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**Original Research Article**

# Identification of Agroecological Practices Used by Farmers for Soil Management and Banana Diseases Control in Kabare Territory, Eastern DR Congo

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**Abstract:** The adoption of agroecological practices for sustainable production and the conservation of renewable natural resources is an urgent priority in the mountainous Kivu region of Eastern Democratic Republic of Congo. To identify current agricultural practices using in this region, two surveys were conducted across six groupements in the Kabare territory: Bugorhe, Irambi-Katana, Luhihi, Bushumba, Mumosho, and Lugendo. The first survey examined agricultural practices related to soil fertility management, while the second focused on the management of banana diseases. These groupements were selected based on the presence of at least one banana field per household, accessibility, and the prevalence of banana diseases. A total of 316 farmers, aged between 25 and 75 years-including 166 men and 150 women-were interviewed. Results revealed that farmers primarily maintain soil fertility through the use of compost, incorporation of dry or green weeds as green manure, mulching, planting cover crops, and establishing live hedges to prevent soil erosion. For disease management, they selectively cut only the single plant infected by bacteria and uproot plants or mats affected by fusarium wilt and banana bunchy top disease. Despite these efforts, ongoing soil degradation in Kabare and its surrounding areas, coupled with the challenges posed by global warming, highlight the critical need to train farmers in improved agroecological practices. Introducing new, more efficient, and resilient techniques is essential to ensure sustainable and productive agriculture in this territory and other similar regions.

**Keywords:** Agroecology, agricultural practices, banana, disease, soil conservation, survey.



## INTRODUCTION

Bananas and plantains are a staple food for many populations worldwide. In most forested regions of tropical Africa, they form a part of the daily diet (Chevalier, 1922). In the Eastern Democratic Republic of Congo (DR Congo), bananas hold a central place in local diets (Désire *et al*., 2016). In the Highland region of South Kivu, Eastern Africa highland bananas are predominantly grown in intercroping with several other crops due to the limited availability of arable land-typically less than 0.5 hectares per household (CIALCA, 2010; Ntamwira *et al*., 2014; Dowiya *et al*., 2009; Ntamwira *et al*., 2021). Ocimati *et al*., 2021

Banana fruit is consumed in various forms: as a dessert, boiled, grilled, or processed into fufu or banana wine. Banana wine has been a traditional beverage in mountainous region of Kivu for centuries and remains integral to social life; no social event, whether joyous or somber, takes place without banana wine (Sebasigari, 1985).

From a socio-cultural perspective, banana beer plays a crucial role in strengthening social bonds within rural Congolese communities. It is commonly consumed during important events such as weddings, births, and funerals. The drink symbolizes recognition, gratitude, and reconciliation among family members. Socially,

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banana beer is offered to friends during these ceremonies. Furthermore, banana plots are considered part of a man's heritage and are passed down to his children upon his death. Among the Shi people of South Kivu, banana plants are cultivated to protect family land (Ntamwira *et al*., 2016).

Economically, although traditionally cultivated near the homestead, banana farming enables farmers in this region to meet various needs, including food, education, clothing, and healthcare. The sale of bananas and banana beer provides a crucial source of income for farmers (Ntamwira *et al*., 2010; Ntamwira *et al*., 2016). Consequently, banana cultivation helps many rural families combat poverty by generating diverse income streams.

Despite its nutritional and economic importance, banana cultivation faces several abiotic and biotic challenges, notably poor soil fertilty, pest and diseases, socio-economic constraints, such as limited access to inputs (Van Asten *et al*., 2004; Ntamwira *et al*., 2010; Blomme *et al*., 2017). Soil degradation on agricultural lands in mountainous Kivu is a primary cause of the ongoing decline in crop yields, including bananas (Sanginga and Woomer, 2009; Ntamwira *et al*., 2023).

Traditional poor agricultural practices-such as burning and removing crop residues and weeds, deep tillage of soil on slopes without erosion control measures, and minimal use of external inputs-contribute significantly to soil degradation in this area (Johan and Corrie, 2015; Ntamwira *et al*., 2023a). Additionally, soil management practices are insufficient to improve banana production or to combat diseases affecting the crop. The main diseases impacting bananas include bacterial wilt, bunchy top, fusarium wilt, and sigatoka, all of which cause substantial yield losses (Désire *et al*., 2016; Blomme *et al*., 2014, 2017 and 2020).

According to research conducted by Safari (2022), the area dedicated to banana plantations in south Kivu highland decreased from 18% to 12% within just five years, between 2016 and 2021. This decline is primarily attributed to diseases such as bacterial wilt caused by *Xanthomonas* and poor agricultural practices (Ntamwira *et al*., 2014; Blomme *et al*., 2014, Ocimati *et al*., 2018, 2021; Blomme *et al*., 2023). The consequences of yield reduction and soil degradation include lower farmer incomes, increased malnutrition, higher school dropout rates, and rising poverty in rural communities (Ntamwira *et al.*, 2023b).

Effective soil fertility management practices are essential to rehabilitate degraded soils and conserve those at risk of degradation, thereby boosting crop yields in the highland region of South Kivu, particularly in the Kabare territory. For instance, the adoption of improved crop varieties and agroecological practices has been used to restore soil fertility and enhance yields in eastern DR Congo, as demonstrated by Pypers *et al*. (2010), Pyame (2016), and Ntamwira *et al*. (2023a).

Therefore, we hypothesize that farmers in Kabare are implementing some of resilient agroecological practices, either developed independently or introduced by development organizations. This study aims to identify the effective practices farmers are using for soil fertility management and banana disease control, which could serve as entry points for advising them on sustainable, healthy, and climate-resilient production systems.

## MATERIALS AND METHODS

**Stady site**

This research aims to lay the groundwork for promoting agroecological practices that support sustainable agricultural production systems in South Kivu.

The study was conducted in the Kabare territory of South Kivu province, specifically within the communities of Bushumba, Irhambi-Katana, Bugorhe, Luhihi, Lugendo, and Mumosho. The area is bordered to the north by Kalehe territory, to the south by Walungu territory, to the east by the city of Bukavu and Lake Kivu, and to the west by Kahuzi-Biega National Park. Annual rainfall ranges from 1300 mm to 1800 mm. The region lies between 28° and 29° East longitude and between 2° North and 3° South latitude (Bahazabule *et al*., 2024). The figure below illustrates the study area.

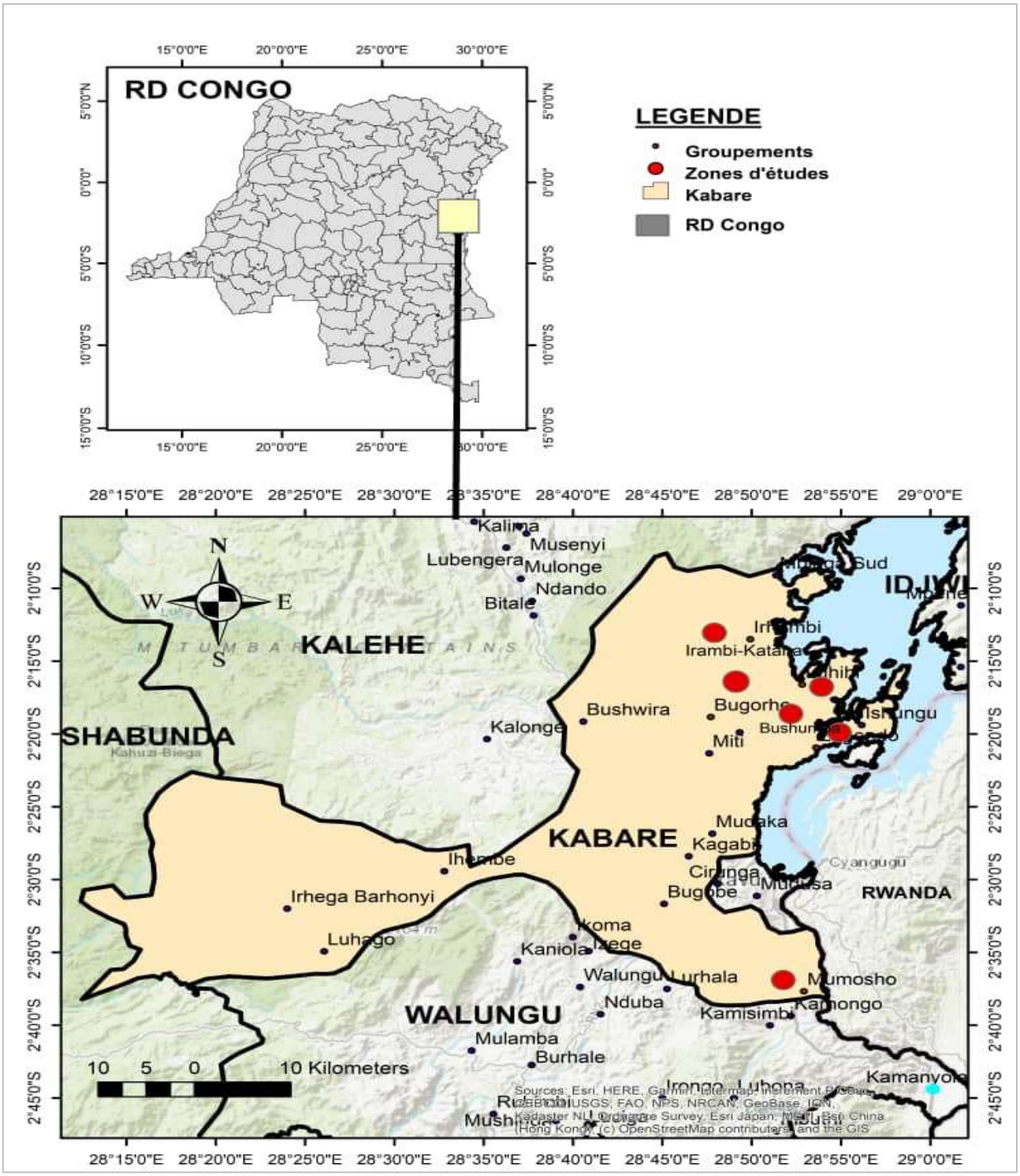


**Figure 1: Administrative map of Kabare, South-Kivu, showing the different groupements**

The climate in the study area is humid tropical, characterized by nine months of rainfall and a three-month dry season. The sites experience an average annual temperature ranging between 16 and 20°C. Rainfall follows a bimodal pattern, with the first cropping season (A) from September to November, and the second (B) from March to May. The average annual rainfall is 1,572 mm (Ngongo and Lunze, 2000).

The Kivu ridge, which includes the Kabare area where the surveys were conducted, has soils derived from sedimentary, metamorphic, and volcanic ash rocks. These soils are slightly acidic, with pH values ranging from 4.3 to 6.2. Phosphorus and potassium levels are generally low. Although these soils have good production potential, nitrogen becomes a limiting factor with continued cultivation. They are predominantly Ferralsols (Muliele, 2014; Heri-Kazi *et al*., 2020).

The Vegetation in the region is dominated by banana, cassava, coffee, and eucalyptus crops, alongside the Kahuzi-Biega National Park.

**Data Collection**

Data collection involved a questionnaire with open-ended questions, the KoboCollect application, and the Tumaini application for identifying banana diseases, alongside ArcGIS 10.8 software for mapping the study areas.

Two surveys were conducted in different groups within the Kabare area: one to identify agricultural practices for soil fertility management, and the other to investigate banana disease control methods.

The first survey was conducted in five clusters in the northern part of the territory-Bugorhe, Irambi-Katana, Luhihi, Bushumba, and Lugendo-randomly selected based on the presence of farms and banana plantations. Fifty individuals aged between 25 and 70 were interviewed per cluster, totaling 250 farmers across the five groups. Respondents answered questions freely. Men were slightly more represented (51.2%) than women (48.8%). Culturally, men typically apply the more complex cultivation techniques, while women often handle ploughing, sowing, weeding, and harvesting.

In addition to the questionnaire, field observations were conducted to verify and observe farmers' practices.

The second survey took place in the Bushumba, Irambi-Katana, and Mumosho groups. These were selected due to the presence of banana plantations, data accessibility, and the occurrence of banana diseases. A total of 66 banana farmers aged 20 to 82 from twenty villages were surveyed in these three clusters, including 28 women and 38 men.

Data collected via KoboCollect were synchronized and imported into Microsoft Excel (2010). Qualitative data were converted into frequencies to calculate percentages.

## RESULTS AND DISCUSSION

**Identification of agroecological practices used by farmers**

The various practices identified during the surveys are summarized in the figure below.

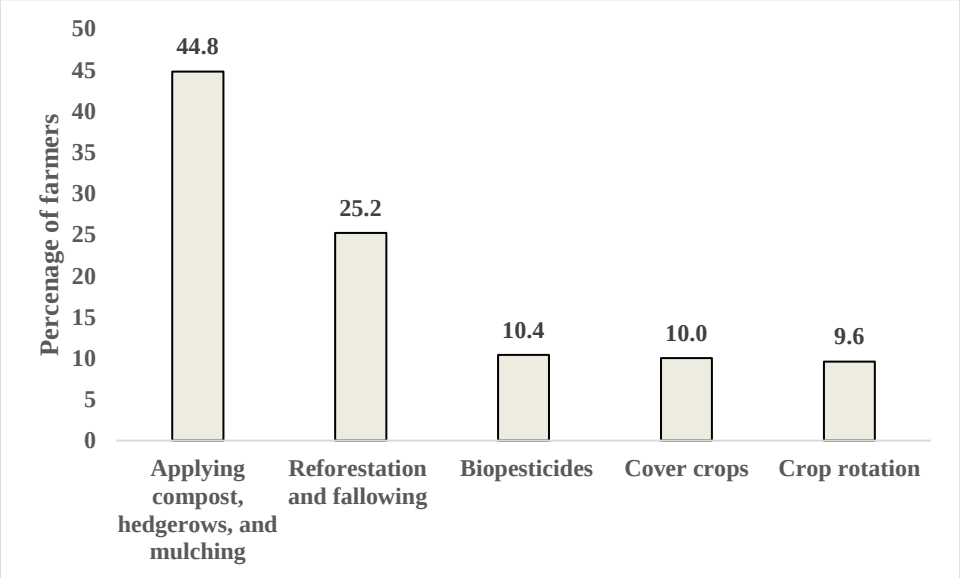


**Figure 2: Different Agro-Ecological Practices Identified in the Kabare territory (N=250)**

This figure illustrates that farmers in Kabare employ various methods to manage soil fertility. Specifically, 44.8% of them combine composting, hedgerows, crop diversification, green manuring, and mulching to enhance and conserve soil fertility.

Regarding composting and green manures, species such as *Tithonia diversifolia*, *Bidens pilosa*, *Galinsoga ciliata*, and other non-lignified green fodder plants are often incorporated into the soil when beans are sown or mixed with other materials during compost production due to their rapid decomposition.

For mulching, farmers use grass straw (*Hyparrhenia diplandra*) and dry banana leaves. Mulching serves to protect the soil from erosion and exposure to various climatic hazards that could damage it. However, this 44.8% adoption rate is relatively low compared to the 78% of farmers reported by Ouedraogo in 2018 in the Lake Chad region, where mulching is used to mitigate the effects of intense sunlight and rainfall scarcity. Mulching reduces runoff by maintaining a layer of dead or living cover. The high biomass resulting from crop residue left on the surface enriches the topsoil with

organic matter, which helps maintain soil structure and improves deep water infiltration (FAO, 2005).

Consequently, soil fertility can be restored, and agricultural productivity improved (Razafindraman et al., 2012). These practices offer a viable response to the challenges of natural resource degradation and declining agricultural yields (FAO, 2012).

To establish living hedges, various plant species such as grasses, Asteraceae, and legumes are planted. The survey results show that 56.4% of farmers planted *Tithonia diversifolia*, grasses (Tripsacum and Pennisetum), and legumes (Leucaena and Calliandra), 28.8% planted nothing, and 14.8% planted lemongrass and green veti. These species improve the resilience of living hedges and help prevent soil erosion by stabilizing the soil. The creation of such synergies enhances essential functions within food systems by contributing to production and multiple ecosystem services.

Crop and livestock diversity also strengthens ecological and socio-economic resilience, partly by creating new market opportunities. Agro-ecological diversity reduces the risk of crop failure under climate change. Local species diversity enables better survival, production, and reproduction in challenging environments. Moreover, diversified systems are more resilient than monocultures (FAO, 2018).

Some farmers use simpler practices such as reforestation or fallowing of degraded land (25.2%), cover crops (10%), and crop rotation (9.6%). To control crop diseases, 10.4% use biopesticides to avoid the harmful effects of chemical pesticides on the environment, human health, and animal health.

The adoption of agro-ecological practices stems from farmers' awareness of land degradation, which leads to reduced production. To counter this, farmers are adopting resilient practices to minimize these negative effects.

A significant portion of respondents (42%) expressed a desire to adopt agro-ecological practices to maximize their income; 29.6% want to use these practices to mitigate the effects of global warming, and 28.4% aim to sustain production throughout the year.

Furthermore, 83.6% of surveyed farmers reported increased production thanks to agro-ecological practices. Similarly, in Niger, over 90% of farmers surveyed by the FAO (2017) stated that well-conserved natural resources significantly boost their income.

Around 52.8% of farmers indicated that food availability and accessibility are the foundation of agro-ecological practices, while 47.2% confirmed that agroecology leads to increased food quantity.

The implementation of agro-ecological techniques enables farmers to increase their yields (Uraanov, 2015). Consequently, more than three-quarters of farmers observed production increases after adopting these practices.

However, 63.2% of farmers reported not applying agro-ecological practices because they cultivate land they do not own, and 38.8% lack knowledge about these practices.

**Identification of Agro-Ecological Practices Used by Farmers to Control Banana Diseases**

The following table summarizes the survey results:

**Table 1: Banana diseases and control methods Used by farmer in the Kabare territory**

| Diseases | Groupements | Number of farmers | Cutting of only the single diseased plant (%) | | Uprooting (%) | |
|---|---|---|---|---|---|---|
| | | | Non | Yes | Non | Yes |
| Bacterial wilt | Mumosho | 22 | 0 | 100 | 100 | 0 |
| | Irhambi-Katana | 9 | 0 | 100 | 100 | 0 |
| | Bushumba | 29 | 0 | 100 | 100 | 0 |
| Banchy top | Mumosho | 22 | 100 | 0 | 17 | 83 |
| | Irhambi-Katana | 9 | 100 | 0 | 20 | 80 |
| | Bushumba | 29 | 100 | 0 | 100 | 0 |
| Fusarium wilt | Mumosho | 22 | 17 | 83 | 83 | 17 |
| | Irhambi-Katana | 9 | 100 | 0 | 100 | 0 |
| | Bushumba | 29 | 100 | 0 | 100 | 0 |

The table indicates that all the farmers surveyed do not use ash or remove stumps containing diseased plants to combat banana bacterial wilt; instead, they only cut down the individual diseased plants (100%). Additionally, farmers in Bushumba reported that the proper application of this method increased banana production by 20 to 52%.

These findings confirm the adoption of this practice, which was promoted by Bioversity and INERA in the Kabare region in 2014. This agro-ecological approach, combined with other BXW control measures (such as cutting the inflorescence and sterilizing tools), facilitated the recovery of banana plantations in Kabare, where disease incidence dropped from 80% to 0.5% within two years of intervention (Blomme et al., 2014).

Similar results, showing a significant reduction in disease incidence by cutting only the diseased plants, were also observed in Rwanda by Blomme *et al*. (2021).

Regarding the control of banana bunchy top virus, farmers in Mumosho (83%) and Kabamba (20%) employed stump removal for all strains carrying the virus. No cases of the disease were observed in Bushumba.

To combat fusariosis, the Mumosho group used the method of cutting out only the diseased plants (83%) and removing diseased stumps (17%). This disease was not observed in the other two groups (Irhambi/Katana and Bushumba).

These results demonstrate that farmers do not rely on chemical treatments to control diseases, thereby reducing environmental harm and the risk of consumer poisoning, making the system both sustainable and profitable. According to the FAO (2015), a sustainable agro-ecological production system should have minimal negative environmental impact and release negligible amounts of toxic substances into the air, surface water, or groundwater.

## CONCLUSION

Farmers in Kabare employ low-cost cultivation practices that are environmentally friendly, increase production, manage soil fertility, and control banana diseases. These practices primarily include fertilization with compost and green manure, mulching, cover cropping, planting hedges for soil management, cutting only bacterial-infected plants, and removing plants or stumps affected by fusariosis and bunchy top disease.

Given the ongoing soil degradation in Kabare and surrounding areas, as well as the challenges posed by global warming, it is crucial to train farmers in sound agro-ecological practices and introduce new, more efficient, and resilient techniques to ensure sustainable and profitable production in this and similar regions.

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**Availability of data**

The datasets supporting the conclusions of this article are included within the article.

**Authors' contributions NJ**, MT, NE, ND, and WD participated in the design of the study, conducted the survey, NJ, prepared the manuscript, and performed the statistical study. BE, ML and BM helped to improve this paper. All authors read and approved the final manuscript.

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