DETERMINANTS OF SMALLHOLDER FARMERS' FOOD SECURITY IN MALI AMIDST CLIMATE CHANGE

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Abstract

In the agrarian landscape of Mali, environmental and climatic changes pose a threat to food stability. This research delves into the impact of these changes on food security among Mali's smallholder farmers. A combination of methodologies was employed, including a survey of 250 farmers across Mali's eight regions and in-depth phone interviews. Results indicated varying degrees of food security: a minimal fraction (1.6%) of farmers reported high food security, a slightly higher percentage (4%) experienced moderate security, 1.6% were neutral, while a significant majority faced moderate (32.4%) to severe (60.4%) food insecurity. Further quantitative analysis indicated minimal correlation between food security and government aid or climate policy. Techniques for climate adaptation, such as drought-resistant crops and efficient water use, were not strongly linked to better food security outcomes. Instead, factors like educational attainment and family size played a pivotal role. Qualitative data shed light on the intricate realities of food security, government actions, and the hurdles in implementing climate-adaptive solutions. This study highlights the need to incorporate socio-demographic factors into policy-making to elevate food security for Mali's smallholder farmers, thereby enriching the dialogue on climate resilience and sustainable agriculture.

Keywords: Agricultural practices, Climate change, Food security, Smallholder farmers, Socio-demographic factors

INTRODUCTION

Mali's heavy reliance on agriculture as a cornerstone of its economy and livelihoods makes it particularly susceptible to environmental and climatic challenges and it is essential for farmers to adopt some strategies in this realm of climate change. Climate change poses a significant threat to global food security, with many countries, such as Mali a West African nation where the agricultural landscape is highly sensitive to climatic variations, the threat to food security looms large. The country is geographically diverse, encompassing regions ranging from the arid Saharo-Sahelian zone in the north, to the Sahelo-Sudanian and Sudano-Guinean zones in the south, each characterized by distinct annual rainfall patterns and variability (Butt et al., 2005). As is the case in many African countries, the convergence of unfavorable environmental conditions and climate shifts renders individuals and communities more vulnerable to food insecurity and escalating poverty rates (Kiprutto et al., 2015).

Like other countries in sub-Saharan Africa, the link between climate change and food insecurity in Mali is well established. Analysis based on data from Mali as well as other countries in sub-Saharan Africa shows that food insecurity increases by 5–20 percentage points with each flood or drought (IMF, 2020). A dynamic quantitative open economy spatial multisector macroeconomic model used by Baptista *et al.*, (2022) also shows the channels by which that can happen. In that model, climate shocks depress agricultural production, such that households are forced to sacrifice productive capital to satisfy their immediate food consumption needs. This further reduces agricultural output. Notwithstanding an increase in food imports, food prices increase in rural and urban areas. Overall, food consumption declines and the number of permanently food insecure households rises, with a long-term scarring effect on growth and productivity.

Mali has encountered challenges that lead to food insecurity such as COVID-19-related supply disruptions, sanctions limiting food imports, and the Russia-Ukrainian conflict that impacting negatively global food supplies. Consequently, Mali saw a roughly 30 percent

increase in food prices by late 2022 compared to their 2019 average (see Figure 1), and these elevated prices have persisted into early 2023. Food expenses now make up just under 60 percent of consumer spending in Mali, and recent data indicates that approximately three-quarters of the population do not have enough food (see Figure 2). Many of these individuals are in dire straits. As of early 2023, over 15 percent of the population, totaling 761,000 people, either face severe food insecurity or are at risk of doing so (2.9 million). Projections indicate that by mid-2023, this percentage is expected to increase to 24 percent, with 1.3 million people experiencing severe food insecurity and an additional 4 million people at risk (FAO et al., 2023).

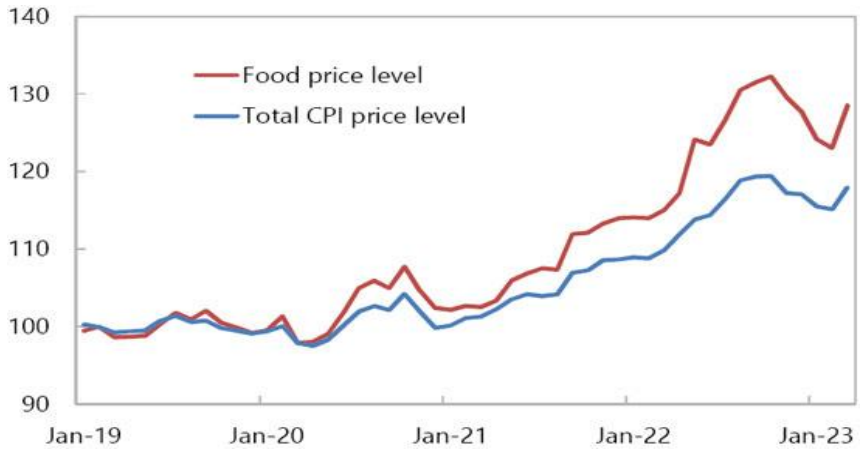

Figure1. Food Price Levels in Mali *(Index Level, 20129= 100)* (FAO et al., 2023)

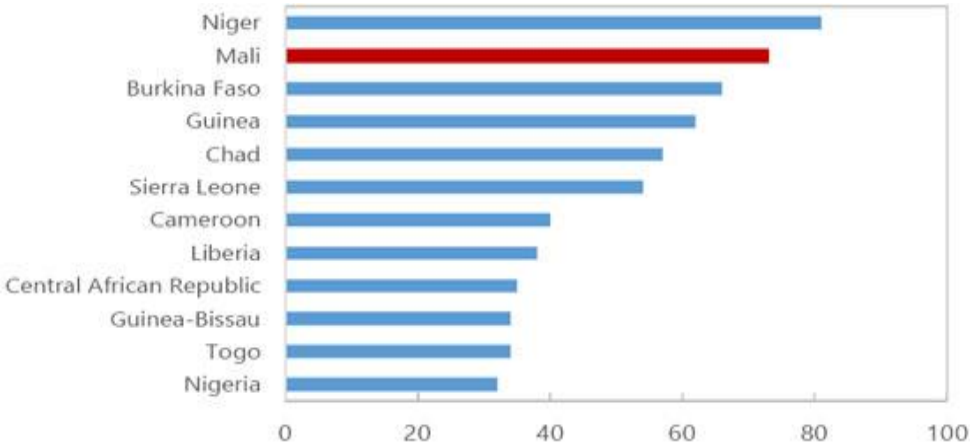

Figure 2. Prevalence of Insufficient Food Consumption in Africa, December 2022 to March 2023 *(Share of Population, percent)* (Tucker, 2023)

The combined impact of climate change and food insecurity has generated a pressing need for a balance of payments due to the global food shock. Mali has experienced a swift increase in food imports in recent years. The cost of imported cereals rose by 5½ percent in 2022, contributing to an 8 percent overall surge in cereal imports. In total, the value of Mali's food imports escalated by 15 percent in 2022, marking a 65 percent increase from 2019 levels (refer to Figure 3). With widespread food insecurity already prevalent in Mali, elevated prices for essential imports pose a critical risk of widespread hunger and potential loss of life.

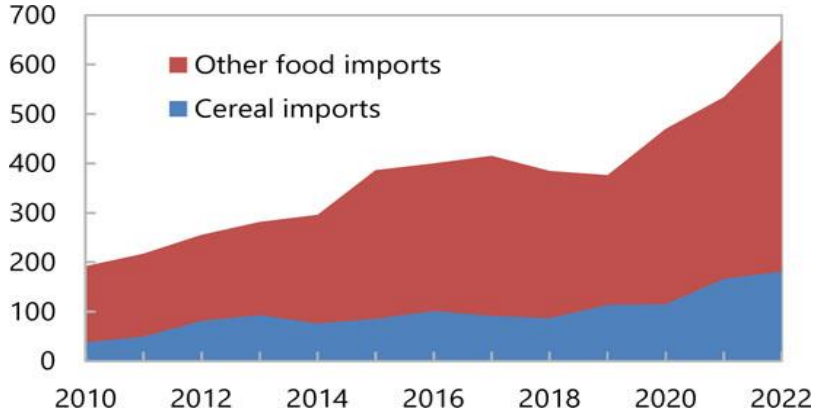

Figure 3. Food Imports in Mali (Tucker, 2023)

Global climate change is a pressing international concern that has far-reaching implications for various aspects of human existence. It continues to pose significant threats to global food security, particularly in regions such as Mali where the economy heavily relies on a climate-dependent agricultural sector (FAO et al., 2023). The Sahelian country is particularly vulnerable due to its geographical location, high levels of poverty, and dependence on rain-fed agriculture (IPCC, 2018). Among the most profoundly affected sectors is agriculture, which is intricately entwined with the changing climate (Dutta & Begum, 2022). Climate change exerts a multifaceted influence on agriculture, causing shifts in crop calendars and requiring the adoption of climate-resilient farming techniques like the System of Rice Intensification (SRI). Furthermore, it brings about transformations in crop, livestock, and fisheries production. Notably, climate change also plays a role in altering the prevalence and distribution patterns of crop pests, thereby affecting the overall dynamics of agricultural ecosystems. (Campbell et al., 2016; Singh & Reddy, 2013; Sogoba et al., 2016).

Therefore, government interventions, climate-resilient agricultural practices play a crucial role in mitigating the impacts of climate change on food security (Hallegatte, 2016). In Mali, efforts have been made to implement policies and strategies aimed at enhancing climate resilience and food security. However, understanding the efficacy of these measures is essential to ensure their success (World Bank, 2019). From that perspective it is crucial to understand the socio-demographic factors such as population growth, urbanization, and changes in dietary habits also significantly influence food security. Given Mali's rapid population growth and urban expansion, these factors are of particular relevance (UN DESA, 2018).

Moreover, the socio-demographic factors such as the age of household members, gender of the household head, education of the household head, household size and household's income play an important role in ensuring food security though it is worthwhile to pinpoint that the climate variables, such as changes in temperature and rainfall patterns, can have direct implications for agricultural productivity and hence food security (IPCC, 2018). In countries like Mali, where the majority of the population is engaged in agriculture, these changes can have profound effects on food availability and access (FAO et al., 2023).

The potential repercussions of climate change on Mali's agricultural practices and food security are substantial. Government interventions have been seen inadequate to tackle the challenges faced by farmers. The country is extremely vulnerable to climate change and the country is already facing acute climate-related challenges from higher temperatures and more frequent extreme weather events. The impact of climate change has also contributed to a rise in food insecurity, with almost a quarter of the population expected to be either facing food insecurity or at risk of doing so by mid-2023 (Tucker, 2023).

Climate change is therefore likely played some roles in the rise in food insecurity since 2018 in Mali, and the challenges are likely to be even greater going forward. Regional analysis in Mali shows a significant overlap between the areas affected by insecurity and climate change and those facing food insecurity (IPCC, 2018). Political instability, security issues and weak institutions such as in Mali can undermine efforts to build resilience and respond to natural disasters (Navone, 2021).

Previous research has shown that climate change can exacerbate existing vulnerabilities in food systems, leading to detrimental effects on the livelihoods and wellbeing of communities (Schmidhuber & Tubiello, 2007; Wheeler & Von Braun, 2013). Mali, as a developing African country with an agrarian economy, has been subjected to substantial climatic variations and increasing food insecurity (Amadou et al., 2022). The government's efforts to address these challenges through policies and climate-resilient agricultural practices are critical in shaping the country's resilience to climate change (Djoudi et al., 2013).

In response to that, the Government of Mali has implemented several policies and initiatives to promote climate-resilient agriculture and improve food security (Sissoko et al., 2011; World Bank, 2019). However, there remains a need for a comprehensive understanding of the effectiveness of these interventions and how specific socio-demographic factors influence their outcomes. This paper endeavors to evaluate the perspectives of smallholder farmers concerning the efficacy of prevailing government subsidies, climate-related policies, and programs. Additionally, it seeks to analyze the extent of adoption of drought-tolerant crop varieties and water-saving technologies, exploring their correlation with reported food security. Furthermore, the study aims to investigate the socio-demographic factors that impact smallholder farmers' food security.

METHOD

A mixed methods sequential explanatory design (Creswell et al., 2007) was used to answer the study research questions. It involved two sequential phases—quantitative and qualitative— which are described in the subsequent sections.

Phase 1: Quantitative Analysis

This study employed a structured survey to investigate the perceptions of food security among smallholder farmers in Mali, particularly in the context of climate change. The survey was administered to a sample of 250 participants, representing diverse backgrounds across eight regions of Mali. The survey instrument included questions addressing key variables such as food security status, government subsidies, climate-related policies and programs, climate-resilient agricultural practices, and socio-demographic characteristics. To analyze the relationships between food security perceptions and these variables, ordinal logistic regression was employed. This statistical method allowed for a nuanced understanding of the factors influencing food security perceptions among the participants. Rigorous measures were implemented to ensure the validity and reliability of the survey data subjected to ordinal regression analysis. This encompassed meticulous questionnaire design, robust sampling techniques, careful model validation, and stringent quality control procedures throughout the data collection and analysis phases, including considerations for informed consent, confidentiality, and mitigation of response bias. Acknowledging the limitations, the study recognizes the generalizability of findings beyond the studied population.

Phase 2: Qualitative Analysis

In addition to the quantitative approach, this study incorporated qualitative insights through telephone interviews of 15 to 20 minutes in length with farmers. A purposefully sampled subset of participants from the survey pool engaged in these interviews, providing rich

qualitative data on key aspects such as government subsidies, climate policies and programs, adoption, and socio-demographic influences with these relevant questions:
Question 1: How is your current food security status (Very Food Secure, Moderately Food Secure, Neutral, Moderately Food Insecure, Very Food Insecure) impacted your daily life as a smallholder farmer?
Question 2: Are there challenges in implementation or discrepancies between policy intentions and on-the-ground realities?
Question 3: Do farmers know about and think climate policies and programs are helpful?
Question 4: Are there obstacles to using certain crops or technologies for saving water during droughts? What do farmers think about these technologies?
Question 5: How does education influence farmers' decisions, and how does the size of their family affect how they share resources and adapt to challenges?

The questions in the interviews were designed to gain a thorough understanding of the key aspects that surfaced in the initial phase of the study. The qualitative data offered a deeper understanding of the lived experiences and perspectives of smallholder farmers in Mali. The data were analyzed using a variation of the constant comparison method introduced by Strauss & Corbin (1990) to categorize the qualities into theme. Comparative analysis of both quantitative and qualitative findings was conducted to enhance the interpretation of results, contributing to the overall validity and reliability of the study. The interviews were recorded, with permission, and then transcribed into Word, therefore ethical research practices were ensured, rigorous measures were implemented, including obtaining informed consent, maintaining participant confidentiality, and addressing potential response biases. The study acknowledges the importance of considering the contextual nuances and recognizes the limitations in generalizing the qualitative insights beyond the specific subset of participants.

RESULT AND DISCUSSION

The literature on the impact of climate change on food security in Mali reveals a complex interplay of socio-economic and environmental factors. Multiple studies have delved into this issue, employing diverse methodologies to elucidate the challenges faced by smallholder farming households. For instance, Giannini et al., (2017) conducted a comprehensive study, integrating socioeconomic and climate data to map the climate sensitivity of food security dimensions in Mali. This approach provided a holistic understanding of the intricate relationship between climate dynamics and food security. On the other hands Butt et al., (2005) utilized biophysical and economic models to simulate the consequences of climate change on crop, forage, and livestock production. This modeling approach allowed for a nuanced exploration of the potential impacts on different facets of agriculture. While Sanga et al., (2021) adopted a systems thinking approach to analyze the complex barriers to food security and climate adaptation. All of these literatures inspired this study to investigate the effect of government intervention in agriculture and climate related policies, the adoption of climate-resilience agriculture, and demographic factors on the food security perception of smallholder farmers in Mali. The result of this study is described below:

Quantitative Analysis

Before displaying the result of the statistical analysis, the description for food security status of smallholder farmers in Mali can be shown in Table 1.

Table 1. Food Security Status

Food Security Status	Percentage(%)
Very Food Secure	1.6%
Moderately Food Secure	4%
Neutral	1.6%
Moderately Food Insecure	32.4%
Very Food Insecure	60.4%

Source: Percentage calculated from primary data of Smallholder Farmers' Food Security

The state of food availability for smallholder farmers in Mali is quite alarming, with a sizeable 60.4% grappling with severe food shortages and another 32.4% dealing with a less severe, yet still significant, lack of food. This situation points to an urgent need for specific measures to tackle the underlying issues causing such widespread food scarcity. On the other end of the spectrum, 4% of farmers are in a better situation with 'Moderate Food Security,' and a very small fraction, at 1.6%, find themselves in a 'Neutral' position or are 'Very Food Secure,' indicating they have a more consistent access to food. These less affected groups constitute a small portion of the population but their circumstances could provide valuable insights into what can be done to improve the situation for the majority. Studying and replicating the factors that contribute to their food security could be key to devising effective, customized solutions aimed at boosting the overall food security and resilience of smallholder farmers across Mali. The result of the quantitative analysis using the Ordinal Logistic Regression is displayed in Table 2 as follows.

Table 2. Model Fit Measurement

				Overall Model Test		
Model	Deviance	AIC	R^2_{McF}	χ^2	Df	p
1	699	725	0.0253	18.2	9	0.033

Note. The dependent variable 'Food Security' has the following order: 1 | 2 | 3 | 4 | 5

Source : Analyzed Primary Data

Table 3. Model Coefficients - Food Security

Predictor	Coefficient	SE	Z	p
Government Subsidies for Agriculture	-0.0463	0.104	-0.445	0.656
Government Climate Related Policies and Programs	0.0786	0.122	0.644	0.519
Drought-Tolerant Crop Varieties	0.1272	0.122	1.040	0.298
Water-Saving Technologies	0.0290	0.151	0.192	0.848
Age of Household Members	-0.1228	0.150	-0.821	0.411
Gender of Household Head	0.0646	0.117	0.551	0.582
Education Level of Household Head	-0.4872	0.152	-3.212	0.001

Table 3. Model Coefficients - Food Security

Predictor	Coefficient	SE	Z	p
Household Size	-0.2662	0.126	-2.118	0.034
Household Income	0.0343	0.109	0.315	0.753

Source: Analyzed Primary Data

Food Security and Government Interventions in Agriculture and Climate Related Policies

While some studies, such as (Tucker, 2023), briefly touches upon policies and strategies adopted by Mali to cope with climate change and food insecurity, and Generoso (2015) that elaborate upon policy implications but does not extensively evaluate the perceptions of the existing government policies in Mali among smallholder farmers, there is a potential gap to examine the statistical significance of smallholder farmers' perceptions regarding effectiveness of these policies and adaptive measure. This study was designed to fill the gap by conducting a more thorough investigation into the specific government interventions such as the government subsidies for agriculture, climate-related policies and programs and their relationship on food security perceptions among smallholder farmers and the outcomes would enhance the understanding of their role in addressing food security challenges.

The analysis revealed that the variable "Government Subsidies for Agriculture" did not significantly influence food security perceptions among smallholder farmers ($p = 0.656$). This implies that, in the context of climate change, the farmers' perceptions of food security are not substantially impacted by government subsidies for agriculture. In addition, the variable "Government Climate-Related Policies and Programs" also did not show a significant effect on food security perceptions ($p = 0.519$). This suggests that, as perceived by smallholder farmers in Mali, the impact of climate-related policies and programs on food security may not be a major factor.

These results indicate that the government interventions in agriculture did not have a direct effect on the smallholder food security in Mali amidst climate change challenges. However, such interventions may have indirect effect to people's food security in the challenging time of climate change as it can increase the agricultural productivity. The nexus between climate change and agriculture productivity in Mali has garnered considerable attention. For instance, Sogoba et al., (2016) advocated for sustainable improvements in agricultural productivity to mitigate climate change's threat to the national economy. Moreover, the works of Butt et al., (2005) and Ebi et al., (2011) provided nuanced insights into the economic and food security implications of climate change in Mali, emphasizing the need for adaptive measures. These studies underline the vulnerability of Mali's agricultural sector, which is predominantly rainfed and therefore highly susceptible to changes in precipitation patterns and temperature increases. As a result, there is a direct impact on crop yields, which can lead to price volatility and reduced access to food for the most impoverished populations. To address these challenges, practical adaptive measures could include the development and dissemination of drought-resistant crop varieties, improvement of water management systems such as small-scale irrigation, and the implementation of sustainable agricultural practices that improve soil health and reduce erosion. Furthermore, establishing early warning systems and enhancing farmers' knowledge about climate forecasts could enable better planning and reduce the risks associated with climate variability.

Climate Resilience Practices in Agriculture and Food Security

Farmers in Mali, cognizant of climate change, have devised diverse adaptation strategies. While Sanga et al., (2021) and Diiro et al., (2016) discuss adaptation strategies, Halimatou et al., (2016) highlighted the importance of strategies such as selling animals, utilizing improved crop varieties, and diversifying into non-agricultural activities. Building on this, Amadou et al., (2022) underscored the significance of employing drought-tolerant cultivars and water-saving technologies on affecting food security of the smallholder farmers in Mali.

However, result of this study that has been displayed in Table 2 indicates that the climate-resilient agricultural practices that were employed by smallholder in Mali were not associated with their food security. The adoption levels of "Drought-Tolerant Crop Varieties" and "Water-Saving Technologies" did not significantly relate to reported food security ($p = 0.298$ and $p = 0.848$, respectively). This implies that, according to the model, the reported food security of smallholder farmers is not strongly associated with the adoption of these technologies. This result is not consistent with the conclusion of Diallo et al. (2021) who explored climate change adaptation among maize farmers in southern Mali, underscoring the positive effects of adaptation strategies on both maize productivity and household food security and emphasized the influence of factors like farmer experience, access to credit, and technical training on the efficacy of adaptation strategies.

Demographic Factors and Smallholder Farmers' Food Security in Mali

Some demographic factors, such as age, gender, education level, and household size, have been measured to investigate their effects on smallholder farmers' food security in Mali. The quantitative analysis suggests that age and gender were not significant predictors for smallholder farmers' food security, with p-values of 0.411 and 0.582, respectively. On the contrary, education level of household head had been found to be highly significant with a value of $p = 0.001$, indicating that higher education levels are associated with distinct food security perceptions. Finally, the household size has also been found significant with a p-value of 0.034, suggesting a relationship between household size and food security perceptions.

Relatively similar results were advocated by Diiro et al., (2016) contributed by exploring how farmers and communities perceive and adapt to climate change, considering gender and farming system differences. This study brought attention to the nuanced ways in which different demographic groups and farming practices respond to climate challenges. Simultaneously, Rivers et al., (2017) delved into the household level, investigating inter- and intra-family behavioral dynamics in rural Mali. Their findings emphasized the collective nature of food security tasks within households and the specific challenges faced by young women in decision-making. Furthermore, Tucker (2023) conducted a comprehensive analysis using data from various sources, such as the World Bank, FAO, and the Mali Meteorological Agency. This data-driven approach allowed for a detailed examination of the relationship between temperature, rainfall, crop production, and food insecurity indicators in Mali. Additionally, Generoso (2015) employed a composite food security index to classify households into different categories, providing insights into the determinants of switching between low, intermediate, and high food security. This method offered a quantitative perspective on the impacts of climate-related variables on food security.

Qualitative Analysis

When delving into the food security situation of Mali's smallholder farmers, a distressing picture emerges, with over half (60.4%) suffering from severe food shortages. Conversations with these farmers reveal the depth of their hardship, as they recount

struggles such as the devastating impact of unpredictable weather on their harvests and the constant battle with limited resources. One farmer mentioned:

"The rain doesn't come when we need it, and our crops fail. It's a struggle every day to feed my family."

In contrast, a slightly smaller number, 32.4%, face a somewhat less dire situation but still endure considerable challenges in securing a reliable food supply. These farmers often share their apprehension about the future, with one stated:

"We are never sure if our fields will yield enough, and it's a constant worry that weighs on us."

The remaining smallholder farmers who are 'Moderately Food Secure' (4%), 'Neutral' (1.6%), or 'Very Food Secure' (1.6%) represent a more fortunate minority. These individuals have managed to achieve a level of stability that eludes many of their peers. A farmer in this group shares an optimistic view:

"This year was good for us, we had enough. But it's not the same for everyone, and I wish we could all find this stability."

These narratives from the ground underscore the complex and layered nature of food security among Mali's smallholder farmers. They highlight the importance of crafting tailored solutions that not only address immediate needs but also build long-term resilience and capacity within these communities.

The quantitative results suggest that, in the context of climate change in Mali, government subsidies and climate-related policies may not be the primary drivers of smallholder farmers' food security perceptions. Instead, education level and household size emerge as influential factors. The significance of education aligns with existing literature, highlighting the role of knowledge and awareness in shaping perceptions of food security. The influence of household size indicates the complex interplay of social dynamics. The deeper analysis on this phenomenon was investigated qualitatively in this study that was elaborated in this section.

Smallholder farmers provided a variety of viewpoints regarding government subsidies for agriculture, with some expressing gratitude for the financial support while others reported challenges in accessing the programs. One participant remarked,

"The subsidy program has been a crucial financial lifeline for me as a smallholder farmer. The support provided has undoubtedly eased some of the economic burdens we face"

However, the positivity was tempered by challenges, as another participant noted:

"Dealing with bureaucratic hurdles often puts a damper on the situation, making the process more complex than it needs to be"

Farmers noted discrepancies between policy intentions and on-the-ground realities, such as limited awareness of eligibility criteria and unclear application processes. These insights help to contextualize the non-significant quantitative findings. There were varying levels of awareness among smallholder farmers about climate-related policies and programs, with some acknowledging their existence but lacking detailed knowledge. One farmer stated:

"Have heard about these policies, but not sure how they actually affect him. It would be beneficial to have more information that directly connects the policies to our specific challenges. "

The interviews revealed examples of localized adaptation strategies in response to climate change, such as traditional knowledge transfer within communities and grassroots initiatives aimed at sustainable agriculture practices.

The qualitative data sheds light on barriers that hinder farmers from adopting drought-tolerant crop varieties and water-saving technologies. Barriers include limited access to information, financial constraints, and skepticism about the efficacy of these innovations. As one farmer explained:

> *"Would like to try these new technologies, but not sure if they're worth the investment. It's not just about the cost, but also understanding how these technologies align with our traditional farming practices."*

The study found that higher education significantly influences farmers' perceptions of climate challenges and their engagement in adaptive strategies. Examples from the data show that educated farmers demonstrate a heightened awareness of climate challenges. As stated by one farmer:

> *"As a college-educated farmer, I am more aware of the need to adapt to changing weather conditions."*

Additionally, education was connected to improve decision-making processes, which reflects the complex role of knowledge in shaping perceptions of food security. Another theme that emerged from the qualitative data was the influence of household size on resource distribution and adaptation strategies within families. For example, one participant from a larger household shared:

> *"Have to think critically about how to allocate their resources since there are so many mouths to feed. This challenge goes beyond just adapting to climate change; it's about ensuring the well-being of everyone in the family. Our adaptation strategies are not only about crops; they extend to managing our household resources effectively."*

The data reveals that larger households face unique challenges in resource allocation, which impacts their ability to cope with climate-induced stresses. This finding supports the quantitative result that household size is a significant factor in understanding adaptation strategies.

Quantitative – Qualitative Join Analysis

The statistical examination of food security among Mali's small-scale farmers paints a stark picture, revealing that a substantial majority (60.4%) are grappling with intense food deficits, and another sizable group (32.4%) confronts substantial hurdles in maintaining a steady supply of food. On the other end of the spectrum, a modest 4% manage to maintain a moderate level of food security, and a mere 1.6% are classified as 'Neutral' or 'Very Food Secure.' These figures highlight the critical need to tackle the prevalent issue of food scarcity.

The impact of government assistance on the farmers' sense of food security was also assessed quantitatively, revealing that neither "Agricultural Subsidies" nor "Climate-Related Government Policies and Programs" had a statistically significant effect, with p-values of 0.656 and 0.519 respectively. This outcome points to a potential disparity between the intent of government policies and their practical effectiveness in the eyes of the farmers.

When complemented with qualitative data, a richer picture emerges. Personal accounts from farmers provide insight into the real-life implications of weather unpredictability and resource constraints on their ability to produce and access food. While some farmers appreciate government subsidies as an essential aid, others point out the inefficiencies and implementation gaps.

Both quantitative and qualitative analyses underscore the influence of educational attainment and family size on food security. Statistically, higher education correlates with different perceptions of food security, and household size is also a pivotal factor. Farmers with more education are more cognizant of environmental issues and exhibit improved decision-making, whereas larger families face more pronounced struggles in distributing their resources.

The combined analysis suggests that, while numerical data offers a broad view of the situation, the qualitative insights provide a richer understanding of the complex realities and personal experiences related to food security. The quantitative findings on government intervention contrast with the diverse opinions gathered from farmers through interviews, emphasizing the importance of incorporating the human element, their challenges, and varying perspectives when formulating effective solutions.

CONCLUSION AND SUGGESTIONS

Conclusion

In summary, the research delved into the complex perceptions of food security among Mali's small-scale farmers amidst climate challenges. The findings show a stark distribution of food security, with only 1.6% of farmers feeling highly secure, 4% moderately secure, 1.6% neutral, a significant 32.4% moderately insecure, and a majority of 60.4% highly insecure. The combination of quantitative and qualitative analyses offered a deeper perspective on the diverse factors that shape farmers' experiences with food security.

Key discoveries include the surprising lack of significant influence from government interventions and climate policies on food security perceptions, despite initial assumptions. Interviews revealed that the practical application of these policies requires refinement to better suit the farmers' needs.

Furthermore, climate-adaptive agricultural methods like drought-resistant crops and efficient water use were not strongly linked to improvements in food security, with qualitative responses highlighting obstacles such as awareness levels and economic limitations. Addressing these issues could amplify the impact of such innovations.

Lastly, educational attainment and family size were identified as key influencers of food security perceptions. Education correlated with a better understanding of climate issues, suggesting the value of spreading knowledge. The influence of household size on resources and adaptation methods underlines the necessity for customized solutions.

Suggestions

To build upon the findings of the present investigation, it is recommended that subsequent research endeavors address the following areas to inform policy development:

1. Future investigations should aim to elucidate the specific obstacles that preclude smallholder farmers from accessing and deriving benefits from governmental support and climate-focused policies. Efforts must be directed towards refining these initiatives to resonate more effectively with the lived experiences and requirements of the farming populace, thereby bolstering their impact.
2. It is imperative to explore and devise strategies that surmount the impediments to the uptake of drought-resistant crops and water-efficient technologies. This could include the provision of specialized agricultural extension services, the establishment of financial incentives, and the mobilization of community outreach programs to heighten awareness and cultivate acceptance of these innovations.
3. The development and execution of educational programs, specifically designed for the agricultural sector, warrant attention. Such programs should concentrate on imparting knowledge about climate-resilient farming techniques, thus equipping farmers with the necessary competencies to contend with the ramifications of climatic flux.
4. The conduct of longitudinal research is advocated to monitor the temporal evolution of food security perceptions. This methodical inquiry would yield a deeper comprehension of the enduring effects that policy measures and environmental alterations exert on the food security of smallholder farmers.

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