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Assessment of Knowledge and Implementation of Agro-Environmental Techniques by Farmers in Kanyameshi and Mimbulu Villages, peri-Urban Area of Lubumbashi, Haut-Katanga Democratic Republic of Congo

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Abstract

Agriculture plays a central role in socioeconomic development, especially in the Democratic Republic of Congo, where it employs about 70% of the population. However, dominant agricultural practices negatively impact the environment, threatening biodiversity and ecosystems. This study aims to promote resilient family farming in the peri-urban area of Lubumbashi, Haut-Katanga. It evaluates farmers' knowledge and implementation of agro-environmental techniques to mitigate climate change effects. Based on surveys and direct observations of 150 farmers in Kanyameshi and Mimbulu villages, results show that crop association, rotation and manure pits are the most practiced techniques (38%), while agroforestry and biological control are nearly absent. Knowledge of these techniques is closely linked to their perceived impact on climate, environment and agricultural productivity. Although 47% of farmers believe these practices moderately improve farm performance and profitability. The overall awareness remains low. This highlights the need to intensify agro-environmental practices to strengthen family farming resilience.

Keywords: Agro-Environmental techniques, Family farmers, Lubumbashi, Haut-Katanga, DR Congo

Introduction

Agriculture represents a vital sector for global socioeconomic development, whose progress (intensification) has been accelerated by the extraction of fossil resources and innovations in agricultural technologies for both animal and plant production (Kinmagbahohoue & Yabi, 2023; Pingali, 2012; Pretty et al., 2018; Tittonell, 2014). The dynamism of this sector grants agriculture considerable importance, as it engages the majority of the population not only as a source of food but also as the main income-generating activity and employment provider in developing countries (World Bank. 2024; Sossou et al., 2021; Assogba et al., 2017; FAO, 2020).

In Africa generally, and in the Democratic Republic of Congo (DRC) in particular, agriculture provides employment to more than seventy percent (70%) of the population (IFPRI, 2019; MAAIF, 2018; Tschirley et al., 2015; World Bank, 2019). Due to rapid population growth, the demand for agricultural products is constantly increasing. However, agricultural practices based primarily on slash-and-burn techniques negatively affect the quality of water, air and soil and also alter ecosystems, thereby contributing to biodiversity loss and exacerbating the harmful effects of climate change (Altieri & Nicholls, 2017; Garnett, 2014; Tilman et al., 2011; Foley et al., 2011).

It has been demonstrated that several constraints explain farmers' choices of production types and methods in rural and peri-urban areas, particularly economic incentives that strongly influence their individual and collective behaviors (Pretty et al., 2018; Brussaard et al., 2010; Godfray et al., 2010; Tilman & Clark, 2014). Yet, promoting agro-environmental practices is urgently needed in selecting sustainable agricultural production techniques, which are often correlated with yield signals (Rockström et al., 2017; Vanlauwe et al., 2014; Wezel et al., 2014; Leakey, 1998).

Overall, the coherence of agro-environmental policies has improved over the past two decades. Some countries have taken steps to rationalize these policies within mandatory frameworks or action plans to support environmental or rural development goals (Brondízio, 2019; Garnett et al., 2013; Kremen & Miles, 2012; Herrero et al., 2010). However, in broader contexts, when agro-environmental policies compensate for environmentally harmful effects—such as input use and production-linked policies—the costs of environmental improvement are higher than they would be without such production support measures, especially when domestic prices are maintained above global market levels (Tittonell & Giller, 2013; Pingali, 2012; Tscharntke et al., 2012; Vermeulen et al., 2012).

Nonetheless, some agro-environmental measures not only aim to offset agriculture's negative environmental impacts but also offer optional payments in exchange for additional environmental services provided by the agricultural sector (Ouedraogo, 2022; Van Noordwijk et al., 2020; Power, 2010; Swinton et al., 2007). In most cases, these additional services are associated with specific agricultural practices rather than direct environmental effects. It is crucial to recognize that some farmers globally—and particularly in the DRC—are motivated to implement agro-environmental practices that enhance the sustainability of their production systems (Sindayigaya, 2023a; Zomer et al., 2016).

According to Camirand and Gingras (2011), agriculture which uses approximately 40% of land and water resources, is also a major source of water pollution through runoff of chemical elements from fertilizers and pesticides. It generates greenhouse gas emissions such as methane (FAO. 2019; West et al., 2010; Smith et al., 2008; Steinfeld et al., 2006).

In light of the above, this study addresses the following concerns : (I) What are the dominant recurring agro-environmental practices in the study area ? (II) How do farmers perceive the development of agro-environmental practices on their farms and what constraints are associated ?

The objective is to analyze the knowledge and implementation of agro-environmental techniques within family farms in the peri-urban area of Lubumbashi. Specifically, this study aims to identify commonly practiced agro-environmental techniques among farmers in the Lubumbashi region in order to: (I) Determine the proportion of family farmers who master and apply sustainable agro-environmental techniques; (II) Assess household perceptions and readiness to develop these practices ; (III) as well as constraints reported by farmers. This research is based on the following hypotheses: (i) Agro-environmental practices exist and should be intensified by farmers in the region. However, they are not widely developed due to limited understanding of their benefits in the agricultural sector ; (ii) The development of agro-environmental practices depends on the farmer's profile, crop types and especially their perception of the impact of these techniques. Therefore, constraints are linked to the institutional and economic characteristics of family farming operations.

Methodology

Study Area

The study was conducted among farmers in the villages of Kanyameshi, located between coordinates (−11°76′31.01″S and 27°25′66.93″E), approximately 28 km from Lubumbashi and Mimbulu, located between (−11°31′48.81″S and 27°36′36.84″E), about 18 km southwest of the city of Lubumbashi. Both villages are situated in the Kipushi territory, Haut-Katanga province, Democratic Republic of Congo.

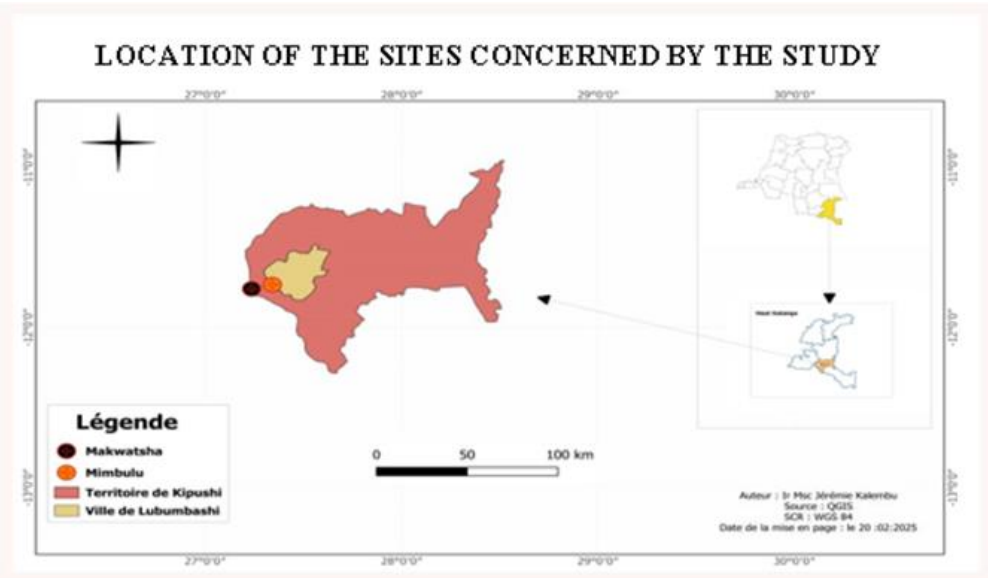


Figure 1: Carte des sites d'enquêtes (Kabala. 2024)

Methods

Survey Approach

A field survey combined with direct observations was conducted in the villages of Kanyameshi and Mimbulu during the period from December 10th, 2024 to March 20th, 2025. These villages were selected based on their accessibility and proximity to the city of Lubumbashi, as well as the fact that the majority of households rely on agriculture for their livelihood.

This quantitative survey approach enabled the collection of data to assess the knowledge and implementation of agro-environmental practices among family farmers, with the aim of promoting sustainable and climate-resilient agricultural production. A semi-structured questionnaire (attached in the annexes) was administered using the Kobocollect application to 75 farming households per village, selected through random sampling.

This sample size was deemed representative due to the lack of reliable data on the number of farming households. The choice of 150 households was motivated by several factors : Random sampling ensured that each household had an equal chance of being interviewed ; Representativeness, allowing for the inclusion of both social and economic characteristics of family farmers and A balance between statistical precision and available resources.

Given the absence of recent census data providing an exact population count in the region, this sample size was considered sufficient to produce statistically reliable results.

Statistical Analysis

The recorded data were harmonized and transferred to SPSS software version 25.0 for processing and statistical analysis. Both inferential and descriptive statistics were performed. Pie charts showing frequency distributions and summary tables were subsequently generated.

Results

Household Head Profile Description

Table 1 below presents the profile of the household head, including age, gender, education level, length of residence in the village, and household size under their responsibility. The sample is predominantly male, with a high proportion of married individuals (84.7%). Overall, the highest level of education attained by household heads is university (13.3%), followed by secondary education (52.7%) and primary education (31.3%).

Table 1: Social Profile of the Agricultural Household Head

Sites	Gender		Average Age		Average tenure		Average Household size
	Male	Female	Male	Female	Male	Female	
Kanyameshi	42	37	45.4±13.3	42.7±8.1	17±2	13.5±1.5	7±3
Mimbulu	44	27	43.6±11.4	43.3±9.9	17.1±1.4	16.2±1.8	8±3
Total	86	64	44.4±10.9	43.0±8.8	17±1.1	14.5±1.1	7±3

Figure 2 below reveals that household survival (income sources) is ensured through various occupations, Including trade, freelance activities, agriculture, private sector employment and public service. However, agriculture stands out as the predominant secondary source of income for 93% of respondents.

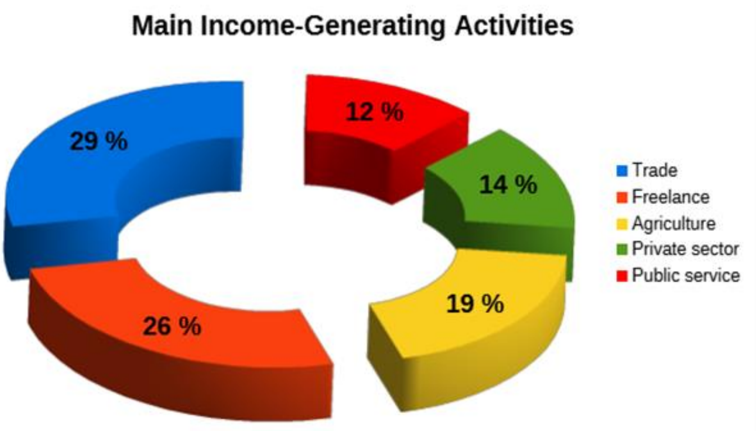


***Figure 2 :** Main Sources of Farmers' Income*

Characteristics of Family Farms and Current Practices

Cultivated Land Area

The results show that, overall, farming households in the study area have sufficient land to carry out their agricultural activities. The average cultivated area per household was approximately 1.5 hectares in Kanyameshi and 2 hectares in Mimbulu during the 2023–2024 agricultural season. Analysis of variance revealed a statistically significant difference in cultivated land area between the two villages (p = 0.014). See the Table 2.

Table 2: Cultivated Land Area by Respondents

Cultivated Area (m²)	**Survey Villages**	
	Kanyameshi	**Mimbulu**
Minimum	4 200	500
Average-SD	14 206.72 ± 1115.42 (b)	18 522.79 ± 1313.33 (a)
Maximum	35 000	50 000

Land Tenure

Survey results indicate that the majority of households cultivate their own land (56%), while 46% are tenants. Among land-owning households, the main modes of land acquisition are purchase (47.6%) and inheritance (41.7%). A minority of households acquired land through donation (10.7%). For tenant households, the average rental price per hectare per agricultural season is approximately 33.992 ± 17.814 CDF (or 12.2 USD) in Kanyameshi and 53.750 ± 18.874 CDF (or 19.2 USD) in Mimbulu. Land acquisition methods were found to be correlated with variables such as education level—particularly secondary education (p = 0.027), marital status—especially among married farmers (p = 0.032), and household size—with an average of more than five members (p = 0.035).

Crop Preferences

Table 3 below presents the priority crops cultivated by respondents within their family farming operations.

Crop	Scientific Name	Count	%
Maize	Zea mays	74	49.3
Beans	Phaseolus vulgaris	27	18.0
Sweet Potato	Ipomoea batatas	12	8.0
Cassava	Manihot esculenta	12	8.0
Groundnuts	Arachis hypogaea	7	4.7
Soybean	Glycine max L	5	3.3
Chili	Capiscum chinense	4	2.7
Bell Pepper	Capiscum annuum	3	2.0
Carrot	Daucus carotte	2	1.3
Amaranth	Amaranthus hybridus	1	0.7
Potato	Solanum tuberosum	2	1.4
Watermelon	Citrullus lanatus	1	0.7
Total		**150**	**100.0**

Analysis of the results presented in the table above shows that maize is the most dominant crop (49%), followed by legumes (26%), and roots and tubers (17.4%). Fruits and vegetables are less commonly cultivated (7.4%). This crop selection is primarily motivated by the contribution of maize, cassava and beans to household staple food needs (66%), profitability considerations (27.3%) and cultural habits (6.7%).

Farming Practices and Identification of Agro-Environmental Techniques

The farming practices commonly employed by producers are summarized in Table 4 below. The results show that, regardless of the village, the farming system is mainly based on shifting cultivation with slash-and-burn techniques. This is followed by crop association and crop rotation. Practices such as mulching and crop striping are less widespread and few households practice fallowing.

In the event of crop attacks, two main strategies are used by family farmers : chemical control (58.7%) and the use of biopesticides (30%). The most frequently observed pest is the fall armyworm (76.3%), particularly affecting maize crops, while 23.7% of farmers report no pest attacks.

Table 4 : Common Agricultural Techniques Used by Farmers

Spéculations	Count	(%)
Slash-and-burn agriculture	150	100.0
Intercropping	92	61.3
Crop rotation	89	59.3
Chemical control	88	58.7
Mulching	69	46.0
Biological control	45	30.0
striping *(*Crop zoning)	37	24.7
Fallowing	26	17.3

Figure 3 below illustrates farmers' perceptions regarding soil fertility levels. Family farming operations are generally characterized by soils perceived as moderately fertile or poor, while only a small proportion of households cultivate on soils considered either very fertile or extremely poor. Appreciable (fertile) soils are reported by only 4% of respondents. These perceptions are significantly correlated with several variables : Survey sites (p = 0.000) ; Secondary income-generating activity**,** notably agriculture (93%) (p = 0.022) ; Land acquisition methods, specifically inheritance and donation (p = 0.004) ; Crop types produced, where farmers cultivating maize, sweet potatoes, and groundnuts tend to report increasingly less fertile soils (p = 0.002).

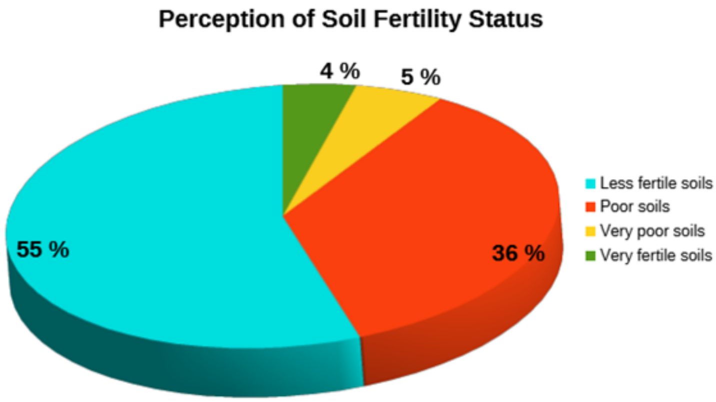


Figure 3: Farmers' Assessment of Soil Fertility

Awareness and Practice of Agro-Environmental Techniques

Interviews conducted during the survey reveal that 45% (76) of farmers are unable to identify agro-environmental techniques. Meanwhile, 17% (13) of respondents have heard of agro-environmental practices (AET), and 38% (57) report knowing and applying at least one agro-environmental technique.

Knowledge of agro-environmental practices appears to be significantly associated with the following variables : Gender of respondents ($p = 0.018$), Education level, with 52.7% having completed secondary school ($p = 0.000$), Farming experience, reflecting the expertise of producers ($p = 0.000$), Agriculture as the household's primary source of income ($p = 0.000$), Land acquisition methods ($p = 0.000$).

Table 5 : Agro-Environmental Practices Implemented by Respondents

Technique	Count	%
Crop association	57	100%
Crop rotation	54	98.1%
Manure pits	36	65.5%
Composting	25	45.5%
Fallowing	20	36.4%
Biological control	15	27.3%
Agroforestry	10	18.0%

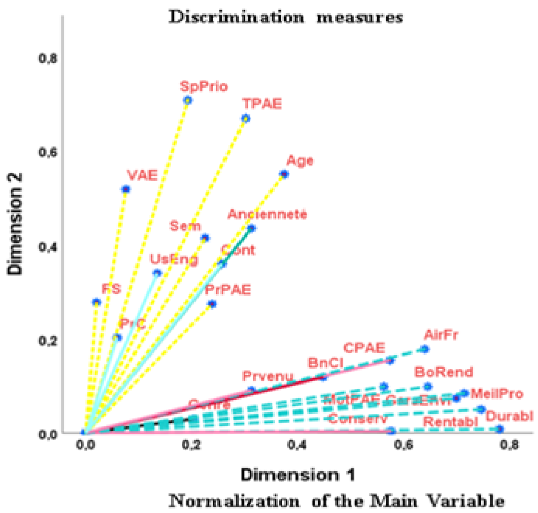
Determinants of Agro-Environmental Practice Adoption

Table 6 below presents, based on logistic regression analysis, the key determinants influencing the adoption of agro-environmental techniques by family farmers in the study area.

Equation Variables							
		B	**E.S**	**Wald**	**Ddl**	**Sig**	**Exp(B)**
Pas 1	Perception of AET Contribution	0.600	0.288	4.334	1	0.037	1.823
	Impact of AET on Profitability	-0.297	0.960	0.096	1	0.043	1.823
	AET as a Guarantee of Environmental Protection	-0.946	0.975	16.394	1	0.000	0.019
	AET Promotes Fresh Air	-2.865	0.745	14.801	1	0.000	0.057
	AET Provides Higher Agricultural Income	-0.778	0.661	1.383	1	0.018	0.460
	Constant	4.354	0.904	23.192	1	0.000	77.768

The table above illustrates that farmers perceive these practices as contributing to crop yield profitability, environmental protection, and climate preservation—particularly by promoting fresh air—while also improving net agricultural income. This perception is one of the key factors influencing both the awareness and implementation of Agro-Environmental Techniques (AET).

Figure 4 below summarizes the multiple component analysis of family farming systems in the study area, specifically in the villages of Kanyameshi and Mimbulu.



Legend :

- -**VAE** : Land acquisition methods
- -**PrPAE** : Practice of agro-environmental techniques
- -**TPAE**: Duration of agro-environmental practice
- -**SpPrio** : Priority crops
- -**BnCl** : Favorable climate
- -**CPAE** : Knowledge of agro-environmental techniques
- -**GaraEnvi** : Guarantee of a healthy environment
- -**BoRend** : Good yield
- -**Conser** : Soil fertility conservation
- -**Pvenu** : Increased agricultural income
- -**MeilPro** : Improved production
- -**Rentabl** : Profitability
- -**Durabl** : Sustainability
- -**MotPAE** : Motivations for practicing agro-environmental techniques
- -**AirFr** : Fresh air
- -**UsEng** : Use of fertilizers
- -**FS** : Soil fertility
- -**Sem** : Cultivated area
- -**Cont** : Constraints

Figure 4 : Constellation of Knowledge, Practice, and Effects of AET

Figure 4 above illustrates that agro-environmental techniques are consistently practiced by farmers who possess knowledge of these techniques, and by those who perceive their impact on a favorable climate and the guarantee of a healthy environment, including the benefit of fresh air. Understanding that AETs ensure good yields, generate higher agricultural income, preserve soil fertility, and lead to improved production that is both profitable and sustainable, motivates farmers to intensify their use of these techniques to the point of making them a habitual part of their farming practices.

However, the commonly used farming practices are correlated with several factors : Farmers' assessment of soil fertility, with 50.7% reporting declining fertility, Use of fertilizers, Cultivated land area, Land tenure methods, Farmers' age and agricultural experience, Operational constraints.

Evaluation of Perception and Willingness to Develop These Practices

Perception of the Contribution of Agro-Environmental Techniques

Table 7 below analyzes how farmers perceive the benefits derived from implementing agro-environmental techniques and their Willingness to further develop these practices.

Table 7 : Perceived Contribution of AETs to Family Farming

Facteur d'impact perçu	Count Yes	Count No
Profitable practices	95 (63.3%)	55 (36.7%)
Improved production	90 (60.0%)	60 (40%)
Good yield	84 (56.0%)	66 (44.0%
Sustainable practices	83 (55.3%)	67 (44.7%)
Guarantee of environmental protection	73 (48.7%)	77 (51.3%)
Soil-conserving practices	64 (42.7%)	86 (57.3%)
Provides fresh air	63 (42.7)	86 (57.3%)
Reduced use of fertilizers	52 (34.7%)	98 (65.3%)
Higher income	51 (34.0%)	99 (66.0%)
Favorable climate	43 (28.7%)	107 (71.3%)

The table above shows that family farmers perceive the effects of agro-environmental techniques as highly beneficial to both crop profitability and overall farm performance, resulting in improved production and good yields. These practices promote sustainable farming due to their soil- and environment-conserving nature, including benefits such as fresher air.

Indeed, the contribution of Agro-Environmental Techniques (AET) to farm success is rated as moderate by 47% of respondents and as high by 44%, as illustrated in Figure 5 below. This perception is influenced by several factors, including : Gender of the farmers (p = 0.003), Age of the farmers, with a mean of 43.7 ± 9.9 years (p = 0.034), Priority crops, with maize–bean and maize–sweet potato combinations preferred by 49.3% and 18% of respondents respectively (p = 0.005), Average cultivated area (p = 0.050), Number of years practicing agro-environmental techniques.

Perspectives and Constraints

The following table summarizes both the motivations behind the demand for a training workshop on agro-environmental techniques and the constraints affecting the family farming sector.

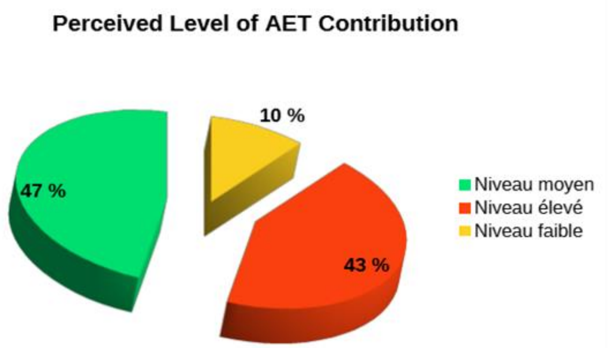


Figure 5 : Perceived Contribution of AETs by Family Farmers

Perspectives and Constraints

The following table summarizes the motivations behind the demand for a training workshop on agro-environmental techniques, as well as the constraints affecting the family farming sector.

Table 8 : Perspectives for Improving the Practice of Agro-Environmental Techniques

Training Motivation	Number of Respondents	Percentage (%)
Enhance knowledge	140 (93.3%)	55 (36.7%)
Improve practices	7 (4.3%)	60 (40%)
Constraints Encountered		
Theft and lack of resources	56 (48.0%)	67 (44.7%)
Late rains and high fertilizer costs	73 (37.4%)	77 (51.3%)
Soil degradation	22 (14.7%)	86 (57.3%)

The previous table indicates that 100% of farmers are motivated to participate in training workshops on cultivation techniques in order to enhance their knowledge and performance regarding agro-environmental practices. However, family farmers face several constraints, including : Technical limitations (limited understanding of the benefits of AETs), Financial barriers, Organizational challenges and the Natural and climatic constraints.

Discussion

Characteristics of Family Farms and Current Practices

The results of this study reveal that the cultivated area within the study zone varies significantly from one farmer to another, averaging 16,380.74 ± 1,021.34 m² during the 2022–2023 agricultural season. This variability aligns with the observations of Pingali (2012), who emphasizes that farm size depends on multiple factors, including socio-economic conditions and land access policies.

Furthermore, the significant difference observed between farmers in Kanyameshi and Mimbulu corroborates the findings of Jayne et al. (2014), which demonstrate that land access and use vary depending on local contexts and land tenure systems.

Analysis of land acquisition methods shows that the majority of farmers (56%) are landowners, while 44% rent agricultural land. This trend is consistent with Place (2009), who argues that land tenure security encourages agricultural investment, although access to ownership is often constrained by economic and social factors. Specifically, 27% of acquisitions are through purchase, 23.3% through inheritance, and 6% through donation. These figures broadly align with the work of Deininger and Feder (2001), who highlight inheritance as a predominant mode of land access in rural areas.

Moreover, the average rental price is 45,917.91 ± 11,623.4 CDF (approximately USD 16.69) per agricultural season. This economic reality reflects the conclusions of Ali et al. (2016), who note that land costs vary according to demand and institutional arrangements. In Sub-Saharan Africa, land rental remains a common option for farmers without ownership, although it may negatively affect agricultural productivity (Holden & Ghebru, 2016).

The results also highlight a significant correlation between land acquisition methods and certain socio-demographic variables. Notably, education level plays a key role in land ownership access, consistent with the findings of Goldstein and Udry (2008), who assert that education enhances farmers' negotiation and management capacity. Additionally, marital status, particularly among married farmers, influences land access. This observation is supported by Fenske (2011), who shows that married households tend to have more stable access to land ownership. Finally, household size (averaging more than five members) is a determining factor, echoing Udry (1996), who found that larger families tend to own and cultivate larger agricultural areas.

Categorization of Farming Techniques

The results show that family farmers adopt a variety of agro-environmental practices, with slash-and-burn agriculture being the most prevalent (100%), followed by intercropping and crop rotation, practiced by 61.3% and 59.3% of respondents, respectively. These practices are often adopted to maximize agricultural yields, despite their environmental implications (Altieri, 2018; Lal, 2020; Pretty & Bharucha, 2014; Tilman, 2021).

However, more sustainable practices such as mulching (46%) and crop striping (24.7%) are also implemented, although their adoption remains limited due to socio-economic constraints and insufficient access to agronomic information (Godfray & Garnett, 2014; Rockström et al., 2017; Vanlauwe et al., 2019; Wezel et al., 2014).

Regarding pest and disease management, most family farmers rely on chemical control (58.7%), using insecticides and fungicides. Meanwhile, biological control (30%) is practiced through the use of plants or ashes applied to crops. Although synthetic pesticides are effective, they raise ecological and health concerns (Geiger et al., 2010; Pimentel & Burgess, 2014; Pretty, 2018; Schmitz et al., 2015). The use of biological alternatives is increasing, though still limited, due to perceived lower efficacy and restricted access to bio-inputs (Gaba et al., 2018; Karp et al., 2018; Simon et al., 2019; Tscharntke et al., 2016).

Fall armyworm (Spodoptera frugiperda) infestations were reported by 76.3% of farmers, confirming trends observed across several regions of Sub-Saharan Africa, where this species has become a major threat to cereal crops (Day et al., 2017; Early et al., 2018; Hruska, 2019; Stokstad, 2017).

Analysis of soil fertility perception reveals that 88.7% of farmers consider their soils degraded, while only 4% believe they have fertile soils. This perception is significantly correlated with contextual variables such as survey location, agriculture as a secondary source of income (93%), land acquisition methods (notably inheritance and donation), and the types of crops grown. Farmers cultivating maize, sweet potato, and groundnut tend to perceive their soils as less fertile. These findings align with studies showing that soil degradation is exacerbated by agricultural intensification without sustainable soil management (Bai et al., 2018; Lal, 2015; Montanarella & Panagos, 2021; Sanchez, 2019).

The link between land acquisition and soil management also underscores the importance of land tenure policies in preserving agricultural land (Deininger, 2017; Jayne et al., 2019; Place, 2009; Tittonell, 2014).

Assessment of Knowledge, Practicability, and Perception of Agro-Environmental Techniques (AETs)

The results of this study reveal a low adoption rate of agro-environmental techniques among surveyed farmers, with 45% neither aware of nor practicing these techniques. This finding supports the work of Pretty and Bharucha (2014), who emphasize that lack of awareness is a major barrier to the adoption of sustainable practices in agriculture. Similarly, Altieri and Nicholls (2017) stress the importance of agricultural extension programs to address this knowledge gap. Farmers who do not receive adequate training remain largely dependent on conventional practices (Tilman et al., 2011). The analysis by Knowler and Bradshaw (2007) also shows that economic and informational barriers limit the adoption of sustainable techniques.

Among the 17% of respondents who have heard of Agro-Environmental Techniques (AETs), this low proportion reflects a lack of information dissemination about these approaches. According to Prokopy et al. (2008), the adoption of new agro-environmental practices is strongly influenced by the availability of information and economic incentives. Furthermore, Giller et al. (2011) explain that farmers' perceptions of sustainable techniques play a crucial role in their implementation. A study by Vanclay (2004) shows that awareness of these practices is often linked to social interactions and farmers' ability to access knowledge networks.

Regarding the 38% of respondents who are familiar with and practice at least one agro-environmental technique, several explanatory factors can be identified. First, the survey sites have a significant impact, confirming the findings of D'Souza et al. (1993), which show that the socio-economic environment influences the adoption of sustainable practices. Gender also plays a role, as reported by Doss and Morris (2001), who note that women are often less exposed to agricultural training programs. Education level is another crucial factor, aligning with Rogers (2003), who argues that higher levels of education promote the acceptance of agricultural innovations. Finally, farmers' experience and the consideration of agriculture as a primary source of income positively influence the adoption of agro-environmental practices, as demonstrated by Feder and Umali (1993), who highlight the role of experience in technology adoption decisions.

Land acquisition also emerges as a key factor in the adoption of agro-environmental practices. According to Place and Hazell (1993), land tenure security is a prerequisite for adopting sustainable agricultural practices, as it directly influences farmers' investment in soil conservation. Additionally, the study by Gebremedhin and Swinton (2003) emphasizes that land ownership strengthens the incentive to adopt environmental practices due to the prospect of long-term land use.

Figure 4 illustrates that the continued adoption of agro-environmental techniques is strongly influenced by several factors, including knowledge of these techniques, perception of their positive impact on climate and the environment, and their ability to improve farm profitability and sustainability (Altieri & Nicholls, 2017; Pretty et al., 2018; Wezel et al., 2020; Tilman et al., 2021). Farmers who better understand these techniques are more likely to implement them, as they perceive their benefits for soil conservation, biodiversity, and improved agricultural yields (Gliessman, 2015; Kremen & Miles, 2012; Ponisio et al., 2015; Reganold & Wachter, 2016).

Correlation analysis shows that farmers' perception of the environmental and climatic benefits of agro-environmental practices plays a key role in their adoption (Brussaard et al., 2010; Foley et al., 2011; Rockström et al., 2017; Smith et al., 2019). These practices promote a milder climate, a healthier environment, and better air quality, contributing to more resilient agriculture in the face of climate change (Garnett et al., 2013; Godfray et al., 2010; Mbow et al., 2019; Vanlauwe et al., 2015). Increased yields and agricultural income also motivate farmers to persist in applying these techniques, despite certain financial constraints (Lal, 2004; Pimentel et al., 2005; Pretty et al., 2018; Tilman et al., 2002).

The results also indicate that commonly used farming practices are correlated with farmers' assessment of soil fertility, which tends to decline in 50.7% of cases (Bai et al., 2008; Montgomery, 2007; Powlson et al., 2011; Scherr, 1999). The use of chemical fertilizers and the evolution of farming techniques strongly influence this trend, with increased dependence on synthetic inputs in rented or small-scale farms (Cassman, 1999; Conant et al., 2001; Kirchmann & Thorvaldsson, 2000; Tilman et al., 2011). Moreover, constraints faced by farmers—such as lack of financial resources and limited access to appropriate technologies—hinder the widespread adoption of agro-environmental practices (Pretty, 1995; Snapp et al., 2010; van der Werf & Petit, 2002; Wezel et al., 2014).

In summary, the implementation of agro-environmental techniques relies on a complex interaction between knowledge, perception of environmental and economic impacts, and the resources available for their application (Gliessman, 2015; Kremen & Miles, 2012; Ponisio et al., 2015; Reganold & Wachter, 2016). An integrated approach that considers these various factors is therefore essential to promote sustainable agricultural development that is resilient to contemporary environmental challenges (Altieri & Nicholls, 2017; Pretty et al., 2018; Wezel et al., 2020; Tilman et al., 2021). Family farmers perceive the effects of agro-environmental practices positively, particularly in terms of crop profitability and overall farm performance. This aligns with the findings of Altieri and Nicholls (2017), who emphasize the importance of sustainable agricultural practices in improving yields. Indeed, such practices promote sustainable farming by preserving soil properties and maintaining a healthy environment (Pretty et al., 2018). According to Tilman et al. (2019), implementing environmentally friendly farming techniques reduces land degradation while sustaining high levels of production. Furthermore, Lele et al. (2020) assert that sustainable agriculture contributes to food security and resilience to climate change.

Analysis of farmers' perceptions reveals that 47% consider the contribution of agro-environmental practices to be moderate, while 44% rate it as high. This finding is consistent with Van der Ploeg et al. (2019), who note that farmers adopt these practices primarily to improve soil fertility and optimize production. According to Garnett et al. (2017), perceptions of the benefits of sustainable agriculture vary depending on farmers' knowledge and experience. Additionally, awareness of ecological issues influences the decision to adopt such practices (Godfray et al., 2018).

The adoption of agro-environmental practices is influenced by several factors. First, gender plays a significant role. Research by Doss et al. (2018) indicates that female farmers are often more inclined to adopt sustainable practices than their male counterparts. Second, the average age of farmers—estimated at 43.7 ± 9.9 years—is a key factor, confirming the conclusions of Knowler and Bradshaw (2007), who demonstrated that accumulated farming experience positively influences the adoption of environmentally friendly techniques. Additionally, priority crops, particularly maize–bean (49.3%) and maize–sweet potato (18%) combinations, affect the use of agroecological practices, as also observed by

Ponisio et al. (2015). The average cultivated area is another determining factor, supporting the findings of Reganold and Wachter (2016), who highlight the influence of farm size on the adoption of sustainable practices.

Finally, the number of years practicing agro-environmental techniques is crucial for both perception and effectiveness. Research by Pretty and Bharucha (2015) revealed that a period of learning and experimentation is often necessary before farmers fully recognize the benefits of these practices. This is supported by Altieri and Nicholls (2020), who argue that the transition to sustainable agriculture requires gradual adaptation and technical support.

Conclusion

The objective of this study was to promote greater consideration of agro-environmental practices as a means to foster sustainable agriculture and ensure food security for family farmers in Haut-Katanga, through the intensification of such practices. The study analyzed farmers' knowledge, application, and perception of agro-environmental techniques in the peri-urban areas surrounding Lubumbashi. The findings revealed a low level of mastery, with only 38% of farmers having knowledge of agro-environmental practices overall, and 23% applying agroecological techniques without fully understanding the concept. However, 60% of farmers who practice agroecological methods are motivated by the perception that these techniques—such as crop association and rotation, compost pits, agroforestry, and biological control—preserve soil fertility, thereby improving yields and agricultural income while ensuring a healthy and sustainable environment. Nevertheless, major constraints identified by farmers include: lack of information, insufficient technical and material support, and limited adaptive awareness in the context of climate change. This study calls attention to the fact that knowledge and intensification of agro-environmental farming practices are key to building entrepreneurial, profitable, sustainable, and climate-resilient family farming systems. This sector is vital not only for farmers themselves but also for urban populations that rely on family farms for food supply. Hence, the involvement of state institutions is essential to strengthen farmers' capacities and support the transition toward sustainable agriculture.

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