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*Article*

# Malian Farmers' Perception of Sustainable Agriculture: A Case of Southern Mali Farmers

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**Abstract:** This study was conducted in the Klela district, Sikasso region of Mali, and aimed to evaluate farmers' perceptions regarding sustainable agriculture while identifying key factors that influenced these perspectives. Using a face-to-face survey with 110 randomly selected farmers, a comprehensive 19-item scale was employed to measure the perception levels of sustainable agricultural practices, scored on a 5-point Likert scale. The analysis highlighted a spectrum of perception levels among participants: 12.7% exhibited the lowest perception, 38.2% had a low perception, 31.8% had a medium perception, and only 17.3% had a high perception. Notably, a majority (50.96%) held perceptions below the average level. Through multiple regression analysis, several factors were identified as influential in shaping these perceptions. Family involvement in farming and weekly working days were negatively associated, whereas daily working hours and household size demonstrated a positive correlation. Additionally, the sources of information regarding sustainable agriculture significantly impacted farmers' perception levels, as indicated by the chi-square test results. The research underscores the necessity for targeted extension programs designed to augment farmers' understanding of sustainable agriculture, aiming to translate these perceptions into attitudes and practical actions effectively. This study contributes valuable insights, emphasizing the significance of tailored interventions geared toward enhancing sustainable agricultural practices among farmers in Mali, with the potential to positively influence their agricultural behaviors.

**Keywords:** sustainable agriculture; farmer's perception; Mali

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## 1. Introduction

Mali, situated in the Sahel region, features an agricultural-based economy, with a significant portion of its population engaged in this sector. The vitality of the agricultural sector has immense influence over various aspects of the nation's economy, including employment, rural household incomes, trade balance, and food security. It accounts for approximately 41% of the gross domestic product (GDP) within the West African States region (Coulibaly, 2021). Mali's economic landscape is primarily characterized by agricultural and forestry activities, which serve as the principal income source for both households and the state. Approximately 80% of the Malian workforce is employed in agriculture, contributing 38% to the country's GDP (Konate et al., 2020; World Bank, 2021).

Mali's agricultural policies are geared toward elevating the agricultural sector's contribution to the national economy. Recent policy initiatives have concentrated on increasing cereal, particularly rice, production while diminishing state involvement in the management of the cotton sector. These policies enhance Mali's food security, boost producer incomes, and improve the country's trade balance through increased cereal exports. A significant portion of the state budget allocated to agriculture, approximately one-quarter, is directed toward rice-related irrigation projects and input subsidies (Fond International de Développement Agricole, 2020). Mali aligns with the Maputo commitment by allocating at least 14% of its public resources to agriculture over the past decade. However, the 2012 political crisis significantly shifted the priorities of Mali's economy toward defense expenditures.

In the context of sustainable agriculture, Mali introduced the Agricultural Orientation Law on December 14, 2005, as a fundamental pillar of its long-term agricultural development policy. This law governs and defines Mali's agricultural development and underscores the importance of sustainable natural resource management. The strategy for land development acknowledges the challenges arising from drought due to the country's weather conditions. Equally crucial is the water control policy, in alignment with the integrated sustainable water resources management policy, as a key component of the agricultural development strategy. Despite the provisions outlined in the Agricultural Guidance Act, the actual implementation of sustainable agriculture policies remains limited. Good agricultural practices are primarily observed in the production of mangoes intended for export to developed countries.

However, the agricultural sector in Mali faces significant environmental threats, including drought, desertification, climate change, and other factors that adversely affect agricultural activities (Moseley, 2005). In response to these challenges, the Malian government, along with local civil society organizations, is actively engaged in safeguarding the country's agricultural sector through the implementation of sustainable agriculture practices. Sustainable agriculture encompasses farming methods that are both environmentally and economically sustainable. These practices enhance soil fertility, conserve natural resources, and increase farmers' incomes. By adopting sustainable agricultural methods, Mali aims to boost productivity by improving soil fertility, preventing desertification by safeguarding against soil erosion, and bolstering the income of agricultural farmers. The promotion of sustainable farming methods by the government and local civil society organizations is instrumental in securing the future of Mali's agricultural sector (World Bank, 2019)

Today, with a growing population and an increasing demand for food, the importance of the agricultural sector has become even more pronounced. However, without sustainable agricultural practices, farming activities can have harmful impacts on the environment and natural resources (Falconnier, et al., 2018). Therefore, in developing countries such as Mali, the sustainability of agriculture takes on paramount significance. These practices encompass more efficient irrigation methods, soil conservation techniques, the use of environmentally friendly pesticides, and the establishment of fairer systems for trading agricultural products.

According to the Organization for Economic Co-operation and Development (OECD), agricultural activities are directly responsible for 17% of greenhouse gas emissions. Environmental experts point out that the primary greenhouse gas emissions from agriculture include nitrogen dioxide ($N_2O$) emissions from soil, manure, and herbivore urine, as well as methane emissions from ruminants and rice paddies. Given its status as a major agricultural producer in West Africa, Mali must prioritize environmental considerations in its agricultural policies to promote a healthier environment.

The Food and Agriculture Organization (FAO) is actively working to raise awareness about climate change through its project on integrating climate change resilience into agricultural production for food security in rural areas of Mali (N'Danikou et al., 2017). According to the report, this project has significantly contributed to enhancing the knowledge and technical capacities of farmers despite climate change. For environmental, social, and economic reasons, adopting sustainable agriculture is highly recommended to address the challenges posed by climate change. Increasing the sustainability of agriculture among farmers can be achieved by reducing practices such as overfilling the soil and minimizing the use of pesticides and chemical fertilizers (Adesida et al., 2021).

With globalization and health crises, the health quality of products has become important for consumers. For this purpose, standards accepted by all countries in the world and named GLOBALGAP have been developed (Ersoy et al., 2017). Considering the new global standards, sustainable agricultural practices are important for farmers in Mali to increase their share in international markets.

In addition, farmers, suppliers, and agricultural development actors in African countries do not have sufficient knowledge about the environmental impacts of pesticides (Le Bars et al., 2020). Fertilizers, such as pesticides, that are used unconsciously by farmers also have negative impacts on soil biodiversity.

To double its production in five years (2014–2018), the Malian government increased subsidies for chemical fertilizers. The use of pesticides increases yields by reducing losses from pests or diseases (Le Bars et al., 2020). However, while the use of these agricultural inputs enables yield increases, it is crucial to use agricultural production methods that respect nature because of the links between the intensive use of agricultural inputs and biodiversity degradation. The situation in developing countries is more serious. Because farmers use pesticides banned in developed countries. Public authorities also fail to take the necessary measures to ban pesticides that are harmful to humans and the environment (Mamane, 2015). According to research in Moldova, agricultural policy orientation is dominated by increasing agricultural production without much concern for environmental impacts. This is also true for most developing countries, and Mali in particular. According to a 2021 study by Adesida et al. (2021), the extensive application of chemical inputs combined with the use of input subsidies, including intensive tillage, has led to severe soil degradation and erosion in Moldova (Adesida et al., 2021).

These problems can be addressed through a sustainable agricultural system approach. According to research, sustainable agriculture can help farmers increase their production and income. According to previous studies conducted by Aydın Eryılmaz et al. (2018), good agricultural practices allow farmers to increase their gross margin. Sustainable agriculture is multidimensional, with an economic dimension in terms of increasing farmers' incomes, a social dimension in terms of providing healthy food to the population, and an environmental dimension in terms of ensuring a better world for future generations (Ansari & Tabassum, 2018). Combating climate change will require profound social, economic, and technological changes, many of which are costly and require large investments. Therefore, it is imperative to combine climate and development issues, and a transformation to sustainable agriculture is required.

With the subsidy policy for agricultural inputs in Mali, farmers tend to use more chemical fertilizers and pesticides. Therefore, it is important to understand the perceptions of farmers toward sustainable agriculture. This study was conducted in the Sikasso region, the agricultural production center of Mali. The Sikasso region is the richest region in Mali in terms of agricultural production, and food surpluses are distributed throughout the country. According to the Ministry of Agriculture's report, fertilizer use by farmers in the Sikasso region is 71% higher than that in other regions. This high fertilizer use is linked to the production of crops such as maize and cotton and market-oriented horticultural crops.

Many countries attempt to achieve food security through agricultural policies that increase agricultural productivity without considering the impact of agricultural policies on sustainability. The overall objective of this study is to characterize the perception of sustainable agriculture among farmers in Mali and identify the factors that influence their perceptions. Based on this main objective, this study aims to identify the socioeconomic factors affecting farmers' perceptions of sustainable agriculture, the impact of agricultural information sources on farmers' perceptions of agriculture, the relationship between agricultural input subsidy policy and farmers' perceptions of sustainable agriculture, and to recommend appropriate policies to ensure sustainability in Mali's agriculture.

## 2. Materials and Methods

### *2.1. Material*

The sampling method used in this study involved a combination of random and stratified sampling techniques. Firstly, the district of Klela, in the Sikasso region, was selected as the research area due to its importance in agricultural production, particularly in maize and cotton cultivation. This decision was motivated by the region's reputation for intensive farming practices and the availability of data from the regional agricultural directorate.

Within the Klela district, two villages were identified as distinct strata: Lutana and Dougoumoussou. Each village was characterized by its farmer population, with Lutana numbering 100 farmers and Dougoumoussou 84, according to data from the regional directorate of agriculture.

To ensure representative sampling, a proportional stratified random sampling method was employed. This involved determining the sample size for each village according to its proportion of the total farming population in the district. For example, if Lutana represented 54% of the total farming population and Dougoumoussou 46%, the sample size for Lutana would be 59 and for Dougoumoussou 51.

Once the sample sizes had been determined, farmers were randomly selected from the household lists in each village. This process was designed to minimize selection bias and ensure that every farmer had an equal chance of being included in the sample. However, despite these precautions, potential biases may remain, such as non-response bias or the under-representation of certain farmer sub-groups due to logistical constraints or other factors.

The sample volume was determined using the proportional sample volume method. According to this method, the formula for calculating the sample volume, based on the known or estimated proportion (p) of individuals with a specific characteristic within a finite main population of size N, is as follows:

$$n = \frac{N_p(1-p)}{(N-1)\sigma^2_{\hat{p}x} + p(1-p)} \tag{1}$$

n = Sample size

N = Number of farmers in the villages covered by the survey

p = 0.5 (for maximum sample size), Estimated proportion of farmers aware of sustainable agriculture

$\sigma_{px}^{2}$ = Variance of the Rate (from the equation 1.645*σp = 0.05 for 90% confidence interval, 0.05 margin of error; σp = 0.03039)

The sample size was calculated at 110 according to a 90% confidence interval and a 5% margin of error. The number of farmers interviewed in each district was determined by considering the ratio of the districts to the total number of farmers (Table 1).

**Table 1.** Number of farmers in the sample by village.

| Villages | Number of Farmers | % | Number Entering the Sample |
|---|---|---|---|
| Dougoumousso | 84 | 46 | 51 |
| Lutana | 100 | 54 | 59 |
| Toplam | 184 | 100.00 | 110 |

Source: Mali Rural Economy Institute (IER).

Before conducting the survey, visits were made to the villages to update the list of farmers. An explanation of the survey's purpose was provided to the traditional village chiefs of the two villages. Simple random sampling was employed through a list of farm managers to select participants for this study's surveys. Expert support was obtained from specialists at the Mali Rural Economy Institute to conduct these surveys. The primary data used in this research were collected through a survey conducted in February and March 2022. The data collected pertain to the previous production period. To minimize data loss, surveys were administered using tablets and the KoBoCollect application, which is commonly used in research by international organizations. As a secondary data source, various organizations and databases were consulted, including the World Bank, FAO, OECD, European Statistics, the U.S. Department of Agriculture, and InsatMali. This included previously published research, conference papers, articles, books, and reports related to the subject matter.

### *2.2. Method*

#### 2.2.1. Determining the Sustainability Index

To establish the sustainable agriculture index, this study employed a 19-item scale that has been used in previous research on farmers' perceptions of sustainable agriculture (Adeola & Adetunbi, 2015). This scale was also used by Hayran et al. (2018). Farmers were tasked with rating each of the 19 items on a 5-point Likert scale, where 1 indicated "strongly disagree," 2 represented "somewhat agree," 3 denoted "moderately agree," 4 signified "somewhat agree," and 5 conveyed "strongly agree." Each question allowed for a maximum score of 5 points. Consequently, if a producer assigned five points to every question (195 = 95), it indicated a very high perception of sustainable agriculture. Conversely, if a producer rated each question with a minimum of 1 point (119 = 19), their perception of sustainable agriculture was considered low. In this study, a producer's perception of sustainability could assume any value between 19 and 95.

The following formula was used to compute the farmer perception index, as outlined by Hossain et al. (2018).

$$FSAPI = \sum_{i=1}^{19}\sum_{j=i}^{5} M_i N_j \tag{2}$$

FSAPI refers to the Farmer Sustainable Agriculture Perception Index. In the context of this study, "$M_i$" denotes the perception of farmers regarding sustainable agricultural practices or statements on sustainability. A value of 1 is allocated to each practice or statement if the farmer is cognizant of it, whereas a value of 0 is designated otherwise. "$N_j$" assesses the farmers' awareness level of a specific sustainable agricultural practice or statement, utilizing a 5-point Likert scale ranging from "very low" to "very high". Ratings for awareness levels range from 1 to 5, correspondingly. A higher index signifies a more favorable perception of sustainable agriculture among farmers, while a lower value indicates a greater lack of awareness regarding sustainable farming practices. The farmers' collective perception of agricultural sustainability is computed by determining the simple arithmetic mean of the indices, while the average perception of sustainability for each practice or statement is derived by dividing the total sum of the indices by the total number of practices or statements. Farmers are typically ranked based on their level of perception of sustainable agriculture, utilizing standard deviation intervals from the mean, consistent with the approach outlined by Sadati et al. (2010) and Hayran et al. (2018).

p = very low: min ≤ p < (mean − standard deviation),
q = low: (mean − standard deviation) ≤ q < mean,
r = moderate: mean ≤ r < (mean + standard deviation),
s = high: (mean + standard deviation) ≤ s ≤ max.

Using these intervals, farmers' perceptions of sustainable agriculture are divided into four levels: very low, low, moderate, and high (Füsun Tatlıdıl et al., 2009; Van Thanh et al., 2015). Cronbach's alpha was used to estimate the reliability of the questionnaire and the internal consistency of the composite score (Kayacan & Demirbaş, 2022). The Cronbach's alpha value obtained from the analysis was calculated as 0.846. Because this value falls within the range of 0.80 ≤ alpha ≤ 1, the scale used is considered highly reliable.

2.2.2. Analysis Methods

The data obtained from the survey were analyzed using Statistical Package for the Social Sciences 23 (SPSS version 23). In this study, descriptive statistics (mean calculation, frequency, percentage, etc.) were used to characterize the socioeconomic status of the farmers (age, gender, income). For each variable in the study, the normality of the distribution was assessed using the Kolmogorov–Smirnov test. Because the data did not exhibit a normal distribution, the Mann–Whitney U test was applied to determine whether there was a relationship between the farmers' use of input subsidies and their perception of sustainable agriculture.

To determine whether there was a relationship between farmers' perceptions of sustainable agriculture and the agricultural information sources they accessed, the chi-square test was used. In addition, a multiple regression model analysis was conducted to determine to what extent the selected socioeconomic characteristics influenced farmers' perceptions of sustainable agriculture.

2.2.3. Regression Model

Regression analysis is a statistical method for studying the relationships between several variables and predicting the results using these relationships. This study aims to answer questions regarding the existence and strength of relationships between variables, the prediction of future dependent variables, and the influence of specific variables or groups of variables on results. When a single independent variable is used, this is referred to as univariate regression analysis, whereas the use of several independent variables is referred to as multivariate regression analysis. The latter simultaneously considers the variations of the independent and dependent variables.

Multivariate regression analysis is a powerful tool for understanding and modeling complex relationships between different variables. It enables us to study how several factors can influence a given dependent variable and provides essential information for decision-making in a variety of fields, from scientific research to public policy planning (Uyanık & Güler, 2013). The multivariate regression analysis model is expressed as follows.

$$Y = \beta_0 + \beta_i X_i + \ldots + \beta_n X_n + \varepsilon \tag{3}$$

Y = Dependent variable
$X_i$ = Independent variable
$\beta_i$ = Parameter
ε = Error

As is common in many previous research studies aimed at identifying the factors influencing farmers' perceptions of sustainable agriculture, a multiple regression model was employed in this study. The model included 18 explanatory variables, which were identified through a synthesis of the literature related to sustainable agriculture to explain the farmers' perception of sustainable agriculture (Table 2). These variables were included in the model to understand the factors that affect farmers' perceptions of sustainable agriculture.

In this study, the variable inclusion and exclusion method, known as stepwise selection, was used within the regression model. With this approach, each variable is sequentially added to the model, and the model's performance is evaluated. If the added variable contributes to the model, it remains included. However, all other variables in the model were retested to assess whether they made a significant contribution. If they do not significantly contribute, they are removed from the model. This process allows the model to be explained using the minimum number of variables necessary.

**Table 2.** Description of variables used in the regression model.

| Name of the Variables | Definition of Variable and Unit of Measure | Data Type |
|---|---|---|
| 1. Dependent variable index | Sustainable agriculture score (Mn = 19; Max = 95; Standard Deviation = 10.38; Mean = 75.64) | Continuous variable (Index) |
| 2. Independent variables | - | - |
| 2.1 Socioeconomic characteristics | - | - |
| Duration of education | Number of years in school (years) | Continuous variable |
| Number of family members | (Person) | Continuous variable |
| Number of family members engaged in agriculture | (Person) | Continuous variable |
| Number of permanent individuals in processing | (Person) | Continuous variable |
| Hours of work in the field per day | (Hours) | Continuous variable |
| Number of working days in the field per week | (Year) | Continuous variable |
| Experience | (Year) | Continuous variable |
| Cooperative membership status | 0) No, 1) Yes | Binary variable |
| Agricultural Extension Services | 0) No, 1) Yes | Binary variable |
| Product Type | 1) Cotton 2) Cereals 3) Livestock 4) Cotton and livestock 5) Cereals and livestock 6) Cotton and Cereals 7) Cereals, cotton and livestock | Polychotomous Variable |
| **The type of livestock** | 1) Bovine 2) Bovie + ovine 3) Ovine + poultry 4) Cattle + poultry 5) Bovine + ovine + poultry | Polychotomous Variable |
| Total land area | Hectare | Continuous variable |
| Total cultivated land area | Hectare | Continuous variable |
| Total number of parcels | Number | Continuous variable |
| Animal assets of the farm | 0) No, 1) Yes | Binary variable |
| Income from Agriculture | The franc of the Financial Community in Africa XOF | Continuous variable |
| Presence of non-agricultural income | 0) No, 1) Yes | Binary variable |
| Agricultural Equipment | 0) No, 1) Yes | Binary variable |

## 3. Results

### *3.1. Socioeconomic Characteristics of Farm Managers*

The research findings reveal significant gender disparities among Klela producers, with 86.4% being men and 13.6% women. Illiteracy is prevalent among farm managers, with 54.5% illiterate and 45.5% literate, averaging only 0.88 years of education. Education's pivotal role in agriculture is underscored, yet only 12% of Malian farm household heads have formal schooling. The average age of farm managers is 47, with 26.7 years of farming experience, highlighting their expertise.

The income level of producers reflects Mali's agricultural development, with a high rural poverty rate of 53.1%, disproportionately affecting agricultural households constituting 74% of Malian households. In 2021, the average income of producers was approximately 980,254. 54-FCFA (Table 3). In Klela, families are primarily nuclear but often include additional members. The average family size was 30.72, emphasizing the community's significance. Despite challenges such as mechanization and modernization lagging in Mali's agricultural sector, manual labor persists. Consequently, families heavily involve members in farming, with an average of 20 individuals per household. Producers spend an average of 8.55 hours per day and 5.21 days per week working in the fields, illustrating their commitment to agricultural livelihoods.

**Table 3.** Socioeconomic characteristics.

| Variables | Freq. | % | Means | St. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| Age | | | 47 | 11,89 | 25 | 83 |
| Experience | | | 26.7 | 10,4 | 10 | 60 |
| Female | 15 | 13.6 | | | | |
| Male | 95 | 86.4 | | | | |
| Single | 1 | 0.9 | | | | |
| Married | 109 | 99 | | | | |
| Year of reading | | | 0.88 | 0.7 | 0 | 3 |
| No literacy | 60 | 54.5 | | | | |
| Literate | 50 | 45.5 | | | | |
| Income | | | 980,254.54 | 1,198,811 | 50,000 | 9,560,000 |
| Number of family members | | | 30.72 | 18.708 | 5 | 98 |
| Number of family members engaged in agriculture | | | 13.65 | 10.359 | 2 | 52 |
| Working time/day | | | 8.55 | 3.117 | 1 | 14 |
| Working time/week | | | 5.21 | 1.182 | 1 | 7 |
| Total farmland (hectare) | | | 30.23 | 16.349 | 1 | 75 |
| Total amount of cultivated land (hectare) | | | 14.18 | 15.276 | 1 | 60 |
| Total number of plots | | | 1.7182 | 0.81423 | 1.00 | 3.00 |

Analysis of agricultural production types in the research area revealed a significant presence of cotton, cereals, and livestock farming, with 41% of producers engaged in these activities, as indicated in Table 4. Mali's Sikasso region has emerged as a crucial hub for agricultural production, particularly in cotton cultivation, with 57.7% of producers actively involved in cotton and cereal farming. However, it is noteworthy that only a small percentage (1%) focused exclusively on cereals or a combination of cereals and livestock, suggesting a diversified approach to farming practices.

Livestock farming holds considerable economic significance in Sahelian countries, contributing between 20% and 25% of the gross domestic agricultural products in nations like Burkina Faso, Cape Verde, Mali, and others, with a growth rate of 5%. Rural farming, which encompasses livestock rearing, remains a primary form of agricultural production in the Sahel, with the region boasting substantial meat production potential. For instance, in 2006, estimates indicated a significant herd size of 63 million cattle, 168 million small ruminants, and over 6 million camels (Diawara et al., 2017).

Understanding the sources from which farmers acquire agricultural information is vital for effective policymaking. Table 3 illustrates the various channels through which farmers can access information on sustainable agriculture. While 17% rely on television broadcasts, over 24% use alternative sources beyond television, radio, researchers, and cooperatives. However, direct input from agricultural researchers is limited, with only 2% of producers citing them as a source of information. Radio broadcasts play a significant role in informing 15% of producers, whereas 20% rely on cooperatives for agricultural knowledge dissemination. These findings underscore the importance of diversifying communication channels to effectively disseminate information on sustainable agricultural practices to farmers.

**Table 4.** Livestock and Information Sources.

| The type of livestock | Freq. | % |
|---|---|---|
| Bovine | 4 | 3.6 |
| Bovine + ovine | 4 | 3.6 |
| Ovine + poultry | 3 | 2.7 |
| Cattle + poultry | 24 | 21.8 |
| Bovine + ovine + poultry | 70 | 63.6 |
| Production type | - | % |
| Grain | 1 | 1 |
| Cereals and livestock | 1 | 1 |
| Cotton and Grain | 63 | 57.3 |
| Grain, Cotton, and Livestock | 45 | 41 |
| Channels | - | % |
| TV | 19 | 17.3 |
| Radio | 17 | 15.5 |
| Cooperative | 23 | 20.9 |
| Agricultural Extension Services | 21 | 19.1 |
| Researchers | 3 | 2.7 |
| Others | 27 | 24.5 |

Source: Own survey, 2022.

### *3.2. Farmers' Perceptions of Sustainable Agriculture*

#### 3.2.1. Farmers' Perception Category

Within the scope of the study, the perception scores of 110 farmers were found to have a maximum value of 95 and a minimum value of 19. The mean score was 75.64, with a standard deviation of 10.38. These calculations allowed for the categorization of farmers into four groups based on their perception of sustainable agriculture, classified as very low (p), low (q), moderate (r), and high (s).

In Table 3, after categorizing the farmers' perceptions regarding sustainable agriculture, it was determined that 12% of the farmers within the research had a very low perception of sustainable agriculture (perception mean = 56.85). According to the analysis results, 38.2% of the farmers (perception mean = 70.33) exhibited a low level of perception, 31.8% (perception mean = 81) had a moderate level of perception, and only 17% of the farmers (perception mean = 89.15) possessed a high perception of sustainable agriculture (Table 5).

When comparing the results of the perception levels of the studied farmers regarding sustainable agriculture with a study conducted in Vietnam (Van Thanh et al., 2015), it is observed that there are similarities in the perception levels (low and moderate) of sustainability.

The predominance of below-average perceptions of sustainable agriculture among the study participants prompts discussion of the potential reasons behind this trend. Several barriers or challenges may contribute to this situation, requiring further exploration to inform appropriate intervention strategies.

**Table 5.** Perception of the sustainable agriculture category (n = 110).

| Categories | Total Points | Frq. | Mean Perception | % |
|---|---|---|---|---|
| (p) | Very low: min ≤ p < (mean - standard deviation), | 14 | 56.85 | 12.72 |
| (q) | Low: (mean - standard deviation) ≤ q < mean | 42 | 70.33 | 38.24 |
| (r) | Medium: mean ≤ r < (mean + standard deviation), | 35 | 81 | 31.84 |
| (s) | High: (mean + standard deviation) ≤ s ≤ max | 19 | 89.15 | 17.3 |
| Total | | 110 | - | 100 |

Note: q = Very Low, p = Low, r = Medium, s = High.
Source: Own survey, 2022.

#### 3.2.2. Factors Affecting Farmers' Perceptions of Sustainable Agriculture

The text discusses the results of a multiple regression analysis aimed at examining the factors influencing farmers' perceptions of sustainable agriculture. The stepwise analysis method was chosen, and 17 independent variables were included in the model; however, only 5 variables were considered significant by the model. The results show that the relationship level among the variables is R = 0.90, and the adjusted determination coefficient is $R^2 = 0.80$. This indicates that 80% of the total variation in farmers' perceptions of sustainable agriculture is explained by independent variables such as weekly working days, the number of family members engaged in agriculture, family size, and crop variety (Table 6).

However, the analysis revealed a negative relationship between the variable "total working days per week" and farmers' perceptions of sustainable agriculture (β = −0.0637 and significance level sig = 0.037). Similarly, the number of family members engaged in agriculture hurts farmers' perception (β = −0.550 and sig = 0.03). In contrast, the other variables in the model positively influence farmers' perceptions of sustainable agriculture. The number of working hours per day and the diversity of agricultural activities on the farm positively affect farmers' perceptions.

The text also cites a study by Füsun Tatlıdil et al. (2009) in Kahramanmaraş, Turkey, which found that the type of agricultural production activity significantly influenced farmers' perceptions of sustainable agriculture. In the current study, the type of agricultural activity is included in the model as a positive factor affecting farmers' perceptions of sustainable agriculture. The variety of agricultural activities is related to the economic dimension of sustainable agriculture, such as the integration of livestock into farming or crop diversification. Overall, the study's findings suggest that various factors, including working conditions, family size, and the diversity of agricultural activities, influence farmers' perceptions of sustainable agriculture. These factors shed light on the social and economic aspects of sustainable agriculture.

**Table 6.** Multiple regression estimates of farmers' perceptions of sustainable agriculture (n = 110).

| Model | B | Bêta | t | Sig. |
|---|---|---|---|---|
| (Constant) | 3.25 | 0.68 | 4.75 | .000* |
| Total hours of work in the field/day | 0.55 | 0.62 | 0.18 | .008* |
| Total working days/week in the field | −0.253 | −0.63 | −3.12 | 0.037* |
| Number of family members | 0.008 | 0.04 | 2.07 | 0.05** |
| Number of family members engaged in agriculture | −0.16 | −0.55 | −2.327 | 0.03** |
| Production activity | 0.15 | 0.48 | 2.126 | 0..05** |

Notes: $R^2 = 0.80$; F = 3.94; Durban Watson test = 2.35, sig. p value < 0.01*; 0.05** and 0.10*** is significant.
Source: Own survey, 2022.

The text discusses the influence of farmers' education levels, age, and experience on their perception of sustainable agriculture. This study highlights the role of education in supporting the adoption of new agricultural technologies, citing previous research by McBride and El-Osta (2002), Bouréma et al. (2021), and Adégbola et al. (2011). Education has traditionally been a significant factor in agricultural research.

Furthermore, the text mentions a study that identified farmers' experience as a crucial factor in the adoption of modern agricultural technologies (Bouréma et al., 2021). A study conducted in Nigeria by Adeola and Adetunbi (2015) found that factors such as age, education level, and experience had an impact on farmers' perceptions of sustainable agriculture.

Interestingly, the text also refers to a study conducted in Iran by Allahyari et al. (2008), which found that age, education level, and experience were not significant factors influencing the perception of sustainable agriculture among the sample of academic staff in that context. In contrast, the present study suggests that variables such as age, experience, and education level do not significantly impact the perception of sustainable agriculture among farmers. The text speculates that this may be related to the generally lower education level of the farmers in the study and the fact that most of them are young farmers.

In summary, the text highlights the varying roles of education, experience, and age in influencing farmers' perceptions of sustainable agriculture, drawing on research from different regions. It notes that the specific findings of this study may be attributed to the young age and low education level of the participating farmers.

### *3.3. Perception Levels of Farmers According to Age Groups and Information Sources*

When examining the levels of sustainable agriculture perception among farmers alongside their ages, it is observed that farmers aged between 41 and 56 years exhibit the highest percentage of sustainable agriculture perception, at 54.55%. Farmers with significantly low perceptions of sustainable agriculture are predominantly found in the 25–40 age group, accounting for 50.00%.

Furthermore, farmers with a moderate level of sustainable agriculture perception are predominantly in the 41–56 age range, with the highest proportion at 53.13% (Table 7). These findings emphasize the significance of considering age groups when developing policies related to sustainable agriculture.

**Table 7.** Distribution by age category and perception level of farmers (n = 110).

| Perception Categories | Age categories | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 25–40 | % | 41–56 | % | 57–70 | % | 71–85 | % | Total |
| P | 7 | 50.00 | 5 | 35.71 | 2 | 14.29 | 0 | 0.00 | 14 |
| Q | 15 | 35.71 | 14 | 33.33 | 9 | 21.43 | 4 | 9.52 | 42 |
| R | 8 | 25.00 | 17 | 53.13 | 7 | 21.88 | 0 | 0.00 | 32 |
| S | 7 | 31.82 | 12 | 54.55 | 3 | 13.64 | 0 | 0.00 | 22 |
| Total | 37 | - | 48 | - | 21 | - | 4 | - | 110 |

Source: Own survey, 2022.

The findings regarding the relationship between farmers' sustainable perception levels and sources of information, which is one of the objectives of the study, are presented in Table 7. To determine if there is a relationship between information sources about sustainable agriculture and the sustainable perception levels of farmers, sustainable agriculture information sources were categorized into two groups: formal agricultural information sources (TV, radio, publishers) and informal sources (neighbors, relatives). According to the results of the chi-square test, a significant relationship between the sustainable agriculture level of farmers and sustainable agricultural information channels was accepted at a significance level of 5% (Table 8). The analysis results indicate that farmers with low sustainable agriculture perception levels tend to rely more on informal sources of information.

In line with these findings, Hayran et al. (2018) also concluded that farmers' communication with publishers and researchers is an important factor influencing farmers' perceptions of sustainable agriculture (Hayran et al., 2018). The use of agricultural radio programs to promote new technologies can have positive and lasting effects on farmers' perceptions of sustainable agriculture. Previous studies, such as those conducted by Van Thanh (2015), have demonstrated the positive impact of TV programs on the perception of sustainable agriculture among banana farmers. This finding suggests that mass media, such as radio and television, can play a crucial role in disseminating information and raising farmers' awareness of sustainable farming practices (Haq et al., 2022).

**Table 8.** Distribution of farmers' perception levels according to information sources (n = 110).

| Information sources | Perception Category | | Total | % | Chi-square |
|---|---|---|---|---|---|
| | (q + p) | (r + s) | | | |
| Formal resources | 33 | 50 | 83 | 75.45 | |
| No formal resources | 22 | 5 | 27 | 24.54 | 0.00 |
| Total | 55 | 55 | 110 | 100 | |

Notes: Sig. p-value < 0.05 indicates significance; q = Very Low, p = Low, r = Medium, s = High.
Source: Own survey, 2022.

### *3.4. Relationship Between the Use of Agricultural Input Subsidies and Farmers' Perceptions of Sustainable Agriculture*

Following the global food crisis in 2007–2008, West African countries, including Mali, decided to increase fertilizer usage per hectare from 8 kg to 50 kg to improve agricultural productivity, food security, and nutrition (Kone et al., 2019; Samake et al., 2007). To achieve this goal, they implemented subsidy policies for agricultural inputs. Despite these efforts, agricultural productivity and fertilizer usage remain low. Various aspects of these subsidy programs, such as targeting farmers, transparency in contract allocation, and private sector participation, etc., contribute to explaining the performance of fertilizer subsidy policies. In Mali, fertilizer subsidies constitute an increasing share of agricultural sector expenditures. After the 2007 global food and nutrition crisis, budget resources allocated to fertilizer subsidies increased significantly, from approximately 11 billion FCFA to approximately 40 billion FCFA between 2009 and 2017. However, these subsidies have not yielded the expected results (Kone et al., 2019).

**Table 9.** Use of pesticide subsidies (n = 110).

| Input subsidy status of farmers | Freq. | % | Mean Perception | Z | Sig |
|---|---|---|---|---|---|
| Benefited farmers (0) | 84 | 76.4 | 76.61 | −2.16 | 0.03** |
| Farmers not benefiting (1) | 26 | 23.6 | 72.5 | | |

Note: Sig = 0.01* 0.05** and 0.10*** is significant.
Source: Own survey, 2022.

Studies that consider the relationship between the sustainable agriculture perception of beneficiaries and non-beneficiaries of agricultural input subsidies are rare. This study aimed to determine whether there is a difference in sustainable agriculture perception between those who benefit from input subsidies and those who do not. However, because 98.18% (108) of the farmers within the scope of this study benefited from fertilizer subsidies, no comparison could be made. Additionally, 76.40% of the farmers in the study benefited from pesticide subsidies (Table 9). Note that agricultural input subsidies are a policy tool used by the Malian government to strengthen the capacity of farmers and support Mali's agricultural production and productivity. As seen in Table 9, the sustainable perception of the beneficiaries and non-beneficiaries of pesticide subsidies shows that, contrary to expectations, the perception of sustainability among the beneficiaries of pesticide subsidies is higher. This result indicates that the perception of sustainable agriculture among farmers has not yet been translated into sustainable agricultural practices. The difference in perceptions between beneficiaries and non-beneficiaries was statistically significant at the 5% level of significance (Table 9). This suggests that despite having a high perception of sustainability, farmers tend to benefit from subsidies if the government continues to provide pesticide subsidies.

## 4. Recommendations

Based on the results of this study conducted in the Klela district, Sikasso region of Mali, it is recommended to implement targeted extension programs aimed at enhancing farmers' understanding of sustainable agriculture. The study revealed varying levels of perception among participants, with a substantial proportion exhibiting perceptions below the average level. Given the identified influential factors such as family involvement in farming, working days, working hours, household size, and sources of information, tailored interventions are crucial to effectively translate these perceptions into attitudes and practical actions.

Specifically, extension programs should focus on addressing the identified influential factors to improve farmers' perceptions and ultimately promote sustainable agricultural practices. This may involve providing targeted training sessions, workshops, and demonstrations tailored to the needs and circumstances of farmers in the region. Additionally, leveraging various communication channels, including face-to-face interactions, radio broadcasts, and mobile applications, can enhance the dissemination of information on sustainable agricultural practices.

Furthermore, collaboration with local agricultural experts, organizations, and community leaders can facilitate the delivery of extension services and ensure their relevance and effectiveness. By targeting interventions to address the identified influential factors and enhancing farmers' understanding of sustainable agriculture, these programs can positively influence agricultural behaviors and contribute to the advancement of sustainable agricultural practices in Mali.

Although the study yielded significant insights, it is not devoid of limitations that may have influenced its outcomes. Selection and response biases may have affected the generalizability and accuracy of the findings. The omission of crucial variables such as socioeconomic factors and inadequate consideration of seasonal and long-term agricultural trends warrant further investigation. Nonetheless, the study offers valuable insights, underscoring the need to acknowledge and address these limitations in future research endeavors.

In conclusion, fostering sustainable agricultural practices in Mali requires collaborative efforts from governmental and international stakeholders, alongside targeted research focusing on adoption challenges and practices in specific regions like Sikasso to inform evidence-based agricultural policies.

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