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# The Impact of Village Savings and Loan Associations as a Financial and Climate Resilience Strategy for Mitigating Food Insecurity in Northern Ghana

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**Abstract:** In semi-arid Northern Ghana, smallholder farmers face food insecurity and financial risk due to climate change. In response, the Village Savings and Loan Association (VSLA) model, a community-led microfinance model, has emerged as a promising finance and climate resilience strategy. VSLAs offer savings, loans, and other financial services to help smallholder farmers cope with climate risks. In northern Ghana, where formal financial banking is limited, VSLAs serve as vital financial resources for smallholder farmers. Nevertheless, it remains to be seen how VSLAs can bridge financial inclusion and climate resilience strategies to address food insecurity. From a sustainable livelihoods framework (SLF) perspective, we utilized data from a cross-sectional survey of 517 smallholder farmers in northern Ghana's Upper West Region to investigate how VSLAs relate to food insecurity. Results from an ordered logistic regression show that households with membership in a VSLA were less likely to experience severe food insecurity (OR = 0.437, $p < 0.01$). In addition, households that reported good resilience, owned land, had higher wealth, were female-headed, and made financial decisions jointly were less likely to experience severe food insecurity. Also, spending time accessing the market increases the risk of severe food insecurity. Despite the challenges of the VSLA model, these findings highlight VSLAs' potential to mitigate food insecurity and serve as a financially resilient and climate-resilient strategy in resource-poor contexts like the UWR and similar areas in Sub-Saharan Africa. VSLAs could contribute to achieving SDG2, zero hunger, and SDG13, climate action. However, policy interventions are necessary to support and scale VSLAs as a sustainable development and food security strategy in vulnerable regions.

**Keywords:** VSLAs; climate resilience; financial resilience; food insecurity; sustainable livelihoods framework; smallholder farmers; semi-arid environment; Ghana



**Citation:** Pienaah, Cornelius K. A., and Isaac Luginaah. 2024. The Impact of Village Savings and Loan Associations as a Financial and Climate Resilience Strategy for Mitigating Food Insecurity in Northern Ghana. *Risks* 12: 58. https://doi.org/10.3390/risks12040058

Academic Editor: Steven Haberman

Received: 14 February 2024
Revised: 19 March 2024
Accepted: 21 March 2024
Published: 25 March 2024



## 1. Introduction

Financial inclusion and climate resilience are crucial to achieving sustainable economic growth and poverty reduction worldwide (Intergovernmental Panel on Climate Change [IPCC] 2018; Mhlanga 2022). The intersection of these issues is particularly pronounced in Sub-Saharan Africa (SSA), where climate change's adverse effects exacerbate financial exclusion, seriously undermining agricultural productivity and livelihood security (Intergovernmental Panel on Climate Change [IPCC] 2023). Food insecurity further complicates this situation as fluctuating environmental conditions disrupt farming systems and food supply chains, putting vulnerable communities at risk (Intergovernmental Panel on Climate Change [IPCC] 2018, 2023). Recent climate change predictions show that SSA recorded increased extreme temperatures and reduced precipitation, which cause far-reaching vulnerability, including poverty, climate-induced migration, and water insecurity (Intergovernmental Panel on Climate Change [IPCC] 2018, 2023). Ghana is no exception in terms of climate change impacts. The United States Agency for International Development's report on Ghana's climate risk predicts a rise in average annual temperatures between 1.4 and 5.8 °C by 2080, with the northern part

of Ghana experiencing the most tremendous increase. Hot days and nights will increase by 18–59 percent by 2060, and there will be an overall decrease in rainfall of 4.4 percent by 2040. The wet season will experience more erratic and intense rainfall, while the dry season will have lower precipitation levels. Sea surface temperatures will rise by approximately 2–4 °C, and the sea level will increase by 75–190 mm by 2100 (United States Agency for International Development [USAID] 2017).

Particularly in the semi-arid Upper West Region (UWR) of northern Ghana, persistent food insecurity disproportionately affects smallholder farmers and their communities due to climate change (Luginaah et al. 2009; Atuoye et al. 2019; Kansanga et al. 2022). Smallholder farmers in the region struggle due to their heavy reliance on rain-fed agriculture, which leads to low productivity and increased vulnerability (Ministry of Food and Agriculture [MOFA] 2019). Smallholder farmers in the UWR have limited access to resources (e.g., finance). They are frequently affected by extreme weather events, such as floods, droughts, dry spells, storm surges, erratic rainfall, pests, and disease outbreaks. This makes their situation more challenging (Nyantakyi-Frimpong and Bezner-Kerr 2015; Pienaah et al. 2023).

The VSLA model has been identified as a promising solution to address the financial challenges, climate change impact, and food insecurity issues faced by smallholder farmers in the UWR. This approach was pioneered by CARE International in Niger in 1991 and has since been implemented successfully in several countries in SSA (CARE International 2017). VSLAs typically consist of 10 to 30 members who meet regularly to save and borrow money. Members contribute a fixed amount of money (i.e., an affordable and agreed-upon amount) each week or month which is then pooled to form a common fund (CARE International 2018). This fund is then used to provide small loans to members at low interest rates (10% to 12%) or to support collective income-generating activities (CARE International 2018; Lanidune 2021). Interest earned from loans contributes to the group's fund, and a portion of savings is set aside in a social fund (also called an emergency fund or welfare fund) (Pienaah et al. 2022). At the end of a cycle, savings and profits are distributed back to members based on their savings, with some profit accumulated from repaid loans. Typically, VSLAs operate in areas with limited access to formal financial services (CARE International 2017).

Previous studies have increasingly recognized VSLAs as powerful tools for supporting smallholder farmers' needs. According to Ksoll et al. (2016), VSLAs provide an opportunity for smallholder farmers to access loans and savings that they may not have been able to access from formal financial institutions due to a lack of collateral or high interest rates (Lanidune 2021; Pienaah et al. 2022). VSLAs also empower individuals, particularly women in rural areas, and promote financial literacy, risk, and management skills (CARE International 2018; Brannen and Sheehan-Connor 2016; CARE International 2017). VSLAs have also been reported to be flexible and can be customized to meet the specific needs of a community (Pienaah et al. 2022). For instance, VSLAs can provide loans for agriculture inputs or support local businesses. VSLAs also promote community participation and ownership, develop a solid social network and sense of community, and serve as platforms for training (Brannen and Sheehan-Connor 2016; CARE International 2017). The core tenet of the VSLA model is that the most efficient way to support financially marginalized individuals, particularly women, is by facilitating the acquisition of financial management skills and assets through savings rather than resorting to debt-based financing (Hendricks and Chidiac 2011).

Indeed, studies elsewhere have shown that VSLAs face challenges, such as the theft of VSLA savings boxes, the mismanagement of funds, and unequal access among community members (Marshall et al. 2023; United States Agency for International Development [USAID] 2019). In addition, VSLAs are not yet regulated by financial authorities, which can lead to financial fraud. VSLAs rely heavily on trust and social cohesion within a community, and conflicts, poor leadership, and disagreements among members can disrupt or collapse VSLAs (Pienaah et al. 2022).

Despite several drawbacks, VSLAs operate with financial risk management to ensure longevity and safeguard members' savings. For instance, VSLAs use a lockbox that requires

three keys to manage savings collection and provide security. A different member holds each key, and another member keeps the democratically elected box, preventing unauthorized access to funds (CARE International 2017). To ensure the growth of the group, typical rules for loan disbursement and recovery include loans that cannot exceed three times the amount saved by a member, repayment within six months, and a 10% interest rate that benefits both borrowers and the group. In times of crisis, such as illness or natural disasters, risk pooling is another strategy that VSLAs use to support members (CARE International 2017; Brannen and Sheehan-Connor 2016). Members contribute to a social welfare fund, creating a safety net that reduces individual risk. The loan portfolio is diversified, and loans are encouraged to support various purposes like agriculture, education, and small-scale business startups. This spreads the risk and ensures the group's success does not rely on a single economic activity. VSLAs regularly conduct financial literacy and business management training and capacity-building workshops to improve members' ability to make informed financial decisions (CARE International 2018; CARE International 2017). Governance and policymaking are also essential, with clear rules around loan repayment and the consequences of defaulting. These measures ensure discipline and protect the group's finances. VSLAs manage external shocks, such as adjusting loan terms following poor harvests, to help members recover without jeopardizing their financial standing or the group's resources. Through these practices, VSLAs create a resilient financial ecosystem that supports members' needs while effectively managing and mitigating risks (CARE International 2018; CARE International 2017).

In Ghana's UWR, VSLAs differ from other traditional savings concepts such as "Susu" and "Merry-Go-Round", which have been prevalent for generations. The "Susu" model involves a collector visiting clients regularly to collect fixed amounts of savings which are then returned to the clients after a period, deducting a fee. This approach emphasizes the significance of discipline and regularity in saving. "Merry-Go-Round", on the other hand, is an informal savings scheme that gained popularity in Ghana. During meetings, members contribute fixed amounts into a pot, which is then given entirely to one member at each meeting. The cycle continues until all members have received the pot once, providing access to lump sums useful for various needs or small investments. The primary differences lie in their structure and goals. Susu, for instance, prioritizes savings with the help of a coordinator to simplify the procedure. On the other hand, the Merry-Go-Round system is a savings technique that provides prompt lump sum payouts to members in a rotational approach. Meanwhile, VSLAs adopt a comprehensive approach by integrating savings, loans, financial risk management, and occasionally education into a self-regulated group model. Each method caters to diverse needs and formality levels when managing communal savings and loans.

Nevertheless, for smallholders in the UWR, VSLAs remain reliable sources of funding strength in the absence of banks in rural areas. These resources help farmers invest in their farms and small businesses, enhancing their resilience. In the face of increasing challenges posed by climate change and financial exclusion, addressing food insecurity has become an urgent priority. This is especially true in semi-arid environments (Nyantakyi-Frimpong 2020; Pienaah et al. 2023), where the impact of climate change is particularly severe and the risk of food insecurity is high (Kansanga et al. 2022; Atuoye et al. 2019). To this end, it is essential to understand the role of VSLAs in mitigating financial risks and enhancing food security among smallholder farmers. Although VSLAs have the potential to bring various benefits, more research is needed on their effectiveness in mitigating food insecurity. The impact of VSLAs on reducing food insecurity remains relatively unexplored and requires further investigation. To fill this gap, this study draws on cross-sectional data from smallholder farmers in Ghana's UWR to investigate the impact of VSLAs on food security. Specifically, this study examines the relationship between VSLAs and food insecurity in the context of climate resilience. By understanding the impact of VSLAs on smallholder farmers' financial security and food security, policymakers and other stakeholders can create effective strategies to enhance the livelihoods of vulnerable populations in the face of climate change and economic

uncertainty. This study is timely as it could contribute to promoting financial inclusion, social empowerment, and resilience to climate change and addressing food insecurity in rural areas through VSLAs. Policymakers are urged to support and regulate VSLAs, facilitate access to financial services, and integrate them into broader development programs. These efforts can contribute to achieving several Sustainable Development Goals (SDGs), such as SDG 1 (no poverty), SDG 2 (zero hunger), SDG 5 (gender equality), and SDG 8 (decent work and economic growth). The rest of this paper is structured into six sections following this introduction. The following section provides a theoretical overview. Then, we discuss the context of our study, data collection methods, and analytical approach. Next, we present our results and discuss the results and limitations of this study. Finally, we offer concluding remarks and policy recommendations.

## 2. Theoretical Framework

This study is underpinned by the Sustainable Livelihoods Framework (SLF) developed by (British Department for International Development [DFID] 2000) and complimented with resilience thinking (Folke et al. 2002; Pizzo 2015). The SLF comprehensively explains how individuals and communities sustain their living, particularly in challenging environments such as Ghana's semi-arid UWR. This study utilized the SLF to explore and focus on how VSLAs influence smallholder farmers' food insecurity experience amidst financial risk management and climate change by examining the complex interplay between various SLF assets and external impacts that shape livelihood outcomes. The SLF identifies five types of assets or "capitals" that households rely on to build their livelihoods and resilience: social, human, natural, physical, and financial (British Department for International Development [DFID] 2000; Alhassan et al. 2018). Resilience theory also emphasizes the importance of adaptive management practices, which allow farmers to continually monitor and adjust their strategies in response to changing conditions amidst SLF capitals (Folke et al. 2002). In semi-arid Ghana, VSLAs primarily affect smallholder farmers' financial capital (involving how finances are managed). Still, the effect also extends to social (social cohesion) and human capital (mutual support systems by group members). The International Labour Organization [ILO] (2022) observed that by providing access to savings and loans/credit, VSLAs enable farmers to invest in agricultural inputs (like seeds and fertilizers) and farm mechanization (payment for tractor services), diversify their income sources, and manage risks associated with farming in a semi-arid environment. With access to financial resources, smallholder farmers can better withstand and recover from shocks and stresses, such as by investing in building flood drains and channels, making them resilient (Holling 1973). Moreover, VSLAs foster community networks and collective action, which enhance social capital while developing financial management skills and sustainable farming practices that improve human capital (Bolin 2020). VSLAs significantly influence the livelihood strategies of smallholder farmers by enabling them to take action to secure necessities like shelter, water, and food. By providing financial resources and a platform for collective action and learning, VSLAs enable farmers to enhance their social networks, thereby building social capital that can further strengthen their climate change resilience. For example, the welfare fund of a VSLA can be utilized to invest in climate actions like raising seedlings of economic trees such as shea, mango, moringa, and cashews for restoration and agroforestry practices. This investment could lead to increased finances, food resources, and building community environmental stewardship through collective action. By incorporating resilience theory into their farming practices, smallholder farmers can increase their ability to withstand and adapt to various challenges and uncertainties (Walker et al. 2004). The SLF also considers the external environment in which livelihoods are pursued, including policies, institutions, and processes that impact livelihood options (British Department for International Development [DFID] 2000). External factors such as limited market access and fluctuation can impact VSLAs and their members. VSLA members might find selling their goods or services challenging, reducing their income and ability to repay loans. Fluctuating market conditions can also affect the value of goods and services, leading to uncertainty and

financial instability for VSLA members. For example, severe and frequent extreme weather events, such as floods, droughts, and erratic rainfall, disrupt farming systems and food supply chains, putting vulnerable communities at risk of food insecurity. Also, unfavorable policies, such as high taxes and tariffs on agricultural products, can constrain smallholder farmers' profitability and discourage them from participating in VSLAs. In addition, failed agricultural policies [such as the Government of Ghana's planting for food and job (PFJ), One Village one Dam (1V1D), and Planting for export and rural development (PERD)] and climate variability contribute, affecting smallholder farmers in the UWR. VSLAs can mitigate some of these external vulnerabilities by providing a buffer against economic stress and shocks, providing access to information and resources that help farmers adapt to external impacts. Sustainability is a crucial aspect of the SLF (British Department for International Development [DFID] 2000; International Labour Organization [ILO] (2022)). For smallholder farmers in semi-arid regions, a sustainable livelihood suggests maintaining and enhancing food security over time, regardless of economic and environmental challenges. In this context, VSLAs contribute to this sustainability by improving the resilience of smallholder farmers' livelihoods, allowing them to adapt to and recover from economic, social, and environmental stresses and shocks (by pooling their savings). While the SLF and resilience theory may not completely capture all the complexity of local contexts, the dynamic nature of climate resilience, or economic and food insecurity vulnerabilities, applying the theories provides deeper insights into how VSLAs can contribute to more resilient and sustainable livelihoods, ultimately leading to enhanced regional food security.

## 3. Study Context

This study was conducted in the Upper West Region (UWR) of Ghana, located between the coordinates 9.8° 11.0° N and 1.6° 3.0° W, which is a vast, semi-arid area of 18,476 square kilometers (Figure 1). The region has a population of 901,502 people (Ghana Statistical Services [GSS] 2021). It is characterized by the Guinea Savannah zone that experiences a single rainfall season from April/May to October, followed by a long dry season (with harmattan) from November to March (GSS 2020). The unpredictable temperatures in the region range from 21 °C to 40 °C. The annual precipitation varies from 840 mm to 1400 mm. These factors lead to changes in the cropping calendar of smallholder farmers and ultimately impact agricultural productivity (Ministry of Food and Agriculture [MOFA] 2019). The landscape of the UWR is characterized by perennial bushfire and drought-tolerant scattered trees such as *Parkia biglobosa* (dawadawa), *Blighia sapida* (ackee), *Vitellaria paradoxa* (shea), *Faidherbia albida* (Acacia albida), and *Adansonia digitata* (baobab) (Pienaah et al. 2024). The region is primarily rural and is considered one of Ghana's economically underdeveloped areas. The region is regarded as the poorest in the country, with 90% of the residents living on less than one dollar (1 USD) daily (GSS 2019). The poverty rates are the highest in the Wa East, Wa West, and Nadowli-Kaleo Districts, with 92.4%, 83.8%, and 68.5%, respectively (GSS 2015). In the UWR, most households rely on agriculture as their primary source of income. About 80.4% of the workforce comprises smallholder farmers, with 42% of them being women (Ministry of Food and Agriculture [MOFA] 2019). The region also offers apiculture opportunities. Smallholder farmers cultivate rainfed plots smaller than 2 acres with limited irrigation systems in the UWR (Ministry of Food and Agriculture [MOFA] 2019; GSS 2020). The region faces soil degradation and water scarcity, exacerbating the vulnerability of smallholders due to the limited resources they have to invest to maintain soil health and secure water for domestic, livestock, and agricultural needs (GSS 2020). Shea is a crucial livelihood source for women in the UWR but faces a decline, further restraining women's income and livelihood and resulting in less livelihood to save in VSLAs (Pienaah et al. 2024). The UWR has four major ethnic groups (Dagaaba, Sissala, Waala, and Brifo). It is a male-dominated society, which can affect VSLAs in this social context.

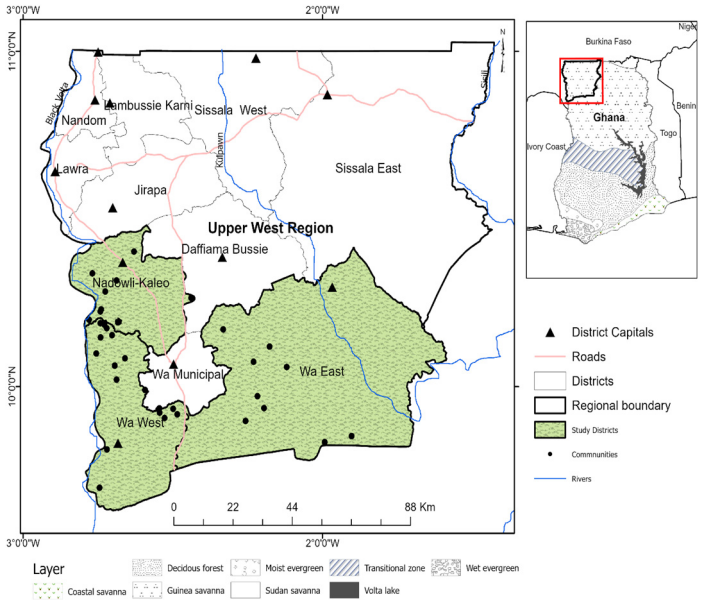


**Figure 1.** A modified map of the UWR showing the study area (Pienaah et al. 2023).

The UWR faces numerous challenges, including migration, poor health and sanitation, and high illiteracy rates (Luginaah et al. 2009). The local economy heavily relies on subsistence agriculture, with smallholder farming as the livelihood approach (GSS 2020; Pienaah et al. 2022). However, limited access to technology and dependence on traditional farming methods intensify smallholder farmers' challenges in the semi-arid climate, making farming highly vulnerable to changes in extreme weather patterns and directly affecting food security in the region (Pienaah et al. 2023). Moreover, the region has limited financial service opportunities, which further constrains economic prospects and resilience within local communities (GSS 2015; Kansanga et al. 2022; Pienaah et al. 2023). In the region, there are approximately 6 to 10 formal banks. These banks are mainly located in the regional capital, the UWR, Wa, and a few others in three additional municipalities, namely Lawra, Tumu, and Nandom. However, regarding the specific districts under study, only one rural bank and one cooperative credit union are operational. This highlights the existence of a formal financial gap in these areas. Agriculture in the UWR primarily depends on rainfall for crop growth rather than irrigation systems, making it highly susceptible to fluctuations caused by its semi-arid climate. This reliance on rain as the source for growing crops leads to variations in the annual agricultural output, directly impacting food availability and security (GSS 2020). The region often experiences problems such as crop failures and food shortages, putting the population at a heightened risk of food insecurity (Luginaah et al. 2009; GSS 2020). In this situation, VSLAs emerge as a solution to mitigate the effects of these challenges on food security. However, Ghana has no legally binding policy regulating VSLA operations despite their contribution to the financial sector. The UWR boasts a wealth of diversity, with various ethnic groups coexisting cordially with their unique traditions and social systems. This cultural richness greatly influences community dynamics, affecting how decisions are made collectively, gender roles are defined, and resources are shared. These factors ultimately have an impact on the issue of food security. Therefore, this study's focus within the context of Ghana's UWR is strategically important due to the convergence of constraints, challenges, and the potential role of VSLAs in addressing food insecurity.

## 4. Materials and Methods

### *4.1. Data and Sample*

As part of a larger study on the impact of Community Resource Management Areas (CREMAs) on improving livelihoods and climate change resilience, we collected data

from 517 households involved in agricultural activities in the UWR of Ghana. The households were chosen based on the criteria outlined in the 2017/18 Census of Agriculture conducted by the Ghana Statistical Service (GSS 2020). We employed a two-stage sampling approach to obtain data that accurately represent the population. This involved surveying 517 households across 36 communities in three districts—Wa East, Wa West, and Nadowli-Kaleo—using a systematic sampling technique. Our objective was to ensure that the sample size of 517 households accurately reflects the estimated population of 2604 households. We started by creating a comprehensive list of households, which we then used to randomly select one household from the first five on the list. After that, we systematically selected every household to participate in the survey. We analyzed the data gathered from these households and concluded that our sampling method achieved an unbiased and well-balanced survey outcome. We chose the districts and communities because they are integral to the broader study. In all, we identified 520 households, representing a response rate of 99%, and we successfully interviewed 517 household representatives. Using a questionnaire, we conducted surveys with the lead farmer of each household who was at least 18 years old and could effectively represent their household's perspective. We utilized the Household Food Insecurity Access Scale (HFIAS) developed by Coates et al. (2007) to assess household food insecurity experience. Scholars have previously used the HFIAS, including Atuoye et al. (2019) and Kansanga et al. (2022). We collected data on climate change resilience and preparedness, water and energy security, dietary diversity, government and community support systems, household demographics, sociocultural, socioeconomic, agriculture outputs, and health-related characteristics. The data collection occurred between 10 November 2022 and 31 January 2023 in the UWR of Ghana. This period was strategically chosen to coincide with the post-harvest season in Northern Ghana, which is a critical time for evaluating food security and VSLA effectiveness in managing financial risks associated with agricultural outputs. It was also a reasonable period to survey smallholder farmers and obtain specific responses regarding the production and harvest seasons and their experiences with climatic conditions like drought, erratic/no rainfalls, the harmattan, and water scarcity. The University of Western Ontario Non-Medical Research Board ethically approved this research.

### *4.2. Measurement*

This study measured food insecurity as the outcome variable, using the Household Food Insecurity Access Scale (Coates et al. 2007; Knueppel et al. 2010) to understand how households experienced access, affordability, utilization, and food stability over the past four weeks. The HFIAS is a questionnaire-based tool that explores the psychosocial aspects of food insecurity within households using a set of nine items. These items capture the occurrence and frequency of manifestations of food insecurity by assigning scores ranging from 0 to 3 based on the frequency of feelings of anxiety about food access, the perception of food quality, inadequate food intake, and hunger. For example, study participants were asked to indicate if they or any household member needed help consuming the foods they usually preferred due to a lack of resources in the past month. They responded with a "yes" or "no" and then specified how often it occurred using predefined options like "rarely", "sometimes", or "often." The scores ranged from 0 to 27. To create the food security metric, the responses to the nine questions were combined with their associated frequencies, resulting in a four-tiered classification system for food insecurity. Participants were classified as food secure (coded as "1"), mildly food insecure (coded as "2"), moderately food insecure (coded as "3"), and severely food insecure (coded as "4"). Other studies that utilized this measurement include Miller et al. (2021) and Bethancourt et al. (2023).

The focal independent variable in this study is membership in a VSLA. The study participants were asked to indicate if any household member was active in a VSLA in the past 12 months before the survey. VSLA members typically enjoy the advantages of saving money through contributions to the group's funds, accessing loans, and receiving a share of the profits generated by interest on loans. Members actively participate in decision-making

processes, influence the VSLA's rules, and take out loans. On the other hand, non-members do not have access to these benefits and cannot save or borrow with a VSLA. Non-members only interact with a VSLA for external transactions if they comply with the rules set by the VSLA. The response was coded as 0 = non-member and 1 = member.

Other theoretically relevant explanatory variables were included. We measured the climate change resilience of smallholder farming households as Jones and Tanner (2017) suggested. To assess the households' resilience, we asked them about their ability to anticipate, adapt to, and recover from extreme climate events such as floods, droughts, dry spells, erratic rainfall, and storm surges they had experienced in the previous 12 months. We asked them to rate their overall climate resilience on a scale of 0 (poor) to 3 (good). We coded the responses as follows: poor and satisfactory resilience were coded as 1 (poor climate resilience), while good resilience was coded as 2 (good climate resilience). Other scholars have also used this measurement, including Oriangi et al. (2020), Kansanga et al. (2022), and Pienaah et al. (2023). Apart from climate resilience, we also measured other variables, such as access to credit (0 = no; 1 = yes) from other financial sources (like Susu and Merry-Go-Round systems and banks), excluding the VSLA system. We also looked at households receiving remittances based on other external sources of financial resources, received and coded as 0 = no and 1 = yes. We added continuous variables such as time spent accessing the market, land ownership, and age. Education was measured as no formal education = 0, primary education = 1, and secondary education or above = 2; marital status was measured as 0 = single, 1 = married, and 2 = widowed/divorced; and ethnicity was measured as 0 = Dagaaba, 1 = Sissala, 2 = Brifo, and 3 = Waala. Household size was measured as 0 = 1–4, 1 = 5–8, and 2 = 9+, while wealth quantile was measured as 0 = poorest, 1 = poorer, 2 = middle, 3 = richer, and 4 = richest. We also looked at whether participants had received financial management training from sources such as cooperative credit unions, workshops, and seminars (0 = no; 1 = yes), if their household was involved in government subsidy programs, such as receiving fertilizer coupons or having a household member enrolled in a social protection scheme like livelihood empowerment against poverty (LEAP) and whether they had National Health Insurance Scheme (NHIS) coverage (0 = no; 1 = yes). Finally, we determined gender roles in household financial decision making based on how participants described daily financial decisions are made in their households. We coded it as follows: 0 = male head only, 1 = female head only, and 2 = joint decision making including all household members. In addition, we also combined participants' self-rated health responses into two categories, following the work of Amoak et al. (2023): poor health (comprising "fair" and "poor") and good health (including "excellent", "very good", and "good"), which was coded as 0 = poor health and 1 = good health. Furthermore, we also considered the residential district of participants and coded it as follows: 0 = Nadowli-Kaleo, 1 = Wa East, and 2 = Wa West.

### *4.3. Analytic Approach*

We employed a three-stage analysis involving descriptive statistics, bivariate, and multiple logistic regression analyses. Firstly, we conducted a univariate analysis to examine the distribution of all the variables in our study. Subsequently, we utilized ordinal logistic regression (OLR) at the bivariate level to investigate the association between each predictor variable and the food insecurity situation experienced by smallholder farmers. Finally, we employed multiple proportional odds logistic regressions to examine the combined effect of the predictor variables on smallholder farmers' food insecurity experiences. Since the outcome variable (food insecurity) was ordered into four categories, we determined that ordinal logistic regression was the most appropriate method. Other scholars who have measured the outcome variable using OLR include Atuoye et al. (2019) and Amoak et al. (2023). The formula for OLR is as follows (Hedeker et al. 2000):

$$log\frac{P(Yij \leq 1)}{(1 - P(Yij \leq 1)} = \alpha_0 + \sum_{k=1}^{p-1}\left(\alpha_{jk}X_{ijk} + V_{ij,}C = 1, \ldots .\Omega - 1\right)$$

where $P\ (Yij \leq 1)$ represents the probability of an event occurring, $[(1 - P(Yij \leq 1))]$ represents the probability that the event will not happen, $\alpha_{jk}$ denotes the coefficient element, $X_{ijk}$ represents the determining variables, $k = 1$ indicates the initial and $p - 1$ indicates the final explanatory variables, $\alpha_0$ and $\Omega - 1$ act as intercept components, and *Vij* represents the difference term in the model (Snijders and Berkhof 2008; Murad et al. 2003). We employed a likelihood estimation method to calculate the odds ratios for households reporting levels of food insecurity (Hedeker et al. 2000; Akaike 1998). The OLR coefficients are shown as odds ratios. Odds ratios exceeding one (OR > 1) show a higher likelihood of food insecurity, and odds ratios below one (OR < 1) demonstrate a lower likelihood (Hedeker et al. 2000). We examined the regression model for multicollinearity by utilizing the Variable Inflation Factor (VIF). The VIF values for all variables were below 2.0 with a 1.32 VIF average, indicating minimal multicollinearity in the multivariate regression model. We assessed the model's reliability using R-squared, the Akaike Information Criterion (AIC), and the Bayesian Information Criterion (BIC), which show a good fit for our model. Our model explains 12% of the variance in food insecurity among smallholder farmers in semi-arid Northern Ghana, with an R-squared value of 0.12. While this value might appear modest, it is significant within the complex and multifactorial context of climate resilience and agricultural productivity. This highlights the contribution of VSLAs amidst other unquantified variables influencing food security. Our model's AIC and BIC values are 1080.10 and 1202.29, respectively, indicating a good balance between goodness of fit and parsimony. Although no single model can capture all the nuances of climate impacts on agriculture, our analysis demonstrates a judicious application of statistical measures to ensure the reliability and validity of our findings. We conducted a reliability analysis of our questionnaire data to ensure consistency and stability (George and Mallery 2003), enhancing the study's credibility. Our analysis included Cronbach's Alpha, split-half reliability, and test–retest reliability tests. We achieved a Cronbach's Alpha scale reliability of 0.085 with 19 items on the scale and an average inter-item covariance of 6.815, a good split-half reliability coefficient of 0.80, and an acceptable to good test–retest reliability coefficient of 0.78. These reliability measures confirm the robustness of our data collection process and reinforce the validity of our conclusions. The analysis was performed using Stata 18.

## 5. Results

### *5.1. Univariate Results*

The univariate results are presented in Table 1, providing an overview of the variables examined. The HFIAS scale shows a mean score of 11.741, with 15.09% of households being food secure and 21.28% severely food insecure. Also, 51.26% of households have at least one member in a VSLA, but 67.7% perceive their climate resilience to be poor. In addition, 40.23% have access to farming credit, and 12.19% receive remittances. Households take an average of 66.28 min to reach the nearest market, own an average of 51 acres of land, and range in age from 18 to 91. Additionally, 57.45% have no access to government subsidies (like fertilizer) or social protection programs like LEAP and the NHIS, and 36.56% employ joint decision-making regarding household finances.

**Table 1.** Descriptive statistics of smallholder livelihoods and food insecurity.

| Variables | Percentage (%)/Mean |
|---|---|
| Household food insecurity (HFIAS scale) | 11.741 (mean) |
| Food secure | 15.09 |
| Mildly food insecure | 37.72 |
| Moderately food insecure | 25.92 |
| Severely food insecure | 21.28 |
| Village Savings and Loans Association (VSLA) | |
| Non-member | 48.74 |
| Member | 51.26 |
| Climate resilience | |
| Poor | 67.70 |
| Good | 32.30 |
| Access to credit (Excluding VSLAs) | |
| No | 59.77 |
| Yes | 40.23 |
| Receipt remittances | |
| No | 87.81 |
| Yes | 12.19 |
| Time spent to access the market | 66.28 (mean) |
| Land ownership | 50.766 (mean) |
| Age | 44.37 (mean) |
| Gender | |
| Male | 88.59 |
| Female | 11.41 |
| Level of education | |
| No formal education | 71.95 |
| Primary | 18.57 |
| Secondary or higher | 9.48 |
| Marital status | |
| Single | 10.83 |
| Married | 77.37 |
| Divorced/Widowed/Separated | 11.80 |
| Ethnicity | |
| Dagaaba | 60.54 |
| Sissala | 15.28 |
| Brifo | 12.38 |
| Waala | 11.80 |
| Household size | |
| 1–4 | 26.89 |
| 5–8 | 43.71 |
| 9+ | 29.40 |
| Household wealth | |
| Poorest | 24.95 |
| Poorer | 16.63 |
| Middle | 19.92 |

**Table 1.** *Cont.*

| Variables | Percentage (%)/Mean |
|---|---|
| Richer | 17.60 |
| Richest | 20.89 |
| Financial management training | |
| No | 61.32 |
| Yes | 38.68 |
| Enrolled in government social protection and subsidy | |
| No | 57.45 |
| Yes | 42.55 |
| Gender roles in financial decision making | |
| Male head | 31.14 |
| Female head | 32.30 |
| Joint decision | 36.56 |
| Self-rated health | |
| Poor | 62.48 |
| Good | 37.52 |
| Residential district | |
| Nadowli-Kaleo | 23.40 |
| Wa East | 32.30 |
| Wa West | 44.29 |

### *5.2. Bivariate Results*

Table 2 presents the results of our study, indicating the relationship between several factors and the risk of food insecurity. Our findings revealed that the time spent accessing the market significantly impacted food insecurity, with an increase in the time spent leading to a decrease in the likelihood of experiencing food insecurity (OR = 0.003, $p < 0.01$). Similarly, owning land was associated with an increased risk of food insecurity (OR = 0.001, $p < 0.001$). Ethnicity also emerged as a factor, with the Sissala (OR = 1.992, $p < 0.001$), Brifo (OR = 7.637, $p < 0.001$), and Waala (OR = 2.576, $p < 0.001$) ethnic groups being at a higher risk of experiencing severe food insecurity compared to the Dagaaba group. Our study also found a relationship between household wealth and food insecurity, with households classified as poorer (OR = 0.538, $p < 0.01$), middle (OR = 0.504, $p < 0.001$), richer (OR = 0.341, $p < 0.001$), and richest (OR = 0.400, $p < 0.001$) being less likely to experience severe food insecurity compared to the poorest. Gender roles in financial decision making also played a role in the risk of severe food insecurity. Households in which decisions were made jointly (OR = 0.376, $p < 0.001$) or with a female head (OR = 0.375, $p < 0.001$) were less likely to face severe food insecurity compared to those with a male head. Additionally, the individuals who rated their health as good had a lower likelihood of experiencing food insecurity than those who rated it as poor (OR = 0.685, $p < 0.01$). Geographical location was also found to affect food insecurity, with residents of Wa East having a higher chance of experiencing food insecurity than those in Nadowli-Kaleo (OR = 1.826, $p < 0.001$). These findings highlight the importance of considering demographic, socioeconomic, household decision-making, and geographic factors when assessing the risk of severe food insecurity.

**Table 2.** Bivariate ordered logistic regression predicting food insecurity.

| Variable | Bivariate OR (SE) | [95% CI] |
|---|---|---|
| VSLA (ref: non-member) | | |
| Member | 0.779 (0.124) | 0.570–1.066 |
| Climate resilience (ref: poor) | | |
| Good | 0.750 (0.130) | 0.533 (1.055) |
| Access to credit excluding VSLAs (ref: no) | | |
| Yes | 0.912 (0.148) | 0.662–1.256 |
| Receipt remittances (ref: no) | | |
| Yes | 0.717 (0.184) | 0.433–1.186 |
| Time spent to access the market | 0.003 (0.001) ** | 0.001–0.006 |
| Land ownership | −0.001 (0.001) *** | −0.002–−0.001 |
| Age | 0.002 (0.005) | −0.008–0.0137 |
| Gender (ref: male) | | |
| Female | 1.444 (0.372) | 0.871–2.395 |
| Level of education (ref: no formal education) | | |
| Primary | 1.114 (0.232) | 0.740–1.677 |
| Secondary or higher | 0.800 (0.214) | 0.474–1.352 |
| Marital status (ref: single) | | |
| Married | 0.606 (0.158) | 0.362–1.013 |
| Divorced/widowed/separated | 0.862 (0.291) | 0.444–1.673 |
| Ethnicity (ref. Dagaaba) | | |
| Sissala | 1.992 (0.452) *** | 1.277–3.108 |
| Brifo | 7.637 (2.135) *** | 4.414–13.212 |
| Waala | 2.576 (0.669) *** | 1.548–4.287 |
| Household size (ref: 1–4) | | |
| 5–8 | 0.947 (0.185) | 0.645–1.390 |
| 9+ | 0.943 (0.203) | 0.619–1.438 |
| Household wealth (ref: poorest) | | |
| Poorer | 0.538 (0.137) ** | 0.326–0.888 |
| Middle | 0.504 (0.120) *** | 0.316–0.805 |
| Richer | 0.341 (0.086) *** | 0.208–0.561 |
| Richest | 0.400 (0.097) *** | 0.248–0.645 |
| Financial management training (ref: no) | | |
| Yes | 0.967(0.160) | 0.699–1.338 |
| Enrolled in government social protection and subsidy (ref: no) | | |
| Yes | 0.982 (0.158) | 0.715–1.347 |
| Gender roles in financial decision-making (ref: male head) | | |
| Female head | 0.375 (0.075) *** | 0.252–0.557 |
| Joint decision | 0.376 (0.075) *** | 0.254–0.557 |
| Self-rated health (ref: poor) | | |
| Good | 0.685 (0.115) ** | 0.493–0.953 |
| Residential district (ref: Nadowli-Kaleo) | | |
| Wa East | 1.826 (0.386) *** | 1.205–2.765 |
| Wa West | 1.284 (0.259) | 0.864–1.908 |

** $p < 0.01$; *** $p < 0.001$. OR = odds ratio; SE = standard error; CI = confidence interval.

### *5.3. Multiple Regression Analysis Results*

The results of the multiple ordered logistic regression analysis are presented in Table 3. The analysis reveals that becoming a VSLA member can significantly reduce the chances of severe food insecurity (OR = 0.437, $p < 0.01$) compared to non-VSLA members. This indicates that participating in VSLA programs can positively impact households' food security outcomes. Additionally, households that rate their climate resilience as good are less likely to experience severe food insecurity than those with poor climate resilience (OR = 0.560, $p < 0.001$). Interestingly, spending more time accessing the market can increase the risk of severe food insecurity (OR = 1.005, $p < 0.001$), while owning land is somewhat associated with a decreased risk (OR = 0.998, $p < 0.001$). Ethnicity also plays a significant role in this context. For instance, compared to the Dagaaba group, the Sissala group has a lower likelihood of experiencing severe food insecurity. In contrast, the Brifo group has a substantially higher risk of severe food insecurity (OR = 7.271, $p < 0.001$). Household wealth also emerged as a significant predictor, with the richer (OR = 0.398, $p < 0.001$) and the richest (OR = 0.411, $p < 0.001$) categories being less prone to severe food insecurity compared to the poorest. Gender roles in financial decision making also revealed that households with a female head (OR = 0.559, $p < 0.01$) or households in which decisions were made jointly by male and female heads and other household members (OR = 0.351, $p < 0.001$) were less likely to experience severe food insecurity compared to male-headed households. Furthermore, the residential district also played a role, with living in Wa East (OR = 6.753, $p < 0.001$) being associated with a higher risk of severe food insecurity than Nadowli-Kaleo. These results indicate that food insecurity is a complex issue requiring a nuanced approach. The findings suggest that interventions should consider factors such as VSLA membership, climate vulnerability, household wealth, gender equality, ethnicity, and geographic considerations to address food insecurity effectively.

**Table 3.** Ordered logistic regression analysis predicting severe food insecurity.

| Variable | Multivariate OR (SE) | [95% CI] |
|---|---|---|
| VSLA (ref: non-member) | | |
| Member | 0.424 (0.167) ** | 0.195–0.921 |
| Climate resilience (ref: poor) | | |
| Good | 0.560 (0.122) *** | 0.365–0.860 |
| Access to credit excluding VSLAs (ref: no) | | |
| Yes | 1.090 (0.247) | 0.699–1.701 |
| Receipt remittances (ref: no) | | |
| Yes | 0.750 (0.220) | 0.421–1.336 |
| Time spent to access the market | 1.005 (0.001) *** | 1.001–1.008 |
| Land ownership | 0.998 (0.001) *** | 0.997–0.999 |
| Age | 1.007 (0.007) | 0.992–1.023 |
| Gender (ref: male) | | |
| Female | 0.815 (0.335) | 0.363–1.826 |
| Level of education (ref: no formal education) | | |
| Primary | 1.023 (0.273) | 0.605–1.728 |
| Secondary or higher | 1.106 (0.398) | 0.546–2.241 |
| Marital status (ref: single) | | |
| Married | 0.823 (0.284) | 0.418–1.619 |
| Divorced/widowed/separated | 0.969 (0.473) | 0.372–2.526 |

**Table 3.** *Cont.*

| Variable | Multivariate OR (SE) | [95% CI] |
|---|---|---|
| Ethnicity (ref. Dagaaba) | | |
| Sissala | 0.388 (0.156) ** | 0.176–0.854 |
| Brifo | 7.216 (2.726) *** | 3.441–15.134 |
| Waala | 1.942 (0.669) | 0.988–3.818 |
| Household size (ref: 1–4) | | |
| 5–8 | 1.066 (0.260) | 0.660–1.722 |
| 9+ | 0.973 (0.279) | 0.553–1.710 |
| Household wealth (ref: poorest) | | |
| Poorer | 0.841 (0.265) | 0.452–1.563 |
| Middle | 0.721 (0.211) | 0.406–1.279 |
| Richer | 0.390 (0.121) *** | 0.211–0.719 |
| Richest | 0.391(0.124) *** | 0.209–0.730 |
| Financial management training (ref: no) | | |
| Yes | 0.875(0.195) | 0.564–1.357 |
| Enrolled in government social protection and subsidy (ref: no) | | |
| Yes | 0.643(0.260) | 0.291–1.421 |
| Gender roles in financial decision making (ref: male head) | | |
| Female head | 0.552(0.150) ** | 0.323–0.941 |
| Joint decision | 0.435(0.110) *** | 0.264–0.714 |
| Self-rated health (ref: poor) | | |
| Good | 0.715(0.162) | 0.458–1.117 |
| Residential district (ref: Nadowli-Kaleo) | | |
| Wa East | 7.617(2.999) *** | 3.520–15.479 |
| Wa West | 0.887(0.257) | 0.502–1.565 |
| Akaike Information Criteria (AIC) | 1080.10 | |
| Bayesian Information Criteria (BIC) | 1202.29 | |
| LR chi2 (28) | 151.13 | |
| Pseudo R2 | 0.12 | |
| Log-likelihood | −506.51 | |

** $p < 0.01$; *** $p < 0.001$, OR = odds ratio; SE = standard error; CI = confidence interval.

## 6. Discussion

Smallholder farmers in semi-arid environments are severely impacted by climate change and face economic uncertainties. However, examining sustainable solutions to food insecurity through community-based financial models remains underexplored in smallholder farmers' context. We drew data from a cross-sectional survey in Ghana's Upper West region and employed a sustainable livelihood framework (SLF) perspective to assess the association between Village Savings and Loan Associations (VSLAs) and smallholder households' food security outcomes amidst extreme climate risk within the context of semi-arid environments.

As observed from the SLF perspective, a VSLA promotes food security as its members report less risk of severe food insecurity. This is consistent with the works of Kwilasa (2017) in southern Africa, Mbiro and Ndlovu (2021) in Zimbabwe, and Ksoll et al. (2016) in Malawi, whereby VSLAs were found to reduce nutrition and food insecurity. The SLF emphasizes the importance of financial capital, and VSLAs contribute significantly to its enhancement among rural households in the UWR. By providing access to savings and loan facilities, VSLAs enable their members to manage financial shocks and invest in both

off-farm and on-farm activities (like shea butter processing, livestock rearing, beekeeping, and backyard gardening) crucial to their livelihoods, decreasing their vulnerability to food insecurity (Pienaah et al. 2024). The success of VSLAs in mitigating food insecurity in the UWR is likely due to several critical factors, including their ability to foster and promote savings and loan culture and improve financial literacy among smallholder farmers. In addition to these benefits, VSLAs provide a vital platform for social networking and collaboration between farmers and NGOs, promoting community cohesion and collective problem-solving. For example, NGOs collaborate with smallholder farmers in VSLAs to deliver agricultural extension programs (like farmer-filed schools/days and establishing farm demonstration plots) which help farmers acquire new skills to improve their agricultural productivity. By bridging the gap between formal banking and local communities, VSLAs enable smallholder farmers to access basic financial needs and manage agricultural and financial challenges (CARE International 2018; Brannen and Sheehan-Connor 2016), particularly during the COVID-19 pandemic. Finally, it is worth noting that VSLAs in the UWR are essential in supporting women, children, and youth disproportionately affected by food, nutrition, and income insecurity (Pienaah et al. 2022). The findings could also explain that VSLA members may have purchasing power, access to the market, and the ability to access and invest in farms that could improve their food security. Also, the financial management and literacy skills VSLA members acquire could translate to their households' long-term and sustainable financial decisions.

Our findings further demonstrated that households with good resilience, likely due to effective resource management and implementing sustainable farming practices, have a lower likelihood of severe food insecurity. This finding also reiterates the SLF, highlighting the critical role of "natural capital" in enhancing climate resilience, which is central to securing food resources in climate-vulnerable regions like the UWR. This finding is consistent with earlier studies emphasizing the importance of adaptive and sustainable capacities in semi-arid environments where agricultural productivity is closely tied to climatic conditions (Antwi-Agyei and Nyantakyi-Frimpong 2021; Nyantakyi-Frimpong and Bezner-Kerr 2015). VSLAs provide opportunities for individuals to save money and access loans, which can help them cope with financial emergencies and climatic risks (such as floods, erratic rainfall, and pest and disease outbreaks) and invest in income-generating activities (such as livestock rearing) toward building climate resilience. Furthermore, land ownership can also contribute to building resilience as it provides a secure and stable base for agricultural production, which can help smallholders deal with weather shocks and stresses.

Additionally, the findings show that an increased time required to access the market increases the chances of experiencing food insecurity. This can be explained by emphasizing the crucial role of "physical capital" in the context of the SLF. The association between food security and market accessibility, as observed in our study, aligns with the idea that market accessibility is an essential determinant of food security (Quaye 2008; Azechum 2017). In rural areas, limited transportation and infrastructure options can make it challenging to reach markets, which can considerably impact the cost, availability, quantity, and quality of food resources. This can worsen food insecurity, making it challenging to address. For instance, in the UWR, where communities depend on agriculture, market accessibility becomes even more threatening. Local production might not meet all food needs, making market reliance necessary for food security. Also, the travel time required to reach markets can limit the frequency of market visits, reducing households' access to fresh and diverse food items, a crucial aspect of food security. Furthermore, the time spent in transit can lessen other productive activities, such as farm work, petty trade, or employment, further challenging household economic stability and food security.

Moreover, the findings showed a relationship between land ownership and a reduced risk of severe food insecurity. This underscores the implication of "natural capital" within the SLF, adding to the discussion on food security. Owning land (a form of productive natural capital) is critical in mitigating food insecurity. Empirical evidence in the UWR

shows that land ownership provides a direct food source through agricultural production (on-farm activities) and generates income, which is fundamental in ensuring food security (Sabogu et al. 2020). In addition, owning land provides a support system (buffer) against food scarcity by enabling the cultivation of crops and rearing livestock for consumption and sale, which augments household food availability (Nchanji et al. 2023). This observed relationship is particularly relevant in agrarian communities where agriculture is the primary driver (backbone) of individuals' livelihoods and their economy. Also, in the UWR, landowners could have more stability and resources (for example, savings from a VSLA) to invest in agricultural improvements, such as backyard farming, fertilizers, improved seeds, and small-scale irrigation systems, which can enhance food production and reduce food insecurity vulnerability. Moreover, land ownership is also linked to increased social and economic status, which provides greater access to resources and markets, further contributing to food security. However, equitable land distribution and ownership remain significant barriers to food security, especially in developing countries. For example, landless populations, particularly women in the UWR, often face a more significant effect of food insecurity owing to their dependence on unstable agricultural productivity (Dery Bolang et al. 2023).

In furtherance of the analysis, the results show ethnic disparities in food insecurity, with the Sissala ethnic group having a reduced risk and the Brifo group showing a higher risk. This underscores the importance of "social and cultural capital" in the SLF. The findings suggest that access to critical resources and traditional knowledge varies among ethnic groups, significantly impacting food security. For instance, the Sissala group's lower odds of food insecurity could be explained through the significant presence of NGOs in the agricultural sector, such as GIZ, MEDA, Yara Ghana, AGRA, Voluntary Service Overseas (VSO), the Northern Rural Growth Programme (NRGP), and CARE International. Also, effective traditional agricultural practices such as organic farming and robust community support systems could enhance food security. On the other hand, the higher odds among the Brifo group could suggest limitations in these areas, possibly due to a lack of support systems or geographical factors that constrain their access to food security resources.

Consistent with Atuoye et al. (2019), the findings show a wealth disparity influencing food insecurity, with households classified as "richer" and "richest" having less risk of experiencing food insecurity. This finding strengthens the significance of "financial capital" as a crucial factor in the SLF. This study implies that economic resources (wealth, money, and assets) are necessary for safeguarding households against food insecurity. In Ghana's UWR, households with improved financial capital (purchasing power) can invest in essential agricultural labor, farm power, and inputs, adopt new technologies, and implement more sustainable and effective farming practices. These investments enhance the productivity and stability of their agricultural activities and protect against uncertainties and risks associated with a semi-arid environment. Higher household wealth and access to VSLA funds also facilitate access to diverse and nutritious food sources. They act as a safety net during economic or environmental shocks, improving food security outcomes.

This study's results on gender roles in financial decision making reveal that households headed by women and those in which financial choices are made jointly have a lower risk of experiencing food insecurity. The results resonate similarly with Malabayabas et al. (2023), who underscored joint decisions in households to reduce food insecurity. These findings align with the SLF 's emphasis on gender dynamics and "social capital", highlighting the broader impact of gender roles on decision-making processes, resource allocation, provisioning fairly and equitably, and household food security. In the context of Ghana's UWR, these outcomes suggest that households are more likely to attain and sustain food security outcomes when women participate equally or lead in financial decision making. Households prioritizing spending on nutritious food, healthcare, education, and sustainable agricultural practices are more likely to achieve and maintain food security. This can help ensure that food security needs are prioritized and resources are allocated fairly and

equitably. This can reduce the likelihood of severe food insecurity, particularly among vulnerable groups such as women and children.

Finally, the results show that stallholder farmers residing in the Wa East district are at a higher risk of food insecurity than those in the Nadowli-Kaleo district in Ghana's UWR. This disparity demonstrates the influence of geographic location (place factor) on food security, a fundamental concept at the center of the SLF. This study revealed that various aspects of "natural and physical capital", such as water availability, land fertility, varying exposure to specific climatic conditions, and access to services and markets, can differ significantly between different locations and can intensely impact food security outcomes. The findings could be explained from the perspective that the Wa East district, which has a significant poverty rate of 83.8% (GSS 2015), faces significant challenges related to "natural capital", such as severe water scarcity or less fertile land, which can hinder agricultural productivity and, in turn, enhance the risk of food insecurity. Furthermore, the higher odds of food insecurity in Wa East may also echo limitations in "physical capital", including poorer infrastructure (such as roads, telecommunication, health facilities, and transportation systems) and reduced market access.

While it offers valuable insights, our study on severe food insecurity has several limitations that warrant careful consideration. Firstly, the cross-sectional design limits our ability to infer causality between the observed factors and food insecurity. Additionally, reliance on self-reported data introduces potential biases due to inaccuracies in perception and recall. This study's geographic scope, confined to specific districts, may also limit the generalizability of the findings to other regions with different socio-economic and cultural dynamics. The operationalization and categorization of complex variables like household wealth and ethnicity might only partially capture their nuances. Finally, the sensitive nature of topics like food insecurity and poverty could impact the reliability of responses as participants might be influenced by social desirability bias or a reluctance to disclose certain information. These limitations highlight the necessity for cautious interpretations of our findings and underscore the importance of further research in this area.

## 7. Conclusions and Policy Implications

This study focused on the risk factors contributing to food insecurity among smallholder farmer households in the semi-arid Upper West Region of Ghana and identified several factors that policymakers need to consider. This study found that VSLAs, climate resilience, access to the market, land ownership, ethnicity, wealth, gender roles in financial decision making, and geographic location are all significant determinants of food insecurity risk in the UWR. This study emphasizes the positive impact of VSLAs in reducing food insecurity. It also shows that VSLAs have the potential to contribute greatly to achieving Sustainable Development Goals in rural areas, particularly in promoting financial inclusion and social empowerment, building resilience to climate change, and addressing food insecurity. Policymakers should consider supporting the establishment and expansion of VSLAs, ensuring they are appropriately regulated and supervised to protect participants from fraud or other abuses. They should also design policies facilitating access to financial services, including credit, savings, and insurance, for rural communities, particularly those that are underserved or marginalized. Moreover, policymakers should encourage the integration of VSLAs into broader development programs and policies, such as improving agricultural productivity, strengthening local governance, or promoting gender equality. By doing so, they can help maximize the impact of VSLAs on rural development and ensure that they contribute to a more sustainable and equitable future for all. This study suggests integrating digital financial literacy strategies (such as digital or electronic financial transactions, including Ghana's mobile money system operated by telecommunication networks) within VSLA activities, empowering members to make informed financial decisions that enhance food security. This study suggests that policymakers should recognize climate change as a threat to agricultural productivity and take measures to reinforce climate resilience through climate-smart agriculture. This can be achieved by providing farmers access to climate-

friendly crops, subsidies for climate-resilient seeds, and training in sustainable agricultural practices. Efficient irrigation systems, climate information delivery, and sustainable farming techniques such as compost making and application, crop residue retention, minimum soil disturbance, crop rotation, mixed cropping, and water management can also combat climate change's effects on agriculture. In addition, investing in agricultural research to develop and disseminate climate-resilient technologies is also essential. To improve market accessibility, policymakers must invest in infrastructure development, such as road networks and transportation services, which can significantly reduce market travel time and enhance food security. Policymakers should consider alternative solutions, such as mobile markets or community-supported agriculture programs (farmer market demonstrations), to bring food sources closer to remote communities. This study highlights the negative association between land ownership and food insecurity and suggests policymakers implement land reform policies that ensure equitable access to agricultural land. Policymakers must ensure fair access to land and support for smallholder farmers who play a crucial role in local and regional food systems. Policymakers must implement culturally sensitive and inclusive interventions that address the unique challenges of different ethnic groups. Initiatives to increase income-generating opportunities, enhance access to credit, and provide financial literacy training can be pivotal in building the financial resilience required to overcome food insecurity challenges. Gender-inclusive policies that promote the equal participation of women in VSLAs, and agricultural decision making can also enhance the overall resilience and food security of communities in semi-arid regions (such as sustainable credit systems). Finally, policymakers must implement location-specific interventions such as strengthening agricultural extension support services [such as farmer-to-farmer led extension, farmer-based organizations (FBOs), farmer field schools, and lead farmer system], engaging more agricultural extension agents (AEAs), investing in infrastructure development, and implementing targeted programs to improve water management and land use practices. By implementing these strategic policies and interventions, policymakers can mitigate food insecurity risk and enhance households' social and economic well-being in semi-arid regions. Participatory workshops, collaborations, and consultations with community stakeholders are relevant to implementing the strategies and proposed policies. Finally, monitoring and evaluating policies and interventions over time is important to ensure they are effective and responsive to changing conditions. This requires establishing strong monitoring and evaluation frameworks to assess the long-term impact of VSLA-supportive policies. Data collected should be used to inform policy adjustments and scaling decisions, ensuring interventions remain effective in the face of evolving challenges.

**Author Contributions:** Conceptualization C.K.A.P. and I.L.; software, C.K.A.P.; formal analysis, C.K.A.P.; data curation C.K.A.P. and I.L.; writing—original draft, C.K.A.P.; supervision, I.L. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Data Availability Statement:** All data are contained within the article.

**Acknowledgments:** We acknowledge the support of CREMA executives, community leadership, and the contribution of data collectors, including Moomin Abdul Kasim, Albert Azaasuma, Bashirudeen Mahamood Kanmaaliba, Eunice Sindim, Joseph Zuolo Tietaa, Edith Putiere, Adam Bondogbo, Hasim Funjumah, Michael Kogo, Bawa Chakilia Alidu, Seidu Baleri, Charity Naalane Yirberyogr, and Ganiu Issah.

**Conflicts of Interest:** The authors declare no conflicts of interest.

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