et al., 2016). This study adopted the later definition as it pursued to gain insight to the implementation of the current farming practices in banana production among smallholders in Mwense in relation to standard sustainable production practices.

Agricultural production systems are dynamic to respond to the ever-changing swings in input costs, market demands, the need for food safety, and ecological concerns (Hanson et al., 2008; Hendrickson et al., 2008). To this effect, production practices especially among small-scale producers must be aligned to focus on concern for the environment and food value, while preserving a production method that is economically viable for farmers (Walters et al., 2016). Sassenrath et al. (2009) postulate that sustainable agricultural production is a food and fibre production approach that is profitable and premised on efficient use of farm resources to reduce antithetical consequences on the ecosystem and people, conserves the natural yield and quality of the land and water, and sustains vivacious rural societies. Sustainable agricultural practices are those that aim to make the best use of ecological goods and services without damaging them (Pretty, 2008). This study placed itself in this context by seeking to assess the performance of current agricultural practices among smallholders in Mwense Zambia, in light of the selected environmental sustainability indicators.

Suffice to say that the current production practices, even among smallholders, are not devoid of negative impacts on sustainable production and environmental sustainability. Lampridi et al, (2019) illustrate, as shown in figure 3, the various activities that form part of agricultural production practices. These practices follow the production cycle of crops from soil preparation to transportation and storage. This research pursued to understand the existing practices or activities of banana production among smallholders along the entire production process. This formed part of the basis for a sustainability assessment of the current production practices in Mwense Zambia.

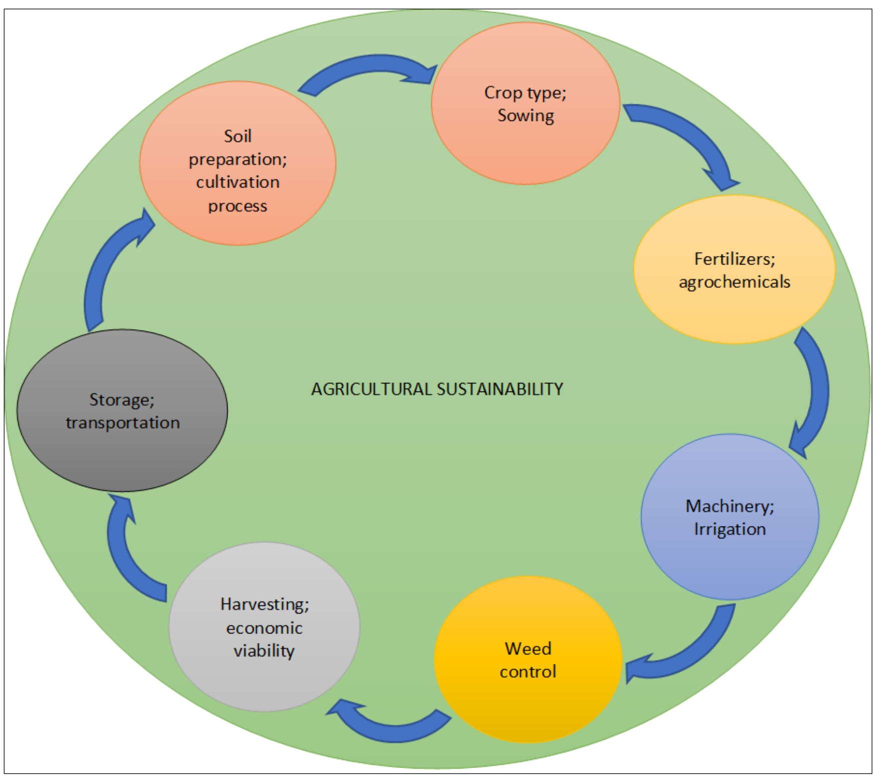


Figure 3. Production practices and variables considered in agricultural sustainability assessment

Source: Author based on Lampridi et al, (2019).

2.4 Sustainability Assessment of Farming Practices

Sustainability assessment is a useful tool to support the transition towards sustainability and its application globally has gained momentum. However, there remain limited examples of sustainability assessment studies especially in African agricultural context. Sustainability assessment is often explained as a method by which the repercussions of an action on sustainability are assessed, in which case an action can be a planned or current policy, programme, project, or a current practice or activity (Pope et al., 2016). The concept of sustainability is premised on the interrelationship between people and the environment. Thus, measurement of agricultural sustainability is intricately related to the three main pillars or broad dimensions of sustainability namely Environmental, Economic and Social.

As interest to assess sustainability issues related to agriculture escalates, several tools and methodologies have evolved (Cerutti et al., 2011; De Olde et al., 2016). Some tools have gained a wider use and acceptance worldwide such as the life cycle assessment (LCA), which is standardized by the International Organization for Standardization (ISO) (Yan et al., 2011). In addition, several indicator-based approaches exist for the sustainability assessment of agricultural practices that use different methodologies with regard to the intended objectives, users, and the employed description of agricultural sustainability (Binder et al., 2010). Table 2 shows a compilation of latest examples of tools and methodologies that have been employed by various authors for sustainability assessment in African agricultural context. It must be noted that the examples provided in table two are not exhaustive but only capture examples of interest and relevance as referred to in this study and based on thorough literature review.

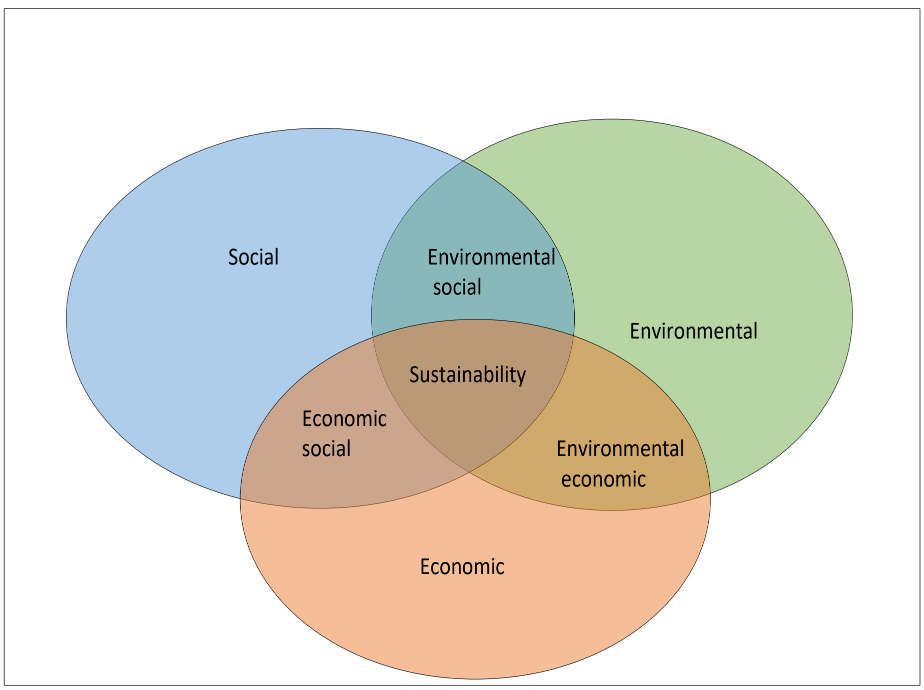
Table 2. Studies employing sustainability assessment tools in African agricultural context

Author(s)	**Year**	**Title**	**Location**	**Methodology/Tool**
Gebre & Eweg	2016	Sustainability Assessment of a Banana Value Chain: The Case of Arba Minch, Ethiopia	Ethiopia	Sustainability Assessment of Food and Agricultural Systems (SAFA)
Snapp et al.	2018	Maize yield and profitability trade-offs with social, human, and environmental performance: Is sustainable intensification feasible?	Malawi	Sustainable intensification (SI) Indicators
Sottile et al.	2016	An interpretive framework for assessing and monitoring the sustainability of school gardens	Kenya	Sustainable Agri-Food Evaluation Methodology-Garden (SAEMETH-G)
Braber, H.	2018	Deploying indicators to measure the impact of Banana Xanthomonas Wilt disease in Uganda	Uganda	Sustainable intensification (SI) Indicators
Gebre, Eweg & Kijne	2020	Analysis of banana value chain in Ethiopia: Approaches to sustainable value chain development	Ethiopia	Sustainability Assessment of Food and Agricultural Systems (SAFA)
George, S. O	2020	Agriculture Sustainability Assessment: A Case Study of Malakal State in South Sudan	Sudan	Agricultural Sustainability Index (ASI)

Source: Author's compilation (2022)

Sustainability assessment involves sequestering the specific dimension of concern into attributes which are then assessed using indicators. Indicators are qualitative or quantitative variables that are examined, quantified, or computed to provide data for decision making (Latruffe et al, 2016). However, there is deficiency of unanimity among scientists on which sustainability indicators to incorporate in sustainability assessment and this results into a wider range of methods for measuring sustainability (Bockstaller et al. 2009). However, a growing number of scientists agree that choice of sustainability indicators is based on several criteria (Dale and Beyeler 2001). The criteria for choosing individual sustainability indicators as discussed in extant literature takes into account importance, legitimacy, quantifiability, sensitivity and clarity by stakeholders and decision-makers (Dale and Beyeler 2001; Lebacq et al. 2013). Additionally, the totality of a set of indicators chosen should exhaustively characterize the agricultural system (Binder et al. 2010; Marchand et al. 2014). Niemeijer and de Groot (2008) further add that describing the criteria employed for selecting indicators is cardinal for the reliability and transparency of the evaluation.

Suffice to say that there are still debates over the measurement of sustainability. Lampridi et al (2019) argue that sustainability assessment of agricultural practices can be a daunting task as it includes situation specific variables to be considered. Lampridi et al (2019) further note that the diverse practices, inputs, and outputs concerned with agricultural production demonstrate the complexity in generalizing the assessment process. The variations in cultivation procedures for crops such as seeding, irrigation, and harvesting further make the assessment complex. However, it is general understanding that any comprehensive sustainability assessment in agriculture ecosystems should account for the environmental, the economic and the social dimensions. In practice, these three dimensions overlap as shown in figure 4. However, for the purpose of this study, only the environmental dimension was investigated and was treated individually for clarity. The corresponding environmental sustainability indicators were thus specifically adapted to the context of the Zambian banana sector in Mwense.



Source: FAO (2014)

Figure 4. Interplay between the three sustainability dimensions

2.5 Environmental Sustainability

A growing number of studies show the connection between environmental sustainability and sustainable agricultural production. Singh et al. (2009) postulate that to increase production and productivity sustainably, farmers must not only make better use of natural goods and services for human needs but also avoid causing damage to the environment. Thus, a better understanding of environmental sustainability is essential for maintaining productivity of farm environments. According to FAO (2014), environmental sustainability entails maintaining life support systems vital for human existence by lessening adverse ecological consequences. Other literature defines environmental sustainability as:

> *meeting the resource and services needs of current and future generations without compromising the health of the ecosystems that provide them, and more specifically, as a condition of balance, resilience, and interconnectedness that allows human society to satisfy its needs while neither exceeding the capacity of its supporting ecosystems to continue to regenerate the services necessary to meet those needs nor by actions diminishing biological diversity*. (Morelli, 2011).

This research used a combined understanding Morelli, (2011) and the FAO (2014) regarding environmental sustainability. A sustainability issue arises whenever a treasured system, object, process, or attribute is under threat or faces the risk of not being maintained, vis-à-vis, banana production in the context of the banana value chain in Mwense. There exists a wide understanding in literature of what indicators constitute environmental sustainability. William et al (2011) identify natural resource use, environmental management, pollution prevention as key aspects to consider when evaluating environmental sustainability. The OECD (2001) considers nutrient management, irrigation and water management, soil, and land management as key environmental indicators. According to the FAO (2014) environmental sustainability must address the main environmental themes namely atmosphere, water, land, materials and energy, biodiversity, and animal welfare for the environmental system to support sustainable production that meets human needs. This study adopted the FAO environmental sustainability themes and indicators as shown in table 3 in assessing the banana production practices among smallholders in Mwense Zambia.

Table 3. SAFA dimensions, themes, and indicators

Dimension	Theme	Sub-theme	Indicators
	E2 Water	E 2.1 Water Withdrawal	E 2.1.2 Water Conservation Practices
		E. 2.2 Water Quality	E 2.2.2 Water Pollution Prevention Practices
	E3 Land	E 3.1 Soil Quality	E 3.1.1 Soil Improvement Practices
			E 3.1.5 Soil Organic Matter
		E 3.2 Land Degradation	E 3.2.2 Land Conservation and Rehabilitation Practices
	E4 Biodiversity	E 4. 1 Ecosystem Diversity	E 4.1.2 Ecosystem Enhancing Practices

Source: FAO (2014)

2.6 Implementation of Sustainable Farming Practices

Adoption and implementation of sustainable farming practices (SFPs) is an important aspect of environmental sustainability. SFPs are intuitively evaluated for their compatibility with the present beliefs, previous encounters, and demands of prospective adopters. According to Waseem et al (2020), adoption is a choice to use an invention as the best course of action. Regarding SFPs, the decision-making includes multi-dimensional factors categorized into (i) socioeconomic factors, (ii) agro-ecological factors, (iii) institutional factors, (iv) informational factors, (v) perceived attributes and (vi) psychosocial factors (Waseem *et al*, 2020).

Socioeconomic characteristics of farmers widely studied in extant literature include age and sex of a farmer, farm experience, education level, farm size, cultivated area, land tenure, economic status, size of household, household labour, access to extension services, access to agricultural TV programs, access to agricultural radio programs (Waseem *et al*, 2020; Nguyen and Chinawat (2015). Meanwhile, existing literature also presents studies into a wide range of behavioural control factors including but not limited to sustainable agricultural perception, feasibility of sustainable agricultural practices, labour access, machine access, fertilizer access, pesticide access, and credit access (Waseem *et al*, 2020; Nguyen and Chinawat (2015).

Kassie et al. (2013) found that age of the farmer had a substantial effect on farmer's adoption of SFPs. Meanwhile, education level of farmers has been found to positively affect their choice to implement SFPs (Ngombe et al. 2014). In other studies, farm experience was shown to have positive influence on the adoption as shown in the study by Adeola (2010). However, Rezvanfar et al. (2009) did not find any positive correlation between farm experience and adoption of SFPs. Household labour was found to be associated to farmer's adoption of SFPs by studies done by Ngombe et al. (2014) while the study done by Okuthe (2014) found otherwise. Regarding household income, Ngombe et al. (2014) indicated that it had no impact on adoption. Regarding land ownership, Adeola (2010) and Ngombe et al. (2014) found no influence of land ownership on the SFPs adoption while the study of Okuthe (2014) found it to have substantial influence. Adeola (2010) established that farm size had a substantial impact on adoption of soil conservation practices, but then Wollni and Andersson (2014) did not.

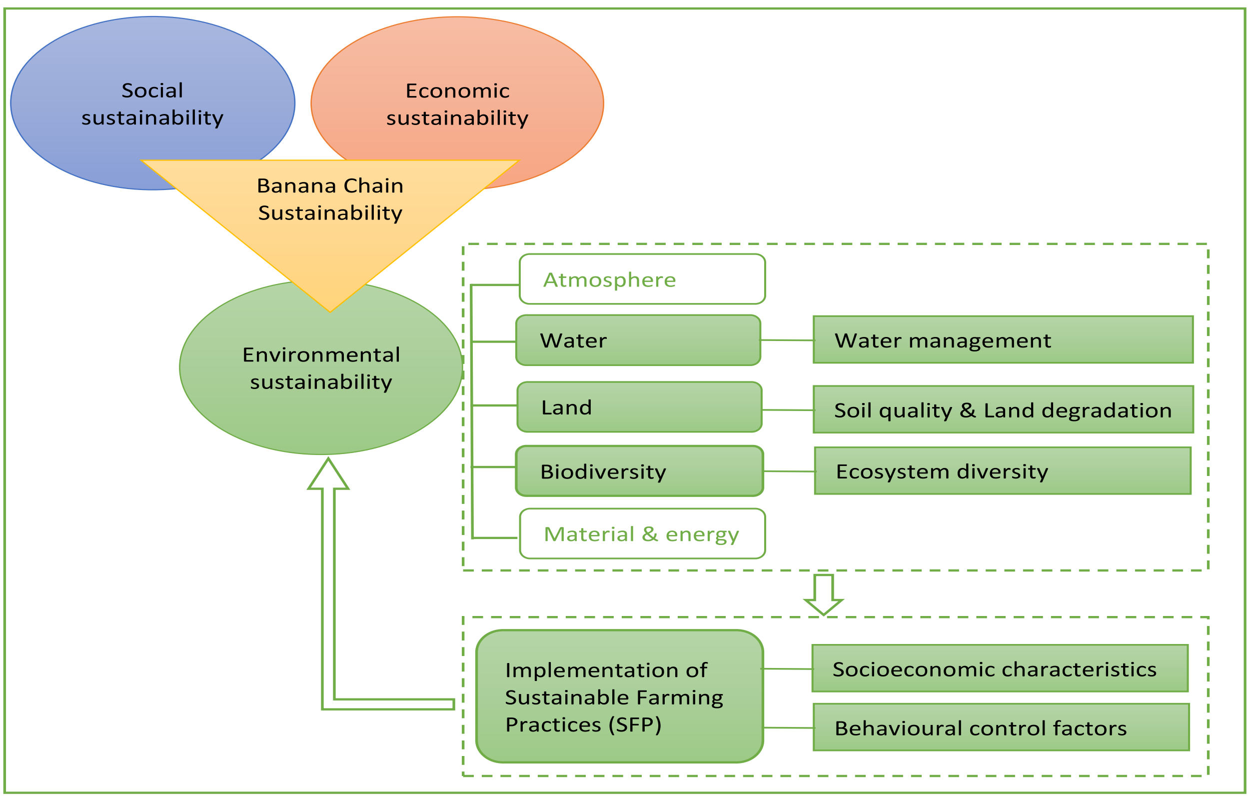
Farmers perception of SFPs has been studied and assumed to be a precondition to adoption of SFPs (Mahboubi et al. 2005) whereas Rogers (2003) argues that farmer's perception of a technology leads to its adoption. Farmer's source of information has been found to play a pivotal role in deciding to adopt SFP as it helps to reduce risks and uncertainties (Nkomoki et al., 2018). Similarly, Okuthe's study (2014) postulated that farmers' access to mass media, vis-a-vis TV, and Radio programs, was significantly related to farmers adoption of SFPs. Okuthe (2014) further found a positive influence of inputs such as fertilizers on the adoption of SFPs. On one hand, access to credit has also been found to have positive influence on adoption of SFPs in the studies conducted by Kassie et al. (2013), Ngombe et al. (2014) and Okuthe, (2014). On the other hand, Wollni and Andersson (2014) found otherwise.

The foregoing reviewed literature presents diverse findings regarding what influences adoption of SFPs among farming households. Diverse factors are at play regarding adoption of SFPs. It can further be deduced that farmer's motivation to adopt SFPs differs from case to case and from one location to another. Notwithstanding the ongoing debate on what really influences motivation of farmers to adopt SFPs, this study placed itself in the current debates and investigated twenty factors, not only to contribute to the existing body of knowledge but also as basis for formulating recommendations to policy makers and extension providers promoting SFPs to farmers.

2.7 Conceptual framework for environmental sustainability assessment

A conceptual framework is visual representation of the concept to be studied or explored. Various frameworks have been developed to conceptualise measurement of sustainability in the agriculture sector. The conceptual framework that guided this study was designed as illustrated in Figure 5. The framework was premised on the FAO framework of Sustainability Assessment of Food and Agricultural Systems (SAFA) which formed the integral basis for selection of indicators measured in the study. The SAFA framework is a universal global reference framework for the assessment of sustainability along agriculture, forestry, and fisheries value chains (FAO, 2014). The choice and design of the framework was tailored to explore the topic in specific details and to formulate the right research questions that guided the study towards achieving the research objective of developing tailor-made interventions for improving sustainability of the banana value chain in Mwense Zambia.

The SAFA framework begins with the higher level, all-encompassing dimensions of sustainability, namely good governance, environmental integrity, economic resilience, and social well-being (FAO, 2014). This study however focused on the environmental sustainability dimension and three corresponding themes as illustrated in figure 5. The implementation of Sustainable Farming Practices was included in the framework as an extra dimension to be explored in the study. This was because assessment of sustainability depends on the adoption and implementation of SFP among producers.



Source: Adapted from FAO (2014)

Figure 5. Conceptual framework of the study

CHAPTER 3: METHODOLOGY

CHAPTER 3: METHODOLOGY

This chapter describes the description of the study area, research strategy, variables and measurements of the study, data collection methods, data processing and analysis, ethical considerations and ends with a description of limitations encountered during the implementation of the research. The detail of each item is now described in the sections that follow.

3.1 Description of the Study Area

The research was conducted in Mwense district of Luapula province located in Northern Zambia (figure 6). Mwense is a 2,403.3 km² (240,331.3ha) district located in Luapula Province of Zambia, at 10.383°S and 28.63◦E, about 867km from Lusaka the capital city of Zambia, with about 107,000 inhabitants (Zambia Statistical Agency, 2021). The geographical location of the district offers a comparative advantage to the horticulture subsector. The district falls in region III of Zambia's agro-ecological zones which receives the highest average rainfall in the country ranging between 1,000-1,500 mm/year and average temperature of 18 – 23^{O}C (MOA, 2020). The typical growing season starts from early November to late April with an average growing period of 120-150 days. The district has enough water sources suitable for all year-round irrigation, productive soils that favour growth of various fruits and vegetables and market opportunities locally and abroad in the neighbouring Democratic Republic of Congo.

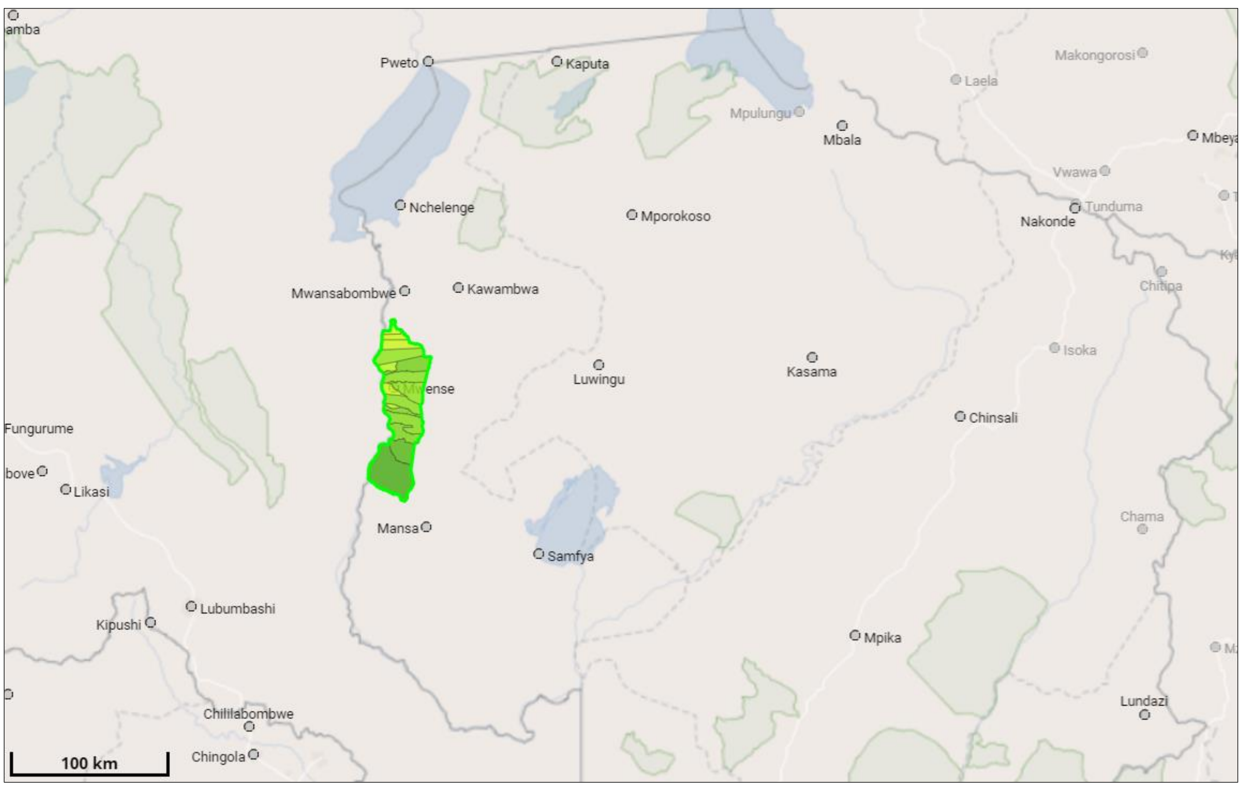


Figure 6. Location of study area

Source: City population (2022)

3.2 Research Strategy

This study aimed at exploring and recommending tailor-made interventions that enhance environmental sustainability of smallholder banana production. To achieve this objective, the study employed both qualitative and quantitative research strategies in the study area. The qualitative approach included focus group discussions (FGD) with banana producers and semi-structured interviews (SSI) with key informants in the banana value chain. The quantitative approach employed a structured survey by means of an aided questionnaire with sampled banana producers in the study area. The study design and implementation followed the steps as illustrated in figure 7.

The study design started with definition of the research problem, definition of the research objective and formulation of research questions. The research focus, objective and research questions were set in consultation with the study commissioner. This was followed by a review of related literature on the topic of sustainability assessment of agricultural practices, formulation of the conceptual framework and its operationalisation. The identification of environmental sustainability issues in agricultural production and listing of proposed indicators followed next. The outcome of this process was based on a literature review of previous work on the topic, study area and experts' opinion through consultation.

The implementation of the research design commenced with field data collection. Primary data collection was through a questionnaire survey with banana producers, interviews with key informants and Focus Group Discussions (FGD) in two locations across the district. Processing of primary and secondary data was followed immediately. This was followed through with processing and analysis of both secondary and primary data. The last step involved summarizing and presentation of results and finally formulation of conclusions and applied recommendations.

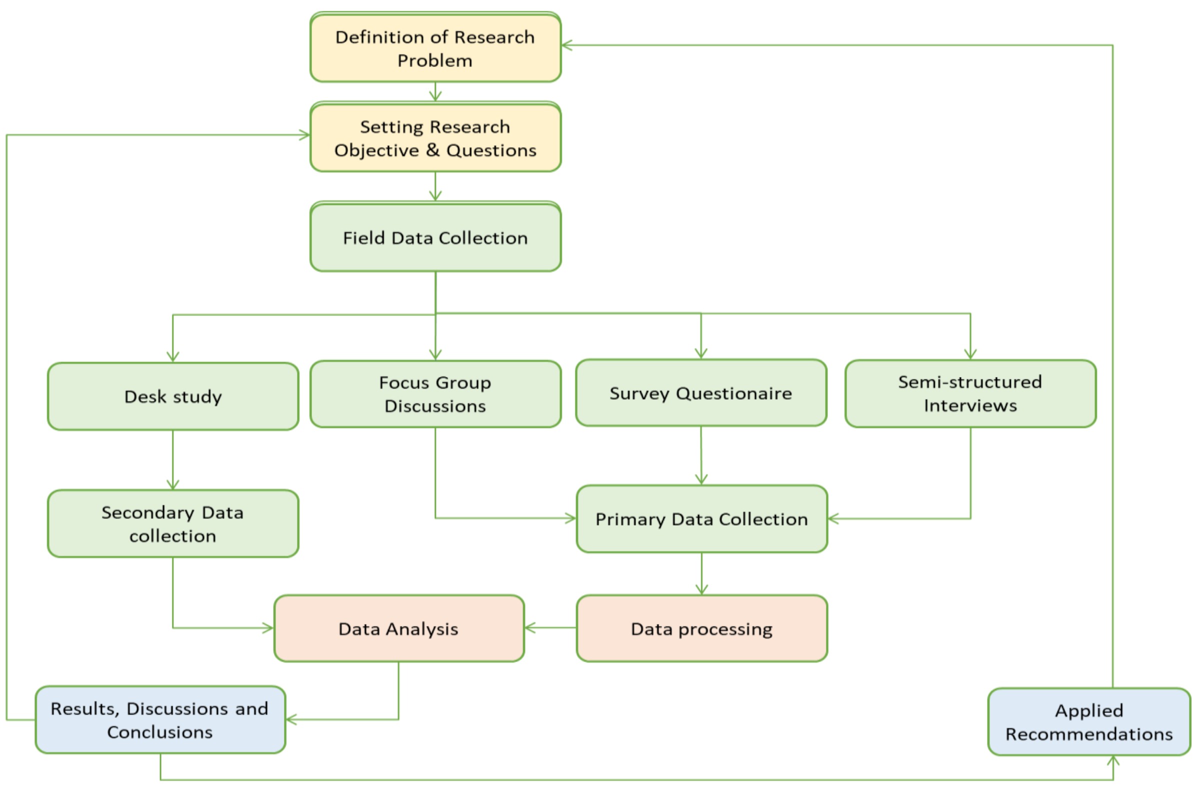


Figure 7. Steps used in the study

Source: Author's design, 2022

3.3 Variables and Measurements

The focus of this study was on three themes of the FAO-SAFA environmental sustainability namely water, land, and biodiversity. These themes are now explained.

3.3.1 Land

According to FAO (2014), land entails the soil resources. The goal of this theme is to protect loss of land due to mishandling of arable lands and pastures, and to preserve and enhance soil fertility. This study focused on soil quality and land degradation indicators as shown in table 4. Soil quality covers the safeguard and improvement of soil physical, chemical, and biological attributes whereas land degradation means the loss of productive soils.

3.3.2 Water

According to the FAO (2014), water is one of the main constraining aspects to food production. Agriculture uses a significant amount of freshwater on an average of 70% of global surface water supplies. This consumption rate is increasing at two folds the pace of population increase. The FAO further approximate that about fifty nations are presently facing moderate or severe water shortage and the number of people suffering from year-round or seasonal water shortages is projected to rise as a consequence of climate change. This study will focus on water quality and its related conservation practices indicators as shown in table 4.

3.3.3. Biodiversity

According to the FAO (2014), biodiversity entails the diversity of ecosystems, of species in these ecosystems and of the genome within these species. Agricultural biodiversity comprises an assortment of animals, plants and micro-organisms needed to sustain the functions of the agro ecosystem, its structure, and in support of food security. The sub-themes included are ecosystem diversity; species diversity; and genetic diversity. This study focused on ecosystem diversity whose aim is that areas under agriculture are managed sustainably, ensuring conservation of all forms of biodiversity. Ecosystem services that benefit and are moulded by agricultural practices consist of nutrient cycling, pest regulation, pollination, maintenance of soil fertility, water quality and climate regulation. The implementation of ecosystem-enhancing practices creates useful interactions and processes within ecosystems.

3.3.4 Definition and Selection of Sustainability Indicators

The selection of indicators for measurement of sustainability of the banana production practices in Mwense was based on the SAFA Framework of sustainability (2014). A total of three indicators covering water, land, and biodiversity themes of the environmental sustainability dimension were used for assessment. The criteria for selection of these indicators were based on the local situation of the study area. Further, selection of the indicators followed the quest to meet the criteria of relevance, validity, measurability, sensitivity and comprehensibility by stakeholders and decision-makers as proposed in literature (Dale and Beyeler 2001; Lebacq et al. 2013). The environmental sustainability performance of the three selected indicators were determined by measuring the implementation of a total of nineteen practices among banana producers, categorised under the three selected indicators. Table 4 provides a list of selected environmental indicators and measured practices for the study. The SAFA guideline (2014) further provides comprehensive definitions of each of the selected indicators. Table 5 provides the working definition of each sustainability indicator selected for this study.

Table 4. Selected environmental sustainability indicators and practices for the study

Theme	Indicator	Measurable parameters
Water	Water Conservation Practices	- Mulching - Drainage - Conservation tillage - Raised beds - Water harvesting
Land	Soil Improvement and Land Conservation Practices	- Cover crop - Soil drainage - Liming - Agroforestry - Crop rotation - Organic fertilisers
Biodiversity	Ecosystem Enhancing Practices	-Soil coverage -Mixed cropping -Intercropping -Integrated weed management -Diverse crop rotation -Integrated pest management -Mixed crop-livestock systems -Agroforestry

Source: FAO (2014)

Table 5.Working definitions of selected indicators for the study

Dimension	**Indicator**	**Indicator definition**
Environmental	Water Conservation Practices	Practices that aim at saving water in agriculture and fisheries-based food chains
	Soil Improvement Practices	Practices that aim at improving the physical, chemical, and biological properties of the soils used by an enterprise
	Land Conservation Practices	Practices that aim at preventing the loss of productive soils and at rehabilitating degraded soils
	Ecosystem Enhancing Practices	Practices that aim at enhancing functional relationships and processes within ecosystems by different actors in agriculture-based food chains

Source: FAO (2014)

3.3.5 Measurement of current farming practices

Determination of environmental sustainability status of farming practices in Mwense entailed understanding the current farming practices of banana producers in the study area. These practices were broadly categorised into land preparation practices, crop management practices, fertilizers and agrochemical use, harvest and postharvest management practices as shown in table 6. Selection of these practices was based on relevance, applicability among targeted respondents and in relation to environmental sustainability indicators selected for the study.

Table 6. Selected farming practices for the study

Category	Practices of interest
Land Preparation and Cultivation Process	Land clearing practice(s)
	Soil preparation practice(s)
	Machinery/equipment type
Crop management	Crop types and varieties
	Sowing methods or practice(s)
	Weed management practices
	Irrigation practices
	Fertilizer application practices
	Pest management practices
	Disease management practices
Fertilizer and agrochemical use	Fertilizer type(s)
	Soil fertility determination method(s)
	Pesticides type(s)
	Pesticides disposal method(s)
Harvest management	Harvest determination methods
	Harvesting methods
Post-harvest management	Pre-cooling methods
	Storage or preservation practices
	Transportation methods
	Waste management practices
	Quality control and certifications

Source: Author based on Lampridi et al, (2019).

3.3.6 Selection of factors influencing Adoption of Sustainability Farming Practices

Nguyen and Chinawat (2015) in their evaluation study of factors influencing banana farmer's adoption of sustainable agricultural practices (SAPs) postulated that several factors are behind the farmer's decision to adopt and implement SFPs which they broadly categorised into socioeconomic characteristics of farmers (Age, Sex, Farm experience, Education, Farm size, Cultivated area, Land tenure, Economic status, HH SIZE, HH Labour, Access to extension services, Access to Agricultural TV Programs, Access to Agricultural Radio Programs) and behavioural control factors (Sustainable agricultural perception, Feasibility of practices, Labour access, Machine access, Fertilizer access, Pesticide access, and Credit access).

This study explored both the socioeconomic and behavioural factors influencing implementation of SFPs in Mwense Zambia. Socioeconomic factors relate to the social standing or class of an individual or group whereas behavioural factors are those related to the individual. Table 7 shows the influencing factors explored in this study. Choice of these factors relate to what has been extensively proposed in literature based on theories such as the theory of planned behaviour and studied in similar geographical locations and ethnic characteristics to the study area.

Table 7. Variables measured as factors influencing implementation of SFPs

Category of factor (Variable)	Unit of Measure
Age	Age in years of farmer (years)
Sex	Male or female
Farm experience	Number of years in farm experience (years
Education	Education level (years)
Farm size	Total farm area of households (ha)
Cultivated area	Banana area of households (ha)
Land tenure	Land tenure (Landowner = 1, 0 otherwise)
Economic status	Economic status (above poverty line = 1; 0 otherwise)
Household Size	Size of household (number)
Labour	Household labour (number)
Feasibility of practices	Feasibility of SAPs (scores)
Sustainable agricultural perception	Farmers perception of sustainable agriculture (scores)
Access to extension services	Access to extension services (times/month)
Access to Agricultural TV Programs	Agricultural TV programs (times/month)
Access to Agricultural Radio Programs	Agricultural radio programs (times/month)
Labour access	Access to rent labour (access to labour = 1; 0 otherwise)
Machine access	Access to machines (access to machines = 1; 0 otherwise)
Fertilizer access	Access to fertilizers (access to fertilizer = 1; 0 otherwise)
Pesticide access	Access to pesticides (access to pesticide = 1; 0 otherwise)
Credit access	Access to bank credit (access to credit = 1; 0 otherwise)

Source: Nguyen and Chinawat (2015); Waseem et al (2020)

3.4 Data Collection

The sustainability assessment approach employed in this study was a district level assessment of small-scale banana production. To achieve this, the research involved collecting data and values to be used in the analysis using a participatory approach which involved the researched as much as possible. Therefore, the data collection strategies employed in this study aimed at triangulating the research findings as much as possible to increase validity and reliability of the findings by getting data from various sources using different methods. Consequently, the study employed four main data collection methods, namely Desk Study, Questionnaire Survey, Semi-structured Interviews and Focus Group Discussions (FGD). Table 9 gives the data collection methods used for the study according to the research questions. Details of the four data collection methods to be employed are now described.

3.4.1 Desk study

Desk study consisted of data collection from secondary sources. This method was used to relate the current study to previous studies that have employed the approach of agricultural sustainability assessment, specifically in African agricultural context and elsewhere. In this research, desk study was chosen as method to identify environmental sustainability standards against which the current farming practices were compared for measuring their performance. In this regard, the desk study involved a review of documents available on online resources (Google Scholar, Greeni and online agricultural journal databases). Gray literature consisting of reports from government agencies and official local and international organizations was consulted to further understand the local situation better.

3.4.2 Questionnaire survey

The survey questionnaire (see Annex 1) was the main quantitative data capturing tool used in this study. This method was chosen for this study because it was deemed cost-effective and efficient by the author at capturing enough data from sampled respondents within the study timeframe. Due to low literacy levels of the anticipated respondents, and for the purpose of increasing the response rate, the questionnaire was administered with the help of research assistants, who were extension officers under the Ministry of Agriculture in the study area. These officers know and work closely with the targeted respondents and were used as key entry points in identifying, informing, and gathering of the sampled respondents for easy access. The administration strategy of the questionnaire was meeting of a group of respondents in one location. Respondents were asked to provide responses to questionnaire questions while research assistants entered the responses in an online version of the questionnaire using google forms. This strategy ensured effective time management and resource conservation.

The questionnaire was structured with short answers, multiple choice questions and rankings that facilitated collection of required data, as accurate as possible, to be used as basis for assessing each selected sustainability indicator for the study. The questions for the questionnaire were aligned to the indicator measurement procedure and criteria as described in the FAO-SAFA (2014) indicator guideline. The questionnaire was the primary tool used for capturing needed information to answer sub-question 2.2 and 2.3 of this study regarding performance of the selected sustainability indicators among smallholder banana farmers and to identify the factors influencing the implementation of sustainable farming practices among smallholder banana producers, respectively.

For the study, a total of sixty (60) banana producers were sampled and interviewed using the questionnaire survey. The sampling frame used was the Mwense District Farmer Register which was accessed from the Zambia Integrated Agriculture Management Information System (ZIAMIS) of the Ministry of Agriculture. Sampling of individual respondents for questionnaire survey was done by simple random sampling method. This ensured a wide and unbiased representation of respondents across the district.

3.4.3 Semi-structured Interviews

This data collection method was employed to collect primary data from key informants in the study area using a pre-designed interview guide (Annex 2). This method was used to collect qualitative data to answer main question 1.0 and sub-question 2.1 regarding the current farming practices among smallholder banana producers and whether the current farming practices are following environmental sustainability standards, respectively. Interviews were conducted to a total of eight key informants. The key informants interviewed were 7 ministry officials and 1 District Farmers Union representative. A representative of a commercial farm was not interviewed due to extenuating circumstances of the researcher.

Table 8 provides a comprehensive list of key informants interviewed. Further, the interview guide (see annex 2) was prepared based on the indicator measurement parameters and criteria as described in the FAO SAFA (2014) indicator guideline which was used as primary reference standard for indicator measurement in this study. The sampling method employed for key informant interviews was purposive. Thus, selection criteria for key informants were based on years of experience, active participation in the banana value chain, and depth of knowledge of the banana sub-sector in Mwense district. Stakeholders with years of experience and understanding of the banana value chain and its history were purposely sampled for interviews.

3.4.4 Focus Group Discussions (FGD)

FGD is a qualitative tool that consists of a group interview where the respondents discuss and agree on a certain issue (Laws et al, 2013). The primary purpose of conducting FGD in this study was to get a group understanding of the production practices of banana production in the study area which formed the basis for answering sub-question 1.0. The groups were asked to brainstorm, evaluate, and describe the predominant practices of banana production in the study area. Thereafter, the groups were asked to produce a production calendar/cycle indicating key practices followed by banana producers in the study area. The FGD were facilitated though a prepared guide as shown in Annex 3. For FGD, selection of ten participants in each of the two locations in the study area was based on years of experience and scale of banana production. Thus, sampling used was purposive. This ensured a deeper understanding of the production practices by real banana producers in the study area.

Table 8. Sampling list for key informant interviews and questionnaire survey

Interviewee	Organisation	Sampling method	Role in the chain (Reason for selection)	Number
District Agriculture Coordinator	Ministry of Agriculture	Purposive	Coordination of extension services	01
Agricultural Extension Officers	Ministry of Agriculture	Purposive	Provision of extension services to farmers	06
Farmer representative	District Farmer's Union	Purposive	Banana farmer and coordinator of farmer activities	01
Farm manager	Mununshi Fruit Company (MFC)	Purposive	Large scale banana production and wholesaling	00
Individual farmers	Individual farmers	Simple random sampling	Small-scale banana production	60
Groups of farmers (FGDS)	Individual farmers	Purposive	Small-scale banana production	20

Source: Author, 2022

Table 9. Data collection methods based on research questions

Research Objective	Sub-questions	Information needed	Source of information	Data Collection method	Data analysis method	Output/Results
To develop tailor-made interventions targeting to enhance the environmental sustainability of smallholder banana production in Mwense, Zambia.	1.0 What are the current farming practices among smallholder banana producers?	•Current farming practices among smallholder banana producers	•20 Banana producers •8 Key informants	•FGDs in two locations •Semi-structured interviews with Key informants	•Qualitative analysis of FGD data, interview transcripts	•Production calendar/cycle of current production practices
	2.1 Are the current farming practices following environmental sustainability standards?	•Current farming practices among smallholder producers •Environmental sustainability standards	•20 Banana producers •8 Key informants •Literature sources for environmental sustainability standards	•FDGs in two locations •Semi-structured interviews with Key informants •Desk study/Literature review	•Qualitative analysis of FGD data, interview transcripts and literature review	•Sustainability performance score or profile of current farming practices
	2.2 What is the performance of water management, soil conservation, land rehabilitation and ecosystem conservation indicators of sustainability among smallholder banana producers?	•Information on adoption of specific water, soil, land & ecosystem conservation practices among smallholder banana producers	•60 Banana producers •8 Key informants	•Survey questionnaire •Semi-structured interviews with Key informants	•Descriptive statistics using SPSS •Qualitative analysis of interview transcripts (QAIT)	•Frequencies, percentages, mean and standard deviations, Bar charts
	2.3 What are the factors hindering the implementation of sustainable farming practices among smallholder banana producers?	•Factors influencing farmer's adoption of sustainable farming practices (SFP)	•60 Banana producers •8 Key informants	•Survey questionnaire •Semi-structured interviews with Key informants	•Descriptive statistics using SPSS •Regression analysis •(QAIT)	•Frequencies, percentages, mean and standard deviations, Bar charts •Multiple regression table

Source: Author (2022).

3.5 Data Processing and Analysis

The collected data from questionnaire survey, key informant interviews and focus group discussion was analysed by qualitative and quantitative analytical and statistical tools as described in the sections that follow.

3.5.1 Analysis of Quantitative Data

3.5.1.1 Analysis of the Survey Questionnaire Data

The quantitative data collected using the questionnaire was processed and analysed to answer sub-question 2.2 and 2.3 of this study. For sub-question 2.2, information on adoption of specific water, soil, land, and ecosystem conservation practices among smallholder banana producers was obtained. Farmers were asked to provide responses to specific practices they have adopted or not out of a total of 19 practices under environmental sustainability indicators checked in this study. Adoption of each practice was given a score of 1 while non-adoption was given a score of 0. Based on the scores, descriptive statistics using IBM SPSS version 27 was used to generate frequencies, means and percentages. Based on the percentages of farmers practicing a set of practices under each indicator, the performance of each indicator was determined based on the five-point scale as shown in table 10. Based on the output of IBM SPSS version 27, Microsoft Excel was used to generate graphs.

For sub-question 2.3, information on factors influencing adoption of Sustainable Farming Practices (SFP) among banana producers was obtained. A total of twenty factors were investigated as variables for each of the respondents sampled. This data was then analysed using descriptive statistics using IBM SPSS version 27 to generate frequencies, means and percentages. Based on SPSS output, adoption of SFP was calculated as an average adoption ratio of all nineteen practices for each respondent. This data was further used for regression analysis to determine which variables have a significant correlation with adoption of SFP.

Table 10. The five-point score for environmental sustainability performance of indicators

Score	Meaning	Percentage
1	Unacceptable	0-20%
2	Limited	20-40%
3	Moderate	40-60%
4	Good	60-80%
5	Best	80-100%

Source: FAO (2014)

3.5.2 Analysis of Qualitative Data

Analysis of qualitative data means taking things apart, putting them together again to work out the links between the respondents' inputs and the original questions, and deciphering the meaning (Laws et al, 2013). Consequently, analysis of qualitative data collected in this study followed the qualitative analysis method as described by Laws, et al (2013). This involved the core process of categorising and coding of collected data from key informant interviews and FGDs. This was followed by entering of responses from interviewees using Microsoft Excel based on the main themes or categories, followed by identification of patterns and contradictions among respondents, and use of the categorised responses to answer the research questions.

3.5.2.1 Analysis of Interview data

The data collected using semi-structured interviews was used to answer main question 1, sub-question 2.1, sub question 2.2 and sub question 2.3. The information collected were the current farming practices among smallholder producers, information on adoption of specific water, soil, land & ecosystem conservation practices among smallholder banana producers, and responses on factors influencing farmer's adoption of sustainable farming practices (SFP). This information was triangulated with information collected using FGDs and survey questionnaire. The analysis followed the approach of qualitative data analysis for interview data. First, recordings and field notes of interviews with each key informant were transcribed into interview transcripts using MS Word software. This was followed by coding of the transcripts.

Analysis followed by reading and analysing responses of each key informant to the set questions in the interview guide, to look for common responses and contradictions. Next, common responses to the questions were identified in each transcript and coded. This was followed by categorising the responses into themes, precisely, common farming practices as mentioned by different key informants, extent of adoption of environmental sustainability practices and extent of influence of specific factors on adoption of SFP among banana producers. Finally, the identified themes were used to answer the research questions.

3.5.2.2 Analysis of Focus Group Data

Focus group data was used to answer main question 1.0. The information collected was the current farming practices among smallholder producers. This data was further triangulated with information collected using semi-structure interviews. As with interview data, the output of each of the two focus group discussions was analysed by identifying the common themes (common farming practices) and contradictions. The common themes or practices were then aggregated into a final set of current farming practices among smallholder banana producers in Mwense Zambia.

3.6 Ethical Considerations

This study adhered to the ethical standards for field research in relation to treatment of respondents and their right to privacy. Specific ethical issue the research paid particular attention to included acquiring voluntary and informed consent to participation by respondents, ensuring anonymity and confidentiality of any obtained personal details from respondents, avoiding potential harm to respondents especially in the rural communities during field data collection by questionnaire and during FGD, and sharing of research findings with relevant stakeholders and the researched if interested. Since the research was conducted in rural setting, the researcher also took care to avoid raising expectations inappropriately, realising the need of impoverished communities for assistance.

3.7 Limitations of the study

This study had limitations that also offer prospects for further research. First, the research acquired a sample representation of banana farmers from Mwense district only. The restricted number of respondents might restrict the generality of results. Second, this study explored only one dimension of sustainability – the environmental aspect. It did not look at the economic and social aspect of sustainability. Furthermore, the study did not include examination of all indicators related to environmental sustainability as proposed by extant literature. The choice and inclusion of indicators and practices explored was limited to geographical and ecological constraints in addition to their applicability in relation to the study area and its production system. This might further constrain generalization of the overall sustainability performance of the banana value chain in Mwense.

CHAPTER 4: RESULTS

CHAPTER 4: RESULTS

4.1 The Current Farming Practices Among Banana Producers in Mwense Zambia

This study pursued to understand the current farming practices among banana producers in Mwense. The practices were categorised into land preparation, crop management, fertilizers and agrochemical use, harvest, and postharvest management practices. The farming practices as currently practiced by banana producers in Mwense are as shown in table 11.

Table 11. Current farming practices among smallholder banana producers in Mwense Zambia

Practice category	Current practice
Land Preparation	
Land clearing practice(s)	Cut and burn residues in the field
Soil preparation practice(s)	Complete soil turnover, use of conventional ridges & planting holes
Machinery/equipment type	Hand tools (Hoes, Axes, Machetes and Shovels)
Crop management	
Crop types and varieties	Uncertified local varieties, suckers passed from farm to farm
Sowing methods or practice(s)	Singe row planting in holes (pits) or conventional ridges
Weed management practices	Manual weeding by hand
Irrigation practices	Rain fed and furrow irrigation
Fertilizer application practices	Spot application at unknown fertilizer rates
Pest management practices	None
Disease management practices	None
Fertilizers and Agrochemical use	
Fertilizer type(s)	Organic compost manure
Soil fertility determination method(s)	Visual assessment (farmer's own experience)
Pesticides type(s)	None
Pesticides disposal method(s)	None
Harvest management	
Harvest determination methods	Visual observation of fruit color change
Harvesting methods	Hand harvesting
Post-harvest management	
Pre-cooling methods	Putting harvested banana in cool area
Storage or preservation practices	Putting is baskets and store in cool room
Transportation methods	Motorbikes, vehicles, and bicycles
Waste management practices	Leaving crop residue to decompose in field, Dispose in pits
Quality control and certifications	None

Source: Research findings, 2022

4.1.1 Land preparation practices

Based on interviews with extension officers, farmer representatives and FGDs, land preparation practices among banana producers in Mwense are characterised by use of hand tools for land clearing. Farmers use hand tools to slash and cut grass and vegetation which they later burn in the field. Other farmers burry grass and vegetation in big moulds months prior to planting. Extension officers reiterated that this process, locally known as '*Fundikila*,' allows for decomposition of residues to increase organic matter in the soil. Further, it was found that farmers practice complete soil turnover, use of conventional ridges and planting holes as soil preparation practices. Machinery and equipment use were limited to hand tools such as hoes, axes, shovels, and machetes. Experts at the ministry of Agriculture revealed that mechanization of agriculture in the district is extremely low as farmers are unable to access mechanised equipment or motorised farm machinery due to their poor economic status and access to credit facilities.

4.1.2 Crop management practices

As confirmed by interviews with extension officers and focus group discussions, farmers plant uncertified local varieties whose propagation materials are passed from farmer to farmer. Few farmers plant hybrid varieties mostly Dwarf cavendish and Williams. According to agricultural extension officers interviewed, farmers plant sword suckers obtained from already established banana plants or from neighbouring farms. Meanwhile, they do not practice disinfection of the suckers either through use of chemicals of by hot water treatment to prevent spread of diseases (figure 9). Tissue cultured seedlings are not available as farmers are not aware of the tissue culture technology. Extension staff and FGDs further elucidated that the knowledge and skill of tissue culture technology is lacking even among extension officers themselves, in addition to lack of appropriate facilities for propagation of tissue cultured seedlings for farmers.

Field extension officers and farmers in FGDs revealed that the predominant sowing method was single row planting of banana suckers in pits that are dug at irregular intervals and filled with compost manure. Majority of farmers were planting bananas in strict pure stand production systems (monocropping) whereas others planted them in mixed crop systems with maize, sugarcane, rice, and vegetables. Weeding was done by hand whereas irrigation was rain fed supplemented by furrow irrigation (figure 9) during the dry periods. Study informants further revealed that application of chemical fertilizers in banana fields was done by spot application but was limited to a minority of farmers who only apply it once as basal application.

Both the district coordinator of agriculture and a farmer representative interviewed revealed that majority of farmers in Mwense were not implementing any pest and disease management practices. A minority of farmers who practiced disease control perform rogueing off and burning of diseased plants from the field. This was alluded to limited knowledge among banana producers on identification and control of pests and diseases on one hand and to excessive cost of chemicals on the other hand. It was further mentioned that very few farmers practiced field hygiene such as leaf pruning, regular weeding of fields, de-suckering, and removal of male inflorescence from banana bunches. Based on survey findings, crop disease and pest attack problems accounted for 100% and 30% respectively, of the environmental challenges faced by banana producers in Mwense as illustrated in figure 8.

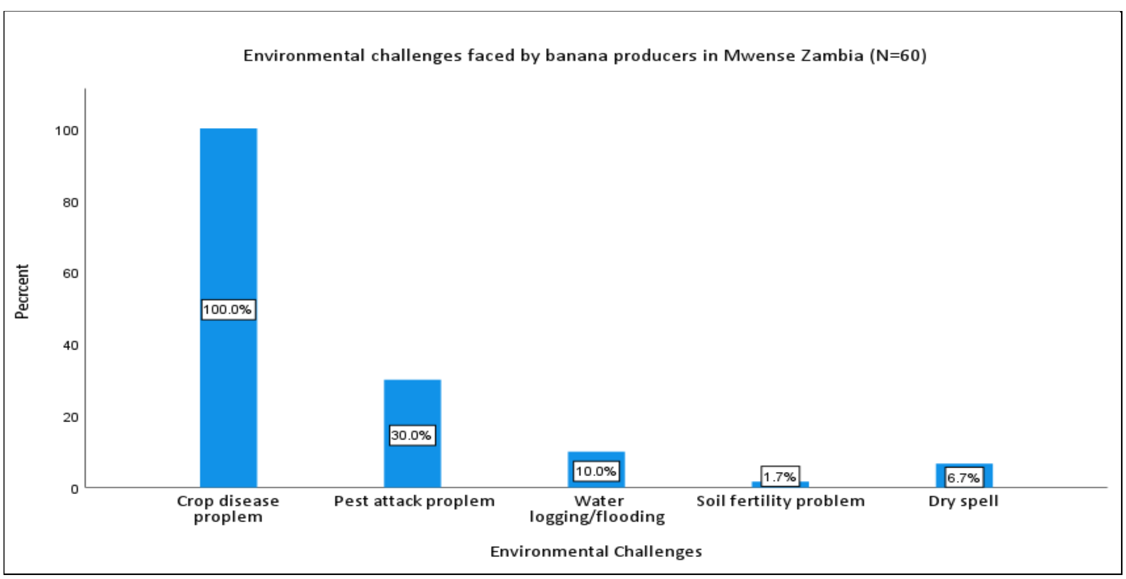


Figure 8. Environmental challenges faced by banana producers in Mwense Zambia

Source. Survey findings, 2022

4.1.3 Agrochemical use

The research interview with extension officers coupled with focus group discussions with farmers revealed that the majority of farmers were not using synthetic fertilizers in banana production and the minority who used this type of fertilizers were not applying them at recommended rates. Most farmers were found using organic material to satisfy the nutrient requirements of bananas. Extension officers further reviewed that farmer’s Soil fertility determination method was by visual assessment based on farmer's own experience and soil color. Similarly, none of the producers in the district were using pesticides and herbicides in banana production.

4.1.4 Harvesting methods

Regarding harvesting methods, research findings-based interviews with extension officers and focus group discussions revealed that banana farmers in Mwense use visual observation of fruit color change to determine harvest timing before they harvest the fruits by hand by cutting the banana bunches using machetes.

4.1.5 Postharvest management practices

At postharvest management stage, both interviews with extension officers and focus group discussions data revealed that banana producers in Mwense lack proper pre-cooling methods. The current storage or preservation practices being performed by farmers include putting harvested bananas in baskets and storing them in their homes. Transportation of the harvested fruits is by use of motorbikes, vehicles, and bicycles. Regarding waste management practices, research findings revealed that crop residues are left to decompose in the field whereas others are disposed in pits. The research however revealed that no quality control and certifications are being practiced by banana producers in Mwense.

9A 9B 9C

Figure 9. Field management, residue retention and water management practices in banana fields

Source: Author, 2022

Photo 9A: Poor managed disease banana plant
Photo 9B: Residue retention
Photo 9C: Water furrow for supplementary irrigation

4.2 Environmental Sustainability Status of the Current Farming Practices in Mwense Zambia

The environmental sustainability status of the current farming practices was assessed based on a comparative analysis of the current practices against the environmental sustainability standards recommended by the FAO (2014) and GLOBAL GAP (2022) standards. Results of the analysis are as shown in table 12. Based on the FAO (2014) SAFA sustainability performance scale, the overall environmental sustainability status of the current farming practices among banana producers in Mwense Zambia was found to be limited in adhering to environmental sustainability standards.

Regarding land preparation practices, both the GLOBAL GAP (2022) and the FAO (2014) standards recommend conservation tillage practices such as residue retention, potholing, ripping, permanent ridges and planting basins. The analysis revealed that most banana farmers in Mwense do not retain the residues in the field after land clearing, use conventional ridges and planting basins, and use hand tools for land preparation. It was thus found that that banana producers in Mwense were practicing unacceptable and environmentally sustainable land preparation practices.

Concerning crop management practices, both the GLOBAL GAP (2022) and the FAO (2014) standards recommend use of certified or hybrid crop varieties, precision planting for optimal plant population, integrated weed, pest and disease management practices, judicious use of fertilisers, herbicides and pesticides, and efficient water management practices. However, the analysis revealed that banana producers were not using certified banana varieties for planting. The spacing used in banana fields was neither based on expert advice nor on recommended plant spacing for optimal plant populations. Furthermore, farmers were not practicing integrated management practices for weeds, pests, and disease control in their banana fields. This however compromises enhancement of biodiversity and water use efficiency by preventing losses of produce due to pests, diseases, or lack of nutrients (FAO, 2014). Conclusively, crop management practices measured below acceptable sustainability standards.

As for agrochemical use, the analysis revealed that majority of farmers were practicing organic composting as opposed to use of synthetic fertilizers. This was in line with both the FAO (2014) and GLOBAL GAP (2022) sustainability standards for fertilizers and pesticide use. However, the minority of farmers who were using synthetic fertilizers were neither following recommended application rates nor basing their fertilizer application on standard laboratory soil tests. Additionally, none of the farmers were using pesticides for pests or disease control in their fields. The GLOBAL GAP standards further require that harvesting of banana fruits should be done at the proper time following standard maturity indices such as visual observation of fruit and pulp color change, days to maturity as per variety and, if applicable, based on laboratory test for maturity. The analysis revealed that banana famers in Mwense are in conformity with this standard as they base their harvest timing of fruit or pulp color change.

As for postharvest management practices, the GLOBAL GAP (2022) and other literature recommend precooling methods such as hydrocooling, room cooling or cold rooms, none of which were being practiced by banana producers in Mwense at the time of the research. The standards further recommend storage practices such as use of refrigerators, cold rooms, and packaging materials such as plastic crates, containers, and boxes (Kader et al, 2002), none of which were being used by Mwense farmers. Quality control and certifications is an emerging requirement for farmers to gain access to national and international markets. Despite the growing demand for sustainable certification and product labelling, farmers in Mwense are not practicing any form of produce certification and quality control is limited to size grading and sorting of bananas at point of sale. As this study revealed, majority of farmers in Mwense do not know about sustainable certification and labelling.

Table 12. Environmental sustainability performance of current farming practices in Mwense Zambia

Category	Current practice	Standard Sustainable Practice	Reference standard	Score
Land Preparation/Cultivation Process				
Land clearing practice(s)	Cut and burn residues in the field	Conservation tillage	FAO-SAFA	0
Soil preparation practice(s)	Soil turnover, conventional ridges & planting holes	Conservation tillage	FAO-SAFA	0
Machinery/equipment type	Hand tools (Hoes, Axes, Machetes and Shovels)	Conservation tillage tools/equipment	Global GAP	1
Crop management				
Crop types and varieties	Uncertified local varieties passed from farm to farm	Certified crop types and varieties	Global GAP	0
Sowing methods or practice(s)	Singe row planting in holes (pits) or ridges	Row planting in pits, basins, furrow or otherwise	Global GAP	1
Weed management practices	Irregular weeding by hand tools	Integrated Weed Management (IWM)	Global GAP	0
Irrigation practices	Rain fed and furrow irrigation	Rain fed and/or controlled irrigation	Global GAP	1
Fertilizer application practices	Spot application at unknown fertilizer rates	Spot application methods at recommended rates	Global GAP	0
Pest management practices	None	Integrated Pest Management (IPM)	FAO-SAFA, Global GAP	0
Disease management practices	None	Integrated Disease Management (IDM)	FAO-SAFA, Global GAP	0
Agrochemical use				
Fertilizer type(s)	Organic compost manure	Organic or Synthetic Fertilizers	FAO-SAFA, Global GAP	1
Soil fertility determination method(s)	Visual assessment (farmer's own experience)	Laboratory Soil tests	Global GAP	0
Pesticides type(s)	None	Botanicals or Synthetics	Global GAP	0
Pesticides disposal method(s)	None	Waste bins or waste pits	Global GAP	0
Harvest management				
Harvest determination methods	Visual observation of fruit color change	Visual assessment or Laboratory analysis	Global GAP	1
Harvesting methods	Hand harvesting	Manual or Machine Harvesting	Global GAP	1
Post-harvest management				
Pre-cooling methods	Putting harvested banana in cool area	Water method or Cold chain system	Global GAP	0
Storage or preservation practices	Putting is baskets and store in cool room	Cold rooms	Global GAP	0
Transportation methods	Motorbikes, vehicles, and bicycles	Refrigerated transport	Global GAP	0
Waste management practices	Leaving crop residue to decompose, Dispose in pits	Recycling or Waste Pits or Composting	Global GAP	1
Quality control and certifications	None	Sustainable certification and labelling	Global GAP	0
Final score				**0.3**

Source: Research findings, 2022

Key	
	0-0.2 = Unacceptable
	0.2-0.4 = Limited
	0.4-0.6 = Moderate
	0.6-0.8 = Good
	0.8-1 = Acceptable

4.3 Performance of Environmental Sustainability Indicators Among Banana Producers in Mwense

The performance of selected environmental sustainability indicators among banana producers in Mwense is as shown in table 13. Results of the survey revealed an overall adoption rate of 26.9% of the assessed practices. Based on the FAO (2014) SAFA sustainability performance scale, this indicated a limited performance (20-40%) of the selected environmental sustainability indicators among banana producers in Mwense. Table 13 shows the frequencies and percentages of respondents and the corresponding sustainability performance score.

Table 13. Sustainability performance of selected environmental indicators among banana producers

Indicator	Measured practice	Frequency (N=60)	Percent	Score
Water Conservation Practices	Mulching	33	55.0	3
	Drainage	57	95.0	5
	Conservation tillage	15	25.0	1
	Raised beds	51	85.0	5
	Water harvesting	22	36.7	2
Soil Conservation and Land Rehabilitation Practices	Cover crop	4	6.7	1
	Soil drainage	10	16.7	1
	Liming	1	1.7	1
	Agroforestry	1	1.7	1
	Crop rotation	7	11.7	1
	Organic fertilizers	49	81.7	5
Ecosystem Enhancing Practices	Soil coverage	1	1.7	1
	Mixed cropping	28	46.7	3
	Intercropping	18	30.0	2
	Integrated weed management	4	6.7	1
	Diverse crop rotation	2	3.3	1
	Integrated pest management	1	1.7	1
	Mixed crop-livestock systems	2	3.3	1
	Agroforestry	1	1.7	1
Final Score			**26.9**	**2**

Source: Survey findings, 2022

Scale	Meaning	Performance score
1	Unacceptable	0-20%
2	Limited	20-40%
3	Moderate	40-60%
4	Good	60-80%
5	Best	80-100%

Source: FAO (2014)

4.3.1 Performance of Water Management Indicators

The sustainability performance of the water management indicator among banana producers in Mwense is as shown in figure 10. Results of the survey showed best performance of the water management indicators regarding use of raised beds and practice of water drainage with 85% and 95% (N=60) of farmers implementing the practices respectively, as shown in figure 10. However, survey results revealed a moderate overall indicator performance (Performance score = 40-60%) as shown in table 13.

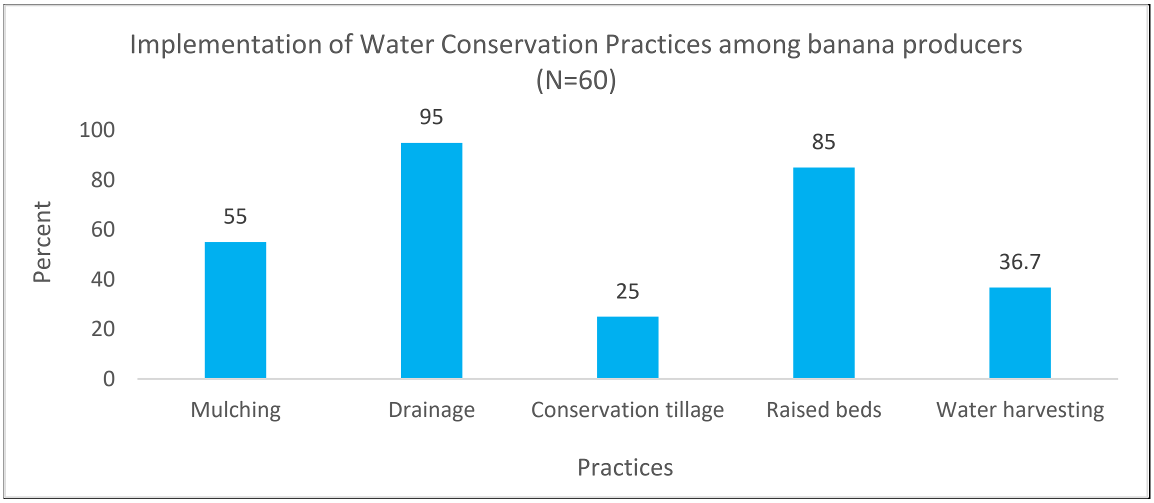


Figure 10. Implementation of Water Conservation Practices among banana producers

Source: Survey findings, 2022

4.3.3 Performance of Soil Conservation and Land Rehabilitation Indicators

The sustainability performance of soil conservation and land rehabilitation indicators among banana producers in Mwense is as shown in figure 11. The survey results showed best performance (performance score = 80-100%) in use of organic fertilizers with 81.7% (N=60) of banana producers implementing the practice as shown in figure 11. However, the survey results showed unacceptable performance (performance score = 0-20%) in implementation of cover crop, soil drainage, liming, agroforestry, and crop rotation practices among banana producers in Mwense Zambia as shown in figure 11. Consequently, the overall indicator performance was found to be unacceptable (Actual score = 20%; Performance score = 0-20%). As shown in table 13.

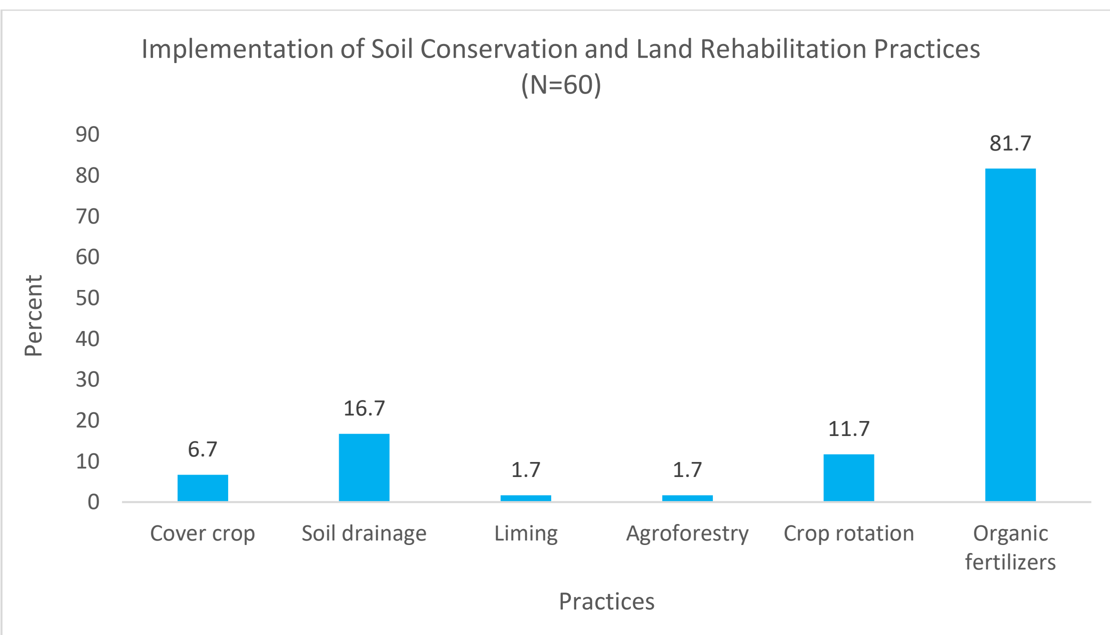


Figure 11. Implementation of Soil Conservation and Land Rehabilitation Practices

Source: Survey findings, 2022

4.3.4 Performance of Ecosystem Conservation Indicators

The environmental sustainability performance of ecosystem conservation indicators among banana producers in Mwense is as shown in figure 12. The survey results revealed a moderate performance in implementation of mixed cropping and limited performance in implementation of intercropping practices with 46.7% and 30% (N=60) of the farmers implementing the two practices in their banana fields, respectively. On the other hand, survey results showed unacceptable performance among banana producers regarding all other practices assessed under ecosystem conservation. Consequently, the overall indicator performance was found to be unacceptable (Performance score = 0-20%) as shown in table 13.

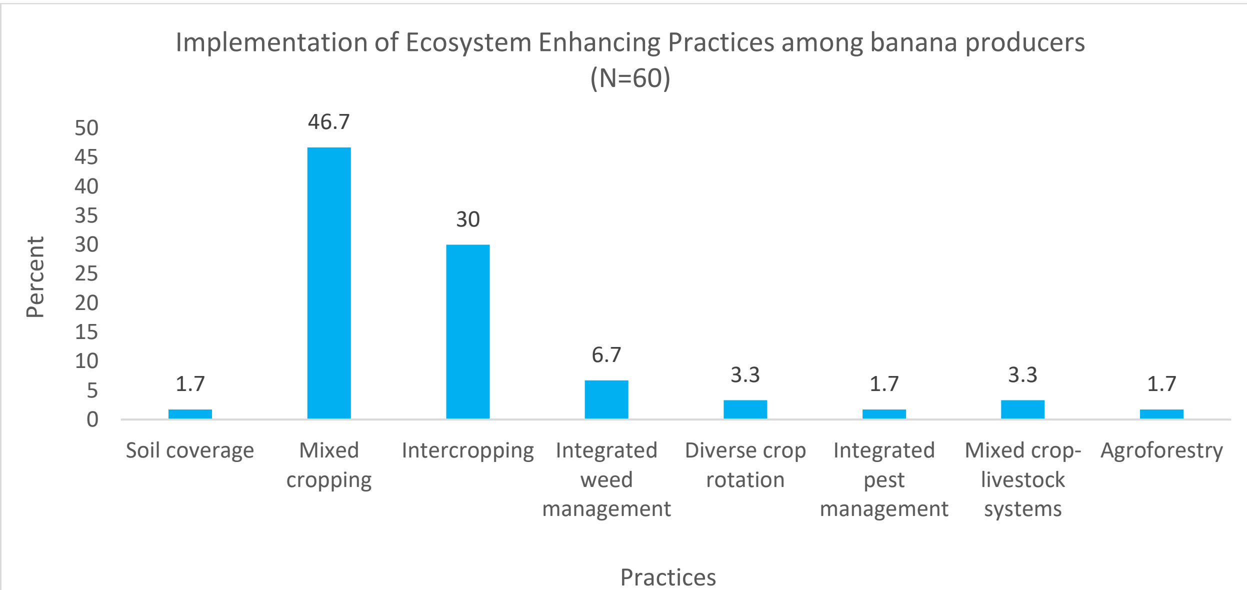


Figure 12. Implementation of Ecosystem Enhancing Practices among banana producers

Source: Survey findings, 2022

4.4 Factors influencing farmer's adoption of sustainable farming practices (SFP)

Tables 14 and 15 provide means, frequencies, and percentages of the investigated factors as per survey results.

Table 14. Table of means for factors influencing adoption of SFPs among banana producers

Statistics (N=60)

		Age	Farm experience	Farm size	Area under banana	Household size	Household labour
N	Valid	60	60	60	60	60	60
	Missing	0	0	0	0	0	0
Mean		**48.7**	**18.8**	**14.5**	**0.6**	**6.8**	**4.3**
Std. Deviation		12.451	11.657	37.577	0.517	2.611	1.730
Minimum		24	3	1.0	.25	2	1
Maximum		79	45	250.0	3.00	13	9

Source: Survey findings, 2022

Table 15. Frequecy table of factors influencing adoption of SFPs among banana producers

Factor	Category	Frequency(N=60)	Percent (%)
Education level	Primary level	30	50
	Secondary level	30	50
Economic status	Below poverty line	36	60
	Above poverty line	24	40
Land tenure	Landowner	60	100
	Otherwise	0	0
Feasibility of SFPs	Not easy	16	26.7
	Quite easy	44	73.3
Farmers perception of SFPs	Negative	12	20
	Positive	48	80
Access to extension services	No	20	33.3
	Yes	40	66.7
Access to Agricultural TV programs	No	44	73.3
	Yes	16	26.7
Access to Agricultural radio programs	No	4	6.7
	Yes	56	93.3
Access to rent labour	No	13	21.7
	Yes	47	78.3
Access to machines	Yes	0	0
	No	60	100
Access to fertilizers	No	7	11.7
	Yes	53	88.3
Access to pesticides	No	49	81.7
	Yes	11	18.3
Access to credit	Yes	0	0
	No	60	100

Source: Survey findings, 2022

4.4.1 Age, Sex, Farm Experience and Education Level of farmers

The survey results showed that 30% the surveyed respondents were female whereas 70% were male as illustrated in figure 13. The mean age of surveyed respondents was 48.7 years with minimum age of 24 and maximum age of 79. The mean farm experience of respondents was 18.8 years ranging from a minimum of 1 year to 45 years. The survey results revealed that education level was 50% primary level (between 1 to 7 years of education) and 50% secondary level (between 7 to 12 years of education).

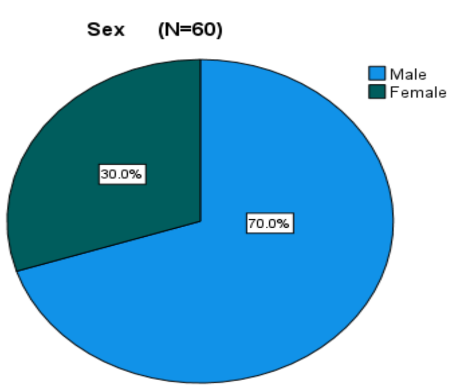


Figure 13. Gender distribution of survey respondents in Mwense Zambia
Source: Survey findings, 2022.

4.4.2 Farm size, Area under banana and Land tenure

According to survey results, the average total farm size was found to be 14.5ha whereas the average area under banana cultivation was found to be 0.6ha. It was thus established that only about 4% of the total farmland owned by banana farmers is used for banana cultivation. It was further established that all the respondents surveyed were landowners.

4.4.3 Economic status, household size and household labour

The survey revealed that 60% of respondents were found to be below the poverty line (i.e., below 2USD per day) whereas 40% were above the poverty line (i.e., above 2USD per day). Furthermore, of the average household size of 6.8 persons, 4.3 persons (63% of total HH size) participated in providing farm family labor for banana production.

4.4.4 Feasibility of SFPs and Farmer's Perception of SFP

The study findings showed that 73% of the respondents said quite easy to feasibility of sustainable farming practices whereas 80% of respondents showed a positive perception of sustainable farming practices.

4.4.5 Access to Extension services, Agricultural TV programs, and Radio programs

Regarding access to extension services, survey results showed that about 67% of respondents said they had access to extension services at least once a month whereas 33% said they had no access at all. The survey further showed that only about 27% of respondents had access to agricultural TV programs at least once a month whereas as 73% had no access at all. On the other hand, about 93% of respondents acknowledged having access to agricultural radio programs at least once a month.

4.4.6 Access to fertilisers and to pesticides

The study survey showed that 88% of respondents had access to fertilizers whereas access to pesticides was limited to only 18% of respondents. Meanwhile, 82% said they have no access at all.

4.4.7 Access to ret labour, to credit and to machines

The survey showed that 78% of respondents said they have access to rent labor. However, none of the respondents acknowledged having access to credit and machines.

4.4.8 Results of multiple regression model on adoption Sustainable Farming Practices

A multiple linear regression analysis was performed to examine the influence of the variables Age, Sex, Farm experience, Education, Farm size, Cultivated area, Land tenure, Economic status, Household Size, Household Labour, Access to extension services, Access to Agricultural TV Programs, Access to Agricultural Radio Programs, Sustainable agricultural perception, Feasibility of practices, Labour access, Machine access, Fertilizer access, Pesticide access, and Credit access on the variable Adoption of SFPs.

Table 16 shows the result of the multiple regression analysis. The result showed that household labor had a positive and noteworthy influence whereas access to fertilizers and access to TV programs had a negative but considerable influence on implementation of sustainable farming practices among surveyed banana producers in Mwense. The R^2 value of 0.232 (23.2%) shows the power of the regression that was statistically significant at 5% level of confidence and F Value of 5.50. The regression thus showed that 23.2% of influence on adoption of sustainable farming practices among banana producers in Mwense Zambia was contributed by household labor, access to fertilizers and access to TV programs.

Table 16. Results of multiple regression model analysis

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.295[a]	.087	.071	7.2174	.087	5.447	1	57	.023
2	.402[b]	.162	.132	6.9786	.074	4.969	1	56	.030
3	.482[c]	.232	.190	6.7387	.071	5.057	1	55	.029

a. Predictors: (Constant), Household labour

b. Predictors: (Constant), Household labour, Access to fertilizers

c. Predictors: (Constant), Household labour, Access to fertilizers, Access to Agricultural TV programs

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
3	(Constant)	28.569	3.550		8.048	.000
	Household labour	1.262	.530	.282	2.382	.021
	Access to fertilizers	-6.341	2.721	-.276	-2.331	.023
	Access to Agricultural TV programs	-4.440	1.974	-.266	-2.249	.029

a. Dependent Variable: Adoption of SFPs

Source. Survey results, 2022.

CHAPTER 5: DISCUSSIONS

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5.1 The Current Farming Practices Among Smallholder Banana Producers in Mwense Zambia

The study revealed that land preparation practices for most farmers in Mwense are characterised by use of hand tools and much less mechanized. This finding might explain why the average field size under banana cultivation was only 4% of total farm size. Maingi *et al.* (2021) reported comparable results that majority of the farmers in three counties of Kenya cultivated farmland with low acreage of 0.4 to 0.5. Obaga & Mwaura (2018) also stated that in Kenya, the country average of banana farms was 0.32ha per farmer. This implies that production of banana is likely to remain low unless interventions to mechanize farm operations of smallholders are put in place.

The study found that banana growers in Mwense were planting suckers of uncertified local varieties. This revelation is a striking commonality among African smallholders. The study of Maingi *et al.* (2021) in three counties of Kenya also reported a higher percentage of farmers using recycled suckers from their own farms. The author is of the view that smallholders lack technical knowledge and resources to propagate quality planting materials, and neither do they have enough resources to purchase certified seedlings. Consequently, the planting of low-quality suckers becomes an inevitable option. However, this option perpetuates spread of diseases and impacts on sustainable banana production. Langat *et al*. (2013) showed a similar view that usage of own farm recycled seedlings may be the main contributing cause of pest and disease incidence as this may offer a way of disease perpetuation through the use of contaminated planting material. Interestingly, majority of farmers in Mwense are neither aware nor use tissue cultured plantlets. A similar trend was observed by Muthee et al (2019) who reported that only 27.8% of the sampled farmers adopted the use of tissue culture (TC) planting materials. The author agrees with Wasala (2014) who suggested the providing inexpensive TC plantlets to smallholders, to lessen their dependence on the use of traditional suckers which are more susceptible to pest and disease attacks, and hence promote the decline in banana production.

Organic matter helps to hold moisture in the soil. Notably, the majority of farmers in Mwense are practicing the use of compost manure. Arati, *et al* (2020) found related results that majority of farmers used organic manure during land preparation and at planting. This could be ascribed to the low cost of obtaining organic materials compared to inorganic fertilizers. In rural farms, materials required for composting are readily available for farmers provided that they have proper knowledge, skills, and labour. The author reiterates the recommendation of Ganapathi and Dharmatti (2018) who suggested a mixture of both organic and inorganic sources of nutrients to attain higher yields, and also to sustain the soil fertility condition eventually.

Regarding irrigation of banana fields, this study has shown that farmers rely on rain fed irrigation whereas furrow irrigation is used as supplementary irrigation during the dry periods. Comparable results were found in the study of Gebre *et al* (2020) who reported that banana farmers in Ethiopia rely on rainfall irrigation and supplement it with irrigation water from water diversions of rivers and streams. Arati, *et al* (2020) further reported that 37.9% of their sampled farmers did not have any source of irrigation in their fields and depended on the rainfall for irrigating their fields. This could be related to the excessive cost of setting up elaborate irrigation facilities which farmers are unable to afford. However, smallholder irrigation technologies such as use of simple weirs and gravity irrigation have been introduced to Mwense farmers as confirmed by the district agriculture office. These technologies are water efficient, low cost and environmentally friendly. Yet, adoption of such innovations has lagged behind among banana growers.

Proper agronomic practices are key to environmental sustainability. Remarkably, Mwense farmers were found not implementing any sustainable weed, pest and disease management practices despite that crop disease and pest attack problems accounted for 100% and 30%, respectively, of the environmental challenges they faced. Pest and disease control is critical to sustainable banana production. On the contrary, this is not being practiced by Mwense farmers. Similarly, the study of Chitamba *et al.* (2016) reported that none of the farmers in Rusitu valley of Zimbabwe implemented pest/disease control in their banana production. The author holds the view that lack of knowledge and training on sustainable pest and disease management practices contribute to farmer's inability to deal with the persistent pests and disease that attack bananas over the years.

Improper use of synthetic fertilizers among farmers poses harm to the environment. Interestingly, farmers in Mwense were found not applying synthetic fertilizers at recommended rates. Chitamba *et al.* (2016) found that rural farmers lack knowledge on proper fertiliser use. Arati *et al.* (2020) also found that only 35.9% of the farmers applied the correct amount of fertilizer to the banana crop, and only a faction top-dress the fertilizers at recommended time, while the majority only apply the fertilizer once. Hassan, (2016) further stated that only 32.5%-50% of banana growers used the recommended quantity of fertilizer in banana in India. These findings point to a huge knowledge gap among banana farmers, and thus impacting negatively on the environment.

Literature has further stressed the importance of proper postharvest handling of bananas to maintain quality and prolong shelf life. Cooling systems, storage systems and transportation are sone key aspects of postharvest handling of bananas (Kader et al, 2002). This study has revealed that Mwense farmers lack proper pre-cooling methods, storage, and transportation methods which predisposes the harvested fruits to deterioration and increases risk of fruit bruising, damage, and high postharvest losses.

5.2 Environmental Sustainability Status of the Current Farming Practices in Mwense Zambia

The implementation of good agriculture practices and adherence to sustainability standards has greater relevance in today's global markets in addition to enhancing environmental sustainability. Adherence to sustainability standards is central to production of safe food, facilitate regional trade and ensure acceptability of fruits on the international markets. This study found that the overall sustainability performance of the current farming practices among banana producers in Mwense was limited. Poor land preparation and crop management practices, improper use of agrochemicals, and poor postharvest management practices contributed significantly to unacceptable performance of the farming practices of Mwense farmers in light of environmental sustainability standards.

This outcome can be explained by banana farmer's low adoption of the sustainable farming practices investigated in this study. Overall adoption of SFPs among banana growers in Mwense was found to be as low as 27%. Muthee *et al.* (2019) arrived at similar a conclusion that there is minimal implementation of suggested production technologies amongst the banana farmers in Embu County of Kenya. Similarly, Arati *et al.* (2020) also found that there was low awareness and practice of good agricultural practices among banana growers in Nepal.

The author argues that current state of farming practices in Mwense has both environmental and economic implications. Environmentally, there is risk of continuous degradation of natural resources and loss of biodiversity which will have long term effects on the environment, vis-à-vis inability of land resources to support future production of banana. Economically, this is likely to reduce household income and further widen the poverty gap. This finding implies that unless interventions to enhance the environmental sustainability performance of the current farming practices are implemented, farmers in Mwense will be robed of a viable economic activity that has potential to improve their livelihoods and reduce poverty.

5.3 Performance of Environmental Sustainability Indicators Among Banana Producers in Mwense

5.3.1 Water Management Practices

Water is a critical but scarce resource in agricultural production and its availability throughout the growing period is a critical determinant of crop productivity. Consequently, global environmental standards and goals such as the SGDs emphasise the need for water conservation and efficient utilization of irrigation water for sustainable agricultural production. Water management practices are important indicators of environmental sustainability.

This study revealed best use of raised beds and water drainages with 85% and 95% of surveyed banana farmers implementing the practices, respectively. This agrees with the study of Arati *eta al* (2020) who stated that 91% of their respondents had a drainage facility in the banana orchard. The author argues that the high implementation of the two practices is due to the predominant cultivation practice among banana producers in the study area as influenced by geographic and topographic characteristics of the wetlands where bananas are grown. As revealed by key informants of this study, banana farmers in the area have historically been used to making raised beds and drainages as a way of draining excess water to support proper plant growth.

Yet, this does not entail efficient water management among Mwense farmers. This is because implementation of other water conservation practices is poor among banana farmers in Mwense. The author holds the view that limited labor coupled with access to finance and machinery constrains implementation of the practices among producers.

5.3.2 Soil Conservation Practices and Land Rehabilitation Practices

Soil is critical to successful agriculture as it is the principal source of the nutrients and water required to grow crops (Sindelar, 2015). Soil is a critical element for food production, consequently the need for protection of this critical resource.

This study showed best performance in use of organic fertilizers with 81.7% of banana producers implementing the practice. This is contrary to the study of Gebre et al (2020) who found that banana farmers in Arba Minch, Ethiopia were not make use of inputs such as compost, fertilizer, pesticide, and insecticides for their banana cultivation. Despite the widespread use of organic fertiliser among Mwense farmers, the survey results showed unacceptable performance in implementation of cover crop, soil drainage, liming, agroforestry, and crop rotation practices among banana producers in Mwense. This agrees with Tiwari et al. (2006) who indicated that only 12% of banana farmers stick to crop rotation and that only 7.8% planted a cover crop or intercrop between the banana inter-rows. Hassan (2016) recounted that only 2.5-5% of growers have applied intercropping in banana in India. In the author's view, this might be due to lack of awareness among farmers on the importance of soil conservation and land rehabilitation to protect and improve soils.

Furthermore, experts at the Ministry of agriculture argued that the majority of farmers who use dambo (wetlands) areas for banana cultivation do not see the need to conserve soils in wetlands because of the belief that soils in such ecologies are naturally fertile and do not require any soil improvement practices such as liming, agroforestry, cover crop or crop rotation.

5.3.4 Ecosystem Conservation Practices

Ecosystem Enhancing practices seek to improve environmental sustainability by guaranteeing the efficient preservation and enhancement of complex ecosystems, together with those of agricultural and forest elements (FAO, 2014). This is possible through maintenance of a broad landscape approach. This study sought to understand the implementation of eight selected practices for maintaining such broad landscapes to ensure effective conservation of complex ecosystems in Banana farms.

This study found the overall indicator performance of the ecosystem indicator to be unacceptable with an indicator performance score of 0-20%. The worst performing practices were found to be soil coverage, weed management practices, diverse crop rotations, integrated pest management, mixed crop livestock systems and agroforestry practices. Related results were found by Gebre *et al* (2020) who found that a high percentage of banana farmers in Aba Minch, Ethiopia were practicing monocropping as opposed to diverse crop rotations. Similarly, Arati *et al* (2020) found low practice of crop rotation, cover crop and intercropping among banana growers.

These results could be explained by lack of awareness by banana farmers in Mwense on the environmental and economic benefits of implementing the practices in their farms. Based on individual farmer survey, focus group discussions and expert interviews, farmers were found to be practicing a mono-cropping system of banana cultivation with a lower proportion of farmers practicing mixed cropping or intercropping with crops such as sugarcane, sweet potato and leafy vegetables. Farmers justified this action by stating that bananas do not perform well when planted alongside other crops. However, this is contrary to studies that have demonstrated the essential aspect of intercropping bananas with cover crops and other crop species.

5.4 Factors influencing farmer's adoption of sustainable farming practices (SFP)

Adoption of sustainable farming practices is a contentious topic in extant literature but an important determinant as to whether a farmer adopts SFPs or not. This study explored the influence of twenty (20) factors on banana farmer's adoption of sustainable farming practices in Mwense. An in-depth analysis of individual factors generated diverse conclusions regarding the influence of each individual factor on banana farmer's adoption of sustainable farming practices.

5.4.1 Age, Sex, Farm Experience and Education Level of a farmer

Extant literature has often assumed that farmer's age has an influence on implementation of sustainable farming practices (Hamidi & Chavoshi, 2018). Serebrennikov *et al* (2020) in their review of factors influencing adoption of organic farming in Europe found that age of the farmer was a significant determinant. They also found that older farmers have less odds of implementing SFPs relative to their younger colleagues, as older farmers tend to avert risks associated with trying new ways of doing things. In line with this perspective, the study by Chatzimichael et al (2014) analytically showed that age may have a non-linear impact on farmers' adoption behaviour. This study agrees with the foregoing arguments in that the average age of the farmer in Mwense was 48.7 which might explain the poor adoption of sustainable practices among farmers in Mwense.

Closely related to age is farm experience of the farmer. In this study, then mean farm experience was found to be 18.8 years. However, this did not correlate with adoption of SFPs either. The study showed that most farmers were laggards when it comes to implementing SFP.

Another factor related to age and experience is the education level of a farmer. This study revealed that majority of surveyed farmers have only acquired basic education up to secondary level with less than 12 years of education. Chatzimichael et al (2014) showed that, although education might be beneficial to farmer's adoption of SFPs, more years of it result in the deterioration of their adoption chances. As concluded by Mwalupaso (2019) with advancement in age, farmers become too familiar with adopted practices and are thus unwilling to adopt new practices. This agrees with the analysis of this study in that age of farmers did not show any association to implementation of SFPs as both young and old farmers similarly showed poor adoption patterns. Equally, education level did not correlate with adoption of SFPs.

The study revealed a sex variance among farmers surveyed with 70% being male and 30% being female. This agrees with studies of Maingi *et al* (2021) and Chitamba *et al* (2016) who also found that the majority of banana farmers they surveyed were male. The studies of Burton et al (2003) and Tiffin and Balcombe (2011) found that female farmers have better chances of adopting organic farming compared to their male companions. This study disagrees with this conclusion but agrees with Mzoughi (2011) who did not find the effect of gender significant. Analysis of the difference in adoption of SFPs between men and women in Mwense did not equally show any significant association to adoption of SFPs. The author holds the view that being male of female does not necessarily predispose farmers to adoption of SFPs.

5.4.2 Farm size, Area under banana and Land tenure

Farm size has been discussed in literature to have both positive and negative influence on adoption of SFPs. Serebrennikov *et al.* (2020) asserts that farm size might influence adoption probability of SFP, and that it is an indication of farm financial strength. This study showed that land ownership was not a factor. However, it is imperative to question the lower percentage of land allocated to banana cultivation. The author holds the view that this might be due to labour and financial constraints that impede investment into banana farming and expansion of area under cultivation. Based on focus group discussions, farmers expressed willingness to expand area under cultivation but alluded to challenges such as pest and disease attack, market access and low productivity.

Land tenure was not found to be factor as the study revealed that 100% of respondents own their own land. However, it might be imperative to question the suitability of the landscapes for productive banana cultivation or the extent of degradation that might have resulted from the poor implementation of soil improvement and land rehabilitation practices as revealed by this study.

5.4.3 Economic status, household size and household labour

Mwalupaso *et al*. (2019) describe extreme severity (poverty line) as living on 2USD per day. This implies that households below the poverty line are poor, and thus any SFPs requiring farmers' costly expenditure may not be adopted. This study found that 60% of the farmers in Mwense live below the poverty line of USD2.0 per day. This might explain why the majority of farmers are unable to acquire equipment and machinery, or better still hire the needed labour to implement environmentally sustainable farming practices in banana cultivation. Due to low-income status of the banana households, there is usually a trade-off between household survival and investment into sustainable farming technologies, and in most cases, the former takes priority.

Economic status is intricately linked to household size and labour. This study showed a strong association between household labour and adoption of SFPs. Notably, farm family labour is not sufficient for most farming households due to huge labour demands of various farm activities. This is because rural faming households engage in diverse agricultural enterprises to earn diverse income for the household. Therefore, spreading the limited farm family labour is mostly challenging.

5.4.4 Feasibility of SFPs and Farmer's Perception of SFP

The feasibility of SFPs is a central aspect of SFPs adoption. In this study context, feasibility implies how possible a practice can be achievable or implemented by farmers (Waseem, 2020). Labour availability and the cost of inputs is among factors affecting feasibility. Although more than 70% of the respondents affirmed that it was quite easy to implement sustainable farming practices whereas 80% affirmed a positive perception of SFPs, this did not agree with regression results. Granted, farmers claimed to understand the importance of practicing good farming practices, but survey results showed that they are reluctant to adopt them. Wachira *et al*. (2013) similarly postulated that banana growers in the Murang'a County showed sufficient awareness of good banana practices but were hesitant to adopt them, citing high-cost and lack of technical skill. The author argues that since it takes time for farmers to see the benefits of implementing SFPs, effective awareness is needed to boost understanding of sustainable agricultural practices along with their immediate and long term environmental, economic, and social benefits is lacking among banana producers in Mwense. This view is in line with Gebre et al (2020) who also attributed the lack of implementing pest and disease control measures to lack of awareness on identification and control of symptoms of pests and disease among banana farmers in Ethiopia.

5.4.5 Access to Extension services, Agricultural TV programs, and Radio programs

Awareness and knowledge of sustainable farming practices are intricately linked to access to agricultural information. This study investigated banana farmer's access to knowledge and awareness through access to extension services, agricultural radio, and TV programs. As revealed by the survey findings, 66.7% of respondents affirmed having access to extension services provided by the government extension system while 93.3% and 26.7% affirmed having access to radio and TV programs on agriculture, respectively. Interestingly, regression analysis showed a strong association between adoption of SFPs and access to agricultural TV programmes. Some studies have reported the influence of an advisory service on farmers, with some showing the negative effect (Burton et al, 2003; Tiffin et al, 2011), one identifying the positive relationship (Kaufmann et al, 2009) and the others stating a lack of significant evidence of any relationship (Läpple and Kelley, 2015; Läpple and Van Rensburg, 2011).

Although a considerable proportion of farmers were having access to extension services and agricultural radio programs, the study revealed that the frequency of access to such services was extremely low (an average of one time per month for extension services and two times per month for radio programs). In the author's view, although access to information is critical to implementation of environmentally friendly agricultural practices, the quality and easy of application of the information provided along with the method of information dissemination are equally indispensable factors that must be taken into consideration for future studies.

5.4. 6 Access to ret labour, access to credit access to fertilisers and pesticides

In this study, about 78% of farmers had access to rent labour. However, lack of access to credit and low income of households might have hindered hiring of extra labour by famers for effective implementation of sustainable practices. This could be deduced from the survey findings which showed that none of the farmers had access to credit. Regarding access to fertilizers and pesticides, 86.7% and 18.3% of farmers affirmed having access but this did not translate into actual usage as revealed by the findings that none of the farmers used pesticides in their fields. This is in line with the study of Gebre et al (2020) who also found that farmer in Aba Minch, Ethiopia do not use fertilizers and chemicals in their banana production. Meanwhile, regression analysis revealed a strong association between access to fertilizers and adoption of SFPs. Based on regression analysis, Household labour, Access to fertilizers, Access to Agricultural TV programs are the only factors that showed strong association to adoption of SFPs in this study. In the author's view, these factors may have shown a significant influence on adoption, but as postulated in other studies, it might be imperative to dwell on the attitude and motivations of banana farmers towards implementation of SFPs. This is because, in the opinion of the author, some farmers have received enough extension services and exposure to sustainable agricultural innovations but have not shown commitment and the right attitude towards adoption.

5.5 Reflection on the Research Process

This piece of work involved conducting applied research with the goal of developing tailor-made interventions targeting to enhance environmental sustainability of banana production in Mwense Zambia. The research followed the typical process of setting the research focus, definition of the research problem, formulation of research objective and questions, selection of research approach and methods, developing data collection tools, field data collection, analysis, and reporting.

During the research design and planning, there arose the pitfall of being too ambitious in what the research intended to achieve in the given context and period. Laws et al (2013) emphasize the need to strike a balance between quality, cost, and time. They further argue that There is never enough time or money to do the perfect piece of work. With this guidance of that of the research supervisor, the research objective and context were adjusted to reflect realism, objectivity and feasibility within the available time and resources.

For field data collection, it was initially planned that respondents provide responses to the questionnaire on their own. However, this was later changed. This is because there was a challenge of understanding technical and scientific terminologies by respondents of limited education, and this needed a translation into their local language. This might have affected the quality of research data collected. Regarding this, the realization was that there was omission of this consideration during the process of preparing data collection tools.

The choice of study location also brought about unanticipated challenges. During field work, it was realised that the research was to be conducted in a location with respondents of low-income status. This raised undue expectations in respondents as they looked forward to other benefits after the research. On one hand, it was realised that the choice of the research topic was appropriate and timely. On the other hand, this invoked undue expectations among respondents who expected immediate solutions to the daunting environmental challenges they faced in banana production.

The methods of data collection chosen proved appropriate for this study. For example, focus group discussions and personal interviews with banana farmers generated deep insights into the topic studied. Initially, a total of forty individual farmers were planned to be interviewed for the survey, but during field work, an overwhelming willingness by other farmers who were not sampled was observed. This led to increasing the sample size from 40 to 60. This was justifiable to increase the reliability of and generalizability of the findings. However, one of the planned key informants representing the commercial farm could not be interviewed as planned due to extenuating circumstances of the researcher. This meant replacing the key informant with another informant within the reach of the researcher.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

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6.1 Conclusions

This study aimed to conduct an environmental sustainability assessment of the current farming practices with a view to developing tailor-made interventions targeting to enhance the environmental sustainability of smallholder banana production in Mwense. This broad objective was explored through two main questions that investigated the current farming practices and the environmental sustainability status of the present farming practices among smallholders in Mwense. Based on the results, this study draws the subsequent conclusions.

Concerning the first question, this study has established the current state of farming practices among banana producers in Mwense. The study revealed that land preparation is characterised by burning of residues, conventional tillage practices, and use of conservation tillage tools. Crop management is characterised by use of uncertified local varieties, irregular weeding of fields, non-implementation of integrated practices for weed, pest and disease control and improper application of chemical fertilizers. Fertilizer types were organic while agrochemical use is non-existent. Harvest determination was by visual assessment whereas actual harvesting was done by hand. Postharvest management was characterised by poor cooling, storage, and transportation practices whereas quality control and produce certification was non-existent.

Regarding the second question, the study has established that the current farming practices among banana producers are characterised by environmentally unsustainable practices with limited adherence to environmental sustainability standards. This was due to poor adherence to proper land preparation, crop management, fertilizer use, and postharvest handling practices. The study also found that there is limited performance of the Water Conservation, Soil Conservation, Land Rehabilitation, and ecosystem conservation indicators of environmental sustainability among banana producers in Mwense with an overall implementation status of 20-40% based on the FAO-SAFA indicator performance rating. The study has further revealed that implementation of SFPs was influenced by household labour, access to fertilizers and agricultural TV programs in a disproportionate manner.

Conclusively, this study argues that the environmental sustainability status of smallholder banana production in Mwense is lacking in resilience and stability to sustainably support future production and productivity, and to meet future livelihood needs of concerned households in the study area unless robust interventions to boost the sustainability performance of the production practices are implemented.

6.2 Recommendations

Based on the results of this study, it has been concluded that there is unacceptable performance and adherence to environmental sustainability standards and practices among banana producers in Mwense which resulted in limited performance of environmental sustainability indicators. In view the foregoing conclusions, this paper puts forward the subsequent recommendations to the commissioner of this research, the Ministry of Agriculture in Luapula province of Zambia, to enhance environmental sustainability status of banana production in Mwense. These recommendations are at two levels of implementation, namely the provincial level and district level.

The paper presents these recommendations as a set of practical interventions broadly categorised into those targeting to enhance sustainability performance of the current farming practices and environmental sustainability indicators, and interventions to improve farmer's adoption of sustainable farming practices. Figure 14 provides a summary of the proposed model in the theory of change to enhance environmental sustainability of banana production in Mwense Zambia.

6.2.1 Interventions to enhance sustainability performance of the current farming practices

a. Promotion of Regenerative Agriculture

Assessment of environmental sustainability of smallholder banana production in Mwense revealed that farmers are not practicing sustainable practices that protect their agricultural land from degradation, erosion, nutrient loss, water conservation and biodiversity conservation. This has resulted into loss of arable land and low productivity of bananas in the area. This study therefore recommends implementation of activities to promote regenerative agriculture practices among banana producers in Mwense as recommended by the FAO (2022). The proposed activities are as follows:

- Training of farmers in sustainable crop management and postharvest handling practices to improve sustainability performance of the current farming practices.
- Training of farmers in integrated weed, pest, and disease management practices to increase productivity and promote ecosystem conservation.
- Training of farmers through conservation agriculture demonstrations on cover crops, liming and agroforestry practices to improve soil health, water retention and enhance biodiversity.

6.2.2 Interventions to improve farmer's adoption of sustainable farming practices

a. Improving farmers access to finance, inputs, and agricultural information

Diffusion of technology or innovation within a population is intricately related to how popular or appealing the innovation or technology is among the target population. This study has shown that part of the factors affecting adoption of sustainable farming practices among producers is labour constraints, access to agricultural information, and inputs. The study thus recommends the following activities targeting to improve farmers access to finance, inputs, and agricultural information.

- Promotion of community lending initiatives and linking of farmers to local credit institutions to access finance to boost their capacity to invest in implementation of sustainable farming practices.
- Introduction of small-scale input subsidy programme for banana producers to enhance access to required inputs for implementation of sustainable farming practices.
- Establishment of community-based technology promotion centres (innovation hubs) to increase farmers access to agricultural information and technologies. The core idea of this intervention is to demonstrate and promote sustainable farming practices to banana farmers within the local communities by the local people. These centres will serve the purpose of bringing application of environmentally sustainable agricultural practices closer to the target beneficiaries for easy and quick diffusion of sustainable practices among banana producers. The innovation hubs will also serve as demonstration centres for sustainable agriculture systems including circular agriculture and the food forest concept.

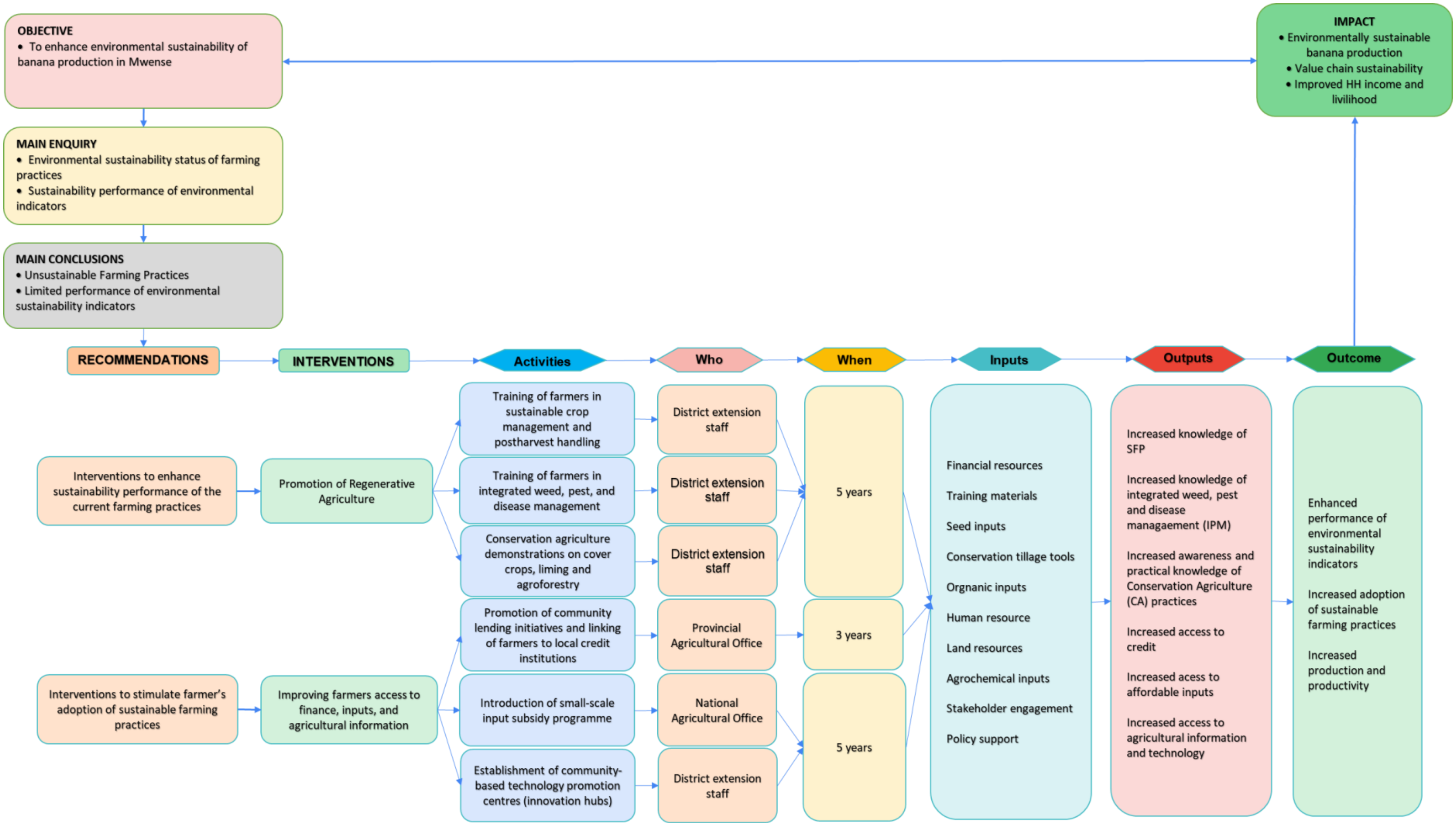

Figure 14. TOC model to enhance environmental sustainability of banana production in Mwense

Source: Author, 2022

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ANNEXES

Annex 1. Questionnaire for assessing banana environmental sustainability in Mwense

Dear Farmer,

You have been selected to be part of the respondents for research on improving sustainable production of bananas in Mwense district. You are kindly requested to answer the questions in this questionnaire as honestly as possible. All your responses will be kept entirely confidential and processed together with those of other farmers. The questionnaire takes approximately 20 minutes to be completed. Thank you for your participation.

PART 1: Demographic Characteristics of Farming Households

1. What is your sex? [**Sex**] ☐ Male ☐ Female
2. What is your age? [**Age of farmer**] ☐ Years
3. How many years did you spend in school? [**Education level**] ☐ Years
4. What is your monthly household income? [**Economic status**] ☐ ZMW
5. How many years have you spent in farming? [**Farm experience**] ☐ Years
6. Do you own land? [**Land tenure**] ☐ Yes ☐ No
7. What is your total Farm Size? [**Farm size**] ☐ ha
8. What is the size of the area under banana cultivation?

[**Area under banana**] ☐ ha

9. What is the size of your household? [**Household size**] ☐ Members
10. How many of your household members provide labour for farm activities?

[**Household labour**] ☐ Members

PART 2: Environmental Issues Faced at the Farm

11. Which of the following environmental challenges related to banana production did you experience at your farm in the last five years?

☐ Pest attack problem ☐ Crop diseases problem ☐ Water Logging/flooding

☐ Soil Fertility Problem ☐ Soil degradation ☐ Biodiversity loss

☐ Dry spells ☐ Other____

12. How have these challenges affected banana production at your farm?

☐ Low productivity ☐ Poor banana quality

☐ Reduced cultivation area ☐ Other_____________________________________

PART 3: Practice of Environmental Sustainability Indicators

13. Do you practice any of the following water conservation practices in your banana field?

Mulching ☐ Yes ☐ No

Drainage ☐ Yes ☐ No

Conservation tillage ☐ Yes ☐ No

Raised beds ☐ Yes ☐ No

Water harvesting ☐ Yes ☐ No

14. Do you practice any of the following soil improvement and land conservation practices at your farm?

Cover crop ☐ Yes ☐ No

Soil drainage ☐ Yes ☐ No

Liming ☐ Yes ☐ No

Agroforestry ☐ Yes ☐ No

Crop rotation ☐ Yes ☐ No

Organic fertilisers ☐ Yes ☐ No

15. Do you practice any of the following ecosystem enhancing practices at your farm?

Soil coverage ☐ Yes ☐ No

Mixed cropping ☐ Yes ☐ No

Intercropping ☐ Yes ☐ No

Integrated weed management ☐ Yes ☐ No

Diverse crop rotation ☐ Yes ☐ No

Integrated pest management ☐ Yes ☐ No

Mixed crop-livestock systems ☐ Yes ☐ No

Agroforestry ☐ Yes ☐ No

PART 4: Factors Influencing Adoption of Sustainable Farming Practices

16. How easy is it for you to implement any of the sustainable farming practices in part 3 above at the farm?

[**Feasibility of SFPs**] ☐ Very easy ☐ Moderate ☐ Not easy

17. What is your overall perception of sustainable farming practices (SFPs) mentioned in part 3 above?

[**Farmers perception of SFPs**] ☐ Positive ☐ Neutral ☐ Negative

18. How many times do you access extension services in a month?

[**Access to extension services**] ☐ Times/month

19. How many times do you watch agricultural TV programs in a month?

[**Agricultural TV programs**] ☐ Times/month

20. How many times do you listen to agricultural radio programs in a month?

[**Agricultural radio programs**] ☐ Times/month

21. Do you have access to the following farm inputs?

[**Access to rent labour**] ☐ Yes ☐ No

[**Machine access**] ☐ Yes ☐ No

[**Fertilizer access**] ☐ Yes ☐ No

[**Pesticide access**] ☐ Yes ☐ No

[**Credit access**] ☐ Yes ☐ No

THANK YOU FOR YOUR PARTICIPATION!

Annex 2. Interview Guide for Key Informants

Dear Key informant. You have been selected to be part of the key respondent for research on improving sustainable production of bananas in Mwense district. You are kindly requested to answer the questions to be discussed openly and as honestly as possible. All your responses will be kept entirely confidential and processed solely for the research purpose. The interview will take approximately 30 minutes. Thank you for your participation.

Date of interview: _____________Name of interviewee: _____________Contact: _____________

Name of organisation represented: __________________________

PART 1: Environmental Issues Faced at the Farm

1. What environmental challenges related to banana production have farmers experienced at their farms in the last five years?
2. How have these challenges affected banana production in the district?

PART 2: Current farming practices among smallholder banana producers

3. What land management practices are farmers using for banana production? Make specific reference to land clearing practice(s) and Soil preparation practice(s)
4. What crop management practices are farmers using in banana production? Make specific reference to Crop types and varieties; Sowing methods, or practice(s); Weed management practices; Irrigation practices; Fertilizer application practices; Pest management practices; and Disease management practices.
5. What is the current agrochemical use among banana producers in the district? Make specific reference to fertilizer type(s); Soil fertility determination method(s); Pesticides type(s); and Pesticides disposal method(s).
6. What are the harvest determination and harvesting methods for bananas in the district?
7. What are the current post-harvest management practices among banana farmers in the district? Make specific reference to pre-cooling methods; Storage or preservation practices; Transportation methods; Waste management practices; and Quality control and certifications

PART 3: Practice of Sustainable Farming Practices among Banana producers

8. What is the extent of implementation of water conservation practices among banana farmers in the district? [Mulching, Drainage, Conservation tillage, Raised beds and Water harvesting]
9. What is the extent of implementation of soil improvement and land conservation practices among banana farmers in the district? [Cover crop, Soil drainage, Liming, Agroforestry, Crop rotation, and Organic fertilisers].
10. What is the extent of implementation of ecosystem enhancing practices among banana farmers in the district? [Soil coverage, Mixed cropping, Intercropping, Integrated weed management, Diverse crop rotation, Integrated pest management, Mixed crop-livestock systems, Agroforestry]

PART 4: Factors influencing farmer's adoption of sustainable farming practices (SFP)

11. What are the challenges to implementation of sustainable farming practices among banana farmers?
12. What factors or motivations influence farmers to adopt sustainable farming practices in the district?
13. What would be recommended to improve banana production and adoption of sustainable farming practices in the district?

Annex 3. Guide for Focus Group Discussion

Introduction

Dear participants,

Thank you for accepting to be part of this focus group discussion which is part of the research on improving sustainable production of bananas in Mwense district. The purpose of this discussion is to brainstorm as a group which practices are used by banana farmers and how these practices have affected production of bananas at farm level and in the district. Further, the discussion will welcome your group opinion on what should be done, related to the environment, to improve banana production in Mwense district. Feel free to participate and let your opinion known. All your answers and opinions will be treated with respect, confidentially will be used only the sole purpose of the research. The discussion will last for a maximum of two hours. Thank you for your participation.

- Location of FDG: ___________________________
- Number of participants: Male_________ Female___________
- Date of meeting: ___________________________
- Time/duration: ____________________________

Activity	Method	Responsibility
1. Registration and welcome remarks	Open plenary	Lead farmer
2. Introducing the research topic and discussion questions	Brief flip chart presentation	Research assistant
3. Brainstorming and identification of current production practices for bananas	Open brainstorming session by all participants	Research assistant
4. Illustration of production practices in a production cycle	Flipchart drawing of production cycle/calendar by participants	Lead farmer/research assistant
5. Review and validation of group work	Open plenary	Research assistant
6. Brainstorming and identification of factors that influence farmer's adoption of sustainable farming practices in banana production based on group opinion	Open brainstorming session by all participants	Research assistant
7. Brainstorming on viable solutions to improve banana production	Open plenary with use of flip chart	Research assistant
8. Closing		Lead farmer/Research Assistant
9. Refreshments		All

Annex 4. Outputs for SPSS data Analysis

Frequency Tables for Water conservation practices

Mulching

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	27	45.0	45.0	45.0
	Yes	33	55.0	55.0	100.0
	Total	60	100.0	100.0	

Conservation tillage

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	45	75.0	75.0	75.0
	Yes	15	25.0	25.0	100.0
	Total	60	100.0	100.0	

Raised beds

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	9	15.0	15.0	15.0
	Yes	51	85.0	85.0	100.0
	Total	60	100.0	100.0	

Water harvesting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	38	63.3	63.3	63.3
	Yes	22	36.7	36.7	100.0
	Total	60	100.0	100.0	

Frequency tables for Soil conservation and Land rehabilitation practices

Cover crop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	56	93.3	93.3	93.3
	Yes	4	6.7	6.7	100.0
	Total	60	100.0	100.0	

Soil drainage

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	50	83.3	83.3	83.3
	Yes	10	16.7	16.7	100.0
	Total	60	100.0	100.0	

Liming

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	59	98.3	98.3	98.3
	Yes	1	1.7	1.7	100.0
	Total	60	100.0	100.0	

Agroforestry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	59	98.3	98.3	98.3
	Yes	1	1.7	1.7	100.0
	Total	60	100.0	100.0	

Crop rotation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	53	88.3	88.3	88.3
	Yes	7	11.7	11.7	100.0

	Total	60	100.0	100.0	

Organic fertilizers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	11	18.3	18.3	18.3
	Yes	49	81.7	81.7	100.0
	Total	60	100.0	100.0	

Frequency tables for Ecosystem conservation practices

Soil coverage

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	59	98.3	98.3	98.3
	Yes	1	1.7	1.7	100.0
	Total	60	100.0	100.0	

Mixed cropping

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	32	53.3	53.3	53.3
	Yes	28	46.7	46.7	100.0
	Total	60	100.0	100.0	

Intercropping

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	42	70.0	70.0	70.0
	Yes	18	30.0	30.0	100.0
	Total	60	100.0	100.0	

Integrated weed management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	56	93.3	93.3	93.3
	Yes	4	6.7	6.7	100.0
	Total	60	100.0	100.0	

Diverse crop rotation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	58	96.7	96.7	96.7
	Yes	2	3.3	3.3	100.0
	Total	60	100.0	100.0	

Integrated pest management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	59	98.3	98.3	98.3
	Yes	1	1.7	1.7	100.0
	Total	60	100.0	100.0	

Mixed crop-livestock systems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	58	96.7	96.7	96.7
	Yes	2	3.3	3.3	100.0
	Total	60	100.0	100.0	

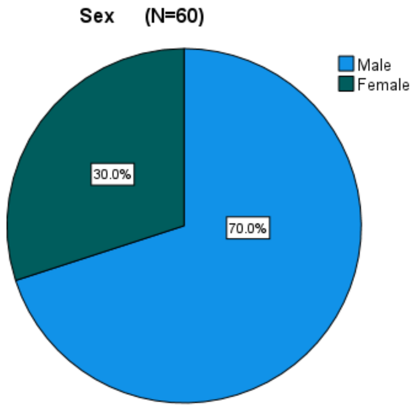
Agroforestry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	59	98.3	98.3	98.3
	Yes	1	1.7	1.7	100.0
	Total	60	100.0	100.0	

Frequency tables for factors influencing adoption of SFPs

Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	42	70.0	70.0	70.0
	Female	18	30.0	30.0	100.0
	Total	60	100.0	100.0	



Frequency Table

Education level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Primary	30	50.0	50.0	50.0
	Secondary	30	50.0	50.0	100.0
	Total	60	100.0	100.0	

Economic status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below poverty line	36	60.0	60.0	60.0
	Above poverty line	24	40.0	40.0	100.0
	Total	60	100.0	100.0	

Land tenure

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Landowner	60	100.0	100.0	100.0

Feasibility of SFPs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not easy	16	26.7	26.7	26.7
	Very easy	44	73.3	73.3	100.0
	Total	60	100.0	100.0	

Farmers perception of SFPs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Negative	12	20.0	20.0	20.0
	Positive	48	80.0	80.0	100.0
	Total	60	100.0	100.0	

Access to extension services

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	20	33.3	33.3	33.3

		Frequency	Percent	Valid Percent	Cumulative Percent
	Yes	40	66.7	66.7	100.0
	Total	60	100.0	100.0	

Access to Agricultural TV programs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	44	73.3	73.3	73.3
	Yes	16	26.7	26.7	100.0
	Total	60	100.0	100.0	

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	4	6.7	6.7	6.7
	Yes	56	93.3	93.3	100.0
	Total	60	100.0	100.0	

Access to rent labour

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	13	21.7	21.7	21.7
	Yes	47	78.3	78.3	100.0
	Total	60	100.0	100.0	

Access to machines

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	60	100.0	100.0	100.0

Access to fertilizers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	7	11.7	11.7	11.7
	Yes	53	88.3	88.3	100.0
	Total	60	100.0	100.0	

Access to pesticides

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	49	81.7	81.7	81.7
	Yes	11	18.3	18.3	100.0
	Total	60	100.0	100.0	

Access to credit

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	60	100.0	100.0	100.0

Multiple regression analysis outputs

Model Summary

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.295[a]	.087	.071	7.2174	.087	5.447	1	57	.023
2	.402[b]	.162	.132	6.9786	.074	4.969	1	56	.030
3	.482[c]	.232	.190	6.7387	.071	5.057	1	55	.029

a. Predictors: (Constant), Household labour

b. Predictors: (Constant), Household labour, Access to fertilizers

c. Predictors: (Constant), Household labour, Access to fertilizers, Access to Agricultural TV programs

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	283.738	1	283.738	5.447	.023[b]
	Residual	2969.214	57	52.091		
	Total	3252.952	58			
2	Regression	525.724	2	262.862	5.398	.007[c]
	Residual	2727.228	56	48.700		
	Total	3252.952	58			
3	Regression	755.369	3	251.790	5.545	.002[d]
	Residual	2497.583	55	45.411		
	Total	3252.952	58			

a. Dependent Variable: Adoption of SFPs

b. Predictors: (Constant), Household labour

c. Predictors: (Constant), Household labour, Access to fertilizers

d. Predictors: (Constant), Household labour, Access to fertilizers, Access to Agricultural TV programs

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
Model		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	21.529	2.575		8.360	.000	16.372	26.686
	Household labour	1.321	.566	.295	2.334	.023	.188	2.454
2	(Constant)	27.447	3.640		7.541	.000	20.156	34.738
	Household labour	1.230	.549	.275	2.243	.029	.131	2.329
	Access to fertilizers	-6.280	2.817	-.273	-2.229	.030	-11.924	-.636
3	(Constant)	28.569	3.550		8.048	.000	21.455	35.683
	Household labour	1.262	.530	.282	2.382	.021	.200	2.324
	Access to fertilizers	-6.341	2.721	-.276	-2.331	.023	-11.793	-.889
	Access to Agricultural TV programs	-4.440	1.974	-.266	-2.249	.029	-8.396	-.483

a. Dependent Variable: Adoption of SFPs

Annex 5. Transcribed key informant interview responses

Date of Interview	Name of Informat	Name of organization	What environmental challenges related to banana production have farmers experienced at their farms in the last five years?	How have these challenges affected banana production in the district?	What land management practices are farmers using for banana production? Make specific reference to: a) land clearing practice(s)	b) Soil preparation practice(s)
8/1/2022	Lucky Witika	Ministry of Agriculture	Pest attack problem, Soil Fertility Problem, Crop diseases problem, Water Logging/flooding	Low productivity, Poor banana quality, Low prices.	Cut and burn [Cut, pile and burn in the field]	Complete soil turn over by hand hoe cultivation
8/1/2022	Fridah Chifuwa Bwalya	Ministry of Agriculture	Pest attack problem, Crop diseases problem, Water Logging/flooding	Low productivity, Reduced cultivation area	Cut and grind [Cut and spread over the field and left to decompose]	Complete soil turn over by hand hoe cultivation
8/2/2022	Thomas phiri	Ministry of Agriculture	Pest attack problem, Soil Fertility Problem, Crop diseases problem, Soil degradation	Low productivity, Reduced cultivation area, Poor banana quality	Cut and burn [Cut, pile and burn in the field]	Complete soil turn over by hand hoe cultivation
8/2/2022	Chilufya Timothy	Ministry of Agriculture	Pest attack problem, Soil Fertility Problem, Crop diseases problem	Low productivity, Reduced cultivation area	Cut and grind [Cut and spread over the field and left to decompose]	Complete soil turn over by hand hoe cultivation
8/2/2022	Fred Chilembelemebe	District Farmers Union representative	Pest attack problem, Crop diseases problem	Low productivity, Reduced cultivation area, Poor banana quality	Cut and burn [Cut, pile and burn in the field]	Complete soil turn over by hand hoe cultivation
7/3/2022	Lombe Musole	Ministry of Agriculture	Pest attack problem, Soil Fertility Problem, Crop diseases problem	Low productivity, Reduced cultivation area, Poor banana quality	Cut and burn [Cut, pile and burn in the field]	Complete soil turn over by hand hoe cultivation, Ridging
7/3/2022	Ngwenya Esther	Ministry of Agriculture	Soil Fertility Problem, Crop diseases problem, Water Logging/flooding	Low productivity, Poor banana quality	Cut and burn [Cut, pile and burn in the field], Cut and grind [Cut and spread over the field and left to decompose]	Complete soil turn over by hand hoe cultivation, Ridging
7/3/2022	Justine Chanda	Ministry of Agriculture	Soil Fertility Problem, Dry spells, Crop diseases problem, Water Logging/flooding	Low productivity, Poor banana quality	Cut and burn [Cut, pile and burn in the field], Cut and grind [Cut and spread over the field and left to decompose]	Complete soil turn over by hand hoe cultivation

Note: Each row represents a respondent

What crop management practices are farmers using in banana production? Make specific reference to a) Crop types and varieties [Local or Hybrids?]	b) Sowing methods, or practice(s)	c) Weed management practices	d) Irrigation practices	e) Fertilizer application practices	f) Pest management practices	g) Disease management practices
Dwarf cavendish and willams	Making of planting holes	Its done by means of a hand hoe and a slasher.	Its by means of a bucket	Mainly its composting and crop residue	Crop rotation and planting sccaring of birds	Removing out the the diseased plants and burn them
Mansa and cavandish bananas	Making of big ridges using a hand hole and digging of planting holes on top. Then suckers are uprooted and the roots are removed before planting.	Hand weeding using a hole.	Bananas are planted in damboos, so no need to irrigate.	D- compound and most banana farmers don't use any fertilizer because the damboo is very fertile.	There is nothing.	There is nothing.
ocal	Direct planting on ridges of flat land	Handhoe	Fallow irrigation	Only chicken manure	Use of pesticides	Field hygiene and application of pesticides
	Planting stations on flat land or ridges	Inter-cultivation and inter cropping	Rainfall and furrow irrigation	Mostly chicken manure is used	Mostly not applicable to our farmers	Not mostly applicable
nansa	They make holes on the lined ridges	They slash the weeds by using slahers and others they use holes	Farrow irrigation	Nill	Nill	Nill
	Use of suckers from mothers plants which are planted on conventional ridges. Mostly recycled.	Periodical weeding with hand hoes but not consistent.	Rain fed for most farmers. Few use furrow irrigation.	Unpopular. Most farmers don't apply fertilizer.	This is something most farmers don't practice.	Many farmers just cut down the diseased crop and plant new suckers.
	Use of basins and conventional ridges	Use of a hoe	Non	Non	Non	Non
Hybrids- William and Cavendish	They use suckers which are removed from growing mother banana plants using a hoe or spade. These are planted either on conventional ridges or basins.	Most farmers use mechanical control through the use of hoes (manual). In some instances, other short crops are grown in between banana planting stations as a means of weeding and at the same time maximizing land use.	Furrows are used, water get into the fields by gravity. while others they depend on rains (rain fed)	No chemical fertilized is used. usually, after pruning waste materials are left to decompose around banana stations and thus helps in improving the soil nutrients and structure.	use of cultural weed control using a hoe, the field is kept weed free. Bunches are covered with plastic bags or sacks for protection against pests and wind	farmers do not use disease tolerant varieties, do close check of their fields and do pruning as well as maintaining good hygiene in their fields

Note: Each row represents a respondent

What is the current agrochemical use among banana producers in the district? Make specific reference to a) Fertilizer type(s)	b) Soil fertility determination method(s)	c) Pesticides type(s)	d) Pesticides disposal method(s)	What are the harvest determination and harvesting methods for bananas in the district?
No chemical fertilizer is used apart from Animal manure and crop residues	Presence of certain grass spicies and accacia trees.	No pesticides are used	Pesticide containers are thrown in pit latrines	Harvesting method is by use of matchetes and harvest determination is mainly by visual assessment
- compounds fertilizer	Nil	No idea / Nil	If any pesticides is used, the used bottles are just left in the fields.	Bananas are harvested when to are mature and they use knifes to cut the bunch to prevent damage.
ompound D and nitrogen fertilizer	Just by looking at the soil	Sypermethrine,	Burrying	Hand harvesting
nimal manure	Feel method and observation by sight	Not applicable	Burrying	Harvest is determined by counting the number of bunches and harvesting is done by cutting the bunches with nives
ill	They see the colour of the soil (black or grey soil	Nill	Nill	When they see banana banch change it's colour from dark green to light green or yellowish and when the flowers from the tip of banana banch dry. Method, they cut the banana banch.
ew use manure. Most don't apply fertilizer at all.	Use of traditional visual methods.	Use of pesticides is uncommon.	Non-existent.	The crop is harvested when 80-90 of the fruits on the bunch are mature. The bunch is then cut down and kept in a dark room for a few days to quicken ripening.
on	Non	Non	Non	The mainly harvesting method they use is cutting the batches
Farmers depends on compost manure derived from the waste materials decomposition that are left in the field during pruning and weeding periods.	Basically this is determined through visual observation of vegetation growth around the area and how well the crop is growing in the field gives the soil fertility content.	No synthetic pesticides are used by most farmers in the district, majority of them leave it for nature to take its course. Only the plastic bag or sack is used to prevent pest attack to the bunches.	Plastic bags are kept for second usage until the are torn apart and pieces are not usually considered for proper disposal off.	Farmers usually harvest bananas when they see that banana hands are fully developed and shape have disappeared and to some extent, when one or two ripens in the bunch. The bunch is cut and hands are moved from the stalk.

Note: Each row represents a respondent

What are the current post-harvest management practices among banana farmers in the district? Make specific reference to pre-cooling and Transportation methods	d) Waste management practices	e) Quality control and certifications	What is the extent of implementation of water conservation practices among banana farmers in the district? [Mulching]	What is the extent of implementation of water conservation practices among banana farmers in the district? [Drainage]	What is the extent of implementation of water conservation practices among banana farmers in the district? [Conservation tillage]	What is the extent of implementation of water conservation practices among banana farmers in the district? [Raised beds]	What is the extent of implementation of water conservation practices among banana farmers in the district? [Water harvesting]
Its mainly done by bicycles, vehicles and motorbikes to markets	The peels and waste are put in rubbish pits	Quality control is usually done by visual assessment where small fingers are separated from biggers	40% - 60%	40% - 60%	0% - 20%	60% - 80%	20% - 40%
rcycle and vehicles	There is nothing if any , they just leave the bananas stalks after harvesting in the field.	There is nothing, because farmers just get sucks from any source thus spreading the diseases.	40% - 60%	40% - 60%	40% - 60%	40% - 60%	40% - 60%
Use of vehicles, bicycles and motorbikes	By not weeding, pesticides application to control pests	Not to sure	20% - 40%	20% - 40%	20% - 40%	20% - 40%	20% - 40%
Transported in sacks and buckets on bicycles and motorbikes	Left in the field to decompose	None	20% - 40%	0% - 20%	0% - 20%	40% - 60%	20% - 40%
ad and bicycles	They leave it in the field for improvement of soil fertility	They clean bananas before putting in baskets and sack bags	20% - 40%	60% - 80%	0% - 20%	80% - 100%	20% - 40%
Mostly bicycles and motorbikes are used to transport bananas from fields to homes and homes to the market.	No determined methods. Random disposal of waste.	Non-existent	20% - 40%	20% - 40%	0% - 20%	40% - 60%	0% - 20%
It's by bicycle/carrying the bananas on their heads	Throw the waste in the pit	Nil	40% - 60%	20% - 40%	0% - 20%	20% - 40%	0% - 20%
From field to home steady, farmers put bunches on their shoulders. However, who buy from farm gate carry bunches in large baskets.	There is no proper and defined waste management practices in bananas reason being that the value chain is long and consumers tend to throw waste in the bin or worse still just litter the environment	Since the production of bananas is at small scale, statutory bodies mandated to regulate quality and certification of the products/produce find it difficult to work because most activities happen at farm gates/ homestead.	0% - 20%	20% - 40%	0% - 20%	20% - 40%	20% - 40%

Note: Each row represents a respondent

What is the extent of implementation of soil improvement and land conservation practices among banana farmers in the district? [Cover crop]	What is the extent of implementation of soil improvement and land conservation practices among banana farmers in the district? [Soil drainage]	What is the extent of implementation of soil improvement and land conservation practices among banana farmers in the district? [Liming]	What is the extent of implementation of soil improvement and land conservation practices among banana farmers in the district? [Agroforestry]	What is the extent of implementation of soil improvement and land conservation practices among banana farmers in the district? [Crop rotation]	What is the extent of implementation of soil improvement and land conservation practices among banana farmers in the district? [Organic fertilizers]
	40% - 60%	0% - 20%	0% - 20%	40% - 60%	60% - 80%
	40% - 60%	0% - 20%	0% - 20%	0% - 20%	0% - 20%
	20% - 40%	20% - 40%	20% - 40%	0% - 20%	0% - 20%
	20% - 40%	0% - 20%	20% - 40%	0% - 20%	40% - 60%
	0% - 20%	0% - 20%	0% - 20%	20% - 40%	80% - 100%
	20% - 40%	0% - 20%	0% - 20%	20% - 40%	0% - 20%
	0% - 20%	0% - 20%	0% - 20%	40% - 60%	20% - 40%
	20% - 40%	0% - 20%	0% - 20%	0% - 20%	40% - 60%

Note: Each row represents a respondent

What is the extent of implementation of ecosystem enhancing practices among banana farmers in the district? [Soil coverage]	What is the extent of implementation of ecosystem enhancing practices among banana farmers in the district? [Mixed cropping]	What is the extent of implementation of ecosystem enhancing practices among banana farmers in the district? [Intercropping]	What is the extent of implementation of ecosystem enhancing practices among banana farmers in the district? [Integrated weed management]	What is the extent of implementation of ecosystem enhancing practices among banana farmers in the district? [Diverse crop rotation]	What is the extent of implementation of ecosystem enhancing practices among banana farmers in the district? [Integrated pest management]	What is the extent of implementation of ecosystem enhancing practices among banana farmers in the district? [Mixed crop-livestock systems]	What is the extent of implementation of ecosystem enhancing practices among banana farmers in the district? [Agroforestry]
60% - 80%	60% - 80%	40% - 60%	20% - 40%	40% - 60%	20% - 40%	0% - 20%	0% - 20%
40% - 60%	20% - 40%	40% - 60%	0% - 20%	0% - 20%	0% - 20%	0% - 20%	0% - 20%
20% - 40%	0% - 20%	0% - 20%	20% - 40%	0% - 20%	20% - 40%	0% - 20%	0% - 20%
0% - 20%	20% - 40%	20% - 40%	0% - 20%	0% - 20%	0% - 20%	0% - 20%	20% - 40%
0% - 20%	20% - 40%	20% - 40%	0% - 20%	0% - 20%	0% - 20%	0% - 20%	0% - 20%
0% - 20%	0% - 20%	0% - 20%	0% - 20%	0% - 20%	0% - 20%	0% - 20%	0% - 20%
0% - 20%	0% - 20%	20% - 40%	0% - 20%	0% - 20%	0% - 20%	0% - 20%	0% - 20%
0% - 20%	0% - 20%	20% - 40%	20% - 40%	0% - 20%	20% - 40%	0% - 20%	0% - 20%

Note: Each row represents a respondent

What are the challenges to implementation of sustainable farming practices among banana farmers?	What factors or motivations influence farmers to adopt sustainable farming practices in the district?	What would be recommended to improve banana production and adoption of sustainable farming practices in the district?
ıditinal hand tools	Availability of market potential n neighbouring country	To mechanise the cultivation of bananas and also availability of improved disease torelant planting materials. Introduction of plant clinics for bananas
Changing mindset of the bananas farmers to understand that sustainable farming is the way to go.	Giving them free pesticides, fertilizers and even sprayers can influence them to adopt.	Training banana farmers to understand that farming is business as such adoption of sustainable farming is the way to go not just sticking to there old farming methods.
t manure for continuation of making organic fertilizer	It's cheaper because u use locally available resources	Use of high breed varieties such as Williams,and educate people on how the banana is grown from day one until to the harvesting time.
Difficulty to do crop rotation None adherence to disease and pest management	Increased productivity Increased income Available market	Make improved varieties accessible to small scale farmers Introduce out-grower schemes to small scale farmers
	When they slash grasses, they don't burn but left in the field to decompose which improve soil fertility in their fields	More trainings on how to grow banana production
Adoption of sustainable farming practices still remains the biggest challenge.	Availability of resources to use in the banana farming.	Investment in the banana value chain from extension, equipment to irrigation and tissue cultured suckers of hybrid seeds varieties will help enhance the banana farming practices in Mwense district.
ıbility	Introduction of improved variety New practices	Teach the farmers on new practices on harvest and post harvest Introduce new technologies Also to encourage them when and how they should plant the bananas
lack of availability of disease tolerant varieties, un coordinated and fragmented market system, high in put costs, low soil fertility, un stable climate and pest and diseases, post harvest losses.	good climatic temperatures, availability of land and water, Good road network, available market opportunity across DRC congo.and available agricultural extension service.	intensive farmer training in banana production, set up banana production schemes by mununshi banana production project. establish a lot of on farm demonstrations. and strengthen farmer field schools in banana production, establish market linkages in the banana value chain and also strengthen bulking strategy system.

Note: Each row represents a respondent

Annex 6. Transcripts for Focus Group Discussions

Focus Group Reponses. Location: Lukwesa Block, Mwense District. Date: 12th July, 2022	
Practice category	**Group response**
Land Preparation	
Land clearing practice(s)	Most farmers use slashers to slash the field first and then pile the residues in heaps and burn in the field. But some farmers do not burn. They spread the residues in the field and let them rot. This helps to add manure to the soil.
Soil preparation practice(s)	Mostly we use hand hoes to make ridges on which we plant banana suckers. Other farmers simply clear the field and dig planting pits or holes where they plant the suckers.
Machinery/equipment type	We do not have access to machines and other equipment to help us in farming. So, we use hand tools such as hoes as the means to our farm operations. It is difficult in this area to get loans from banks and use the money to buy equipment like hand operated tractors. Most farmers do not even have information on where to get loans.
Crop management	
Crop types and varieties	We use our own suckers from previous seasons. Sometimes we obtain the suckers from neighboring farms. The local varieties we plant are Malindi, Mansa and Mutema. Getting improved varieties here is a challenge. We have heard about the commercial farm in the district who have improved William varieties, but they don't sell us the suckers. We have not heard about tissue culture seedlings.
Sowing methods or practice(s)	We plant suckers in single rows. Some farmers space the plants at 3m but most of them don't follow regular spacing.
Weed management practices	We weed bananas manually by hand using hoes and machetes. But due to shortage of labor, most farmers do not weed regularly.
Irrigation practices	Farmers depend on rain to irrigate their bananas. Those farmers who have land in dambo areas make irrigation furrows to supplement rainfed system.
Fertilizer application practices	Most farmers don't apply chemical fertilizers because they are expensive. Only a few farmers who are on the Maize government subsidy programme have access to fertilizers for maize growing, but they use part of that fertilizer to apply in bananas. Those who use chemical fertilizers apply directly to planting stations, but they do not use any recommended rates for application. The rest of the farmers use compost manure to grow bananas. Fertilizer is a big challenge here.
Pest management practices	In most case, farmers do not do anything about pests. There is not enough money to buy pesticides as they are very expensive.
Disease management practices	Farmer do not practice any disease management. A few who do it just uproot the diseased plants and burn them.
Agrochemical use	
Fertilizer type(s)	Farmers usually use organic compost manure
Soil fertility determination method(s)	Farmers do this by visual assessment of the soil based on their own experience
Pesticides type(s)	We don't use any
Pesticides disposal method(s)	We don't use any
Harvest management	
Harvest determination methods	Famers usually check the color of fruits when they turn from green to yellowish color.
Harvesting methods	Farmers harvest by cutting the bunch from the plant using a machete.
Post-harvest management	
Pre-cooling methods	We just put the bananas in a shed.
Storage or preservation practices	Bananas are usually kept in baskets and stored in a cool room until they are sold too buyers. Sometimes buyers just come to the farm and choose the bunches themselves, harvest and transport them.
Transportation methods	This is done mostly by using motorbikes and bicycles. Some farmers put bunches on trucks and small vehicles.
Waste management practices	Leaving crop residue to decompose in field, Dispose in pits
Quality control and certifications	We only do sort, Certification and quality control does not happen here.

Focus Group Reponses. Location: Kashiba Block, Mwense District. Date: 14 July, 2022	
Practice category	**Group response**
Land Preparation	
Land clearing practice(s)	Farmers use slashers to slash the field first and then pile the residues in heaps and burn in the field. But some farmers do not burn. They spread the residues in the field and let them rot. This helps to add manure to the soil.
Soil preparation practice(s)	Farmers use hand hoes to make ridges for planting banana suckers. Other farmers dig planting basins in which they plant the suckers.
Machinery/equipment type	Farmers have no access to machines and other equipment to help them in farming because of difficulties in get loans from banks. Farmers do not have required collateral banks want. Banks only give loans to salaried government workers mostly.
Crop management	
Crop types and varieties	We use our own suckers from previous seasons. Sometimes we obtain the suckers from neighboring farms. The common local variety we plant here are Malindi and Mutema. We do not know about tissue culture seedlings.
Sowing methods or practice(s)	We plant suckers in singe rows. Some farmers space the plants at 3m but most of them don't follow regular spacing.
Weed management practices	We weed bananas manually by hand using hoes and machetes. But due to shortage of labor, most farmers do not weed regularly.
Irrigation practices	Farmers depend on rain to irrigate their bananas. Those farmers who have land in dambo areas make irrigation furrows to supplement rainfed system.
Fertilizer application practices	Most farmers don't apply chemical fertilizers because they are expensive. Only a few farmers who are on the Maize government subsidy programme have access to fertilizers for maize growing, but they use part of that fertilizer to apply in bananas. Those who use chemical fertilizers apply directly to planting stations, but they do not use any recommended rates for application. The rest of the farmers use compost manure to grow bananas. Fertilizer is a big challenge here.
Pest management practices	In most case, farmers do not do anything about pests. There is not enough money to buy pesticides as they are very expensive.
Disease management practices	Farmer do not practice any disease management. A few who do it just uproot the diseased plants and burn them.
Agrochemical use	
Fertilizer type(s)	Farmers usually use organic compost manure
Soil fertility determination method(s)	Farmers do this by visual assessment of the soil based on their own experience
Pesticides type(s)	We don't use any
Pesticides disposal method(s)	We don't use any
Harvest management	
Harvest determination methods	Famers usually check the color of fruits. The leaves turn brownish, and the fruits begin to change color from dark green to yellowish color.
Harvesting methods	Farmers harvest cutting the whole stem and later cut the bunch from the plant using a machete.
Post-harvest management	
Pre-cooling methods	We just put the bananas in a shed.
Storage or preservation practices	Bananas are usually kept in baskets and stored in a cool room until they are sold too buyers. Sometimes buyers just come to the farm and choose the bunches themselves, harvest and transport them.
Transportation methods	The traders are the ones who transport bananas from the field or homes of farmers by use of motorbikes and bicycles.
Waste management practices	Leaving crop residue to decompose in field, Dispose in pits
Quality control and certifications	We only do sort, Certification and quality control does not happen here.