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Research Article

Beyond fences and titles: How do farmers' backgrounds and knowledge influence their efforts to protect farmland in the Thiès region, Senegal?

Bonoua Faye [1*], Helene Véronique Marie Thérèse Faye[2], Henri Marcel Seck[3], Jeanne Colette Diène[2], Edmée Mbaye[4], Abdoulaye Kane[4], and **Mathurin Maurice Diouf[5]**

1. School of Public Administration and Law, Northeast Agricultural University, Harbin 150030, China.
2. School of Economics and Management, Northeast Agricultural University, Harbin 150038, China.
3. Department of Geography, UFR Sciences, and Technologies, Assane Seck University, Ziguinchor P.O. Box 523, Senegal.
4. Department of Geography, Cheikh Anta Diop University, Dakar P.O. Box 5003, Senegal.
5. Higher Institute of Management in Dakar (ISM), Legal and Political Sciences, Dakar, Senegal.

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Corresponding Author
Prof. Dr. Bonoua Faye
E-mail:
bonoua.faye08@gmail.com
Tel: +221 779424347

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Abstract

This study examines the factors influencing the protection of farmland and agricultural practices in Senegal, with a particular focus on the relationship between cultivated land ownership, land tenure, educational level, and various farming methods. Using survey data (n = 600) from the Thiès region and the endogenous switching method, the analyzed data encompassed a range of variables, including farming strategies, types of land tenure, farmer demographics, and knowledge of land policies. The results show that land tenure is a significant factor in farmland protection, with individuals holding secure land tenure exhibiting a positive association with agricultural outcomes (coefficient = 0.435, $p < 0.01$). This suggests that securing land rights is crucial for encouraging investment in farmland protection and improving the agricultural productivity. In contrast, methods like fencing, title deeds, or orchard farming do not significantly effect on farmland protection. Similarly, farmland abandonment was not significantly associated with the implementation of farmland protection strategies. Education level also plays an important role in agricultural practices. Farmers with primary or lower secondary education demonstrate more significant improvements in farmland protection practices compared to those with higher levels of education. Primary education is particularly influential, with a coefficient of 0.466 ($p = 0.001$), highlighting its importance in fostering effective farming practices. However, higher levels of education, including university education, do not appear to have a significant impact on farmland protection. Farmer age and gender were not strongly associated with farmland protection. Male farmers tended to have slightly negative coefficients, but the results were not statistically significant ($p > 0.05$). Age groups, including farmers aged 31-40 and 41-50 years, also exhibited non-significant coefficients, suggesting that age does not strongly influence farming methods or land management in Senegal. Additionally, the results indicate that knowledge of land policies and awareness of land policies do not significantly affect farmland protection. Farmers with knowledge or awareness of land policies do not exhibit notable improvements in their farmland protection practices. These findings highlight the significance of secure land tenure and primary education in promoting farmland protection and enhancing agricultural practices in Senegal. These factors should be prioritized in policy interventions designed to promote sustainable agriculture and rural development in the region.

1. Introduction

Land is crucial for tackling global development challenges, while land governance lies at the core of achieving sustainability and resilience [1]. Farmland, as a strategic resource, plays a crucial role in providing essential services, including the production of food, fiber, and fuel for human populations [2]. Hence, the ongoing degradation of cultivated land and decline in soil fertility in Senegal underscore the urgent need for targeted and sustainable interventions [3]. The right to food asserts that every individual should have regular, permanent, and affordable access to sufficient food, both in terms of quantity and quality, either directly or through monetary transactions [4]. In Senegal, perceived food insecurity significantly decreased from 46% in 2016 to 15% in 2020, highlighting notable progress in food security [5]. Agricultural land resources are fundamental to a country's economy and food stability [6], and their effective management is crucial for sustaining improvements and ensuring long-term food security.

In the context of Senegal, where agriculture remains a major pillar of the economy, analyzing the use of agricultural land and its impact on agricultural production sheds light on the complex dynamics between urban and rural transformations. Moreover, agricultural production has a positive and significant impact on Senegal's economic growth, both in the short and long term [7]. Agriculture accounts for 16.6% of the Gross Domestic Product (GDP) and employs 49.5% of the workforce, with 70% of the rural population engaged in agriculture [8, 9]. Notably, 95% of farms are family-owned, highlighting the importance of small-scale agriculture in the country's agricultural sector [10, 11]. This trend, driven by global population growth, underscores the vital role of agriculture in ensuring food security, particularly in rural areas of Senegal.

In Senegal, a significant portion of the rural population depends on agriculture for their livelihood. This process takes into account several factors, including the characteristics of farmers, such as their experience in agriculture, which directly influences their land use choices and farming practices. The aging population has a significant impact on the economy and agriculture, particularly in developing countries [12]. The evolution of cultivated areas in Senegal is influenced by climatic, economic, and human factors that impact production [13]. Social factors, such as national macro-policies and the market economy, have contributed to the transformation of farmers' planting decisions [14].

Furthermore, the modernization of agricultural equipment and the introduction of new fertilizers have significantly improved the production capacity of major cereal crops [15]. Social factors, such as national macro-policies and the market economy, have contributed to the transformation of farmers' planting decisions [16]. Furthermore, the modernization of agricultural equipment and the introduction of new fertilizers have significantly enhanced the production capacity of major cereal crops [14], thereby reinforcing the importance of optimizing agricultural resources to meet the population's needs.

Studying these relationships enables a deeper understanding of how land management affects agricultural production, particularly in regions like Thiès. Agriculture, a fundamental pillar of Senegal's economy, plays a crucial role in ensuring food security and serves as the primary source of livelihood for a significant portion of the population, particularly in rural areas [8]. However, agricultural performance is closely linked to various factors, including the availability of arable land, farming techniques, agricultural policies, and climate [17]. In addition the mean land policy in Senegal did not undergo significant change until 1960 [18, 19]. Accordingly, several questions arise. How do farmer characteristics influence agricultural practices and land protection methods in the Thiès region of Senegal? What impact do climatic, economic, and social factors have on farming practices and land protection in Thiès?

In this context, the key characteristics of farms significantly affect farmers' decisions to adopt sustainable farming systems [20], including farmland protection practices. Analyzing the relationship between agricultural production and cultivated areas

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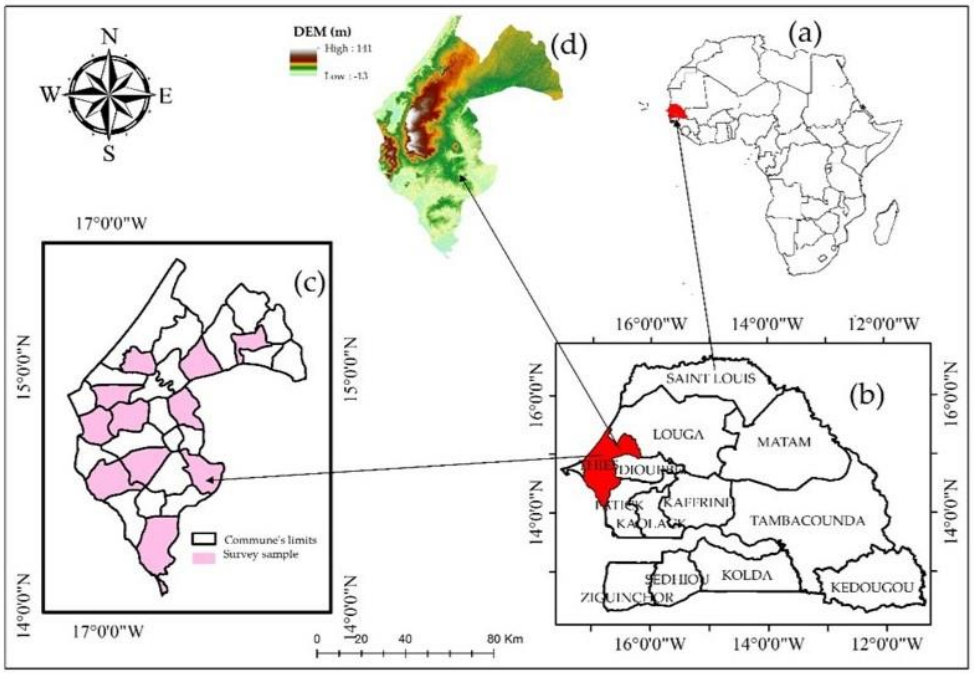

Figure 1. (a)and (b) localization of the Senegal and Study area, respectively, (c) survey sample, and (d) the DEM.

is strategically important. In China, for example, farmers who employed methods to enhance land quality and safeguard their farmland experienced increases in well-being of 9.6% and 11.5%, respectively [21]. The Thiès region plays a crucial role in Senegal's agricultural sector, and known for its significant agricultural potential. However, it faces challenges, including soil degradation, climate variability, and limited access to quality agricultural inputs [22, 23]. Understanding how the evolution of cultivated areas affects production is essential for informing agricultural policies and promoting sustainable resource management. In essence, sustainable and resource-conserving cultivation methods that preserve the soil, protect the environment, and enhance productivity are, therefore, necessary and have become major research and policy issues [24].

The study aimed to investigate the relationship between agricultural production and land use in the Thiès region, a significant agricultural production hub in Senegal. Despite its agricultural potential, farming in the region faces significant challenges, including a lack of financial resources and complex natural resource management [13]. this study analyzed the impact of farmer characteristics on agricultural practices and land protection methods, selecting the Thiès region in Senegal as an example.

2. Materials and methods

2.1. Study area and data collection

2.1.1. Study area

Senegal is an agriculture-dependent country where farming largely relies on rainfall [25]. The Thiès region, of Senegal's is geographically located between latitude 10°44′46″ N and 10°52′46″ N, and longitude 78°39′11″ W and 78°44′13″ W [23]. Covering an area of approximately 6,669.6 km², the region had a population of 2,162,831 in 2020, according to the National Agency of Statistics and Demography of Senegal (ANSD). The key crops in Thiès region's are peanuts, maize, millet, sorghum, and cowpea. In 2020, 266,668.24 hectares yielded 253,784.08 tons, with peanuts and millet accounting for 78.1% of the total production. In summary, this study was conducted in the Thiès region of Senegal, a key agricultural area that faces significant climate variability. Primary data were collected through a comprehensive survey of 600 farm households in the study area. These households were selected from 11 administrative

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communes based on population size and agricultural activity, as shown in Fig. 1 (c). As shown in Fig. 1(d), the topography, represented by the Digital Elevation Model (DEM), is flat, with a maximum elevation of 141 m.

2.1.2. Survey design and sampling

Questionnaires and social surveys are commonly used tools in empirical social science research to collect data and analyze trends [23]. The survey began with interviews with district authorities to understand regional variations in agriculture, land use, and socio-economic conditions. Districts were spatially selected, and villages were randomly chosen from the 2013 Senegalese census based on population size. In each village, approximately 15 farmers were randomly selected, resulting in a total of 600 responses collected in October 2022. The survey instrument, structured into four sections, focused on farmers' perceptions of agricultural production. Data collection was facilitated using CommCare HQ software through face-to-face interviews, with ethical considerations ensured, particularly for sensitive information, such as farm revenue. Additionally, interviews with local government leaders provided further context.

In the data filtering process, the survey used different Likert scales for rainfall, temperature, and salinity. The data show that farmers' responses to temperature and soil salinity were ranked as agree, neutral, and disagree. Therefore, in comparison to rainfall, the Likert scales for these two variables were merged and summarized into three levels. Moreover, 15 questionnaires were discarded due to incomplete or missing information, such as unanswered key questions on age, education level, and other critical demographic details, which were essential for the analysis. Consequently, 585 completed questionnaires were used for the subsequent analysis. After the screening process, the reliability of the questionnaires was assessed. There are various methods were used to evaluate questionnaire reliability. The Kaiser–Meyer–Olkin (KMO) measure assesses the suitability of data for factor analysis, with values near 1 indicating suitability and those below 0.5 suggesting unsuitability [26, 27]. In our study, the KMO test yielded values greater than 0.6, and Bartlett's test of sphericity resulted in a p-value of 0. These findings confirmed the high reliability and strong construct validity of the questionnaire.

2.1.3. The description of the selected variables

Sub-Saharan Africa faces significant land-related challenges, including private appropriation of farmland and conflicts over land use [28]. In this research, we investigated the determinants of cultivated land protection in the Thiès Region, Senegal, focusing on land governance, land-use dynamics, and agricultural conservation techniques, following previous studies [15, 29]. Farmers' protection behavior largely depends on their perceived value of cultivated land quality protection [30]. In essence, their perceptions can shape their attitudes, behaviors, and decisions regarding land management, which are key to promoting sustainable land use and ensuring the long-term viability of agricultural practices in the region. The survey data indicate that, on average, farmers have sown land between 1 and 3 hectares (mean = 2.14). For this interval, plots with documented ownership constituted 3.2% of the total at the national level, while those without documentation comprised approximately 91.3%, according to the ANSD in 2020. For the increase in farm size, some policies encourage the circulation of agricultural land management rights [31]. Therefore, the size of farmland can influence how resources are allocated for land protection. Larger sown areas may require more intensive management and protection strategies to ensure their sustainable use.

Furthermore, larger farmland can make it more susceptible to land degradation due to overuse and mismanagement. In the West African Sahel, climate variability and climate change pose significant challenges to food security, influencing farmers' decisions regarding land expansion for cultivation [32]. In addition to these dependent variables, farmers who have received assistance to combat cultivated land degradation were selected as treatment variables, using a binary variable that takes the value of 1 if the farmers have received assistance to combat farmland degradation and 0 otherwise.

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In this study, farmers who received assistance to combat cultivated land degradation referred to the support they received from the government or NGOs, including awareness programs, training, financial aid, and project implementation. Globally, the dependent variable, farmers' perceptions of the quality of their cultivated land, was selected because it directly influences land protection behaviors. These perceptions shape land management decisions, which are crucial for promoting sustainable practices and understanding the dynamics of land protection in the Thiès Region.

Identifying the key factors influencing the protection of cultivated land is crucial for developing countries aiming to establish a comprehensive land-use structure and management framework. Agricultural land expansion is prominent in developing countries [33]. At the same time, while the impact of land tenure security on farm yield has been extensively investigated in the literature, little is known about the role tenure security plays in mitigating risk exposure [34]. Between 2009 and 2018, urbanization resulted in the loss of 7.94% of cultivated land [17]. In this context, implementing orchard farming systems has been a common practice among farmers to combat various types of cultivated land loss and degradation in this region. Hence, the farmland protection methods in this study include land registration, title deeds, fencing, orchard farming, and no strategy, all aimed at securing, maintaining, and ensuring the long-term viability of agricultural land through various legal and physical practices.

However, weak law enforcement elsewhere enables Kazakh farmers to violate the land-use restrictions [35]. In our study area, about 18.6% of farmers received formal documentation from the state. Furthermore, 15.4% of farmers sold their cultivated land, and only 2.6% of farmers had knowledge of land protection policies. From that point, onward, the lack of robust land tenure can adversely impact the protection of cultivated land. Land use and its dynamics have garnered considerable attention from researchers due to their ecological and socioeconomic implications [36]. Farmwork crop rotation is challenging to implement when farmers lack technical and policy knowledge, as well as awareness of the benefits of crop rotation [37]. In this study, about 68.4% of farmers practiced crop rotation. Farmers receiving aid to improve soil health generally have better perceptions of the quality of cultivated land and larger farmlands. The educational levels, agricultural training, and formal land documentation of the assistance recipients were significantly higher.

Moreover, awareness and knowledge of land protection laws show significant differences between recipients and non-recipients. Finally, traditional ploughing methods and cultivated land propriety also showed significant differences, indicating possible influences on land protection practices. In summary, as detailed in Table 1, this study examined 14 independent variables to investigate how household behaviors influence the protection of cultivated land in the Thiès region.

2.2. Method

In several contexts, researcher must fit Endogenous Switching (ES) or Sample Selection (SS) to ordinal variables. In these cases, the variable of interest, y, takes on H response categories y_h, h = 1, 2, …, H [38]. Moreover, categories are ordered, $y_1 < y_2 < \cdots < y_H$ but the difference between any pair of categories has no cardinal interpretation. In our case, we cultivated land protection levels as ordinal variables that included many responses (1= very high; 2= high; 3= moderate; 4= poor). Latent variable models can be employed for dichotomous variables. In particular, the latent response y_i^* for the individual is assumed to be determined according to

$$y_i^* = x_i'\beta + \theta s_i + \lambda\varepsilon_i + \tau_i$$

in an ES problem or according to

$$y_i^* = x_i'\beta + \theta s_i + \tau_i$$

In an SS framework. As before, λ, ε_i and τ_i represent a factor loading, an unobserved heterogeneity term, and a random error, respectively. The vector of explanatory variables, x_i, does not include a constant term.

Instead, a threshold model determines the observed response,

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Table 1. Descriptive statistics of the variables used in the study.

Variables	Definition
Dependent variable	
Cultivated land protection level	Perceptions of farmers about the quality of cultivated land. 1= Very high; 2= Hight; 3= Moderate; 4= Poor
Explanatory variables	
Education *(X1)*	Farmers' education level: 0 = Illiterate, 1 = primary, 2 = Lower secondary education, 3 = Upper secondary education; 4=university
Gender *(X2)*	1 if the farmer is male; 0 = Female
Age *(X3)*	Age of the farmers 1 = {18–30} years, 2 = {31–40} years, 3 = {41–50} years, 4 = {51–60} years, 5 <60 years
Training in agricultural *(X4)*	If farmers have received training in agricultural; Yes =1, no =0
Cultivated land protection method (X5)	Farmers practiced one of these methods or more; 1= land registration; 2= Get title deed; 3= secure land by fencing; 4= orchard farming; 5= No strategy
Crop rotation practices *(X6)*	Whether farmers practice crop rotation or not; yes=1; no=0
Traditional plough *(X7)*	Whether farmers practice traditional ploughing or not, yes=1; no=0
Land tenure *(X8)*	If the farmer has received a formal document from the state: yes=1; no=0
Cultivated land propriety *(X9)*	Farmers' mode of acquisition of cultivated land. 1= inheritance; 2= Rental; 3=loan; 4= purchase; 5=other
knowledge about land policies*(X10)*	If farmers know any laws or texts regarding land protection, yes=1; no=0
Awareness of land policies (X11)	If farmers are aware of the law regarding protected cultivated land, yes=1; no=0
Cultivated land abandonment (X12)	If farmers had abandoned cultivated land yes=1; no=0
Cultivated land transfer(X13)	If a farmer has sold cultivated land, yes=1; no=0
Cultivated land evolution trends(X14)	Relate to farmers' size of farmland evolution trends: 0 =decreased; 1 = increased; 2= stagnating

$$y_i = \begin{cases} y_1 \; if \; -\infty < y_i^* < k_1 \\ y_2 \; if \; k_1 < y_i^* < k_2 \\ \vdots \\ y_H \; if \; k_{H-1} < y_i^* < \infty \end{cases}$$

where k_s, $s = 1,\ldots, H-1$ represent the threshold parameters. The model for the switching or selection dummy remains as follows: In the SS problem, the main outcome variable. y_i is observed only if a selection condition *($S_i = g$, $g=1,2,\ldots,G$)* is met. The SS model for multinomial order variables can be easily written as a system of equations for two latent variables as follows:

$$\begin{cases} y_i^* = x_i'\beta + \lambda\varepsilon_i + \tau_i \\ s_i^* = z_i'\gamma + \varepsilon_i + \varsigma_i \end{cases}$$

The Endogenous Switching (ES) model is justified for analyzing farmland protection in Senegal's Thiès region due to its ability to handle ordinal outcome variables, address endogeneity and selection bias, capture unobserved heterogeneity, and provide policy-relevant insights through counterfactual analysis. Unlike simpler models, the ES respects the ordinal nature of protection levels, corrects for endogeneity in farmers' choices, and accommodates complex behavioral factors, thereby ensuring the robust identification of causal drivers for sustainable agricultural policies.

3. Results

Table 2 interprets the regression results on factors influencing farmland protection, focusing on various determinants. Land title ownership has a weak

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Table 2. Interpretation of regression results: Farmland protection.

Farmland protection	Coefficient	Std. error	z	P>z	[95% conf. interval]	
(Farmland protection method)						
Get title deed	0.029	0.145	0.200	0.844	-0.255	0.312
secure land by fencing	-0.146	0.145	-1.000	0.315	-0.431	0.139
orchard farming	0.019	0.346	0.050	0.957	-0.659	0.696
No strategy	-0.365	0.190	-1.920	0.054	-0.738	0.007
Education level						
Primary	0.466	0.146	3.200	0.001	0.180	0.752
Lower Secondary	0.446	0.188	2.370	0.018	0.077	0.816
Upper secondary	0.398	0.228	1.750	0.081	-0.049	0.845
University	0.204	0.232	0.880	0.381	-0.251	0.659
Training in agriculture						
Yes	-0.014	0.237	-0.060	0.954	-0.479	0.452
Farmland abandonment						
Yes	0.028	0.124	0.220	0.822	-0.214	0.270
Land tenure						
Yes	0.435	0.151	2.880	0.004	0.138	0.731
Farmland propriety						
Rental	0.245	0.363	0.680	0.499	-0.466	0.956
Loan	-0.313	0.235	-1.330	0.182	-0.773	0.147
Purchase	-0.809	0.375	-2.160	0.031	-1.545	-0.074
Other	0.344	0.591	0.580	0.560	-0.814	1.502
Farmland transfer						
Yes	-0.077	0.160	-0.480	0.630	-0.390	0.236
Knowledge of land policy						
Yes	-0.237	0.393	-0.600	0.546	-1.008	0.533
Awareness of land policies						
Yes	0.056	0.135	0.410	0.681	-0.210	0.321
Farmland evolution						
increased	1.093	0.277	3.940	0.000	0.550	1.636
stagnating	-0.165	0.152	-1.080	0.280	-0.463	0.134
Crop rotation practices						
Yes	-0.057	0.125	-0.450	0.650	-0.301	0.187
Traditional plough						
Yes	0.218	0.152	1.440	0.151	-0.079	0.515
Improve soil health						
Yes	0.053	0.229	0.230	0.818	-0.396	0.502
Farmer gender						
Male	-0.118	0.127	-0.920	0.355	-0.368	0.132
Farmer age						
31-40 years	-0.241	0.181	-1.330	0.184	-0.596	0.114
41-50 years	-0.033	0.186	-0.180	0.860	-0.396	0.331
51-60 years	0.030	0.185	0.160	0.870	-0.333	0.393
More than 60 years	-0.089	0.185	-0.480	0.631	-0.452	0.274

positive effect on farmland protection, whereas securing land by fencing shows a slight negative impact. Orchard farming had a small positive effect that was statistical significance. Education level plays a significant role, with primary and lower secondary education strongly correlating with farmland protection, while university education has a negligible impact. Training in agriculture and

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farmland abandonment showed minimal effects on protection.

Land tenure is a key factor, as formal land tenure has a positive correlation with protection measures, indicating that secure land ownership encourages conservation efforts. The type of farmland property also influences protection; rental land has a slightly positive impact, while purchased land shows a negative relationship. Awareness of land policy negatively impacts farmland protection, suggesting that regulatory constraints may discourage protective measures.

Farmland evolution, especially the expansion of farmland, significantly promotes protective efforts. Crop rotation practices and improved soil health showed weak associations with farmland protection. Age and gender factors, particularly for farmers under 40, also have negligible impacts. The analysis concluded that farming practices, land management evolution, education, and land tenure are the most significant factors influencing the protection of farmland. In contrast, other factors, such as training and policy awareness, have lesserimpact.

4. Discussion

Protecting farmland is crucial for ensuring food security, supporting farmers' livelihoods, maintaining ecological balance, and preserving social stability [3]. The regression results provide valuable insights into the factors influencing farmland protection and land use decisions, revealing how various determinants contribute to the adoption of sustainable farmland practices in Senegal.

In most sub-Saharan African countries, peri-urban areas are undergoing rapid transformation, threatening the livelihoods, land rights, and tenure security of local communities [39]. One key finding from the analysis is the positive, yet weak, impact of land title ownership on farmland protection. This suggests that while securing land ownership may slightly encourage farmers to implement protective measures, the effect is not as strong as expected. Informal land tenure systems are prevalent in many rural areas, particularly in developing countries such as Senegal. These informal systems can lead to insecurity among farmers regarding their land rights, further complicating efforts to ensure effective farmland protection [3]. The stability or security of property rights plays an important role in stimulating the investment of economic entities [40]. Hence, strengthening formal land tenure through land titling could, be an important policy recommendation to improve land security, and encourage farmers to engage in long-term conservation efforts. However, the weak impact also suggests that securing land title alone may not be sufficient to ensure significant protection measures without additional incentives or support. Additionally, increasing land ownership is a key solution to promote food security [41].

Regarding farmland protection methods, interestingly, the use of land fencing showed a slight negative impact on farmland protection, although it was not statistically significant. Farmland preservation has been a longstanding challenge [42]. This could be due to practical challenges or financial constraints that prevent many farmers from investing in fencing. In contrast, orchard farming had a positive and statistically significant impact, which could reflect the more sustainable and long-term nature of orchard farming compared to annual crops, fostering soil conservation and reducing land degradation.

Education and training play crucial roles in farmland protection [43, 44]. The analysis found that education, particularly at the primary and lower secondary levels, has a strong positive correlation with farmland protection. This highlights the importance of educating farmers, especially at the grassroots level, about sustainable farming practices. In contrast, university education had a negligible impact, suggesting that the type of education may be more important than the level in influencing farmland protection behaviors. However, agricultural training, showed minimal effects, which could indicate that practical training is not widespread or fully implemented among farmers or that existing training programs may not adequately address the specific needs of farmers in rural areas.

Land tenure and property type are crucial factors that influences farmland protection [45]. Secure land tenure provides farmers with the confidence and legal

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assurance to invest in long-term land conservation practices. Moreover, land title reduces the likelihood of low-intensity interhousehold conflict [46]. This study highlights the significance of formal land tenure as a key factor in protecting farmland. Secure land tenure provides farmers with the confidence to invest in long-term land management practices. Additionally, the type of farmland property appears to influence protection behavior, with rental land showing a slightly positive relationship with protection, whereas purchased land shows a negative association. This may indicate that farmers who lease land are more likely to implement protection measures to maintain productivity, whereas those who own land might be less inclined to adopt such practices if they perceive a limited return on investment.

Regarding farmland evolution and practices, the results also indicate that farmland evolution, especially the expansion of farmland, significantly promotes protection efforts. This may be due to the adoption of more modern farming techniques or a shift towards sustainable farming practices that prioritize long-term productivity over short-term expansion. However, this exception warrants closer attention, as the transition of agricultural land has become a significant aspect of environmental risk that demands both immediate and long-term solutions [13].

Moreover, crop rotation and improvements in soil health showed weak associations with farmland protection [39], suggesting that while these practices are important, they may not be fully adopted or consistently implemented across different regions. Moreover, household size, perceived climate change, and access to climate advice encouraged 70.4% of farmers to adopt crop rotation [47]. Hence, prioritizing and supporting sustainable practices, such as crop rotation—especially considering that 45% of farms do not practice it is crucial for long-term productivity improvements and enhanced farmland fertility in rural Senegal [9].

Age, gender, and policy awareness are crucial for the protection of cultivated land [44, 48]. The analysis reveals that age and gender have negligible effects on farmland protection; however, younger farmers (under 40 years) are more likely to engage in protective measures. This may reflect a growing awareness among younger generations of the need for sustainable agricultural practices to ensure food security. Furthermore, awareness of land policies had a negative impact on farmland protection, suggesting that policy constraints or unclear regulations may discourage farmers from adopting conservation measures. In addition, farmers often abandon farmland due to urbanization and the appeal of higher incomes from non-agricultural jobs, driven by unclear or overly complex regulations [15, 49].

In summary, this study highlights that land tenure security, education, and farming practices are the most significant factors influencing farmland protection. However, the practical implementation of these factors, such as increasing awareness and providing accessible training, is crucial for the effective adoption of sustainable agricultural practices. Policymakers should focus on enhancing land tenure security, improving agricultural education, and simplifying land policies to encourage long-term land conservation and better environmental management practices.

5. Conclusions

In the context of Senegal, the regression results underscore the significance of land security, education, and policy awareness in influencing farmland protection and land use decisions. Secure landownership, such as obtaining land titles, significantly promotes farmland protection, suggesting that improving land tenure security could be crucial for encouraging sustainable agricultural practices in rural areas. Education, particularly at the primary and secondary levels, is positively correlated with farmland protection, indicating that investing in education, especially agricultural training, can help promote sustainable farming practices in the region. The negative impact of awareness of land policies suggests that farmers may feel discouraged by regulatory constraints, emphasizing the need for clearer and more supportive land policies. Furthermore, younger farmers (31-40 years) are more

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likely to engage in land protection, highlighting the importance of targeting the younger generation for sustainable agricultural initiatives. Overall, these findings suggest that a combination of secure land tenure, education, and supportive policies can drive the adoption of sustainable farming practices in Senegal.

The study's recommendations for policymakers in Senegal include enhancing educational programs to increase knowledge of farmland protection, promoting secure land tenure to improve perceptions of protection, and discouraging land purchases for protection purposes. This suggests encouraging inheritance or rental models and increasing awareness of land policies to impact the sown land area positively. Additionally, it advises re-evaluating agricultural training programs for effectiveness and providing targeted support for female farmers to increase their land area. Age-specific programs for younger and middle-aged farmers are also recommended to enhance their engagement and productivity. Finally, supporting farmland expansion practices is suggested, as they significantly improve protection perceptions and sown land area, contributing to agricultural sustainability in the Thiès region.

Disclaimer (artificial intelligence)

Author(s) hereby state that no generative AI tools such as Large Language Models (ChatGPT, Copilot, etc.) and text-to-image generators were utilized in the preparation or editing of this manuscript.

Authors' contributions

Conceptualization, B.F., J.C.D., H.V.M.T.F.; methodology, B.F.; software, B.F.; formal analysis, H.M.S.; investigation, B.F.; data curation, B.F.; writing—original draft preparation, B.F.; writing—review and editing, B.F.; E.M., A.K., M.M.D; project administration, B.F.

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Availability of data and materials

The data are available from the corresponding author upon request.

Conflicts of interest

The authors declare no conflict of interest.

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