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Determinants of Rice Farmers' Participation in Fertilizer Subsidy Programs: A Case Study from the Baguineda Irrigated Perimeter, Mali.

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Abstract

To increase agricultural productivity and income, while helping to address food insecurity, the Malian government has implemented fertilizer subsidy programs to support farmers, with oversight from agricultural technical services and directorates. This study examines the key factors influencing rice farmers' participation in the agricultural fertilizer subsidy program in the Baguineda Irrigated Perimeter of Mali. Data were collected from 384 rice farmers, including 234 non-beneficiaries and 150 beneficiaries of the subsidized fertilizer. A Logit model was used to analyze the determinants of rice farmers' participation in the fertilizer subsidy program. The results indicate that factors such as cultivated area and yield have a significant positive influence on program participation, while training in agricultural production techniques has a significant negative influence. This is likely due to non-use of chemicals in rice cultivation, based on these results, the study recommends implementing strategies to increase agricultural production including expanding agricultural land development and. It also suggests providing more targeted on the use of chemical and organic fertilizer, training to farmers on different cultivation techniques and promoting participation in agricultural input subsidy programmes, with the overall goal of improving agricultural productivity.

Key words: Fertilizer subsidy - Rice farming – Agricultural productivity, Participation Factors, Mali

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1. Introduction

In Mali, recurring food crises and rising levels of malnutrition continue to undermine sustainable human development. The Baguineda Irrigated Perimeter Office, a key rice-producing area with controlled water management and market gardening, faces multiple challenges. These include declining soil fertility, high agricultural input costs, climate-related risks, pest infestations, and persistent malnutrition. A study by Sidibé (2009) reported a cereal deficit of 1,235.5 tones per household per year in this area. In response to ongoing pressures such as climate variability, land scarcity, population growth driven by migration, and urbanization, rice farmers have adopted various strategies to improve food security in the area (Sidibe et al., 2017). Nevertheless, rice production remains constrained by limited access to and the high cost of agricultural inputs, particularly certified seeds (Arouna & Diagne, 2013; Assigbé, 2011). Despite the introduction of a fertilizer subsidy program, food insecurity persists in the Baguineda Irrigated Perimeter area.

Fertilizers play a central role in agricultural production, as reflected in the substantial budget allocations and quantities distributed under subsidy programmes. The supply and financing of agricultural inputs in Mali are part of a broader policy framework shaped by economic liberalization. The Agricultural Orientation Law (LOA), adopted in 2006, outlines the institutional framework for managing and financing agricultural inputs, including fertilizers and equipment. For the 2021-2022 agricultural season, the government allocated 28.1 billion CFA francs to subsidize agricultural inputs, including 98,527 tones of fertilizer (DNA, 2022). According to the National Directorate of Agriculture, subsidies represent state support provided to producers that cover part of the cost of agricultural inputs, with the government paying the difference between market and subsidized prices for fertilizers and up to 50% for certified seeds (particularly hybrid maize seeds) (DNA, 2023). Since the 2008 food and nutrition crisis, Mali has consistently increased its investment in fertilizer subsidies, with the budget rising from approximately 11 billion CFA francs to nearly 45 billion CFA francs in 2023 (Ministry of Agriculture, 2014). These subsidies now represent an increasingly large share of agricultural expenditure, accounting for nearly 90% of total spending on input subsidies for fertilizers and seeds (Thériault, et al., 2015).

Despite these significant investments, the fertilizer subsidy programme in Mali faces persistent implementation challenges. These include inefficiencies in distribution, delays in delivery, insufficient supply during peak periods, a lack of price controls, and the diversion or resale of subsidised fertilizers. Farmers may also misuse inputs, further reducing programme

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effectiveness. However, subsidised fertilizers prices have generally increased over time. On the national market and in the Baguineda Irrigated Perimeter area, the price of subsidised fertilizers was 14,000 CFA francs in 2013-2024, compared to 12,500 CFA francs in 2008-2012.

Subsidies are defined by institutions such as the World Trade Organisation (WTO) and the Organisation for Economic Co-operation and Development (OECD) as financial contributions or income or price support provided by governments or public bodies within a territory. They may include direct transfers of funds, foregone or uncollected revenue (e.g., tax credits), or in-kind provision of goods or services (Bellmann, 2019). Agricultural input subsidies, a form of social protection, are widely regarded as an important means of boosting agricultural productivity, particularly in low- and middle-income countries where smallholder farmers face financial constraints (Gordon, 2000, Hemming et al., 2018). By improving access to inputs, subsidies can contribute to increasing agricultural productivity, lower food prices, improved food and nutrition security, and a more pro-poor economy (Wiggins and Brooks, 2010) (Walls et al., 2018). Empirical studies generally support the positive impact of fertilizer subsidies on input use and productivity, although debate persists regarding their overall effectiveness (Chibwana et al 2010; Duflo et al. 2011; Ricker-Gilbert et al. 2011; Mason and Jayne 2012; Ricker-Gilbert and Jayne 2012; Carter et al. 2014; Mason et al. 2017; Seck 2017; Coulibaly, 2019).

In the Baguineda Irrigated Perimeter area, the fertilizer subsidy programme is administered by agricultural technical services, which are responsible for identifying eligible beneficiaries. Farmers who are not registered with these services or who operate outside designated production zones are typically excluded from the programme.

Given the continued implementation of Mali's fertilizer subsidy policy since 2008, alongside the challenges described above, this study aimed to examine the factors influencing rice farmers' participation in the fertilizer subsidy programme and to provide actionable recommendations to policymakers to enhance programme effectiveness and improve agricultural productivity, farmer incomes, and food security.

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2. Methodology

This section presents the study framework, participation criteria for the fertilizer subsidy program, the study area, sampling method, and analytical approach.

2.1 Conceptual framework and participation criteria

The conceptual framework guiding participation in the fertilizer subsidy program in Mali is based on both technical and policy considerations. At the national level, the selection of crops eligible for subsidies primarily relies on technical indicators, particularly measures of crop profitability and each crop's contribution to the national economy through value addition. In addition, strategic priorities, such as food security and budgetary constraints, also influence which crops receive support.

The fertilizer subsidy program is implemented under the authority of the Ministry of Agriculture, with operational management carried out by agricultural technical services and directorates in accordance with the Agricultural Orientation Law. In this study, the Baguineda Irrigated Perimeter area was selected due to its importance as a rice-producing area with complete water control and the presence of agricultural technical services. Rice is a strategic crop in Mali, contributing approximately 5% to GDP and requiring intensive input use. In this area, government subsidies cover both mineral and organic fertilizers, whether imported or locally produced.

The eligibility criteria for farmers to receive subsidized fertilizers are as follows:

- Being officially recognized by agricultural support and advisory services (e.g. Directorates, Offices, Technical Agricultural Services) as a producer of one or more eligible crops and belonging to a producer organization within the intervention area;
- Having identifiable arable land, regardless of tenure status, verified by the responsible support and advisory agent;
- Being registered with official planting programs for the current season.

The subsidy provided by the state corresponds to the difference between the supplier reference price (PRF) and the subsidized selling price (PC):

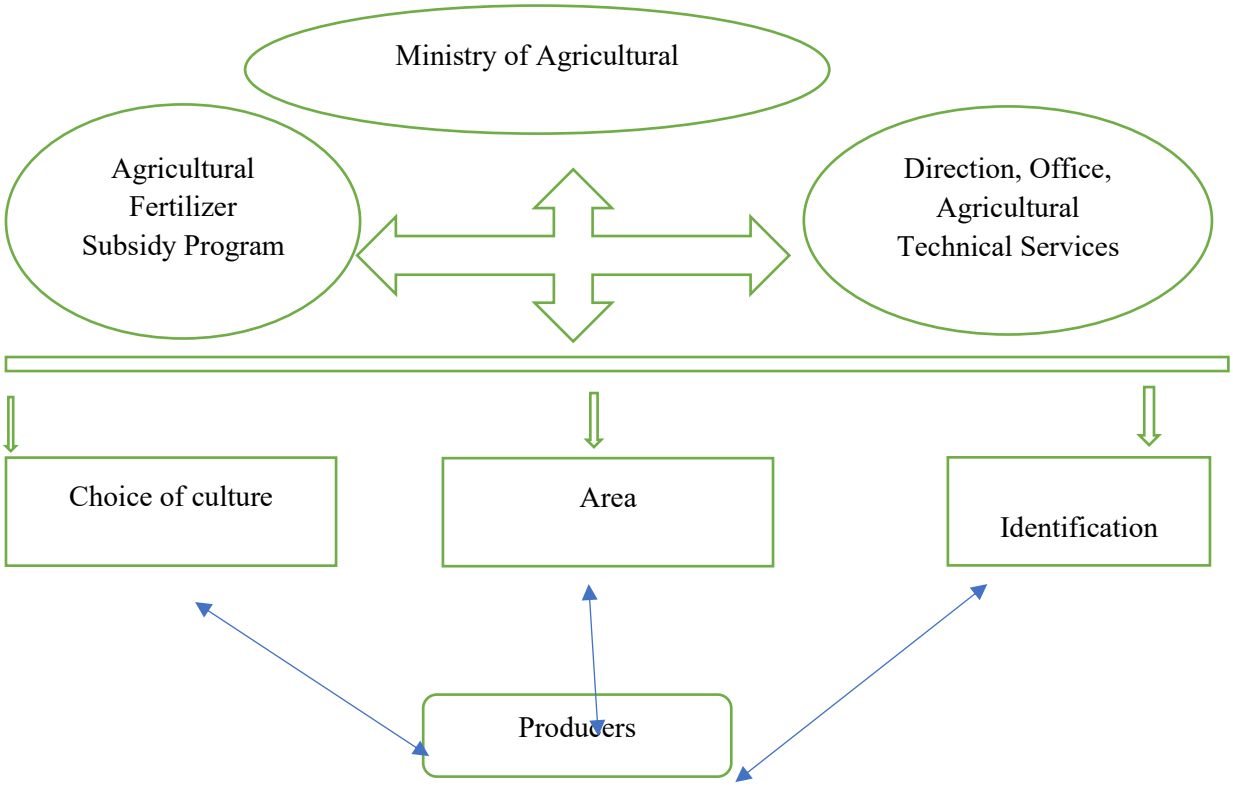
$$SE = PRF - PC$$

Where:

- **SE** = State subsidy
- **PRF** = Supplier reference price
- **PC** = Subsidized selling price

This difference is fully covered by the state for each subsidized input.

Figure 1: Conceptual Framework of Criteria for Participation in the Fertilizer Subsidy Program



Source : Authors, 2025

2.1.Study area and sampling method

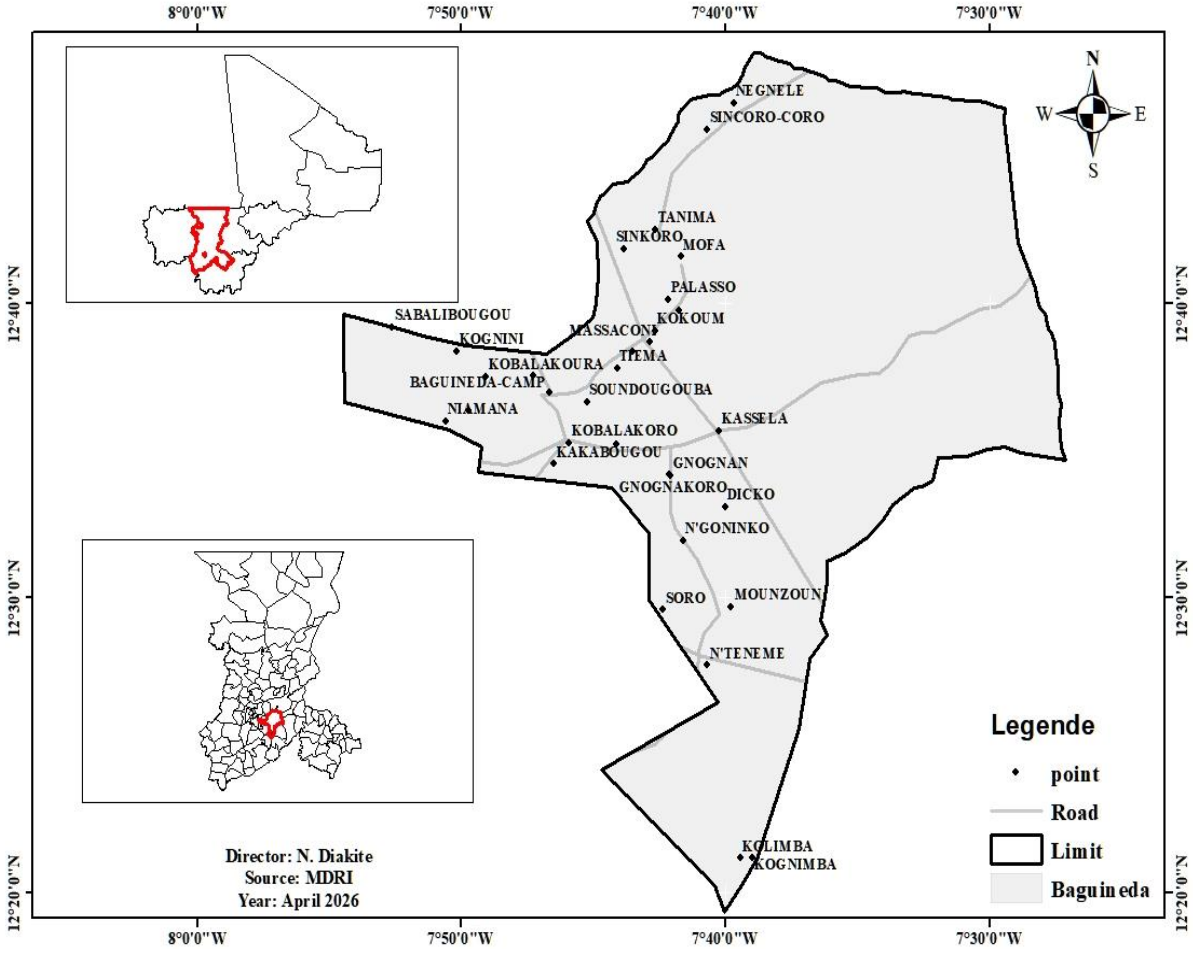
2.2.1. Study area

The study was conducted in the rural municipality of Baguineda, located in the Koulikoro region of Mali, approximately 30km from Bamako on the right bank of the Niger River. The municipality covers an area of 987.04 km² and is bordered by Tienfala and Koulikoro to the north, Mountougoula and N'Gouraba to the south, Binko to the east, and Kalaban-coro and municipality VI of Bamako district to the west.

The OPIB's operates in 22 villages, all located in the rural commune of Baguineda-Camp. Its intervention area covers19708 ha, divided into:

- an irrigable zone of 4500 ha (of which approximately 3000 ha are fully water-controlled), supported by a 44 km main canal from Missabougou (Sotuba Dam) to Tanima ;
- a non-irrigated zone of 15208 ha used for housing, dry crops, plantations and grazing.

Map 1: Map of the rural municipality of Baguineda in Mali



Source : N. Diakité, 2026

2.2.2. The sampling method

A probabilistic sampling technique was employed to ensure that each element of the population had an equal chance of selection. The sample size was determined using Cochran's formula:

Numerical application:

Cochran's formula

$$N_0 = (Z^2pq) / e^2$$

$$N_0 = 384 \text{ rice farmers}$$

- *N_0= sample size*
- *p = probability of the event occurring in the population, expressed as a fraction of 1; (0.5)*
- *q = 1-p, probability of the event not occurring in the population, expressed as a fraction of 1; (0.5)*

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- *Z is a Z-value: 1.96, a standard value based on a confidence level of 95%, which is a standard confidence interval*
- *e is the level of accuracy (margin of error), 5%*

This yielded a sample size of 384 rice farmers, divided into:

- 150 participants (beneficiaries of the subsidy program)
- 234 non-participants (control group)

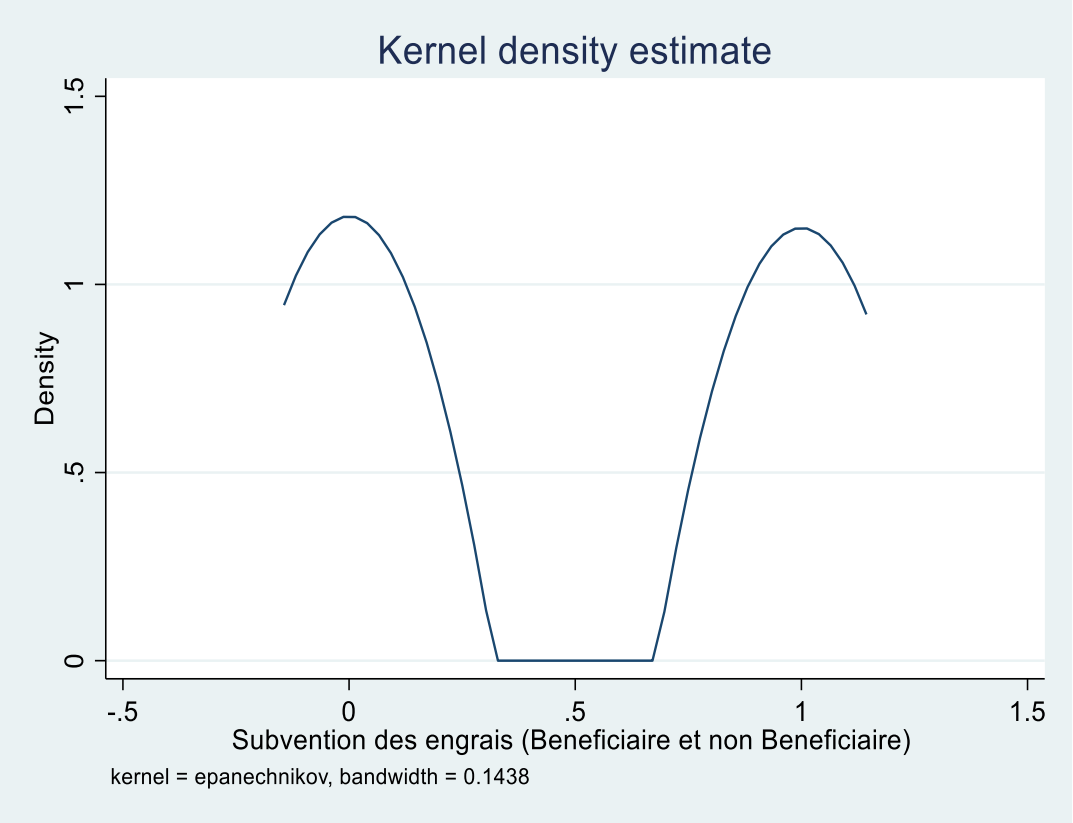
A 5% margin of error and 95% confidence level were selected to ensure representativeness. This approach is consistent with similar studies (e.g., Sangaré et al., 2025; Maiga et al., 2024).

2.2.Method of analysis

The study uses a binary Logit model in which the dependent variable is participation in the fertilizer subsidy programme (1=participant, 0=non-participant). The explanatory variables consist of socio-economic and institutional characteristics that may influence participation. These variables were selected based on correlation tests between the dependent variable and the explanatory variables.

In order to verify whether or not there is a dependency between the various explanatory variables and the status of rice farmers' participation in the fertilizer subsidy policy, the Chi-square test was used for categorical explanatory variables, and for continuous and discrete explanatory variables, the non-parametric equivalent of the student's t-test, i.e. the Mann-Whitney U test, was used. This choice was made because we tested the normality of our distributions using the kernel density estimate of the STATA software. Figure 1.1 shows the normality test, indicating that the distributions do not follow a normal distribution.

Figure 1 1: Kernel density function



Source : Authors, 2025

2.3. Model specification

The participation of rice farmers in the fertilizer subsidy program has been the subject of several econometric models. However, the Logit model is used to analyse the determining factors for rice farmers benefiting from the fertilizer subsidy. This method is necessary due to the nature of the categorical dependent variable. It estimates the probability of rice farmers participating in the fertilizer subsidy policy based on independent variables. Given the binary nature of the dependent variable, a logistic regression model was used to estimate the probability of participation in the fertilizer subsidy program. The dependent variable takes the value 1 if the individual benefits from the fertilizer subsidy and 0 otherwise. As the dependent variable is participation in the fertilizer subsidy policy, the values are coded as follows.

$$Y = \begin{cases} 1: Participating\ in\ the\ fertiliser\ subsidy\ policy \\ 0: Not\ Participating\ in\ the\ fertiliser\ subsidy\ policy \end{cases}$$

The binary nature of our variable justifies the choice of this model for the study. Thus, logistic regression estimates the probability of a rice farmer participating in the fertilizer subsidy policy, but also measures the effect of variables associated with whether or not the farmer participates in the fertilizer subsidy.

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The approach consists of explaining the dichotomous variable Y, which refers to participation in the fertilizer subsidy and takes the value 1 if the rice farmer is assigned to the subsidy and 0 if not, based on a set of K explanatory variables (X_1, X_2, ..., X_k).

The sample is thus subdivided into two groups: rice farmers participating in the fertilizer subsidy Y = 1 and those not participating in the fertilizer subsidy Y = 0.

In our study, we assume that the probability of a rice farmer belonging to the first group Y = 1 benefiting from the fertilizer subsidy.

The principle of the Logit model can be summarised as follows:

- Let Y be a dichotomous dependent variable (taking the value 1 for the modality studied and 0 if not) and K independent variables (X_1, X_2, …, X_k)..
- We also have a sample of n individuals indexed i, so for each individual, the K variables take the values ($x1i$; $x2i$; … …. . . ; xki) ;
- The probability P that individual i will take the value 1 is a function of $x1i$; $x2i$; … .;xki;
- Y can only take two values, F cannot be a linear function, so we use logistic regression to ensure that Y only takes these two values; thus: P (Y =1) = f(X1, X2, …, Xk).

The Logit model corresponds to the logistic distribution function:

$$F(x) = \frac{exp(x)}{1 + exp(x)} = p \qquad (1)$$

Applying the Logit transformation allows us to work with values between [-∞; +∞]. The term Logit refers to the following expression:

$$\text{Logit}\,(p) = \ln\left[\frac{p}{1-p}\right] = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots \ldots \ldots \ldots \ldots \ldots + \beta_k X_{ki} \qquad (2)$$

Where X represents the explanatory variables and β the parameters to be estimated.

2.4.Relationship between categorical variables and participation

Table 1 below is a cross-tabulation of the socio-demographic and economic characteristics of rice farmers and their participation status in the fertilizer subsidy policy (participant and non-participant) in the Baguineda irrigated area in Mali. Table 1 also presents the results of the Chi-square test to determine the relationships of dependence between each explanatory variable and participation status in the fertilizer subsidy policy (participant and non-participant). Chi-square test results indicate that several variables are significantly associated with participation in the subsidy program:

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- Gender: Men participate more than women (significant at 10%);
- Institutional contact: Farmers connected to research and development organizations are more likely to participate (5% significance);
- Education level: Higher education levels are associated with greater participation (5% significance);
- Technical training: Strong positive association with participation (1% significance);
- Domestic transfers: Cash or in-kind support significantly influences participation (1% significance).

The analysis in Table 1 shows that gender is significantly correlated with participation in the fertilizer subsidy policy. The results reveal that 48% of males benefit from the fertilizer subsidy. In contrast, only 2% of females benefit from the fertilizer subsidy. Thus, men participate more than women in the fertilizer subsidy policy in the Baguineda irrigated area, which is statistically significant at 10%. This result is similar to that of the study by Baki et al., 2018, which states that men are more inclined to participate in the fertilizer subsidy programme than women in Niger (Baki et al., 2018). The level of education or instruction of rice farmers is significantly correlated with participation in the fertilizer subsidy policy in the Baguineda irrigated area, which is significant at 5%. The results in Table1 reveal that 19.54% of rice farmers with a basic level of education benefit from the fertilizer subsidy, compared to 17.55% of rice farmers with no education in the Baguineda irrigated area. The results in Table 1 show that rice farmers in contact with research institutions (IER, AfricaRice) and development organisations (GIZ, IFDC, USAID, European Union) are significantly correlated with participation in the fertilizer subsidy programme, statistically significant at 5%. In the Baguineda irrigated area, 29% of rice farmers who are in contact with research institutions (IER, AfricaRice) and development organisations (GIZ, IFDC, USAID, European Union) participate in the fertilizer subsidy policy. Rice farmers who have received training in agricultural production techniques in the Baguineda irrigated area are significantly correlated with participation in the fertilizer subsidy policy, statistically significant at 1%. The results in Table 1 reveal that 15.56% of rice farmers who received cash transfers (cash) or in-kind transfers (agricultural equipment, agricultural inputs) from within the country for agricultural production are significantly correlated with the fertilizer subsidy policy in the Baguineda irrigated area, statistically significant at 1%.

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Table 1: Relationship between categorical variables and participation status in the fertilizer subsidy policy

		Fertiliser subsidy		Overall	Test Chi-2
		Participant	Non participatint		
Sex	Male	48.00%	47.00%	95.00%	2.96*
	Female	2.00%	3%	5.00%	
Marital status	Married	47%	48%	95%	1.76
	Widowed	0.66%	1.66%	2%	
	Divorced	1%	1.66%	3%	
Level of education	Literate	3.97%	5.30%	9.27%	10.29**
	Fundamental	19.54%	12.25%	31.79%	
	Secondary	6.95%	5.96%	12.91%	
	University	1,32%	1,99%	3,31%	
	None	17,55%	25,17%	42,72%	
Membership of an association or village group	Yes	12,91%	14,57%	27,48%	0,25
	No	36,42%	36,09%	72,51%	
Contact with an institution/organisation	Yes	29.80%	23.84%	53.64%	5.40**
	No	19.54%	26.82%	46.36%	
Technical training in agricultural production	Yes	30.46%	17.22%	47.68%	19.26***
	No	32.12%	20.20%	52.32%	
Access to agricultural credit	Yes	8.61%	8.94%	17.55%	0.0020
	No	40.73%	41.72%	82.45%	
Foreign money transfer	Yes	0%	25.17%	25.17%	98.90
	No	49.34%	25.50%	74.83%	
Cash transfer within the country	Yes	15.56%	28.81%	44.37%	19.60***
	No	33.77%	21.85%	55.63%	

***Significant at 1%; **significant at 5% and *significant at 10%

Source: Authors, 2025

2.6 Relationships between quantitative variables and participation status in the fertilizer subsidy policy

The results of the Mann Whitney U test in Table 2 below indicate that the quantitative variables: cultivated area, yield per hectare, number of years of experience in agriculture, number of years of experience in rice cultivation, and income from rice sales are significantly correlated with

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participation status in the fertilizer subsidy policy in the Baguineda irrigated area, statistically significant at 1%. The quantitative variables statistically significant at 1% above may influence the decision to participate in the subsidy policy.

The sociodemographic variable of age is not statistically correlated with participation status in the fertilizer subsidy program in the Baguineda irrigated area.

Table 2: Relationships between quantitative variables and participation in the fertilizer subsidy policy

	Fertiliser subsidy		U de Mann-Whitney
	Participant	Non Participant	
Age (average)	46	47	0.69
Cultivated Area (average)	1.07	1	6.20***
Yield/ha (average)	5472.06	3663.96	6.77***
Number of years of experience in agriculture (average)	27	23	2.89***
Number of years of experience growing rice (average)	26	23	2.97***
Income from rice sales (average)	1 713 088	753 314	6.77***

***Significant at 1%; **significant at 5% and *significant at 10%

Source: Authors, 2025

3. Results

3.1 Determinants of participation in agricultural fertilizer subsidy policy

The results presented in Table 3 indicate that cultivated area and yield per hectare have a positive and statistically significant at 1% influence on participation in the fertilizer subsidy policy in the Baguineda Irrigated Perimeter. However, some arguments in the literature argue that the contribution of fertilizer subsidy to fertilizer use, agricultural productivity and cultivated area remains very limited (Coulibaly, 2019). On the other hand, training on agricultural production techniques significantly and negatively influenced the status of participation in fertilizer subsidy policy. This explains why the training encourages not to use a lot of chemical fertilizers in the intensive rice growing system in the area of the Baguineda Irrigated Perimeter office in Mali.

It appears from Table 3 that the variables sex, level of education, contact with a research institution or development organization, the number of years of experience in agriculture, the number of years of experience in rice cultivation and the monetary transfer from within the

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country or in kind intended for rice farmers do not have significant influences on the status of participation in the fertilizer subsidy policy of rice farmers in the Baguineda Irrigated Perimeter, despite that a dependence relationship is found between them and the dependent variable. On the other hand, in a similar study in Burkina Faso in 2019, the results show that membership in a farmers' organization and the adoption of improved seeds improve the probability of participating in the subsidy program in rural areas (Coulibaly, 2019).

Table 3: Result of logistic regression

Régression logistique				**Number of obs = 384** **LR chi2(22) = 107.48** **Prob > chi2 = 0.0000**		
_cons	-5.84	2.84	-2.05	0.040	-11.43	-0.265
Contact with an institution/organisation						
Cultivated Area	1.58	0.34	4.59	0.000***	0.90	2.25
Foreign money transfer						
Fundamental	0.52	0.52	1.00	0.31	-0.50	1.54
Level of education						
Log likelihood = -156.39885				**Pseudo R2 = 0.2664**		
Male	2.15	2.37	0.91	0.36	-2.49	6.79
None	-0.21	0.50	-0.42	0.67	- 1.21	0.78
Number of years of experience growing rice (average)	-0.03	0.06	-0.54	0.59	-0.154	0.08
Number of years of experience in agriculture (average)	0.005	0.060	0.10	0.923	-0.11	0.12
Participation à la politique de la subvention des engrais	**Coefficient**	**Std. Err.**	**z**	**P>|z|**	**[95% Interval]**	**Conf.**
Secondary	0.91	0.63	1.44	0.15	-0.33	2.16
Sex						
Technical training in agricultural production						
University	0.55	0.98	0.57	0.57	- 1.36	2.48
Yes	0.64	0.53	1.21	0.52	-0.40	1.70
Yes	-0.27	0.32	-0.86	0.387	-0.90	0.35
Yes	-1.07	0.41	-2.60	0.000***	-1.88	-0.26
Yield/ha	0.0005	0.0001	5.53	0.000***	0.0003	0.0007

***Significant at 1%; **significant at 5% and *significant at 10%

Source: Authors, 2025

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4. Discussion

Given Mali's significant agro-sylvo-pastoral potential and the context of recurring multidimensional crises, the government has implemented a range of agricultural policies including agricultural input subsidy policies aimed at increasing agricultural productivity, strengthening food security, and reducing poverty through agricultural intensification. Among these, the agricultural input subsidy policy, particularly the fertilizer subsidy policy introduced in the 2008 agricultural season, has been a key instrument.

The main objective of this study was to identify the determinants of rice farmers' participation in the agricultural fertilizer subsidy policy in the Baguineda Irrigated Perimeter area in Mali. The findings indicate that cultivated area and yield per hectare have a positive and statistically significant influence on participation in the fertilizer subsidy policy. This suggests that farmers with greater production capacity are more likely to access and benefit from the policy.

In Niger, Baki and Yacouba (2018) studies show that variables such as household size, sown area, quantity of fertilizer used, marital status, gender, and seed type are significant in explaining the decision to participate in the subsidy program. However, in our study, gender is not significant in participation in the agricultural fertilizer subsidy policy. Similarly, Ghana the results of the study by Barasa et al. (2019) show that age, access to advisory services, land size, distance from the market, household size, and off-farm income have a significant impact on farmers' access to subsidized fertilizers. Furthermore, in a similar study in Northern Ghana, AlHassan et al. (2020) show that education, nativity, and access to media are factors influencing the likelihood of participation in fertilizer subsidies. Also, in a study in Northern Ghana, Azumah and Zakaria (2019) who worked on fertilizer subsidy and rice productivity in Northern Ghana showed that: farmers' participation in fertilizer subsidy programs was influenced by age, gender, education, farm size, membership in a farmer organization, access to media, knowledge of integrated soil and water conservation practices, farm holding and rice production. It also emerges in a similar study that Paudel et al. (2017) found distance to be the only factor influencing the decision to participate in fertilizer subsidy programs.

Thus, the results of our study corroborate with Baki and Yacouba (2018) and Coulibaly, 2019 that the cultivated area and yield have a positive and significant influence on the status of participation in the agricultural fertilizer subsidy policy. However, in other similar studies in northern Ghana, Niger and Burkina Faso, farmers' participation in fertilizer subsidies was influenced by the amount of fertilizer used, marital status, gender, type of seeds, age, education,

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farm size, membership in a farmers' organization, access to media, knowledge of integrated soil and water conservation practices, farm operation and rice production.

In contrast, training in agricultural production techniques had a significant and negative influence on participation in the fertilizer subsidy policy. This result may be explained by the fact that such training often encourages more sustainable farming practices, including the reduced use of chemical fertilizers in the intensive rice farming system in the Baguineda Irrigation Perimeter area.

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Conclusion

Based on these findings, the study recommends strengthening agricultural land development strategies for increasing agricultural production, providing targeted and context-specific training to farmers on improved cultivation techniques, and improving the design and targeting of agricutlrual in out subsidy policies to ensure broader and more equitable participation.

Overall, better alignment between training programs and subsidy policies could enhance their combined effectiveness in improving agricultural productivity and supporting sustainable farming systems in Mali.

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