ASSESSING DRIVING FACTORS OF AGROFORESTRY ADOPTION AMONG FARMERS IN MADIMBA, DEMOCRATIC REPUBLIC OF CONGO

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ABSTRACT

Agroforestry is a significant solution to the challenges of tropical agriculture, offering substantial socioeconomic and ecological benefits. However, its adoption by farmers in Madimba territory, D.R. Congo, has shown some challenges as a categorical refusal of the majority of the population. This study investigates the factors influencing agroforestry (AFS) adoption by surveying 310 households in 31 villages. The research identified nine key factors affecting AFS adoption: gender, age, land ownership, farming type, germplasm availability, perceived environmental changes, products obtained, opportunity to extension service, and farmers' organization membership. While aligning with some existing studies, unique results on land ownership, membership in farmers' organizations, germplasm availability, and opportunity to extension services provide new insight into targeted interventions and support mechanisms to enhance agroforestry practices adoption in this region.

Keywords: agroforestry, adoption, factor, farmer, Madimba

INTRODUCTION

Agroforestry systems (AFS), the practice of integrating trees and shrubs into crop and animal farming systems, is increasingly recognized as a potent solution to many of the challenges facing agriculture in the 21st century (ATANGANA et al., 2014). It offers a range of benefits, from enhancing biodiversity and soil health to improving crop yields and providing economic resilience (ATANGANA et al., 2014; DOLLINGER & JOSE, 2018; SHARMA & SHARMA, 2017; UDAWATTA et al., 2021). Due to its paramount socioeconomic and ecological significance, numerous concerted efforts are being spearheaded by governmental and non-governmental organizations alike to implement AFS practices. These endeavors aim to create a paradigm shift into eco-friendly agricultural systems (BISHAW et al., 2022; ROLO, 2022). Therefore, farmers are requested to abandon unsustainable farming systems and consequently adopt eco-friendly practices including AFS.

In general, adoption is the act of changing from one practice to another (ALLAN et al., 2022). In this context, AFS adoption is the decision-making process characterized by the farmer's choice to embrace or reject the systems. The adoption decision is driven by many factors including socioeconomic (MUKHLIS et al., 2022), environmental (CYAMWESHI et al., 2023), and technical (MWASE et al., 2015) conditions. These factors may change from one region or population to another. Factors that can facilitate AFS adoption in a given region or population, may hinder that adoption in another region or population. Therefore, each targeted population should be considered with its peculiar characteristics.

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In the specific context of the Madimba territory situated in Central Kongo Province, an intriguing duality emerges in the adoption patterns of AFS practices, where part of the population is actively engaged in AFS, while others are not. This phenomenon invites a scholarly exploration into the underlying factors that contribute to this disparity in AFS adoption within the local community. It is essential to delve into the socio-economic, technical, and environmental intricacies that shape the divergent choices made by individuals regarding the incorporation of AFS into their agricultural practices. Therefore, this paper aims to assess factors that determine AFS adoption in Madimba territory.

STUDY AREA AND METHODS

Madimba is a territory located at 4°9'S 15°2'E in Central Kongo province, Democratic Republic of Congo (Fig. 1). It covers an area of 8,260 km^2 and is situated 100 km away from Kinshasa. Madimba experiences a humid subtropical climate with distinct wet and dry seasons. The annual average temperature is approximately 25°C and rainfall averages 1273.9 mm.

We collected data through a questionnaire administered to 310 heads of households in 31 villages account. The survey was conducted in May and June, 2022. Data were categorized into dependent and independent variables. The adoption of AFS was set as the dependent variable having a binary modality: adoption = 1 and non-adoption = 0. The independent variables were subdivided into 3 dimensions. a) socioeconomics dimension: gender, age, marital status, education, profession, household size, income; b) technical dimension: land ownership, farming type priority, germplasm availability, perceived environmental change, products from AFS, and c) institutional dimension: opportunity to extension including extension agents, access to credit, access to support such as subsidies, access to media, and farmers' organization membership.

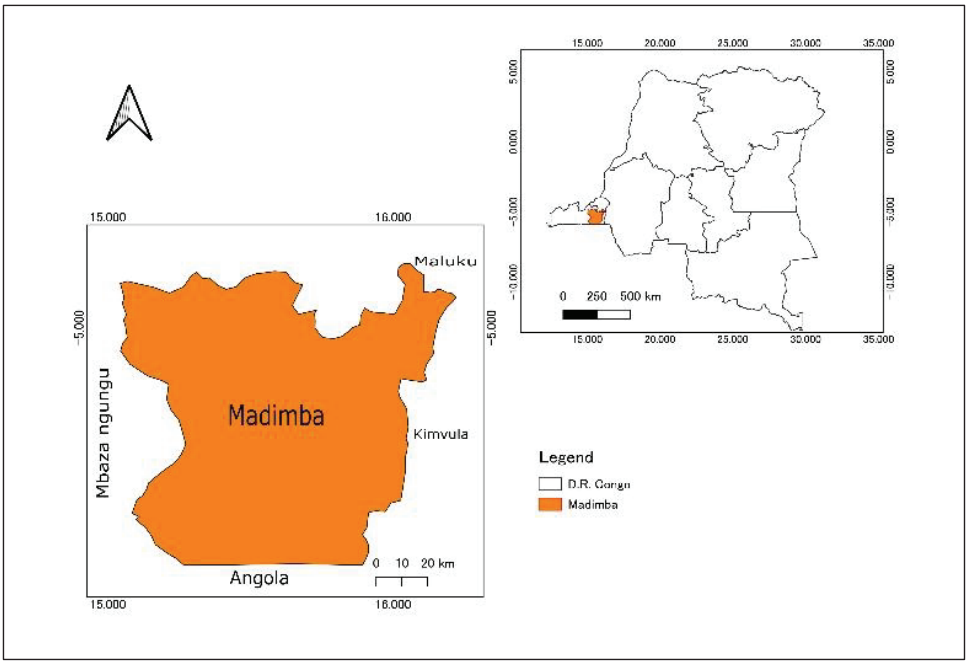

Figure 1. Map of Madimba territory in the Democratic Republic of Congo

Statistical analysis

We used descriptive and inferential analyses. Descriptive analysis was used to present data related to farmers' socioeconomic characteristics. For inferential analyses, we first used the Chi-squared test to explore the relationships between the dependent variable (adoption or non-adoption) and various explanatory variables (determinant factors of adoption). This initial test helped identify which variables show significant associations with the adoption outcome, providing a basis for further investigation. Then, we used the Probit model (HALLI & RAO, 1992) to estimate the probability of the adoption of AFS occurring based on the values of predictor variables that showed significant associations in the chi-square test. Analyses were performed in Stata 15.1 software (DAS, 2019). The probit model formula used is the following:

$$P(Y=1|X) = \Phi(\beta 0 + \beta 1X1 + \beta 2X2 + \ldots + \beta kXk)$$

Where:

P(Y=1|X) is the probability of the dependent variable being 1 given the values of the explanatory variables; Φ is the cumulative distribution function of the standard normal distribution; β0 is the intercept term; β1, β2 ,…, βk are the coefficients associated with the explanatory variables; X1, X2,…, Xk respectively.

RESULTS

The socio-demographic results (Table 1) showed that the majority of respondents were female, accounting for 58.4% of the total. The age group with the highest representation was between 26 and 50 years old, making up 57.7% of the respondents. Most of the respondents were married (74.5%) and had either secondary or higher education (42.3%). A significant portion of the respondents were primarily farmers (75.2%). Most households had between 1 to 5 members (50%), and the largest income group earned between 51 to 100 (32.3%). In terms of technical factors, most respondents were landowners (58.1%) and prioritized crop farming (78.1%). More respondents found the availability of germplasm difficult (51.3%) than easy. The most perceived environmental change was rainfall disruption (78.1%), and the most common product from AFS was woody goods (90.6%). Regarding institutional factors, most respondents did not have access to extension (85.5%) or credit (94.5%). Less than half of the respondents were members of a farmers' organization (35.5%). Most respondents did not have access to subsidies (96.8%), but a majority had access to media (72.3%).

The outcomes of the chi-square test (Table 1) revealed that ten variables exhibited a statistically significant association with the adoption of AFS practices. These variables included gender (p = 0.042), age (p = 0.00), education (p= 0.066), land ownership (p = 0.000), farming type priority (p = 0.000), germplasm availability (p = 0.000), perceived environmental change (p = 0.000), products from AFS (p = 0.000), access to extension (p = 0.000), farmers' organization membership

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Table 1. Descriptive analysis of explanatory variables (n=310) and chi-square test results between explanatory variables and adoption of Agroforestry.

Variables	n = 310	Adoption	Chi^2	p-value
SOCIO-ECONOMIC FACTORS				
Gender			4.15	0.042
Male	129	0.54		
Female	181	0.43		
Age			18.03	0.000
1 - 25	39	0.28		
26 - 50	179	0.42		
> 50	92	0.65		
Marital status			2.34	0.505
Single	32	0.39		
Married	231	0.48		
Divorced	15	0.61		
Widowers	32	0.44		
Education			7.20	0.066
None	10	0.83		
Primary	109	0.51		
Secondary and higher	131	0.49		
Profession			7.56	0.11
Farmer	233	0.49		
Civil servant	36	0.63		
Liberal	35	0.31		
Others	6	0.33		
Household size			2.23	0.328
1 - 5	155	0.52		
6 - 10	145	0.43		
≥ 11	10	0.4		
Income			0.39	0.983
1 - 50	62	0.47		
51 – 100	100	0.49		
101 – 150	69	0.46		
151 – 200	30	0.43		
Over 200	49	0.49		
TECHNICAL DIMENSION				
Land ownership			34.71	0.000
Owners	180	0.61		
Tenants	123	0.27		
Both	7	0.57		
Farming type priority			146.3	0.000
Crop	242	0.39		
Livestock	68	0.98		

Variables	n = 310	Adoption	Chi^2	p-value
Germplasm availability			69.17	0.000
Easy	151	0.86		
Difficult	159	0.3		
Perceived Environmental change			31.87	0.000
None	27	0.7		
Rainfall disruption	242	0.39		
Soil erosion	11	0.64		
Lack of honey	30	0.87		
Products from AF			22.03	0.000
Woody products	281	0.44		
NTFPs	25	0.88		
Livestock	2	0		
Crop and vegetables	2	1		
INSTITUTIONAL DIMENSION				
Access to extension			22.41	0.000
Yes	45	0.8		
No	265	0.42		
Access to credit			0.22	0.635
Yes	17	0.54		
No	293	0.47		
Farmers' organization membership			5.47	0.02
Yes	110	0.56		
No	200	0.42		
Access to support			0.22	0.633
Yes	10	0.40		
No	300	0.48		
Access to media			7.50	0.006
Yes	224	0.52		
No	86	0.35		

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(p = 0.02), and access to media (p = 0.006). Education (p=0.066) presented a weak association. Six variables that did not disclose any significant association were: marital status (p=0.505), household size (p=0.328), access to credit (p=0.635), access to support (p=0.633), income (p=0.983), and profession (p=0.11).

The estimation results of the Probit model (Table 2) showed a globally significant model (at the 1% level, as Prob > x^2 = 0.000 < 1%). This suggests that at least one variable in the model may explains the adoption of AFS by households. Therefore, age, land ownership, farming type priority, germplasm availability, perceived environmental change, products from AFS, access to extension, and farmers' organization membership are all factors that influence the probability of adopting AFS practices. The positive coefficients mean that the occurrence of these factors may increase the probability of AFS adoption, while the negative coefficients mean that they decrease it. However, the negative or positive coefficients do not imply that the opposite factors are bad or good; they just show the average tendency of the studied population.

DISCUSSION

The positive coefficient associated with age in the Probit model indicated that older individuals exhibited a higher probability of embracing AFS practices. This aligns with the notion that age might correlate with accumulated experience and a long-term perspective that resonates with the sustainable ethos of AFS. Notably, this doesn't denote youth as a negative factor but emphasizes the influence of life experiences

Table 2. Probit model analysis between explanatory variables and the adoption decision

Variables	Marginal effects	Coefficients	P>z
SOCIO-ECONOMIC FACTORS			
Gender	-0.0559	-1.1248	0.035**
Age	0.0027	0.0545	0.001***
Education	0.0587	1.1804	0.060
Land ownership	0.1169	2.3515	0.000***
TECHNICAL FACTORS			
Farming type priority	0.0180	0.3618	0.003***
Germplasm availability	0.3142	6.3198	0.000***
Perceived Environmental change	0.0847	1.5635	0.013**
Products from AF	0.0777	1.7034	0.007***
INSTITUTIONAL FACTORS			
Access to extension	0.0758	1.5253	0.050**
Farmers' organization membership	0.0611	1.2299	0.029**
Constant		-13.8134	0.000
Wald $chi^2(30)$ = 134.95 **Prob > chi^2 = 0.0000** Log pseudolikelihood = -19.041742 Pseudo R^2 = 0.8682			

Note: *** (significant at 1%); ** (significant at 5%)

on adoption. Other studies also showed that age is a key factor in the probability of practicing AFS as presented by BANDI et al. (2022). However, their findings suggested that AFS practices were more likely to be adopted by younger farmers compared to their older counterparts (BEYENE et al., 2019; DAVID et al., 2017; JAHAN et al., 2022).

Gender showed a negative coefficient meaning that females are less likely to adopt AFS. This situation has been observed in various other geographical regions and socio-cultural contexts as in Indonesia, Vietnam, Philippines (CATACUTAN & VILLAMOR, 2016), Malawi (THANGATA & ALAVALAPATI, 2003). In our context, a plausible explanation for the observed female less likelihood to adopt AFS may emerge from the significant additional workload imposed by the tree component of AFS, augmenting the multifaceted responsibilities that women routinely undertake within their daily activities. In this study, formal education was not associated with AFS adoption. However, existing literature has portrayed education as a catalyst for innovation and adaptive capacity in agricultural practices (BANDI et al., 2022; SANOU et al., 2019). The robust positive coefficient for land ownership resonates with the broader understanding that ownership of agricultural land enhances the willingness and capacity to adopt sustainable practices. Landowners often invested more in long-term land productivity, aligning with the goals of AFS. MWASE et al. (2015) noted that certain AFS practices pose challenges for adoption in situations characterized by insecure land tenure and communal land ownership. The positive coefficient for prioritizing crop farming aligns with the synergies between AFS and conventional farming. Farmers giving precedence to crop farming may view AFS as a complementary practice, enhancing soil fertility, reducing erosion, and diversifying income sources. This finding harmonizes with the growing emphasis on the potential integration of AFS within existing farming systems (BROWN et al., 2018). The positive coefficient for germplasm availability underscored the significance of access to planting materials in AFS. This aligns with studies emphasizing the role of germplasm accessibility in diversifying tree cover and promoting sustainable farming systems (ATANGANA et al., 2021; KOUASSI et al., 2023). The ease of obtaining germplasm emerged as a pivotal factor that policymakers and institutions should prioritize (BAHTIAR et al., 2021; LILLESØ et al., 2011; LILLESØ et al., 2018). Perceived environmental change was positively associated with AFS adoption. This highlights the role of environmental consciousness as a driver for sustainable agricultural practices (BHUJEL & JOSHI, 2023). Respondents perceiving environmental shifts may recognize AFS as a resilience strategy, enhancing their propensity to adopt such practices. Embracing sustainable agricultural practices presents hopeful prospects in addressing the adverse effects associated with traditional farming systems, including issues like soil erosion, water pollution, and biodiversity loss (BHUJEL & JOSHI, 2023; DURÁN GABELA et al., 2022; LAURETT et al., 2021). The positive coefficient for obtaining various products from AFS underscores the socio-economic and ecosystem functions of these systems. This aligns with the broader literature emphasizing the diverse ecosystem services provided by AFS systems (ATANGANA et al., 2014). Farmers recognizing the tangible benefits of AFS products are more likely to engage with these practices. Opportunity to extension, which refers to the provision of information and awareness-raising activities on the benefits and practices of AFS had a positive but weak effect on AFS adoption. This means that farmers who had opportunity to extension are slightly more likely to adopt AFS than those who didn't (JAHAN et al., 2022; PEROSA et al., 2021). Extension alone did not seem to be enough to motivate farmers to change their

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perception and behavior, especially if they face other constraints such as lack of land and germplasms. Therefore, extension should be complemented by other extension services that can address these barriers and provide more practical and tangible support to farmers.

The positive coefficient for farmers' organization membership to AFS adoption underscored the importance of social dynamics in influencing agricultural practices. It highlighted the value of shared knowledge, pooled resources, and collective decision-making provided by these organizations as also pointed out by other studies (AHMAD et al., 2021; BROCKINGTON et al., 2016; ROMANOVA et al., 2022; ULLAH et al., 2023; YATHOMA et al., 2021).

CONCLUSION

To increase the likelihood of adopting agroforestry in Mabimba, strategies should prioritize engaging women as they are less prone to adopt AFS due to the increase in workload. Relatively older farmers with greater experience are more likely to adopt AFS due to a better understanding of land use systems and the capacity to recognize changes. Specifically, land ownership is very important for the adoption of AFS as programmed future planning is necessary given the slow growth of trees and the requested long-term investment. The perception of environmental changes induced by the adoption of AFS associated with the main interest of farmers in the use of wood can greatly increase the adoption of these systems. In this way, affiliation of individuals to groups or agricultural cooperatives, access to quality germplasm, extension services, and knowledge dissemination are very important in increasing the adoption of AFS and helping farmers in the pursuit of their best interests. These findings provide valuable insights for stakeholders that work toward a widespread of this sustainable farming practice.

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