INNSPUB

**International Journal of Biosciences | IJB |**
**ISSN: 2220-6655 (Print); 2222-5234 (Online)**
**Website: https://www.innspub.net**
**Email contact: info@innspub.net**
**Vol. 27, Issue: 1, p. 132-141, 2025**

RESEARCH PAPER OPEN ACCESS

# Characterization of banana-based farming systems in Rombo District, Tanzania: Implications for sustainable agriculture and food security

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**Key words:** Banana-based farming systems, Rombo district, Agro-ecological zones, Sustainable agriculture, Food security, Tanzania

DOI: https://dx.doi.org/10.12692/ijb/27.1.132-141 Published: July 06, 2025

**ABSTRACT**

Banana-based farming systems are essential for food security and livelihoods in Rombo District, Tanzania. This paper characterizes these systems by assessing current practices, identifying limiting factors, and evaluating labour dynamics across agro-ecological zones. Using a mixed-methods approach that includes participatory questionnaires and transect walks, data were collected from 60 households across three agro-ecological zones. Results reveal a diversity of farming systems, with the predominant intercropping of banana, coffee, maize, and beans. Key challenges include disease prevalence, soil fertility decline, drought, labour shortages, and limited access to improved varieties and organic fertilizers. The study underscores the need for integrated pest management, capacity building, and mechanization to enhance productivity and sustainability. Recommendations include further research on disease-resistant varieties, promotion of organic fertilizers, and strategies to engage youth in agriculture. These findings offer valuable insights for policymakers and stakeholders aiming to improve banana-based farming systems in Tanzania and similar contexts.

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## INTRODUCTION

Bananas (*Musa* spp.) are essential both as a staple food and a cash earner crop for millions of smallholder farmers in the Great Lakes region, including Tanzania (FAO, 2012). According to the Food and Agriculture Organization (FAO) (2024), the Tanzania mainland produced 3.6 million tonnes of bananas (including plantains) in 2023 on 0.35 million hectares. The constant availability of bananas establishes them as a key crop for food security. In the Rombo District, located on the northeastern slopes of Mount Kilimanjaro, banana-based farming systems are vital for sustaining the livelihoods and food security of the smallholder farmers, the majority of banana producers (Chuwa, 2022).

Rombo District is the predominant banana-producing area within the Kilimanjaro Region, representing one of Tanzania's four major banana-growing regions alongside Kagera, Mbeya, and Arusha (URT, 2021). The district's favorable tropical climate with temperatures between 27 and 30 °C and average rainfall between 800 and 2000 mm creates optimal conditions for banana cultivation (FAO, n.d.). For centuries, bananas in the Rombo District, as in the other main banana-growing areas in Tanzania, have been grown in association with various annual and perennial crops within integrated land use systems (Kibona, 2020). Kibona (2020) describes this as "a permanent mixed farming system whereby banana is intercropped with other annual and perennial crops in one land use system." This approach maximizes land utilization on relatively small holdings, with the average land dedicated to banana cultivation in Rombo measuring approximately 0.75 acres per household (Mbwana, 2009). Within these small parcels, farmers maintain a dense intercropping system.

Land pressure in the Rombo District is primarily driven by population growth, leading to land fragmentation into smaller parcels. This fragmentation reduces the available arable land per household, forcing farmers to adopt innovative strategies to maximize productivity. Additionally, climate change has exacerbated the situation by introducing unpredictable weather patterns, soil degradation, and reduced water availability (Venosa and Mamkwe, 2021). These factors collectively threaten the sustainability of banana-based farming systems, which are vital for food security and livelihoods in the region.

Farmers in Rombo District have increasingly adopted dense intercropping systems in response to land pressure. Intercropping, the practice of growing two or more crops simultaneously on the same land, offers several advantages. It allows farmers to diversify their crops, reduce the risk of crop failure, and improve soil fertility through complementary nutrient use (Lv *et al.*, 2021; Schmutz and Schöb, 2024). For instance, intercropping bananas with legumes such as beans or cowpeas has enhanced soil nitrogen levels, reduced pest infestations, and increased overall yield (Layek *et al.*, 2023).

Recent studies highlight the effectiveness of intercropping in mitigating the effects of land pressure. For example, research in the Kagera region of Tanzania demonstrated that banana-coffee intercropping systems improved land use efficiency and provided economic benefits to smallholder farmers (Sesabo, 2024; Mdoe *et al.*, 2014). Similarly, in the Rombo District, farmers have successfully integrated bananas with crops like maize, beans, and vegetables, creating a resilient farming system that can withstand climatic shocks and land scarcity (Venosa and Mamkwe, 2021).

Despite their importance, banana-based farming systems in the Rombo district face several challenges, including pests (insect pests and diseases), declining soil fertility, and labor shortages, threatening their productivity and sustainability. Despite their importance, there is limited documentation on the characteristics of these farming systems and the factors that hinder their productivity (Mhando and Mshindo, 2019; Kihupi, 2018).

This paper, therefore, aims to fill this gap by characterizing the existing banana-based farming systems in the Rombo District, identifying key constraints, and proposing strategies for improvement. The findings are expected to inform policy and intervention programs to enhance the region's banana farming productivity and sustainability.

## MATERIALS AND METHODS

### Description of the study area

The study was conducted in Rombo District, Kilimanjaro Region, Tanzania, along a transect that ran from the Upper zone across the Mid zone to in the Lower zone of the district. The district has a bimodal rainfall pattern, with long rains from March to June and short rains from November to December, which also define the two cropping seasons of the area (Rombo District Council, n.d.). The upper zone lies between 1600 masl and 2000 masl and receives rainfall ranging between 1000 mm and 2000 mm per annum; the mid-zone lies between 1000 masl and 1500 masl and receives rainfall ranging from 900 mm to 1000 mm per annum; the lower zone lies below 1000 masl and receives rainfall ranging from 200 mm to 500 mm per annum. Agriculture is the primary economic activity, with bananas, coffee, maize, and beans being the main crops. Coffee is often intercropped with bananas within agroforestry home gardens.

### Sampling strategy

A stratified sampling method was used to select 60 households from three agro-ecological zones (20 households per zone). Farmsteads were selected based on topography and the presence of banana plants. Data were collected through participatory questionnaires, transect walks and key informant interviews. Employing participatory questionnaires is designed to ensure that farmers contribute their local knowledge. Transect walks involved systematically traversing the landscape to observe and document agroecological features, crop health, soil conditions, and farming practices. Key informants' interviews were employed to obtain data about banana farming systems, historical trends, and localized challenges.

### Data collection

Data were collected on socio-economic characteristics, farming systems and practices, crop yields, soil fertility management practices, labor dynamics, food security and existing banana-based farming systems. Key informants, including agricultural extension officers, provided additional insights. In addition, a thorough analysis was conducted to characterize each farm using data collected through transect walks. This involved defining the farmers' interventions, the farm's existing agroforestry practices and agronomic parameters such as crop yield and irrigation practices. The size of each farm was determined with a Garmin Etrex 30 Global Positioning System (GPS), which provided an accuracy of +/- 4 m.

### Data analysis

Quantitative data were analyzed using SPSS Version 16, developed and released by SPSS Inc. in 2007. Using Braun and Clarke's (2006) framework, qualitative data derived from in-depth interviews, focus group discussions, and participatory observations with banana farmers, agricultural extension officers, and local leaders in Rombo District were analyzed thematically to uncover patterns and insights central to the study's objective. Results were compared across agro-ecological zones to identify variations in farming systems and constraints (Tittonell *et al.*, 2008).

## RESULTS AND DISCUSSION

### Socio-economic characteristics of respondents

Results in Table 1 (a) show that most respondents were male (90%), with an average age of 57 years. Most heads of the households had primary education (83.3%), and the average household size was 4-6 members. The results further showed that the age groups of 17 to 35 and 36 to 60 remained active in farming activities, with only one to two members in a few. Most households had fewer than four members. In smallholder farming systems, labour is a primary input for agricultural activities in terms of field management (i.e., desuckering, pruning, weeding, manure application.

**Table 1(a).** Variations in the number of members per age group in the surveyed households in Rombo district in the Kilimanjaro region, Tanzania

| Number of household members | Age group (0-16 years) | Age group (17-35 years) | Age group (36-60 years) | Age group (over 60 years) |
|---|---|---|---|---|
| Non | 26.7 | 33.3 | 25.0 | 53.3 |
| One | 21.7 | 31.7 | 23.3 | 28.3 |
| Two | 20.0 | 20.0 | 48.3 | 16.7 |
| Three | 18.3 | 5.0 | 3.3 | 1.7 |
| Four | 10.0 | 6.7 | 0 | 0 |
| Five | 3.3 | 1.7 | 0 | 0 |
| Six | 0 | 1.7 | 0 | 0 |

In Rombo District, where banana farming is a dominant agricultural practice, the average household size of 4-6 members provides a moderate labour pool. However, the age structure and gender distribution within households further influence labour availability. For instance, households with more adult members or a balanced gender composition tend to have higher labour efficiency, enabling them to adopt labor-intensive practices like intercropping and composting (Tumusiime and Matotay, 2014; Oyekale, 2016). Youth engagement in agriculture was low, with many migrating to urban areas for non-agricultural employment.

In addition, the results show that most of the households in this study were headed by males. These male household heads were actively involved in the small-scale dairy farming industry. Specifically, the results indicate that 90% of the household respondents were male, while only 10% were female (Table 1 (b)). This implies that gender plays a significant role in managing small-scale dairy farming, with men being the dominant force in this field.

**Table 1 (b).** Sex of the respondents in the surveyed households in Rombo district in the Kilimanjaro region, Tanzania

| Sex | Frequency | Percent |
|---|---|---|
| Male | 54 | 90.0 |
| Female | 6 | 10.0 |
| Total | 60 | 100.0 |

In many rural communities, gender roles are deeply entrenched, with men typically assuming the role of household heads and primary decision-makers in agricultural activities. This is particularly evident in small-scale dairy farming, where men often control access to resources such as land, livestock, and capital, which are critical for dairy production (Kirui *et al.*, 2023; Duguma, 2022). The active involvement of male household heads in dairy farming can be attributed to their greater access to these resources and their ability to leverage social networks and extension services to improve productivity (Oo, 2020; Yusuf, 2017).

**Existing banana-based farming systems**

The results show a diversity of banana-based farming systems, including banana-coffee, banana-coffee-beans, and banana-maize-beans. The Upper and Mid Zones were dominated by coffee-banana-bean systems (44.4%), while the Lower Zone was characterized by banana-maize-groundnut systems (100%) (Table 2). Intercropping was common across the zones, primarily to conserve moisture, suppress weeds, and improve soil fertility.

This diversity reflects the adaptability of farmers to optimize land use and maximize productivity in response to local environmental and socio-economic conditions. The banana-coffee-beans system, which dominates the Upper and Mid Zones (44.4%), is particularly significant due to the favorable climatic conditions for coffee cultivation. As a cash crop, coffee provides economic stability, while bananas and beans contribute to household food security and nutritional diversity (Tei *et al.*, 2020; Chamkhi *et al.*, 2022; Ronner, 2023). In contrast, the Lower Zone is characterized by banana-maize-groundnut systems (100%), better suited to this zone's drier conditions. Maize and groundnuts are staple crops that ensure food availability, while bananas provide a perennial source of income and nutrition (Senkondo *et al.*, 2014; Elser, 2008; Mkonda, 2021).

**Table 2.** Variation of the banana-based farming systems across the agro-ecological zones of Rombo district in the Kilimanjaro region, Tanzania

| Sl | Banana-based farming system | Agro-ecological zones | | |
|---|---|---|---|---|
| | | Lower zone | Mid zone | Upper zone |
| 1 | Coffee/banana | 22.3% | 44.4% | 33.3% |
| 2 | Coffee/Banana/beans | 11.2% | 44.4% | 44.4% |
| 3 | Banana/beans | 66.7% | 23.3% | 10% |
| 4 | Coffee/banana/maize | 60% | 40% | 0% |
| 5 | Coffee/banana/maize/beans | 30% | 40% | 30% |
| 6 | Banana/Maize/beans | 44.4% | 11.2% | 44.4% |
| 7 | Banana/maize/groundnuts/sunflower/legumes/cassava | 100% | 0% | 0% |

The dominance of coffee/banana/beans and banana/maize/beans systems in the highlands of Rombo district could be attributed to favourable weather conditions, viz., cool temperatures, high rainfall, and deep soils with good drainage. The integration of coffee and beans with bananas likely provides multiple benefits, such as improved soil fertility through nitrogen fixation by legumes and additional income streams from coffee production (van Asten *et al.*, 2011).

The adoption of coffee/banana/maize/beans (40%) in the Mid zone indicates a similar trend of diversification as in the Upper zone, but with a greater emphasis on maize as a staple crop. Maize is a critical food security crop in Tanzania, and its inclusion in the farming system likely reflects the need to meet household food requirements while maintaining cash crop production (Kihupi, 2018). The Mid Zone's intermediate altitude and climatic conditions, and reducing the tree component to allow more sunlight for other annual crops like maize, may support the cultivation of both coffee and maize, making this combination viable for farmers in the area.

The lower zone exhibited a distinct farming system, with banana/maize/groundnuts/sunflower/legumes/ cassava being the most common (100%). This system reflects a high level of crop diversity, likely aimed at maximizing land productivity and ensuring food security. The inclusion of legumes and oil crops such as groundnuts and sunflower suggests an emphasis on soil fertility management and income diversification. Additionally, the high adoption of banana/beans (60%) and coffee/banana/maize (66.7%) in the lower zone highlights the adaptability of farmers to the zone's warmer and drier conditions, which may favor drought-tolerant crops like maize and legumes (Mhando and Mshindo, 2019). This also aligns with findings from studies in similar agroecological zones, where legume integration has been shown to improve soil health and crop productivity (Laizer *et al.*, 2019; Ansah and Siaw, 2017). Sunflower, on the other hand, provides an additional income stream for farmers, contributing to economic resilience and reducing reliance on a single crop (Mbwana *et al.*, 2016).

These variations in farming systems across agro-ecological zones underscore the importance of context-specific agricultural practices. Farmers in each zone have developed systems that align with their environmental conditions, resource availability, and socio-economic needs. However, the reliance on traditional practices and limited access to modern technologies, such as improved crop varieties and mechanization, may constrain productivity and sustainability. For instance, the high prevalence of intercropping systems, while beneficial for soil health and risk mitigation, may also lead to competition for resources such as nutrients, water, and light, particularly in resource-limited settings (Tittonell *et al.*, 2008). In addition, the limited adoption of improved banana varieties, which are often more resistant to pests and diseases, can lead to lower yields and increased vulnerability to crop failures (Wanyama *et al.*, 2018; Tamasiga *et al.*, 2023). Similarly, the lack of mechanization in banana farming systems can result in labour-intensive practices that limit the scalability and efficiency of production (Mutekwa and Kusangaya, 2007).

**Table 3.** Limiting factors in banana-based farming systems across the agro-ecological zones of Rombo District in the Kilimanjaro region, Tanzania

| Sl | Banana production limiting factor | Zones | | |
|---|---|---|---|---|
| | | Lower zone | Mid zone | Upper zone |
| 1 | Diseases | 25% | 35% | 40% |
| 2 | Declining soil fertility | 25% | 43.8% | 31.2% |
| 3 | Drought | 71.4% | 25% | 3.6% |
| 4 | Animal manure shortage | 39.5% | 42.1% | 18.4% |
| 5 | Labor shortage | 15.4% | 38.5% | 46.2% |
| 6 | others | 66.7% | 16.7% | 16.7% |

The findings of this study highlight the need for targeted interventions that consider the unique characteristics of each agro-ecological zone. For example, promoting drought-resistant crop varieties and in situ rainwater-harvesting technologies could enhance productivity in the Lower Zone. Meanwhile, capacity-building programs on integrated pest management (IPM) and integrated soil fertility management (ISFM) for enhanced resource use efficiency could benefit farmers in the Upper and Mid Zones because these areas are characterized with high pests pressure and prone to leaching losses caused by high rainfall of more than 2000 mm per year (add reference). Additionally, efforts to improve market access and value addition for banana and coffee products could increase household incomes and incentivize youth engagement in agriculture (CABI, 2021).

**Limiting factors in farming systems across the agro-ecological zones**

The results indicate that high diseases pressure (40% prevalence in the Upper Zone), declining soil fertility (43.8% in the Mid Zone), drought (71.4% in the Lower Zone), labour shortages (46.2% in the Upper Zone), and animal manure shortage (42.1% in the Mid-Zone) are the key constraints of the dominant farming systems in the Rombo district (Table 3). The 40% prevalence of disease in the Upper Zone aligns with findings from Jomanga and Lucas (2021), which report that *Fusarium* wilt and Black Sigatoka can cause yield losses of up to 100% in Tanzania. The Mid Zone's 43.8% soil fertility decline is consistent with studies showing that banana production depletes soil nutrients, particularly nitrogen, phosphorus, and potassium (Suvittawat, 2014; Meya *et al.*, 2023). This is further supported by findings from (Baijukya *et al.*, 2005), which highlight the increasing frequency of erratic rainfall patterns in Tanzania due to climate change. This constraint is linked to rural-urban migration and the labor-intensive nature of banana cultivation, particularly for tasks such as weeding, pruning, and harvesting (Kimanya *et al.*, 2009). Manure is a key source of organic matter and nutrients, but its availability is limited by declining livestock populations and competition for manure as fuel (Meya *et al.*, 2023; Reetsch *et al.*, 2020).

**Food security**

Most of the visited households during the survey stored food for 3-6 months, with shortages occurring between November and February. Poor post-harvest management practices, such as traditional drying and storage methods, appeared to cause substantial post-harvest yield losses consequently, contributing to food insecurity. One respondent explained; "During November, December, January, and February, we often struggle to find enough food because what we have stored starts to run out. We have to look for food elsewhere during these months." This statement reflects households' seasonal challenges as their stored food supplies diminish, forcing them to seek additional resources to meet their needs.

**CONCLUSION**

This study highlights the diversity of banana-based farming systems in Rombo District and their challenges. While farmers are knowledgeable about the traditional farming practices, there is a need for modern techniques to enhance productivity and sustainability in the face of increasing challenges of climate change, land pressure, labour, and organic fertilizer resources shortage. Key recommendations include further research on

developing site-specific disease-resistant varieties to address the prevalence of pests and diseases. Capacity-building programs on integrated pest management (IPM) and good agricultural practices (GAP) should be implemented to improve farming skills and productivity, as suggested by CABI (2021). Promoting ISFM techniques, including combining organic fertilizers/biofertilizers and mineral fertilizer resources, can significantly improve soil fertility and crop yields. Introducing small-scale mechanization can help reduce labor shortages and increase the efficiency of the existing banana-based farming systems, particularly in areas where youth migration is a problem. Finally, strategies to attract youth to agriculture, such as providing credit facilities and improving market access, should be prioritized to ensure the future sustainability of banana-based farming systems. These recommendations, if implemented, can contribute to the resilience and productivity of banana-based farming systems in Rombo District and other main banana-growing areas of the country.

**ACKNOWLEDGMENTS**

The authors acknowledge the Nelson Mandela African Institution of Science and Technology (NM-AIST) and the government of Tanzania for their support. Special thanks to the farmers and key informants who participated in this study.

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