UNIVERSITY OF COPENHAGEN

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MASTER THESIS

MASTER OF SCIENCE (M.Sc) IN GLOBAL FORESTRY

THE ROLE OF VILLAGE SAVINGS AND LOAN ASSOCIATIONS (VSLAS) IN PROMOTING CLIMATE-RESILIENT AGROFORESTRY PRACTICES AMONG COCOA FARMERS IN WASSA AMENFI DISTRICT, GHANA

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Abstracts

Climate change threatens cocoa production in Ghana, where traditional farming systems are struggling to cope with increasing environmental stresses. Despite the proven benefits of agroforestry for climate resilience, adoption rates remain low among smallholder farmers. This study examined how Village Savings and Loan Associations (VSLAs) influence the adoption of climate-resilient agroforestry practices among cocoa farmers in Ghana's Wassa Amenfi West District. A mixed-methods approach was adopted in this study. Two hundred three farmers (102 VSLA members and 101 non-members) across 15 communities combined with focus group discussions and key informant interviews were conducted. Propensity score matching and logistic regression analysis revealed that VSLA members were 7.08 times more likely to adopt agroforestry practices than non-members (p = 0.002). VSLA membership significantly enhanced access to credit, with 55.9% of members obtaining loans compared to 14.9% of non-members. Members also demonstrated higher participation in agroforestry training and knowledge-sharing activities. The finding from qualitative data indicated that VSLAs served as platforms for peer-to-peer knowledge transfer and provided crucial financial resources for purchasing seedlings and hiring labour. Nonetheless, challenges including limited loan sizes, the loss of youth to illegal mining, and inadequate seedling availability constrained broader agroforestry adoption. These findings suggest that VSLAs function as an important players for promoting sustainable agricultural transitions by addressing both financial and knowledge barriers, with important implications for climate adaptation policies targeting smallholder farming communities.

Keywords

Agroforestry, Cocoa, Climate resilience, Logistic regression, Propensity score matching, Smallholder farmers, Village Savings and Loan Associations

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List of Abbreviations and Acronyms

AIC - Akaike Information Criterion

CI - Confidence Interval

DGBP - Danida Green Business Partnerships

EU - European Union

FC - Forestry Commission

FGD - Focus Group Discussion

FPC - Finite Population Correction

FPTS - Farmer-Preferred Tree Species

GHS - Ghanaian Cedis

IITA - International Institute of Tropical Agriculture

KII - Key Informant Interview

ME - Moist Evergreen

NGO - Non-Governmental Organization

OR - Odds Ratio

PSM - Propensity Score Matching

SAP - Sustainable Agricultural Practice

SLA - Sustainable Livelihoods Approach

SMD - Standardized Mean Difference

SSA - Sub-Saharan Africa

USD - United States Dollar

VSLA - Village Savings and Loan Association

WACLI - Wassa Amenfi Cocoa Landscape Initiative

1. Introduction

1.1 Background

The livelihood of over six million smallholder farmers worldwide is dependent on cocoa cultivation, with approximately two-thirds of global production concentrated in West Africa, particularly Ghana and Côte d'Ivoire (Olwig et al., 2023). Climate change is intensifying production challenges in these regions, including rising temperatures, altered rainfall patterns, and more frequent extreme weather events. For instance, farmers in Côte d'Ivoire are experiencing significant climate variability, with projected temperature increases of 1.0 – 2.1°C in the central region by 2041 – 2070. This warming could exceed the maximum daily temperature threshold for cocoa production, leading to reduced yields. (M'bo et al., 2023). These climatic stressors undermine the viability of traditional cocoa systems and threaten the livelihoods of millions who depend on cocoa for income and food security (Mensah et al., 2022; Wessel & Quist-Wessel, 2015).

Agroforestry, defined as the intentional integration of trees with crops and/or livestock within the same land management unit has emerged as a promising strategy to enhance climate resilience and sustainability in cocoa landscapes (Tscharntke et al., 2011; Nair, 1993). Cocoa agroforestry can improve soil fertility, conserve biodiversity, regulate microclimates, diversify incomes, and sequester carbon (Blaser et al., 2017; Asigbaase et al., 2021). Despite these benefits, adoption remains limited. Studies estimate that only 25 – 42% of the 1.6 million hectares of cocoa farmland in Ghana maintain adequate shade cover (Kaba et al., 2020; Somarriba & Lopez-Sampson, 2018; Dawoe et al., 2010).

Low adoption is concerning, especially as climate projections suggest a significant reduction in the climatic suitability of Ghana's cocoa growing regions by 2050 (Läderach et al., 2013). Many farmers continue to remove shade trees, citing perceived yield benefits of full-sun systems, despite growing evidence of their vulnerability to climate-induced shocks (Abdulai et al., 2018). Addressing this challenge requires a deeper understanding of the social and institutional factors shaping farmers' decisions.

Research shows that the adoption of sustainable agricultural practices is influenced not only by individual characteristics, but also by access to resources, social networks, and trust within communities (Leeuwis & Van de Ban, 2004; Kenfack Essougong et al., 2020). These social ties, or "social capital," include bonding capital (close-knit relationships based on trust and reciprocity) and bridging capital (connections across different groups that facilitate information flow and innovation) (Coleman, 1988; Putnam, 2000). Social capital can facilitate or constrain access to knowledge, resources, and collective action in climate adaptation (Iyioku et al., 2024; Isham, 2002; Isaac et al., 2007).

In Ghana's cocoa sector, informal financial institutions such as Village Savings and Loan Associations (VSLAs) are becoming increasingly relevant. According to Beyene (2018) and CARE Internation (2018), VSLA is "a group of 10 to 30 self-selected individuals who save together and take small loans from those savings. In most cases, groups meet weekly, and members save through the purchase of shares. The activities of the group run in cycles of one year, after which the accumulated savings and the loan profits are distributed back to members. These groups are formed primarily to provide simple savings and loan facilities in a community that does not have easy access to formal financial services such as banks and microfinance institutions." VSLAs provide access to microfinance for rural households, and foster collective learning, trust, and support networks that can influence the uptake of climate-smart innovations (Markelova et al., 2009; Karlan et al., 2017). Yet, empirical evidence on the role of VSLAs in promoting climate-resilient agroforestry practices remains scarce.

This study addresses this gap by examining how participation in VSLAs influences the adoption of agroforestry practices among cocoa farmers in Ghana. By focusing on the intersection of financial access, social capital, and environmental adaptation, the research contributes to broader debates on sustainable livelihoods and climate resilience in tropical agriculture.

1.2 Problem statement

Several developmental and environmental challenges confront Ghana. Farmers face increasing climate variability, including rising temperatures and erratic rainfall, which has led to the drying of cocoa trees exposed to direct sunlight and an increased incidence of pests and diseases (M'bo et al., 2023; Mensah et al., 2022; Wessel & Quist-Wessel, 2015). At the same time, the country has experienced substantial forest degradation, with cocoa cultivation identified as a major driver (Appiah et al., 2009). Recent estimates attribute approximately 13% of forest loss within protected areas directly to cocoa expansion (Kalischek et al., 2023), while broader land-use change data show that agricultural activities, including cocoa farming and annual crop cultivation, accounted for 78% of national forest loss between 1986 and 2015 (Acheampong et al., 2019). In parallel, illegal small-scale mining (galamsey) has intensified land degradation and deforestation across cocoa landscapes (Koomson et al., 2025; Ayitey et al., 2022; Wassa Amenfi West Municipal Assembly, 2021). The recent EU Deforestation Regulation, which requires all cocoa imports to be deforestation-free and traceable to the plot of origin (European Commission, 2023), adds further urgency for sustainable land-use transitions. In this context, agroforestry is promoted as a viable strategy to mitigate climate-related risks, curb deforestation and enhance the resilience of cocoa farming systems.

The existing research on agroforestry adoption in Ghana has primarily focused on biophysical determinants such as tree species diversity, soil fertility, and ecological conditions (Wartenberg et al., 2017; Blaser et al., 2017) or farmer-specific characteristics, including land tenure, education, and farm size (Meijer et al., 2015). While these factors offer important insights, they often overlook the broader social and financial mechanisms that shape farmers' decision-making processes.

While some studies have examined knowledge exchange through informal farmer networks (Izuchukwu et al., 2023; Kongor et al., 2019; Isaac et al., 2007), Yet, no research has explicitly examined explored the intersection of social capital's informational and financial dimensions particularly as mediated through Village Savings and Loan Associations (VSLAs) in influencing agroforestry adoption. This gap is critical, given that agroforestry entails long-term commitments that demand both technical knowledge and financial inputs.

While farmer cooperatives have been studied in relation to technology adoption, evidence suggests their impact varies depending on the intervention type. For instance, Zhang et al. (2020) found that cooperatives were more effective in promoting post-harvest innovations than production-based technologies. Similarly, research from Ethiopia indicates heterogeneous outcomes from cooperative membership, with benefits unevenly distributed among farmers (Ahmed & Mesfin, 2017). These findings underscore the need to assess alternative forms of collective action such as VSLAs that may provide more flexible, locally embedded mechanisms for supporting innovation.

Social networks, including VSLAs, may play a vital role in climate adaptation by facilitating credit access, reducing investment risk, and enabling peer-to-peer learning (Arimi & Omoare, 2021). Understanding how such institutions influence the adoption of climate-resilient agroforestry practices can inform the design of more effective and equitable adaptation strategies.

Therefore, this study investigates how membership in VSLAs affects the adoption of climate-resilient agroforestry practices among cocoa farmers in the Wassa Amenfi District of Ghana. Specifically, it examines how VSLAs contribute to knowledge dissemination, and financial access. In doing so, the research highlights the potential of community-based financial institutions to serve as platforms for promoting sustainable land-use transitions in smallholder cocoa systems.

1.3 Research Questions

How does participation in VSLA influence the adoption of climate-resilient agroforestry practices among cocoa farmers?

1.4 Hypothesis

H1: Membership in a VSLA is positively associated with the adoption of climate-smart cocoa agroforestry practices.

1.5 General Objectives

1. To Explore the role of VSLA in encouraging the adoption of climate resilient agroforestry practices among cocoa farmers.

1.6 Specific Objectives

1. Compare adoption rates of agroforestry between members and non-members of VSLAs
2. To analyse the impact of VSLA membership on cocoa farmers' access to finance and its influence on agroforestry adoption
3. To assess how participation in VSLAs supports knowledge transfer and capacity building for adopting cocoa agroforestry practices.
4. Identify challenges that limit joining VSLAs and limiting factors in promoting adoption of agroforestry.

1.7 Conceptual Framework

This study’s conceptual framework shown in Figure 1 is based on the Sustainable Livelihoods Approach (SLA), Social Capital Theory, and Innovation Diffusion Theory, integrating institutional, financial, human, and environmental dimensions to explain how VSLAs facilitate agroforestry adoption and improve rural livelihoods among cocoa farmers.

At the centre of the framework is VSLA membership, which is the key role for enhancing multiple forms of capital essential for sustainable agricultural innovation such as agroforestry. According to the SLA, rural households draw on five capital assets to shape their livelihood strategies and build resilience: human, social, natural, physical, and financial (Scoones, 1998; Morse &

McNamara, 2013). In this context, VSLAs directly strengthen financial capital by providing access to savings and credit, enabling farmers to invest in agroforestry inputs and labour (Ksoll et al., 2022; Agyei et al., 2024). They also enhance social capital through networks of trust and knowledge exchange, which are critical for collective action and the dissemination of new practices (Coleman, 1988; Putnam, 2000; Castillo et al., 2021). Furthermore, VSLAs foster human capital by facilitating knowledge transfer and capacity building, often through training sessions and peer learning activities (Hillbur, 2014; Meijer et al., 2015).

The framework recognizes that policy interventions and training and capacity building are important instruments in reducing barriers to both VSLA participation and agroforestry adoption. These interventions help create a more supportive environment by addressing institutional and informational constraints, while also moderating the influence of individual and contextual control variables such as age, gender, education, farm size, land tenure, and extension access (Beaman et al., 2014; Karlan et al., 2017). The reduction of barriers to VSLA participation, in return, increases the likelihood of farmers joining these associations and benefiting from it.

When farmers are integrated into VSLAs, the framework shows three pathways to agroforestry adoption. A direct pathway through better access to finance, a social pathway through strengthened social and the human capital. Better access to financial capital addresses the economic constraints that often impede the uptake of agroforestry, while enhanced social and human capital facilitate the flow of information, reduce uncertainty, and build the technical capacity necessary for successful adoption (Castillo et al., 2021; Rogers, 2003; Kenfack Essougong et al., 2020). Increased access to training and information further supports farmers to overcome informational and technical barriers, reinforcing the adoption process.

The framework also draws on the Innovation Diffusion Theory (Rogers, 2003) that reflects on knowledge sharing, demonstration effects, and peer influence within VSLAs, which accelerate the spread of agroforestry practices. The framework also incorporates environmental sustainability and ecosystem services as outcomes of agroforestry adoption, recognizing the importance of natural capital in supporting resilient farming systems and mitigating climate impacts (Asigbaase et al., 2021; Blaser et al., 2017). Importantly, the framework also highlights a feedback loop, improved livelihood outcomes such as increased income, resilience, and food security reinforce participation in VSLAs and the continued adoption of sustainable practices. This cyclical relationship shows how VSLAs can be a driving force for a lasting change, benefiting both people and the landscapes they depend on.

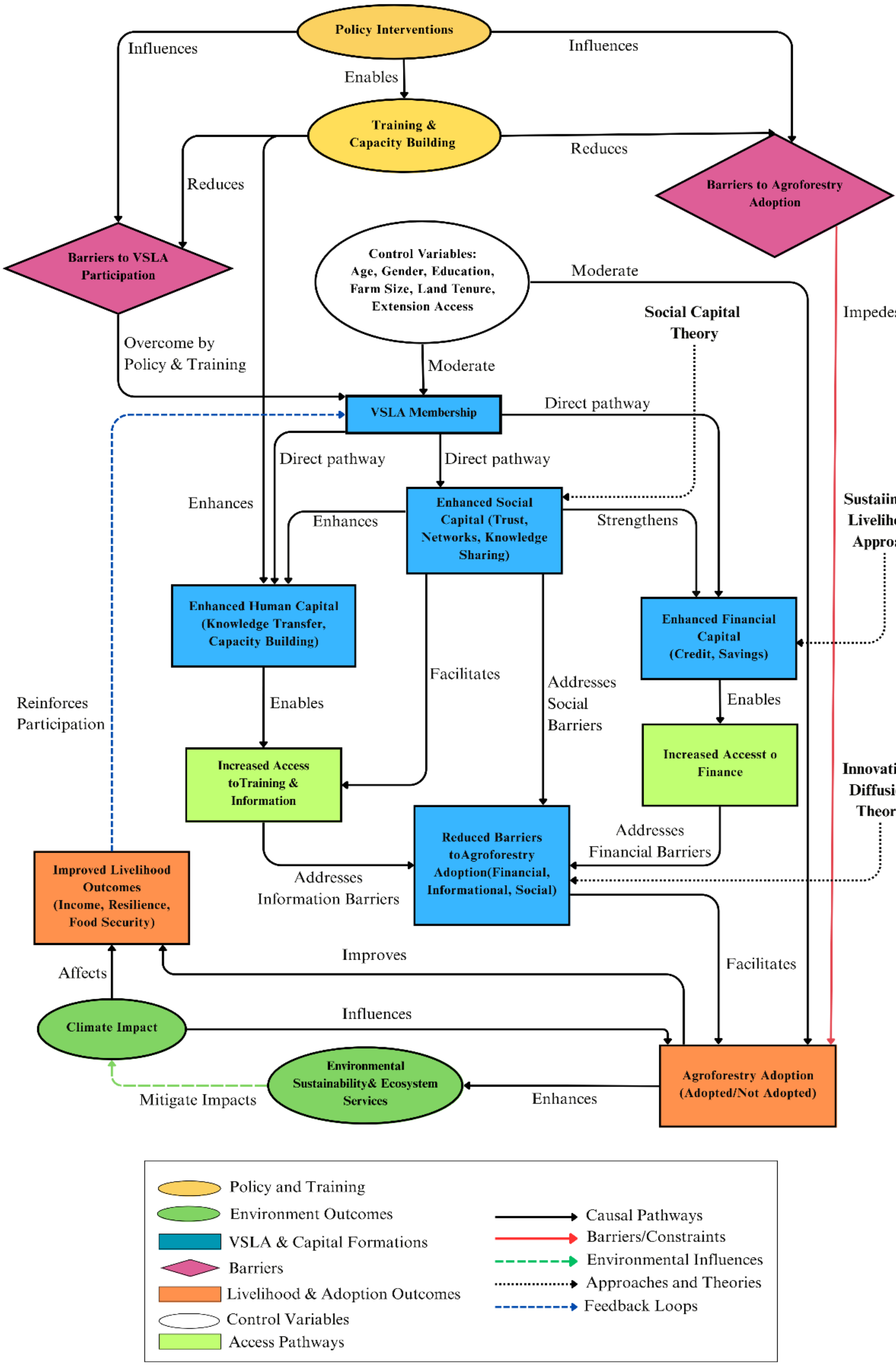

Figure 1

Figure 1*: Conceptual Framework* illustrating how VSLA membership in the centre, through Sustainable Livelihoods Approach, Social Capital, and Innovation Diffusion theories, drives climate-smart agroforestry adoption and improves livelihoods (Sources: Scoones, 1998; Morse & McNamara, 2013; Coleman 1988; Putnam, 2000; Ksoll et al., 2022; Agyei et al., 2024; Castillo et al., 2021; Hillbur, 2014; Meijer et al., 2015; Beaman et al., 2014; Karlan et al., 2017; Rogers, 2003; Kenfack Essougong et al., 2020; Asigbaase et al., 2021; Blaser et al., 2017)

2. Literature Review

2.1 Agroforestry and Climate Resilience

Agroforestry is grounded in ecological principles and aims to optimize synergies among different components of the ecosystem to enhance productivity and sustainability (Nair, 1993). Agroforestry systems contribute to soil conservation, biodiversity, water retention, and climate regulation, offering a nature-based solution to climate resilience and sustainable agriculture (Vaast et al., 2015; Jose, 2009). Cocoa agroforestry systems in West Africa have traditionally entailed the growing of cocoa together with shade trees and food crops for agronomic, economic and environmental benefits as shown in Figure 12 in Appendix (Asare, 2005). These systems differ widely across the region in terms of tree species composition, shade intensity, and spatial structure. While some studies highlight their role in enhancing ecosystem services and biodiversity (Sonwa et al., 2019), others point out inconsistencies in structure and management practices across farms, complicating their optimization (Kouadio et al., 2025).

Although cocoa agroforestry provides multiple benefits, it is not a silver bullet that solves everything; it also comes with its own set of barriers (Grant et al., 2022). One such challenge is the management of shade trees. Excessive shade cover can be a limiting factor to the success and sustainability of cocoa agroforestry systems (Blaser et al., 2017). Farms with more than 50% shade cover may experience intense competition for light, water, and nutrients, leading to reduced cocoa yields (Blaser et al., 2017). Another important limitation is the lack of technical knowledge. For example, Blaser-Hart et al. (2021) estimate that shade trees with elevated crowns store more carbon and produce higher crop yields than those with lower crowns. Regarding crown shape, “spreading to cylindrical” and elongated forms are considered most suitable for integration into cocoa agroforestry systems (Asante et al., 2021). In contrast, shade trees with low crowns contribute minimally to carbon storage and significantly reduce incoming light, which can result in lower cocoa yields (Blaser-Hart et al., 2021). Therefore, cocoa agroforestry systems that include such shade tree structures may be less effective if farmers lack the technical knowledge to manage them appropriately.

Even with these challenges, cocoa agroforestry remains a promising climate-smart strategy, especially places like Ghana where cocoa is increasingly vulnerable to climate variability and extremes. Cocoa is highly sensitive to changes in climatic conditions like drought and high temperatures (Olwig et al., 2023). In Ghana, rising temperatures and altered precipitation patterns are challenging traditional farming systems, with historical analysis from 1960-2020 showing strong correlations between climatic variables and cocoa yields, particularly positive correlations with

November precipitation during pod maturation and negative correlations with temperatures during July-August dry periods (Olwig et al., 2023). Experimental research demonstrates that cocoa seedlings exposed to temperatures 5-7°C above ambient experience reduced photosynthesis, decreased chlorophyll content, and compromised photosystem II efficiency, while drought stress impairs plant physiology through reduced stomatal conductance and potential xylem cavitation, leading to yield reductions of up to 41% under severe water stress (Mensah et al., 2022). In response, cocoa agroforestry has emerged as a climate-smart adaptation strategy integrating trees with cocoa cultivation, providing microclimate moderation through temperature reductions up to 5°C, improved water status, and enhanced resilience to climate stress (Vaast et al., 2015).

Moreover, cocoa agroforestry systems provide multiple benefits, including carbon sequestration, soil fertility enhancement, microclimate regulation, and biodiversity conservation (Blaser-Hart et al., 2021). Socioeconomically, these systems allow diversification of farm income through timber, fruits, and non-wood forest products (Sonwa et al., 2014). Additionally, cocoa agroforests are increasingly seen as climate-smart systems that combine productivity with resilience (Blaser et al., 2018). Even with the recognized benefits, adoption of agroforestry remains limited. Barriers include lack of technical training, conflicting land-use policies, short-term yield trade-offs, and limited access to suitable shade tree species (Arhin et al., 2021).

2.2 Village Savings and Loan Associations (VSLAs)

In Sub-Saharan Africa, formal financial services remain largely inaccessible to rural communities as it is geographically isolated, due to lack of infrastructure, and stringent collateral requirements. Informal financial institutions such as VSLAs have emerged to fill this gap. These self-managed, community-based savings groups allow members to mobilize and access capital without external financial institutions, making them a viable alternative to formal banking in underserved rural areas (Allen, 2006).

VSLAs operate on a community-managed model in which the members contribute savings at regular intervals and subsequently lend loans from the pooled funds at agreed interest rates. The system requires minimal external input and emphasizes transparency, accountability, and peer regulation (Anyango et al., 2007). Key operational features include a constitution, elected leadership, and regular meetings for saving, lending, and recordkeeping.

Empirical evidence demonstrates that VSLAs significantly improve financial inclusion and facilitate access to capital in farming communities. In Ghana and Malawi, participation in VSLAs was associated with increased agricultural investments, higher consumption, and improved food security (Pienaah & Luginaah, 2024; Ksoll et al., 2016). Notably, in regions where formal banking systems are absent, VSLAs serve as critical financial lifelines by offering flexible credit and encouraging savings among smallholder farmers (Frimpong, 2020).

Beyond financial benefits, VSLAs strengthen community ties and build social capital. Regular interactions foster trust, cooperation, and collective action, which are crucial for community-based development. In Rwanda, VSLAs also acted as platforms for informal entrepreneurial training and peer learning, enhancing members' decision-making and empowerment (Rubyutsa et al., 2024). In Ghana, VSLAs significantly contributed to the empowerment of women, enabling greater participation in household financial decisions and investment in farming and education (Sienso et al., 2021).

2.3 Linkages Between VSLAs and Agroforestry Adoption

Access to finance remains one of the most persistent constraints to agroforestry adoption in Sub-Saharan Africa (SSA) (Donkoh, 2019). VSLAs play a key role in alleviating this challenge by providing members with flexible, low-barrier access to financial capital (Hendricks & Chidiac, 2011). This VSLA Model was introduced by CARE International in Niger in 1991 and since then has been implemented successfully in several countries in SSA (CARE International, 2017). These groups usually 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 into a common fund (CARE International, 2018). This fund is then used to provide small loans to members at low interest rates (5% to 12%) or to support collective income-generating activities (Pienaah & Luginaah, 2024; CARE International 2018). Members also contribute a small amount to a social fund (also called an emergency fund or welfare fund) (Pienaah & Luginaah, 2024). At the end of a cycle, savings and profits are distributed as a share-out back to members based on their savings, with some profit accumulated from repaid loans. For example, research in Northern Ghana shows that VSLA participation is associated with improved financial resilience and significantly reduced food insecurity, factors that may indirectly support long-term investments such as agroforestry (Pienaah & Luginaah, 2024). Similarly, adoption of agroforestry practices in Kenya has been shown to increase household income through diversified tree-based products, suggesting that financial liquidity, such as that provided by VSLAs could enable initial adoption costs (Kinyili et al., 2020).

Moreover, VSLAs often act as platforms for knowledge sharing and informal training. While their primary function is financial, the regular meetings and community interactions foster knowledge sharing including farming practices (Musinguz, 2016). In fact, a similar pattern has been observed in community agroforestry assessments in South Africa, which showed that social cohesion and organized group settings facilitated the identification and local adaptation of agroforestry practices (Kelso & Jacobson, 2011). VSLAs can thus serve as informal extension networks, supporting peer-to-peer capacity building, an important ingredient for supporting the cocoa agroforestry.

By linking farmers, facilitating collective action, and building trust, VSLAs not only serve as savings groups but also create space for collective action and innovation (Musinguz, 2016). In the case of Northern Ghana, VSLAs were found to improve household resilience through joint decision-making, empowering members to build confidence to invest in and try out new farming practices (Pienaah & Luginaah, 2024). Agroforestry requires cross-seasonal commitment and a shift from conventional monocropping practices. These institutions like VSLAs can ease the perceived risks by fostering shared norms and learning through observation, like how farmer cooperatives in Zambia encouraged adoption of tree-based farming systems (Chavula & Hassen, 2022).

VSLA participation is strongly shaped by gender, age, and educational factors, which in turn influence access to agricultural innovations. A study conducted in Malawi found that women and younger members were more likely to experience changes in household income and resilience through VSLAs (Munthali et al., 2022). These insights point to the importance of designing an inclusive VSLA that could ensure equitable access to agroforestry benefits. As agroforestry systems mature over years, equitable decision-making and access to financial tools become crucial for sustained participation and impact.

2.4 Empirical Evidence and Gaps in the Literature

Adoption of agroforestry is greatly influenced by a combination of socioeconomic, institutional, and psychological factors. Research from Eastern Kenya and Ghana for example have consistently shown that education, household size, access to credit, and exposure to training are significant predictors of agroforestry uptake (Kinyili et al., 2020; Abukari, 2019). Also in South Africa, attitudes, knowledge, and perceptions also strongly influence agroforestry decisions, highlighting the importance of behavioural and cognitive dimensions (Zaca et al., 2023). Additionally, household land size and farming experience are correlated with higher adoption, indicating that resource access and farmer maturity shape innovation trajectories (Abukari, 2019).

Although still less explored, informal financial and social institutions such as VSLAs are increasingly acknowledged as powerful enablers for technology adoption. While not all empirical studies have directly evaluated the VSLA agroforestry link, literature on informal institutions point to a key factor- that access to credit, training platforms, and peer encouragement helps farmers to take up agroforestry practices (Pienaah & Luginaah, 2024; Chavula & Hassen, 2022). Furthermore, the evidence from Ethiopia showed that social capital can enhance tree diversity and livelihood resilience, both of which contributed to sustained profitability of multistrata agroforestry systems (Waldén et al., 2024).

While VSLAs are increasingly recognized for their role in building climate and livelihood resilience, there's still limited concrete evidence showing how they directly influence agroforestry adoption. Most studies treat financial access and social capital as generic enablers, rather than investigating how specific group mechanisms like those found in VSLAs facilitate investment, knowledge-sharing, or collective experimentation in agroforestry systems (Musinguz, 2016, Issac et al., 2007). Adoption of agroforestry by smallholder cocoa farmers is not solely dependent on ecological or economic motivations but is significantly shaped by access to finance, peer learning, and social cohesion. VSLAs represent a critical intersection of these enablers. They help farmers raise the funds needed to make upfront investment, function as platforms for knowledge exchange, and nurture social capital through mutual trust and accountability. Similarly, studies in Kenya and Ethiopia show that farmers practicing agroforestry had measurably higher livelihood capital scores, affirming its link to resilience through multiple asset streams (Waldén et al., 2024; Quandt et al., 2019).

VSLAs hold a unique potential to advance agroforestry adoption by ability to combine behavioural change, resource mobilization, and group accountability. In cocoa systems, where agroforestry adoption has been linked to perceptions of climate benefits and social endorsement (Hashmiu, 2020), VSLAs offer a ready-made infrastructure for farmer-to-farmer diffusion of innovations. These reduce transaction costs for learning and provide a stable structure for iterative experimentation, feedback, and adaptation. Moreover, VSLA also empower women and youth in financial decisions that can directly address equity gaps in access to land-use innovations (Pienaah & Luginaah, 2024).

This study is positioned at the nexus of climate-resilient agriculture, rural financial systems, and grassroot innovation. While substantial research has explored agroforestry's biophysical and ecological dimensions, and separate literature addresses social capital and financial inclusion, there is a conspicuous gap in understanding how VSLAs as hybrid institutions can enable agroforestry adoption among cocoa farmers. By drawing on the Sustainable Livelihoods Approach, Social Capital Theory, and Innovation Diffusion Theory, this research contributes to bridging empirical and theoretical gaps. It offers a novel framework to evaluate the multi-dimensional role of VSLAs in fostering resilient cocoa agroecosystems in West Africa.

3. Methodology

3.1 Study area

The study was conducted in the Wassa Amenfi West district of the Western Region of Ghana as shown in Figure 2. The municipality covers a geographical area of approximately 1,448.56 square kilometres and is located at the geographical coordinates 50 22’N and 50 60’N latitude and 20 18’W and 20 37’W longitude (Wassa Amenfi West Municipal Assembly, 2021). The study area falls under the Moist Evergreen (ME) forest zones (Hall & Swaine, 1981), which are wettest areas in Ghana, characterized by a bi-modal rainfall pattern. The major rainy season occurs from March to July, and the minor season from September to December, separated by two dry periods from December to February and a brief one in August. The average annual precipitation varies from ~1,400 mm in the north to ~1,730 mm in the south (Wassa Amenfi West Municipal Assembly, 2021). The vegetation is diverse, comprising semi-deciduous forest in the northern parts, transitioning to tropical rainforest in the south. The dominant soil types are Ochrosol-Oxysols and Oxysols, which are well-suited for the cultivation of tree crops (Wassa Amenfi West Municipal Assembly, 2021).

The local economy is predominantly agrarian. The primary cash crop is cocoa (*Theobroma cacao*), with oil palm and rubber also serving as significant sources of income. Key food crops cultivated in the area include maize, rice, plantain, garden eggs, and tomatoes (Amoah-Frimpong, 2013). According to the 2021 Population and Housing Census, the municipality has a population of 129,882 comprising 53% (68,292) males and 47% (61,590) females (Ghana Statistical Service, 2023). The population has experienced significant growth in recent years, intensifying the pressure on land and natural resources.

The selection of Wassa Amenfi West as the study site is justified for three primary reasons. Firstly, the high dependency of the local population on cocoa cultivation makes it a critical area for studying agricultural adaptation strategies (Wassa Amenfi West Municipal Assembly, 2021). Secondly, the active presence of VSLAs, partly facilitated by the Wassa Amenfi Cocoa Landscape Initiative (WACLI) project led by Preferred by Nature (a Danish NGO) in collaboration with Rikolto, Solidaridad, Ferrero, and the International Institute of Tropical Agriculture and funded by the Danida Green Business Partnerships (DGBP), provides an opportunity to assess their role in financing and disseminating knowledge about agroforestry. Finally, given the area’s heightened vulnerability to climate change necessitates the investigation of adaptive strategies like climate-smart agroforestry, making the findings of this research particularly relevant for local and regional policy (Abankwah, 2021).

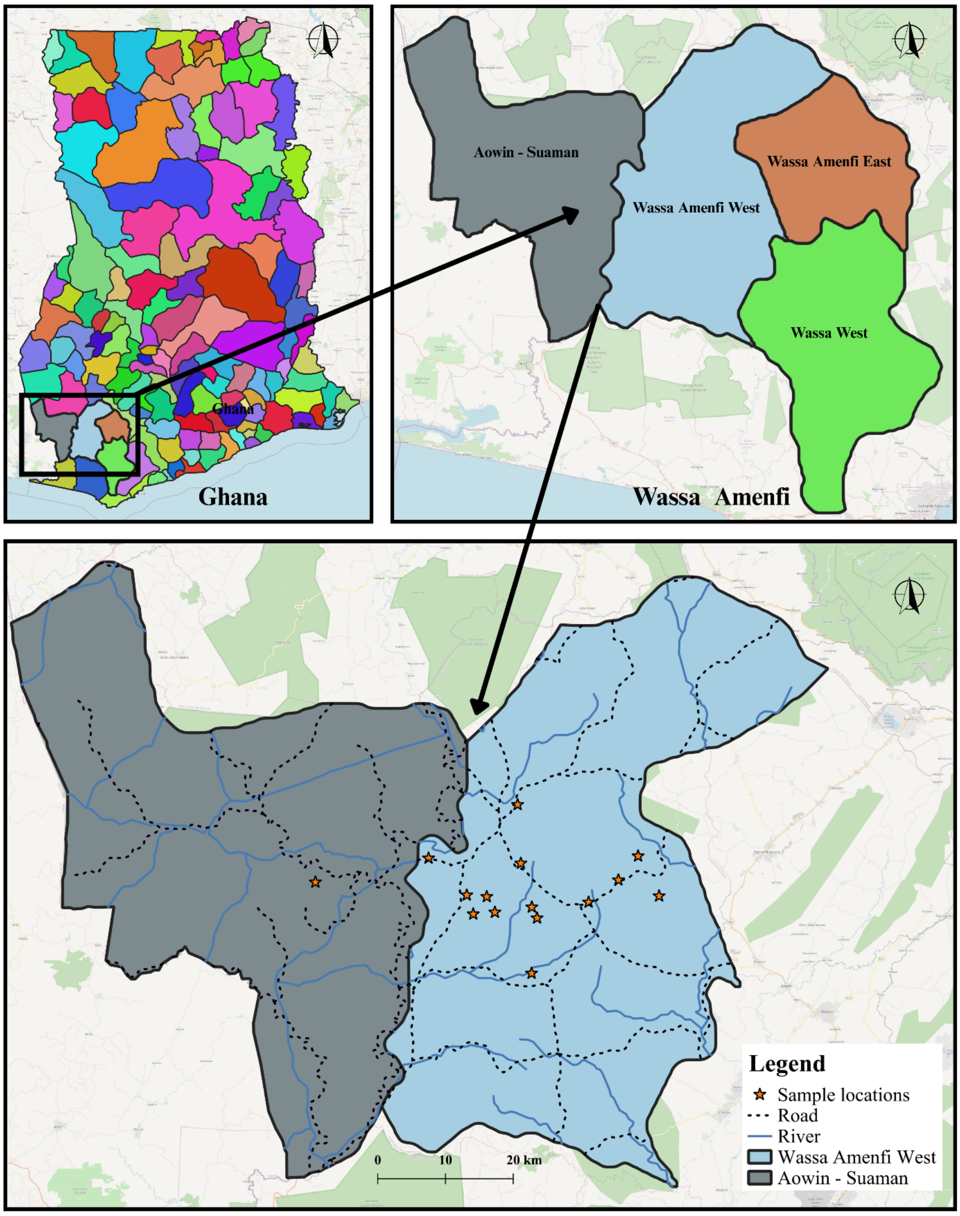

Figure 2: *Map showing study area*

3.2 Target Population

The target population for this research comprised smallholder cocoa farmers within the Wassa Amenfi West District. Stratification by program participation such as VSLA membership is widely used to ensure comparability and control for confounding variables (Karlan et al., 2017; Beaman et al., 2014). The study stratified this population into two distinct categories:

1. VSLA Members: Farmers who were officially registered members of the WACLI project Village Savings and Loan Association and actively participating in its activities. Such

individuals directly benefit from the financial and social services offered by these groups (Alesane et al., 2019).

2. Non-VSLA Members: Farmers who were not affiliated with any VSLA. This group included farmers who lacked access to such groups. To ensure data integrity and avoid confounding variables, individuals who had been previously expelled from a VSLA were explicitly excluded from this category. This exclusion criterion ensures a clear distinction between those integrated into a VSLA structure and those who have never been formally involved.

3.3 Sample Size Determination

The sample size was randomly drawn from a list provided by the project partners for this study and was determined *a priori* to ensure that the research would have adequate statistical power to detect a meaningful difference between VSLA members and non-members, should one exist. A power analysis for comparing two independent proportions was conducted using a standard formula. Sample size calculations based on power analysis and finite population correction are recommended for studies with finite sampling frames (Cohen, 1992; Kadam & Bhalerao, 2010). The calculation aims to determine the minimum number of participants required to be confident that the study's findings are not due to random chance (Biau et al., 2008).

3.3.1 Statistical Formula

The initial sample size required for each group n_{group} was calculated using the following formula.

$$\boldsymbol{n_{group}} = \frac{(\boldsymbol{Z_{\frac{\alpha}{2}}} + \boldsymbol{Z_{\beta}})^2 \,.\, (\boldsymbol{p_1}(\boldsymbol{1} - \boldsymbol{p_1}) + \boldsymbol{p_2}(\boldsymbol{1} - \boldsymbol{p_2}))}{(\boldsymbol{p_1} - \boldsymbol{p_2})^2}$$

It is because the sample is drawn from a known, finite population of 2,131 farmers, a Finite Population Correction (FPC) was applied to adjust the sample size downwards, making it more efficient without losing power (Kadam & Bhalerao, 2010). The FPC formula is:

$$n_{adjusted} = \frac{n_{total}}{1 + \frac{n_{total} - 1}{N}}$$

Where:

$n_{adjusted}$ is the final, adjusted sample size.

n_{total} is the initial total sample size (n_{group} ×2).

N is the total population size (2,131).

3.3.2 Parameter Justification

Confidence Level (1−α): A confidence level of 95% was chosen. This is the academic standard, indicating that there is a 95% probability that the findings from the sample will reflect the true effect in the population, with a 5% margin for error ($\alpha = 0.05$). The corresponding Z-score ($Z\alpha/2$) is 1.96 (Cohen, 1992).

Statistical Power (1−β): A power level of 80% was selected. This ensures an 80% probability of detecting a real difference between the two groups, minimizing the risk of a Type II error (a false negative) ($\beta = 0.2$). The corresponding Z-score ($Z\beta$) is 0.84 (Cohen, 1992).

Baseline Proportion (p_2): This represents the estimated proportion of non-VSLA members who have adopted agroforestry. In the absence of specific prior data from the study area, a conservative estimate of 30% (0.30) was used. This is a plausible baseline for a practice that is being promoted but is not yet universal (Lwanga & Lemeshow, 1991).

Expected Effect Size ($p_1 - p_2$): The study is designed to detect a meaningful and policy-relevant difference in adoption rates. An expected adoption rate for VSLA members (p1) was set at 48% (0.48). This sets the target effect size at an 18-percentage point difference (48% vs. 30%). This difference is considered substantial enough to demonstrate a significant programmatic effect of VSLAs (Hayes & Bennett, 1999).

3.3.3 Calculation

Initial Sample Size Calculation: Plugging the parameters into the formula:

$$n_{group} = \frac{(1.96 + 0.84)^2 . (0.48(1 - 0.48) + 0.30(1 - 0.30))}{(0.48 - 0.30)^2}$$

$$n_{group} = \frac{(2.8)^2 . (0.2496 + 0.21)}{(0.18)^2} = \frac{7.84 . 0.4596)}{0.0324} \approx 111.1$$

Rounding up, this requires 112 participants per group.

The initial total sample size n_{total} is 112+112 = 224.

Finite Population Correction: Adjusting for the total population of 2,131 farmers:

$$n_{adjusted} = \frac{224}{1 + \frac{224 - 1}{2131}} = \frac{224}{1 + \frac{223}{2131}} = \frac{224}{1.1048} \approx 202.79$$

3.3.4 Final Sample Size

Rounding the result to the nearest whole number gives a final required sample size of 203 farmers. This total sample will be stratified to include approximately 102 VSLA members and 101 non-members.

3.4 Sampling Technique

A multi-stage sampling technique was employed for this study, which is widely recommended in agricultural and rural research to enhance representativeness and logistical feasibility (Acharya et al., 2013; Teddlie & Yu, 2007).

3.4.1 Stage 1: Communities Section

A total of 15 cocoa-growing communities were selected from a list provided by the project. First, eight communities were purposely selected based on data provided by the Rikolto, which is an NGO actively involved in establishing VSLAs in the region. This ensured access to a high concentration of the 'VSLA Member' group. Purposeful selection of sites based on program activity or intervention is a common and accepted practice in impact evaluations, especially when target populations are not evenly distributed (Palinkas et al., 2015). Second, an additional seven communities were purposely selected from areas further away from Rikolto's direct intervention zones. These communities were chosen based on their relative isolation and limited access to formal support services, which increased the likelihood of finding farmers who were 'Non-VSLA Members'. This selection strategy was designed to ensure a balanced representation of both farmer categories, consistent with best practices for comparative group studies (Teddlie & Yu, 2007).

3.4.2 Stage 2: Respondent Selection

Within each selected community, a random sampling approach was used to identify and select respondents. For the 'VSLA Member' group, lists of members were obtained from Rikolto, and individuals were randomly selected from these lists. For the 'Non-VSLA Member' group, farmers were randomly picked with the help of a community focal person. Combining purposive and random sampling within a multi-stage framework is recognized as an effective strategy for ensuring both targeted inclusion and statistical validity in community-based research (Acharya et al., 2013; Teddlie & Yu, 2007). In total, 203 cocoa farmers were interviewed across 15 communities as shown in Table 1.

Table 1: *Name of the communities and total respondents.*

Communities	No of Respondents	VSLA Community
Nkrankrom	10	Yes
Kramokrom	14	Yes
Akyekyere	10	Yes
Kamasu	12	Yes
Gyarman	11	Yes
Bowohomoden	10	Yes
Attobrakrom	14	Yes
Yirase	21	Yes
Disue Ano	15	No
Kwaman	16	No
Bonuama	13	No
Asankran Saa	16	No
Fantekrom	16	No
Agyadum	15	No
Bogyakrom	10	No
Total	**203**	

3.5 Data Collection

Primary data was collected over a period of two and a half months, from March to May 2025. Three main instruments were used for data collection as shown in figure 3: Key Informant Interviews (KIIs), a structured household survey, and focus group discussions (FGDs) as shown in figure 3. The use of mixed methods, combining quantitative surveys with qualitative interviews and group discussions is widely recommended in agricultural and rural research to ensure comprehensive and contextually rich findings (Creswell & Plano Clark, 2017; Johnson et al., 2007).

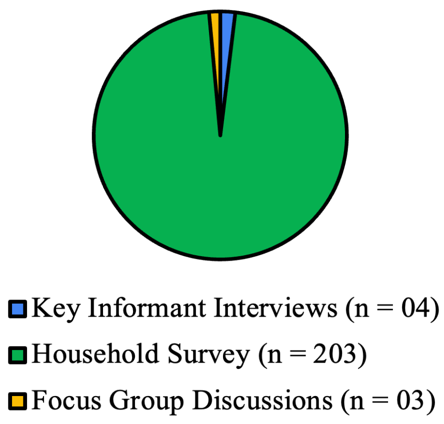

Figure 3: *Number of data collected from the study site*

3.5.1 Key Informant Interviews (KIIs)

Prior to the main farmer survey, KIIs were conducted with representatives from key organizations involved in the cocoa sector in the region, including Touton, Rikolto, Solidaridad and a lead farmer. The purpose of these interviews was to gain in-depth, contextual information about the local cocoa value chain, the operational dynamics of VSLAs, prevalent agroforestry systems, and the key challenges faced by farmers. KIIs are recognized as an effective tool for gathering expert perspectives and contextual background, particularly in agricultural and development studies (Marshall, 1996; Guest et al., 2013) and therefore used in this study.

3.5.2 Household Survey

A structured questionnaire was administered to the sampled smallholder cocoa farmers shown in the Appendix 10.1: Questionnaire. The questionnaire was designed to capture comprehensive data on several thematic areas, including:

- Demographic and Socio-economic Profile: Age, gender, education level, household size, and income sources.
- Farm Characteristics: Farm size, land tenure, and cocoa production levels.
- Financial Access and Savings: Access to credit, savings behaviour, and sources of finance for farm inputs.
- Agroforestry Adoption: Cocoa agroforestry adopted or not, motivations for adoption, and perceived benefits and challenges.
- Knowledge and Information: Sources of agricultural information, access to training, and knowledge transfer mechanisms related to agroforestry and VSLAs.

The use of structured questionnaires is a standard approach in smallholder and rural livelihood research, enabling systematic collection and comparability of data across respondents (Grosh & Glewwe, 2000; Deaton, 1997).

3.5.3 Focus Group Discussions (FGDs)

To gain deeper qualitative insights, three Focus Group Discussions (Two with VSLA members and one with non-members) were conducted with VSLA members and non-members. Each group consisted of 25–30 members, including both male and female farmers, to ensure a diversity of perspectives. The primary objective of the FGDs was to explore the collective experiences, shared perceptions, and challenges associated with VSLA membership and the adoption of agroforestry. FGDs are widely used in agricultural and community-based research to elicit group norms, shared experiences, and nuanced understanding of social dynamics (Krueger & Casey, 2015; Morgan, 1996).

3.6 Data Analysis

Descriptive statistics such as frequencies, and percentages were used to summarize the demographic land tenure systems, asset ownership, crop diversity, and agroforestry practices of the sample. This approach provides a foundational understanding of the population and contextualizes subsequent inferential analyses (Adimassu et al., 2016; Moser & Barrett, 2006).

To compare key numeric livelihood indicators such as age, income, farm size, distance to extension services between VSLA members and non-members, independent samples t-tests were employed. Normality and homogeneity of variance of the data were tested prior to conducting an independent t-test. Thereafter t-test is conducted as it is appropriate for determining whether the means of two independent groups differ significantly, assuming approximately normal distributions and homogeneity of variances (Field, 2013). The t-test is widely used in studies assessing differences in socioeconomic and agricultural outcomes between treatment and control groups in rural and agroforestry contexts (Asfaw et al., 2010; Place et al., 2004).

Associations between VSLA membership and categorical variables such as adoption of agroforestry, access to credit, gender, land tenure status were examined using the chi-square test of independence. This non-parametric test is suitable for assessing relationships between two categorical variables in cross-sectional survey data (Agresti, 2018). When expected cell counts were low, Fisher's Exact Test was used as a more robust alternative, as recommended in the literature for small sample sizes or sparse data (Kim, 2017). The chi-square test is a standard tool in studies exploring the determinants of technology adoption, social capital, and group membership in agricultural settings (Franzel et al., 2001; Meinzen-Dick et al., 2014). Its use here enables the identification of statistically significant associations between VSLA participation and key livelihood factors.

Given that the primary outcome variable, agroforestry adoption, is binary (1 if adopted, 0 if not), a binary logit model is an appropriate baseline econometric approach (Ali et al., 2024; Kassie et al., 2013; Kabwe, 2010). This model estimates the probability of a farmer adopting agroforestry practices conditional on their VSLA membership status and a set of other explanatory variables. The logit model provides an initial quantitative assessment of the association between VSLA membership and agroforestry adoption, while statistically controlling for observable farmer and farm characteristics (Hosmer et al., 2013). However, standard logit models do not inherently correct for selection bias if unobservable factors simultaneously influence both the decision to join a VSLA and the decision to adopt agroforestry. Such unobserved heterogeneity can lead to biased estimates of the VSLA membership effect. Nevertheless, it serves as an important benchmark. The use of binary logistic regression is well established in agricultural technology adoption studies (Abdulai & Huffman, 2014; Kassie et al., 2013).

To address the potential for selection bias more rigorously, propensity score matching (PSM) was conducted (Tucker, 2010; Caliendo & Kopeinig, 2008; Rosenbaum & Rubin, 1983). Prior to matching, multicollinearity among covariates was assessed using pairwise Pearson correlation coefficients as shown in Appendix Table 9. The correlation matrix confirmed moderate associations among a few variables, but none exceeding r = ±0.8, which is consistent with best practices to avoid multicollinearity (Dormann et al., 2013).

VSLA membership is typically a result of self-selection; farmers are not randomly assigned to VSLAs. This means that members and non-members may differ systematically in unobserved ways that also affect their adoption decisions. PSM is a quasi-experimental method that attempts to mimic a randomized experiment by creating a statistically comparable control group (non-VSLA members) for the treated group (VSLA members) based on observable characteristics. The procedure is widely used in agricultural impact evaluation (Caliendo & Kopeinig, 2008; Rosenbaum & Rubin, 1983).

Propensity Score Estimation

Let $D_i \in \{0,1\}$ denote a binary treatment indicator, where $D_i = 1$ if the individual i is a VSLA member (treated group) and $D_i = 0$ otherwise (Control Group). Let X_i be a vector of pre-treatment covariates including age, gender, education level, household size, landholding size, labor hiring status, annual income, access to extension, membership in farmer organizations, and access to credit. The propensity score, defined as the probability of treatment assignment conditional on observed covariates (Rosenbaum & Rubin, 1983), is given by:

$$e(X_i) = Pr(D_i = 1 \mid X_i)$$

This propensity score was estimated via a logistic regression model:

$$logit(e(X_i) = \beta_0 + \beta_1 Age_i + \beta_2 Gender_i + \beta_3 Education_i + \cdots + \beta_k AssetScore_i)$$

Where: $logit(p) = ln(\frac{p}{1-p})$ and β_j are coefficients to estimate

A nearest neighbour matching algorithm with a logit distance metric and 1:1 ratio was used to pair each VSLA member with a non-member of similar propensity score. Matching was performed without replacement to ensure comparability between treated and control groups (Caliendo & Kopeinig, 2008).

Assessment of Matching Quality

To evaluate the balance achieved by matching, we employed Standardized Mean Differences (SMD) for each covariate before and after matching:

$$SMD = \frac{(\underline{X_T} - \underline{X_C})}{\sqrt{\frac{s_T^2 + s_C^2}{2}}}$$

where $\underline{X_T}$ and $\underline{X_C}$ are the sample means of the treated (VSLA members) and control (non-members) groups, respectively, and s_T^2 and s_C^2 are the respective variances. According to Stuart (2010), a standardized mean difference below absolute value of 0.1 is considered a strong indication of covariate balance. Several covariates such as age, gender, average annual income, distance from extension services, credit access, asset score, agroforestry training session in last two years and receive agroforestry training remained slightly imbalanced (SMD > 0.1) and had to be included in a second-stage regression to account for residual confounding. However, descriptive analysis revealed that two variables: agroforestry training sessions in the last two years and receiving agroforestry training exhibited extremely low variability with almost all agroforestry adopters reporting receipt of training. This lack of variation led to quasi-complete separation in the logistic regression model, producing implausibly large coefficients and standard errors, and undermining the reliability of the estimates (Allison, 2008). Therefore, these variables are omitted in the logistic regression model.

Treatment Effect Estimation

Following the matched procedure, accounting for residual confounding we estimated the impact of VSLA membership on agroforestry adoption using a binary logistic regression model. This doubly robust estimation method combines matching with regression adjustment, improving the robustness of causal inference (Funk et al., 2011; Bang & Robins, 2005). Let $Y_i \in \{0,1\}$ denotes whether an individual adopted agroforestry. The model is specified as:

$$logit(Pr(Y_i = 1)) = \alpha_0 + \alpha_1 D_i$$

Here, α_1 captures the log-odds of adopting agroforestry attributable to VSLA membership. The corresponding odds ratio (OR) is obtained as $exp(\alpha_1)$, which represents the multiplicative change in the odds of adoption for VSLA members relative to non-members. The 95% confidence interval for the odds ratio was calculated as:

$$[exp(\alpha_1 \pm 1.96SE(\alpha_1))]$$

Where $SE(\alpha_1)$ is the standard error of the treatment coefficient. Statistical significance was evaluated using Wald tests, and results were reported with corresponding p-values and standard errors (Hosmer et al., 2013).

The qualitative data was analysed using the step-by-step procedure proposed by Braun and Clarke (2006), which includes familiarization, identification, reduction, codification, and analysis, implemented through NVivo software. First, the major themes were identified based on empirical field findings. These consisted of: (1) benefits of VSLA, (2) challenges of VSLA, (3) benefits of agroforestry, and (4) challenges of agroforestry. Next, specific codes were formulated for every theme, predominantly based on the empirical data. The quantitative data was cross-checked with the qualitative data to verify the presence of missing values and other errors. The cleaned and standardized data was then used to extract patterns using R programming in R Studio (Posit, 2024) and cross-verified with the findings from the qualitative analysis.

4. Results

4.1 Demographic Profile

As shown in Figure 4, the most common land tenure system is Abunu (*n* = 74). Abunu is a customary land tenure arrangement in which a landowner grants uncultivated land to a landless farmer (tenant) to establish a cocoa farm. The tenant is responsible for clearing the land, planting, and nurturing the cocoa trees until they reach maturity. Once mature and ready for harvest, the farm is divided equally between the landowner and the tenant. While the Abunu system facilitates land access for the landless, the agreements are often informal and based on oral contracts, which can lead to disputes or misunderstandings (Ruf, 2010). There is a roughly equal number of respondents who own land with a title deed (*n* = 53) and those who have access to family land (*n* = 54). A smaller number of respondents own land without formal documentation (*n* = 22). Despite these different land tenure arrangements, the majority of respondents grow hybrid cocoa varieties (*n* = 190) on their land.

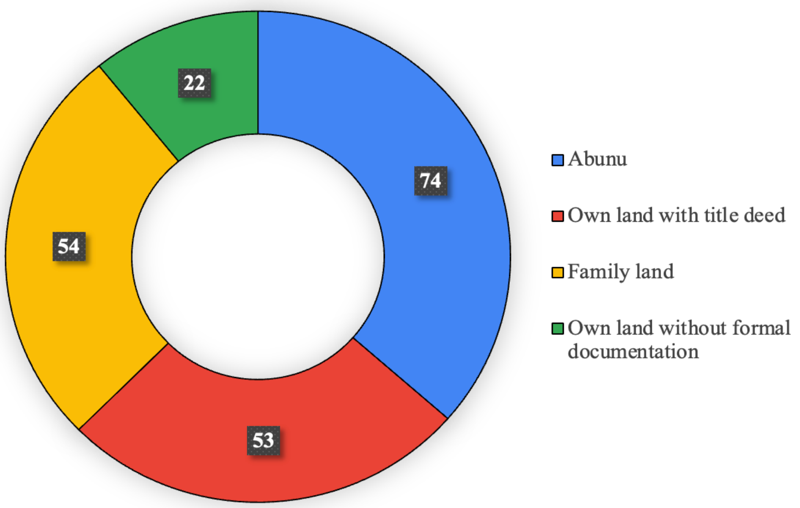

Figure 4: *Showing different land tenure status.*

Table 2 indicates that 92.12% of respondents own mobile phones (*n* = 187). Televisions (*n* = 127) and radios (*n* = 125) are also widely owned, suggesting broad access to communication and media. A significant number of households own motorcycles (n = 83), while ownership of cars or trucks (*n* = 9) is relatively low. Most farmers own some form of agricultural equipment, including cutlasses (*n* = 200), knapsack sprayers (*n* = 77), mist blowers (*n* = 46), pruning machines *(n* = 7), and chainsaws (*n* = 1). A total of 133 respondents reported owning livestock such as chickens, sheep, goats, and pigs.

The respondents also grow various crops on their farm. Cassava (*n* = 190) is the most widely cultivated crop, followed by cocoyam (*n* = 157), maize (*n* = 136), and garden eggs (*n* = 136). Plantain (*n* = 116) and tomatoes (*n* = 115) are also commonly grown as shown in Table 10 in Appendix. A notable number of respondents cultivate rice (*n* = 40). Other crops such as pepper (*n* = 55), yam (*n* = 24), okra (*n* = 13), beans (*n* = 6), banana (*n* = 10), rubber (*n* = 9), and ginger (*n* = 1) are grown by fewer respondents. This indicates a diversified agricultural system among the surveyed population, which can contribute to food security and income generation through various agricultural products.

Most respondents sell their cocoa beans to ELIHO-Touton (*n* = 175), followed by FLUDOR (*n* = 29). The price per kilogram of cocoa beans is 49.6 Ghanaian Cedis (GHS) (approximately 3.32 USD), and this price is uniform across all buyers, as it is a standardized rate set by the Ghana Cocoa Board, which is the regulating authority of cocoa in Ghana. The price for one bag of cocoa is GHS 3,100 (approximately 250 USD), which corresponds to 62.5 kg of beans per bag. When cocoa farms are certified, such as by the 'Rainforest Alliance' the beans are classified as premium cocoa and sold at a higher price. In such cases, the price is GHS 3,100 per bag, plus a premium of GHS 68, making the total GHS 3,168 per bag for premium certified beans.

Table 2: *Household Asset owned by the respondents*

Assets owned by the household	*n*	%
Mobile Phone (S)	187	92.12
Television	127	62.56
Radio	125	61.58
Motorcycle	83	40.89
Car/Truck	9	4.43
Farm Equipments	111	54.68
Livestocks	133	65.52

4.2 Different Agroforestry System

A substantial proportion of farmers (84.24%; *n* = 171) have shade trees on their cocoa farms indicating the critical roles played by these trees as shown in Figure 5. Trees such as Ofram (*Terminalia superba)*, Emire (*Terminalia ivorensis*), Wawa (*Triplochiton scleroxylon*), and Gliricidia (*Gliricidia sepium*) are planted and managed on the farms for shade. Fruit trees with cocoa (*n* = 153) and timber trees with cocoa (*n* = 126) are also widely adopted, suggesting that farmers prioritize diversification, using fruit for short-term income and timber for long-term revenue while maintaining cocoa production. The most common fruit trees include orange, mentioned by 74 respondents, mango (*n* =

68), avocado (n = 68), coconut (n = 38), and guava (n = 7). Some of the timber trees on the cocoa farms include Mahogany (*Khaya anthotheca*), Odum (*Milicia excelsa*), and even Terminalia species, which serve dual purposes (shade and timber). Boundary planting is the least common, with only five respondents mentioning it.

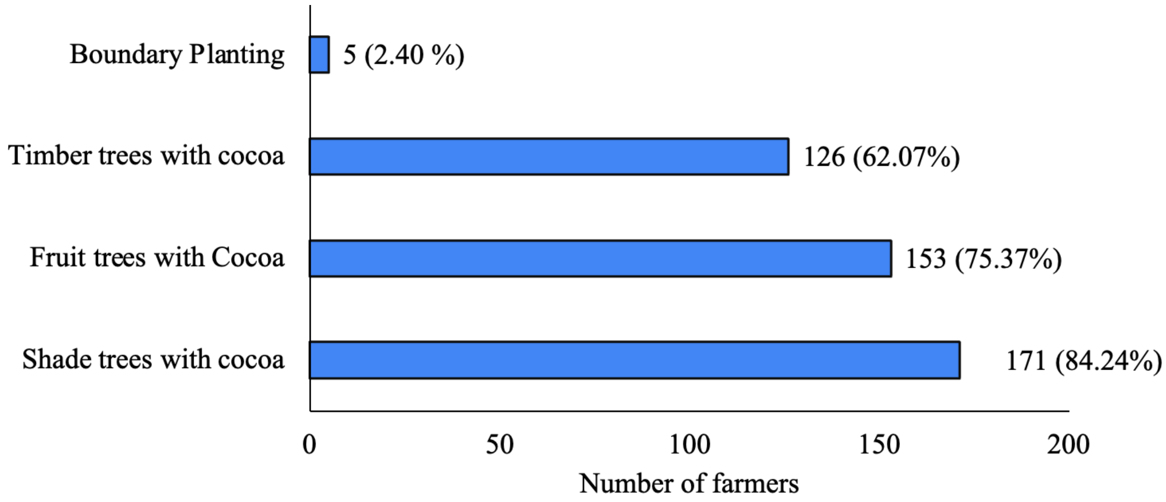

Figure 5: *Different Agroforestry system observed*

4.3 Tree species on Cocoa Farm

Table 3 shows that a total of eight common tree species were recorded on the cocoa farm. The most frequently planted species were Ofram (*Terminalia superba)* and Emire (*Terminalia ivorensis*), planted by 167 and 164 farmers, respectively. These two *Terminalia* species collectively represent the dominant choices among the surveyed population. Following these, Odum (*Milicia excelsa*) was planted by a substantial number of farmers (n = 115), indicating its continued importance, albeit at a lower rate than the *Terminalia* species. Species with moderate adoption included Mahogany (*Khaya anthotheca*) (n = 54), Wawa (*Triplochiton scleroxylon*) (n = 49), and Ciber (*Ceiba pentandra*) (n = 43). These species were planted by roughly one-third to one-half as many farmers compared to Odum. The least frequently planted species were Gliricidia (*Gliricidia sepium*) (n = 24) and Kyen Kyen (*Antiaris toxicaria*) (n = 6), with Kyen showing extremely limited adoption. All the tree species are primarily grown for the shade in the cocoa farm.

Table 3: *Table showing tree species grown on the cocoa farm*

Species	*n*	Primary Role
Ofram (*Terminalia superba*)	167.00	Shade + Timber + Furniture +Fodder + Firewood
Emire (*Terminalia ivorensis*)	164.00	Shade + Timber + Furniture + Firewood
Odum (*Milicia excelsa*)	115.00	Shade + Timber + Medicine + Ediatble Friuts + Firewood
Mahagony (*Khaya anthotheca*)	54.00	Shade + Timber + Furniture + Firewood + Medicine
Wawa (*Triplochiton scleroxylon*)	49.00	Shade + Timber
Ciber (*Ceiba pentradra*)	43.00	Shade + Timber + Fiber
Gliricidia (*Gliricidia sepium*)	24.00	Nitrogen Fixation + Light Shade
Kyen Kyen (*Antiaris toxicaria*)	6.00	Shade + Timber + Medicinal

4.4 Benefits of Agroforestry

Cocoa agroforestry provides both socio-economic and ecological benefits. Figure 6 presents the perceived or experienced benefits of implementing agroforestry or tree planting within cocoa systems, based on responses from 172 out of 203 surveyed individuals. The most frequently cited benefit was climate resilience, recognized by over 155 respondents. It was further supported by key informant, *"In the olden days, we used to have larger forest cover, but not anymore. Now, growing trees on farms might help maintain the microclimate, which would mitigates climate-related challenges such as temperature extremes and drought.*" Improved soil fertility was mentioned by 68% respondents, attributed to factors such as leaf litter decomposition, reduced erosion, and, in some cases, nitrogen fixation from species like *Gliricidia sepium* (*n* = 139). The third most common benefit was food for consumption (*n* = 138), which included integrating food crops such as plantain, cassava, and fruit trees like mango and avocado into the cocoa system. Given that most community members rely primarily on fuelwood as their main energy source, 136 farmers reported obtaining fuelwood directly from their farms by pruning shade or timber trees.

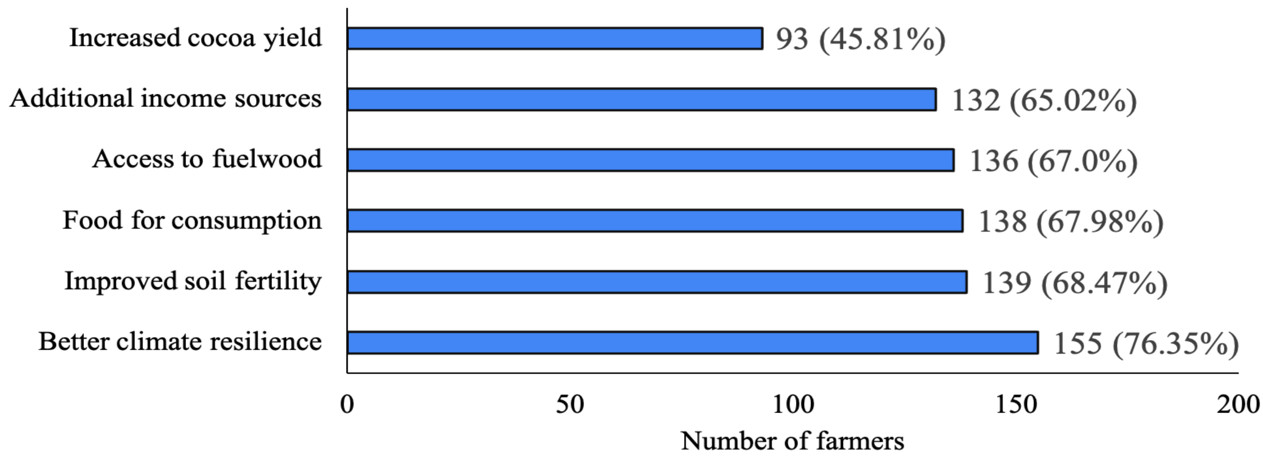

Figure 6: *Perceived or experienced benefits of implementing agroforestry*

A total of 132 respondents reported generating additional income from agroforestry through the sale of fruits and timber. As one respondent explained, "*When cocoa is not producing or during the off-season, I can rely on these fruits for additional income. I also have timber trees growing, and I am planning to sell them in the future.*" This highlights agroforestry's role in enhancing resilience to economic shocks and providing alternative sources of income.

Respondents were asked: "Compared to when you were not practicing agroforestry, has your income from cocoa farming increased or decreased?" Out of 172 respondents, 133 reported a slight increase in income, while 16 reported a significant increase. These responses strongly suggest that the adoption of agroforestry practices has had a positive impact on income from cocoa farming for the majority of farmers.

Only 45% respondents reported increased cocoa yields, although this was the least frequently cited major benefit. While growing trees can improve cocoa quality and tree longevity, yield improvements may vary. In some cases, yields may be reduced due to competition for light, water, or nutrients, depending on shade management and species selection.

4.5 Synergy Between Trees, and Pest Control

A key informant emphasized the importance of promoting biodiversity within cocoa agroforestry systems, particularly through the inclusion of diverse tree species. He explained that while certain tree species may host pests, others can attract natural predators that help regulate these pest populations. Such ecological balance is more likely to be achieved when the agroforestry system includes a variety of species. As the informant noted, "*If biodiversity is high, with more than five different tree species, then the chances of effective natural pest control are much greater*." By increasing plant diversity, farmers can enhance the ecological resilience of their farms and reduce reliance on chemical inputs.

In a separate interview, another respondent highlighted the critical role of shade trees in supporting biological pest control. He explained that tall trees offer refuge for beneficial organisms, including natural pest predators, which is very important because pesticides cannot easily reach pests residing in the upper canopy. As he stated: *"The presence of diverse tree species supports a broader range of beneficial insects such as bees and predatory species, that can access these elevated habitats. Even when pesticides are applied, many of these beneficial organisms can escape exposure by sheltering in the upper canopy. When they return to lower levels, they contribute to controlling harmful pests, such as caterpillars, that damage cocoa plants."* Drawing on these observations, the respondent recommended that shade trees should be maintained at a minimum height of five meters above the cocoa canopy. This spatial separation allows beneficial organisms to take refuge and continue providing natural pest regulation without being directly affected by chemical applications.

4.6 Comparison Between VSLA Members and Non-Members

To assess whether significant differences exist between members and non-members of VSLA across key numeric livelihood indicators, independent sample t-tests were conducted for ten variables. The results are summarized in Table 4. The average age of VSLA members (M = 43.06) is significantly lower than that of non-members (M = 51.27), with a mean difference of 8.21 years (**t** = 4.94, $p < 0.001$). There is no statistically significant difference in household size between the two groups (mean difference = -0.05, $p = 0.903$), nor in total farm size (mean difference = 0.55 hectares, $p = 0.268$) or cocoa land area (mean difference = 0.10 hectares, $p = 0.761$).

Although VSLA members are located slightly farther from extension service points (mean difference = -0.99 km), this difference is not statistically significant ($p = 0.103$). However, a highly significant difference is observed in average annual income, where non-members earn substantially more (M = 4,965.06) than VSLA members (M = 3,051.80), with a mean difference of 1,913.25 (**t** = 3.35, $p < 0.001$).

Participation in agroforestry training sessions within the last two years is significantly higher among VSLA members (M = 3.18) compared to non-members (M = 2.24), with a mean difference of -0.94 (**t** = -3.15, $p = 0.0019$). Furthermore, VSLA members are, on average, located farther from buyers (mean difference = -1.04 km, **t** = -2.33, $p = 0.021$), indicating a potential constraint in market access.

Cocoa season income is significantly lower among VSLA members (M = 8,852.69) compared to non-members (M = 15,973.96), with a large and statistically significant mean difference of 7,121.27 (**t** = 4.17, $p < 0.001$). No statistically significant difference is observed in off-season income between the two groups (mean difference = 177.25, $p = 0.721$). These results suggest that VSLA membership is associated with younger age, lower income levels (both annual and seasonal), greater participation in training, and reduced proximity to markets.

Table 4: *t-test between VSLA members and Non-members*

Variable	Mean (VSLA Member)	Mean (Non-member)	Mean Diff.	t-statistic	p-value
Age	43.06	51.27	8.21	4.94	**0.00***
Household size	7.06	7.01	-0.05	-0.12	0.90
Total farm size	4.31	4.86	0.55	1.11	0.27
Cocoa land	3.27	3.37	0.10	0.30	0.76
Distance extension	11.49	10.50	-0.99	-1.64	0.10
Avg annual income	3051.80	4965.06	1913.25	3.35	**0.00***
Agroforestry training session	3.18	2.24	-0.94	-3.15	**0.00***
Distance buyer	4.70	3.66	-1.04	-2.33	**0.02***
Income cocoa season	8852.69	15973.96	7121.27	4.17	**0.00***
Income off season	1118.16	1295.41	177.25	0.36	0.72

Note: * represents significance level
VSLA member (*n*): 102; Non-member (*n*): 101

The relationship between various nine categorical variables and membership in a VSLA was examined using data from 203 participants as shown in table 5. The analysis revealed a statistically significant association between VSLA membership and two key variables. A strong relationship was observed with the adoption of agroforestry practices ($\chi2 = 18.68$, $p < 0.001$) and with access to credit ($\chi2 = 35.56$, $p < 0.001$). These results suggest that VSLA members differ significantly from non-members regarding these two factors.

In contrast, no significant associations were found for the remaining variables. There was no statistical evidence of an association between VSLA membership and gender ($\chi2 = 2.21$, $p = 0.137$), receiving agroforestry training ($\chi2 = 2.22$, $p = 0.137$), the hiring of labour ($\chi2 = 2.64$, $p = 0.104$), land tenure status ($\chi2 = 1.42$, $p = 0.234$), or membership in other farmer organizations ($\chi2 = 0$, $p = 1.0$). Furthermore, Fisher's Exact Tests confirmed a lack of significant association with the participants' education level ($p = 0.457$) and their perception of climate change impacts ($p = 0.498$).

Table 5: *Association Between VSLA Membership and Categorical Variables*

Variables	Test Statistic (χ2)	p-value
Agroforestry adopted	18.68	**< 0.001***
Credit access	35.56	**< 0.001***
Gender	2.21	0.137
Receive agroforestry training	2.22	0.137
Hire labor	2.64	0.104
Land tenure	1.42	0.234
Farmer org membership	0.00	1.000
Education level	NA	0.457
Climate change impact	NA	0.498

Note: * represent significance level, Fisher's Exact Test does not report a test statistic., *n* = 203

4.7 Test of Matching quality

In the PSM, a total of 203 observations were initially included in the analysis, comprising 102 VSLA members (treated group) and 101 non-members (control group) as shown in figure 7. Following the matching process, 101 treated units were successfully matched with 101 control units, resulting in a matched sample size of 202 observations. Only one treated unit (VSLA member) remained unmatched due to a lack of sufficiently similar control units in terms of estimated propensity scores. Importantly, no control units were unmatched, and no observations were discarded for falling outside the region of common support. This outcome indicates a high-quality match with minimal data loss, effectively addressing potential selection bias. The close alignment in matched sample sizes between treated and control groups enhances the comparability of the two groups and strengthens the internal validity of the subsequent causal inference.

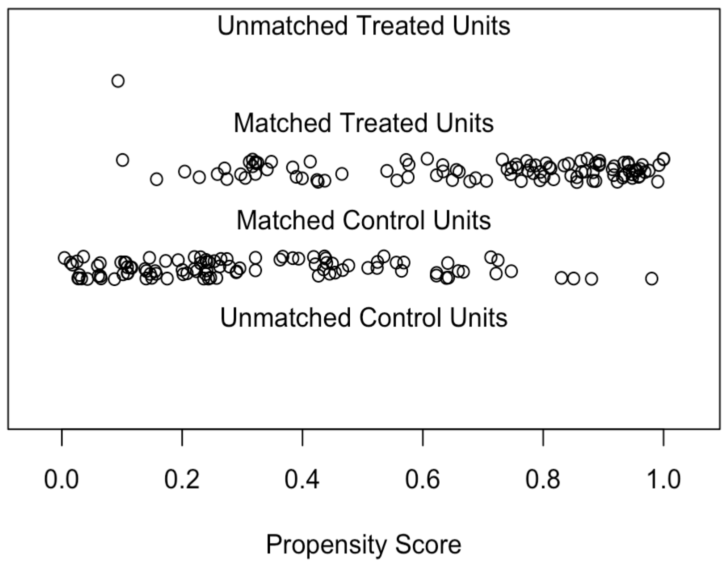

Figure 7: *Distribution of propensity score*

4.8 Covariate Balance Before and After Matching

Table 6 presents the standardized mean differences, and group means for covariates used in the propensity score model before and after treated group with control group. The goal of matching is to ensure covariate balance, thereby reducing selection bias in estimating the effect of VSLA membership on agroforestry adoption. Before matching, several covariates exhibited substantial imbalance between the treatment and control groups, indicated by standardized mean differences (SMDs) greater than 0.1. Notably, credit access (SMD = 0.83), age (SMD = -0.68), average annual income (SMD = -0.55), and agroforestry training sessions (SMD = 0.41) were particularly imbalanced. After matching, the sample was improved in terms of balance for several variables, although some large imbalances remained. For instance, credit access (SMD = 0.84), age (SMD = -0.68), average annual income (SMD = -0.55), and agroforestry training sessions (SMD = 0.42) continued to show substantial imbalance even after matching. Other variables such as education level (SMD = 0.08), land tenure (SMD = 0.20), and receive agroforestry training (SMD = 0.27) showed only minor differences before and after matching (SMDs < 0.25 or slightly above), indicating acceptable balance. Importantly, categorical variables such as hire labour (SMD = -0.23), gender (SMD = -0.24), and farmer organisation membership (SMD = 0.00) also exhibited relatively low standardized mean differences post-matching, suggesting that the matching procedure was moderately effective for these covariates.

Table 6: *Table showing Covariate Balance Before and After PSM Matching*

	Before Matching			After Matching		
Variable	Mean Treated	Mean Control	Std. Mean Diff.)	Mean Treated	Mean Control	Std. Mean Diff.
Age	43.06	51.27	-0.68	43.01	51.27	-0.68
Agroforestry training session	3.18	2.24	0.41	3.21	2.24	0.42
Asset score	4.11	3.72	0.27	4.11	3.72	0.27
Avg annual income	3051.80	4965.06	-0.55	3058.59	4965.06	-0.55
Climate change impact	0.98	1.00	-0.14	0.98	1.00	-0.14
Cocoa land	3.27	3.37	-0.04	3.27	3.37	-0.04
Credit access	0.56	0.15	0.83	0.56	0.15	0.84
Distance extension	11.49	10.50	0.28	11.55	10.50	0.30
Education level	2.40	2.31	0.07	2.42	2.31	0.08
Farmer org membership	0.37	0.38	-0.01	0.38	0.38	0.00
Gender	0.49	0.60	-0.23	0.49	0.60	-0.24
Household size	7.06	7.01	0.02	7.06	7.01	0.02
Hire labor	0.86	0.94	-0.23	0.86	0.94	-0.23
Land tenure	0.58	0.49	0.19	0.58	0.49	0.20
Receive agroforestry training	0.79	0.69	0.25	0.80	0.69	0.27

Results from the logistic regression analysis are presented in Table 7. The coefficient for VSLA membership was statistically significant and positive (log-odds = 1.957, $p = 0.002$), indicating that VSLA membership was strongly associated with higher odds of adopting agroforestry. When exponentiated, this coefficient yields an odds ratio (OR) of 7.08 with a 95% confidence interval (CI) of 2.10 to 23.86. This means that, after matching and controlling for observed confounding variables, VSLA members were approximately 7.08 times more likely to adopt agroforestry practices compared to non-members. These findings provide strong empirical support for the hypothesis that membership in a VSLA is positively associated with the adoption of climate-smart cocoa agroforestry practices.

The intercept (β = -0.468, OR = 0.63, $p = 0.709$) represents the baseline log-odds of agroforestry adoption for non-VSLA members with zero values on all continuous covariates. The non-significant intercept suggests that baseline adoption probability is moderate when accounting for the included covariates. In contrast, none of the control variables demonstrated statistically significant associations with adoption outcomes at conventional significance levels. Age showed minimal influence (β = 0.015, OR = 1.01, $p = 0.417$), while economic factors including average annual income (β < 0.001, OR = 1.00, $p = 0.427$) and asset score (β = 0.24, OR = 1.27, $p = 0.106$) exhibited negligible effects. Similarly, access variables including credit access (β = 0.621, OR = 1.86, $p = 0.313$) and distance to extension services (β = -0.003, OR = 1.00, $p = 0.955$) failed to reach statistical significance.

The model fit was acceptable, with a residual deviance of 146.12 on 195 degrees of freedom and an Akaike Information Criterion (AIC) of 160.12. The null deviance was 173.18 on 201 degrees of freedom, indicating that including VSLA membership and other covariates improved the model's explanatory power. The logistic regression model converged successfully after six Fisher Scoring iterations, and the dispersion parameter for the binomial family was taken to be 1.

Table 7: *Logistic Regression Results on Matched Data*

Variables	β (Log-Odds)	SE	z	p	OR	95% CI (Lower–Upper)
(Intercept)	-0.468	1.255	-0.373	0.709	0.63	0.05 – 7.33
VSLA Member	1.957	0.62	3.157	0.002 **	7.08	2.10 – 23.86
Age	0.015	0.018	0.812	0.417	1.01	0.98 – 1.05
Avg. Annual Income	<0.001	<0.001	-0.795	0.427	1	1.00 – 1.00
Distance to Extension	-0.003	0.045	-0.056	0.955	1	0.91 – 1.09
Credit Access	0.621	0.616	1.008	0.313	1.86	0.56 – 6.22
Asset Score	0.24	0.148	1.615	0.106	1.27	0.95 – 1.70

p < 0.01, indicated with '**'.

Odds Ratios (ORs) and Confidence Intervals (CIs) are exponentiated.

4.9 Association Between VSLA Membership and Access to Finance

The relationship between VSLA membership and credit access among cocoa farmers was analysed using Pearson's Chi-squared test with Yates' continuity correction. The results revealed a highly significant association ($\chi^2 = 35.56$, df = 1, $p < 0.001$), indicating a strong statistical difference in credit access between VSLA members and non-members.

As presented in Figure 8, 55.9% of VSLA members reported accessing loans, compared to only 14.9% of non-members. Conversely, 44.1% of VSLA members indicated they had not accessed loans, while a markedly higher proportion of non-members (85.1%) reported no loan access. This distribution underscores the substantial role of VSLA participation in enhancing financial inclusion among cocoa farmers.

Further analysis of loan sources revealed that most loan recipients obtained credit through their VSLA, accounting for 56 individuals (27.6% of all respondents). In contrast, only 14 respondents (6.9%) accessed credit from formal financial institutions such as banks, while 4 respondents (2.0%) relied on informal sources such as friends and family. These findings emphasize the pivotal role of VSLAs as the most accessible and utilized source of credit within rural cocoa-farming communities, where traditional banking services remain limited or inaccessible.

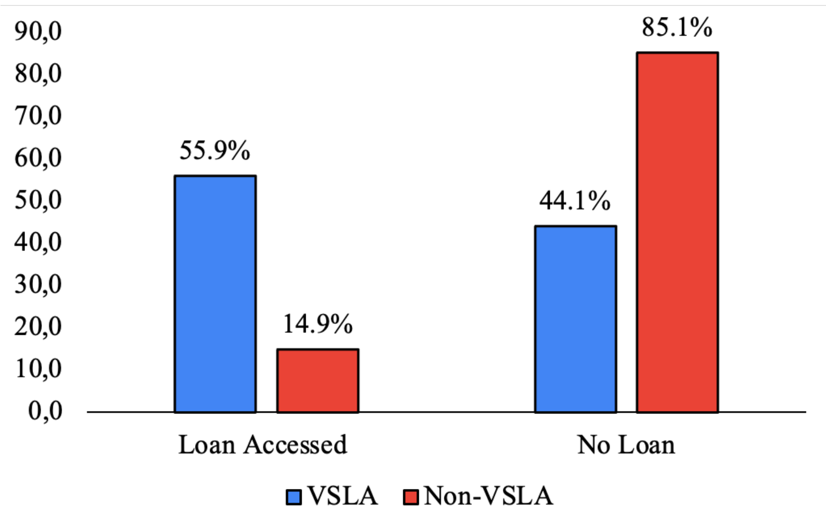

Figure 8: *Showing loan accessed between member and non-member*

4.10 VSLA and adoption of agroforestry

As illustrated in Figure 9, 64.71% of respondents (*n* = 66 out of 102) reported investing their VSLA share-out funds directly into cocoa farming activities. Additionally, 48.04% of respondents (49 out of 102) specifically allocated funds toward agroforestry practices. Other notable uses of VSLA funds included education (*n* = 55), with members using funds to pay school fees and support children's attendance at tertiary institutions, and general household expenses (*n* = 37), including the purchase of building materials, debt repayment, funeral costs, and buying of livestock or transportation equipment such as motorbikes. While 31 respondents reported using share-out funds for business investment, this use was less frequent than those directly tied to cocoa farming. A smaller proportion of respondents used their funds for healthcare expenses.

In areas lacking access to formal financial services such as banks or microfinance institutions, VSLAs serve as community-managed alternatives that offer both secure savings options and low-interest loans. Focus group participants emphasized that formal bank loans are difficult to access due to requirements such as collateral and high interest rates. Cocoa farms are often deemed too risky by banks, making it harder for farmers to secure financing. Moreover, with most banks located in distant district capitals requiring travel times of one to three hours accessibility remains a significant barrier. Consequently, VSLAs emerge as critical financial institutions for rural populations.

Among the 73 respondents who accessed loans from both bank and VSLAs, 41.10% (*n* = 30) reported utilizing loans for cocoa farm investment, while 23.29% (*n* = 17) used them specifically for agroforestry activities as shown in Table 11 in Appendix. One respondent noted, *"Through the VSLA, I can easily access loans to purchase farm inputs such as fertilizers and chemicals, which help improve soil fertility and control pests and diseases."* Another stated, *"With the loan, I was able to buy a mist blower to spray chemicals on my cocoa trees."* These investments in farming equipment and inputs contribute directly to productivity and climate-smart practices. Other uses of loans included education (36.99%) and business ventures (16.44%), both of which support broader household economic resilience and indirectly enhance capacity for agricultural reinvestment.

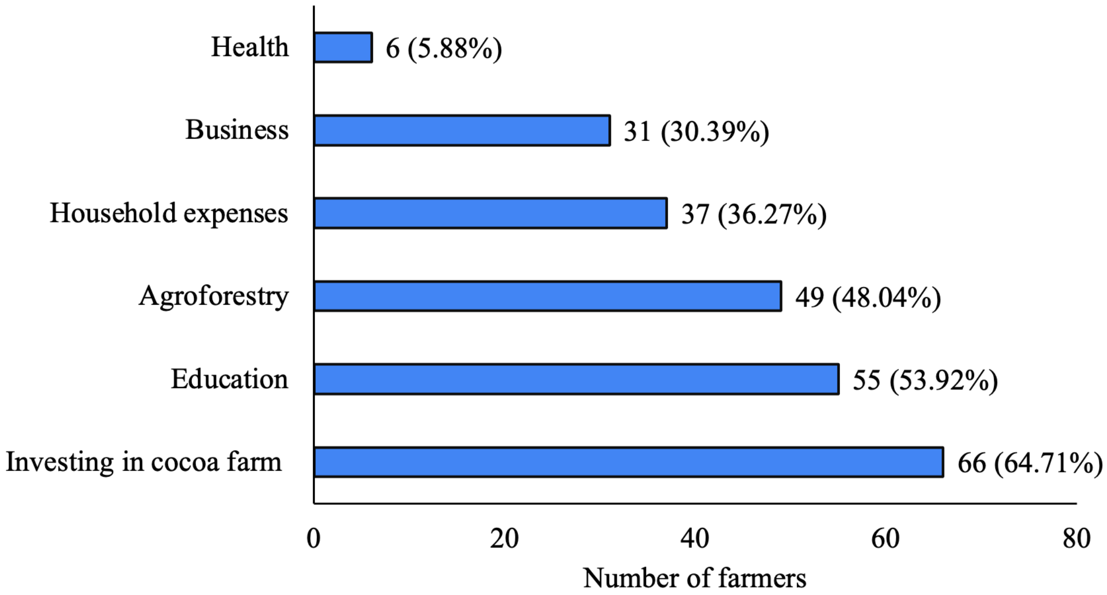

Figure 9: *Use of Share Out Money from VSLA*

4.11 VSLA and Training

Figure 10 presents the cross-tabulation of VSLA membership and receipt of agricultural training among cocoa farmers. The analysis reveals that a higher proportion of VSLA members (79.4%) reported having received agricultural training compared to non-members (69.3%). Specifically, out of 102 VSLA members, 81 had received training, while 21 had not. Among 101 non-members, 70 had received training, and 31 had not.

Furthermore, a Pearson's Chi-squared test with Yates' continuity correction was also conducted to examine the association between VSLA membership and participation in agricultural training. While a higher proportion of VSLA members (79.4%, n = 81) reported receiving training compared to non-members (69.3%, n = 70), the difference was not statistically significant, χ^2 (1, n = 203) = 2.22, p = 0.137. This suggests that, although VSLA members appear more likely to access training opportunities, the relationship is not strong enough to rule out the possibility of random variation.

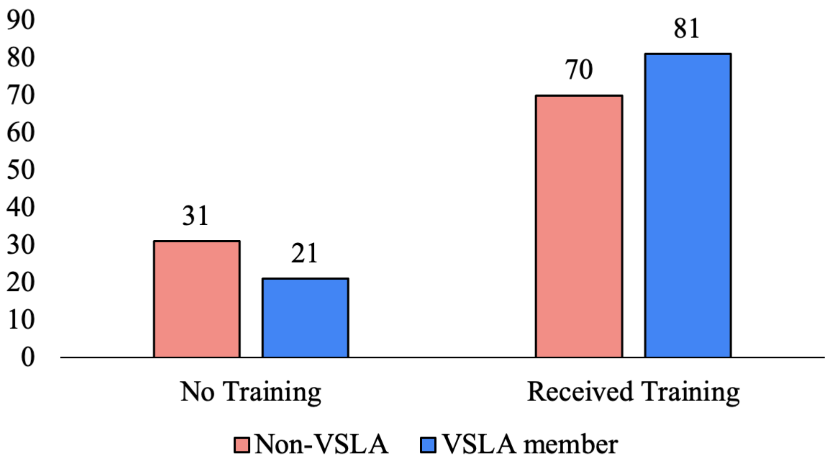

Figure 10: *Cross-tabulation of VSLA membership and agriculture training*

4.12 Association Between VSLA Membership and Agricultural Knowledge Sharing

Table 8 presents the comparison of agroforestry knowledge-sharing behaviours between members and non-members of VSLAs. Chi-square tests were conducted to determine the statistical significance of differences in knowledge-sharing practices. A higher proportion of VSLA members (65.7%) reported sharing agroforestry knowledge compared to non-members (51.5%). However, this difference approached but did not reach statistical significance (χ^2 (1) = 3.65, p = 0.056).

There was a highly significant association between VSLA membership and sharing knowledge specifically with other VSLA members. Among VSLA members, 56.9% shared knowledge with other members, compared to only 1.0% of non-members (χ^2 (1) = 74.16, $p < 0.001$), indicating that VSLA membership strongly facilitates intra-group knowledge exchange. Moreover, VSLA members revealed high levels of trust and solidarity within the groups. When asked about trust among VSLA members, 33 respondents strongly agreed and 54 agreed, indicating a strong sense of trust. Similarly, regarding solidarity within the VSLA group, 65 respondents agreed and 20 strongly agreed, demonstrating significant unity among members.

Similarly, VSLA members were significantly more likely to share agroforestry knowledge with neighbours (48.0%) than non-members (22.8%) (χ^2 (1) = 13.07, $p < 0.001$), suggesting broader community engagement among VSLA members.

Conversely, sharing knowledge with family members did not differ significantly between the two groups. Approximately 55.9% of VSLA members and 44.6% of non-members reported doing so (χ^2 (1) = 2.17, p = 0.141), indicating that familial knowledge-sharing may be independent of VSLA affiliation. These results highlight the role of VSLA membership in promoting the diffusion of agroforestry knowledge, particularly within the VSLA network and the broader community, but not necessarily within family units.

The respondents are also asked about the knowledge acquisition and information source. Agricultural Extension Agents serve as the primary source of information about new farming techniques (80.79% of respondents, n = 164). This is followed by input suppliers (44.33%, n = 90) and VSLA members (37.44%, n = 76), indicating that VSLAs represent the third most important knowledge source within farming communities. The prominence of VSLA members as information sources suggests these associations function as critical nodes in agricultural knowledge networks, facilitating the dissemination of technical information beyond financial services.

VSLA also serves as a platform sharing agricultural and agroforestry knowledge within the meetings. VSLAs actively facilitate agricultural knowledge sharing, with 40.39% of respondents (n = 82) confirming that VSLA meetings include discussions about agricultural practices. Among those participating in such knowledge sharing, the majority engage occasionally (32.51%, n = 66), while others participate monthly (5.42%, n = 11) or rarely (1.97%, n = 4). This pattern indicates that knowledge transfer within VSLAs is institutionalized but occurs with varying frequency, suggesting a systematic yet flexible approach to information dissemination.

The qualitative evidence from key informant interviews corroborates these findings, revealing a structured knowledge transfer mechanism: "*if a farmer has gone to a training and comes back, and if that farmer belongs to the VSLA, after they have finished with the VSLA meeting, they will stand up and share the knowledge about what they learned from the training*." This practice indicates how VSLAs serve as multiplier platforms, amplifying the reach of formal training programs through peer-to-peer knowledge transfer.

Regarding agroforestry-specific knowledge in general, 58.62% of respondents (n = 119) reported sharing agroforestry knowledge with others, indicating active knowledge transfer within farming communities. The primary recipients of this knowledge are family members (50.25%, n = 102), followed by other farmers (41.38%, n = 84), neighbours (35.47%, n = 72), and other VSLA members (29.06%, n = 59). Notably, VSLA members constitute a substantial proportion of knowledge recipients, reinforcing the role of these associations as platforms for technical information exchange.

Table 8: *Cross-tabulation of VSLA Membership and Agricultural Knowledge Sharing*

variables	1: Yes 0: No	VSLA member (102) N	%	Non-member (101) N	%	χ^2 (df = 1)	p-value
Shared agroforestry knowledge	1	67.00	65.70	52.00	51.50	3.65	0.056
	0	35.00	34.30	49.00	48.50		
Shared with VSLA members	1	58.00	56.90	1.00	1.00	74.16	**<0.001***
	0	44.00	43.10	100.00	99.00		
Shared with neighbors	1	49.00	48.00	23.00	22.80	13.07	**<0.001***
	0	53.00	52.00	78.00	77.20		
Shared with family	1	57.00	55.90	45.00	44.60	2.17	0.141
	0	45.00	44.10	56.00	55.40		

Note: * represents significance level

4.13 Challenges of VSLAs

The establishment and sustainability of VSLAs face several contextual and operational challenges. A key informant involved in VSLA setup identified access-related constraints, stating: *"Accessing the communities is very difficult, especially during the rainy season, as they do not have road connectivity. During the busy season, the farmers are all occupied, so it is sometimes difficult to gather them together for mobilization and training."*

Cultural practices also shape VSLA scheduling and participation. In the study district, 'Wednesday' is traditionally observed as a rest day, resulting in most VSLA groups choosing to meet on that day, typically in the morning. This leads to overlapping meetings, which limits the ability of facilitators to attend and support multiple groups weekly. This logistical constraint reduces the overall reach and efficiency of support efforts. Another significant challenge identified is the impact of illegal mining (*galamsey*). Youths are often drawn away from the VSLA model due to the promise of higher immediate financial returns through mining activities. As noted by an informant, *"Once they become involved in galamsey and begin earning more, they tend to abandon the VSLA.*"

Figure 11 showed challenges of VSLA when functioning. Despite establishment and sustainability challenges, a majority of VSLA members (n = 55) reported experiencing no challenges within the VSLA functioning, indicating the model's perceived efficacy. However, a notable proportion of respondents (n = 27) cited 'Limited Financial Capacity' as a significant constraint. Specific concerns included the insufficiency of loan amounts, as evidenced by repeated comments by respondents mentioning "*not enough loan,*" "*very low loan*," and "*not sufficient loan for all the people.*" These limitations hinder members' ability to undertake larger-scale investments, such as availing loans for business or purchasing property.

The financial constraints are further illustrated by members' difficulties in accumulating savings and purchasing shares. One of the respondents mentioned, "*We are unable to save regularly due to a high family dependency ratio and limited income from few earning adults, making it difficult to buy shares regularly*." These reflect systemic income limitations. Seasonal income variations exacerbate this issue, as expressed by another respondent *"During the off-season, it is difficult to purchase the shares."* The agricultural nature of the local economy, combined with high dependency ratios and limited income-generating opportunities, creates cyclical constraints on savings and loan participation.

Additionally, participants emphasized the need for capacity-building interventions to address these challenges. One participant said, *"Most of us are farmers: higher dependency ratio, large family size, and low income. Families are confronted with galamsey, which is a disturbance to activities. We need training to generate additional income to support and save in the VSLA. There are not enough loans."* This suggests an interlinked web of demographic, economic, and environmental challenges that constrain financial inclusion.

Governance and behavioural issues (n = 11) are less common in VSLA operations. A few respondents mentioned misunderstandings, timing conflicts, and quarrels among members, resulting in fines. Some people also show non-adherence to rules. One respondent stated, *"Some people don't follow the constitution," and "People come from different groups and don't follow rules. They are difficult, and there are quarrels among members.*" This highlights challenges in enforcing the VSLA's operational guidelines, due to diverse member backgrounds or insufficient understanding of the rules. Other challenges include high absenteeism. Respondents mentioned, *"People don't come on time and need to pay fines.*" One respondent noted that at the last meeting, only 5 out of 25 members attended. This indicates issues with member commitment to meetings, which are crucial for the proper functioning of a VSLA.

Loan Defaults and Repayment (n = 6) are less frequent but remain critical, as they directly undermine the financial health and sustainability of the VSLA fund. One respondent stated, *"Sometimes people come with false requests; loans are issued for genuine reasons,"* suggesting that some members may misrepresent their intentions, while VSLAs attempt to prioritize productive, income-generating uses. *"The member who takes the loan, after not paying it, stops coming to meetings. When asked why, they say, 'I will come when I get the money,"* said another respondent. It illustrates the common challenge of defaulters disengaging from the group, making recovery difficult. This behaviour directly affects the revolving fund. *"They provide a loan with a deadline of 3 months, but members don't repay it on time. It becomes difficult to pay. This affects access to future loans and* *impacts loan interest. According to the constitution, they renew it for 6 months with interest,"* said another respondent. It highlights systemic issues with repayment capacity or willingness, necessitating renewals that strain the VSLA's liquidity and reduce interest gains. In one of the VSLA groups, members also expressed a desire to share the social fund. The social fund is a contribution collected at every meeting (one cedi per member) used for buying books and other necessary items.

In communities without an existing VSLA, respondents were asked about the factors that have prevented them from joining and majority cited the absence of a nearby VSLA (n = 99), followed by a lack of awareness (n = 24). Respondents were subsequently asked whether they were interested in joining a VSLA. Of the 95 respondents, 49 expressed interests in joining, 39 responded ‘Maybe,’ and only 7 said ‘No.’ These findings indicate a substantial level of interest in joining a VSLA among the active participants. Additionally, a significant portion of respondents remain undecided, neither fully committed nor entirely opposed. This group may be open to joining if provided with more information, and traning.

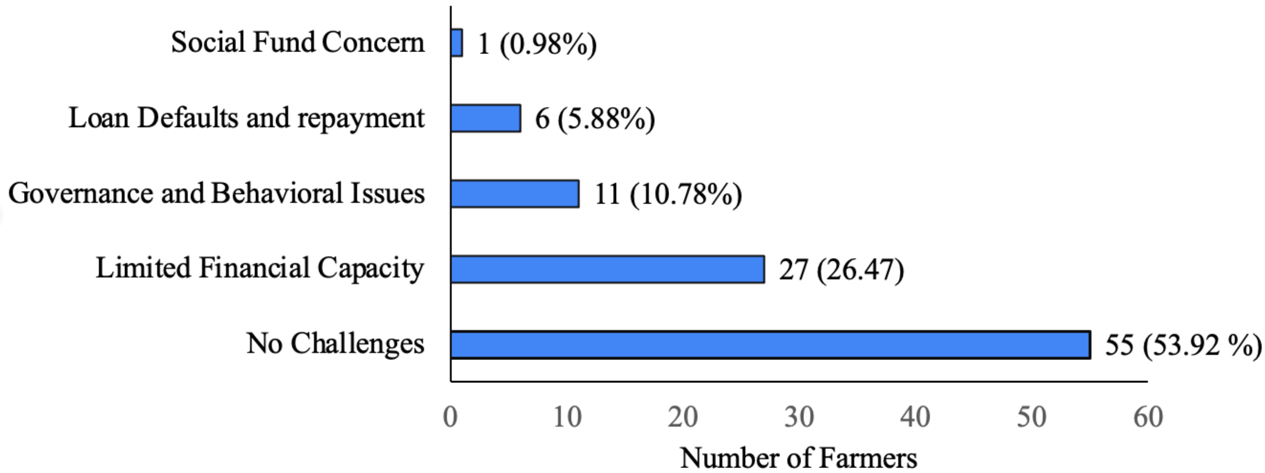

Figure 11: *Showing challenges of VSLA*

4.14 Deterrent of Climate Smart Cocoa Agroforestry

A critical bottleneck in the early stages of agroforestry implementation is the limited availability of tree seedlings and essential farm inputs, cited by 125 farmers as the most significant challenge as shown in Figure 12. One farmer noted, *“One of the main challenges of growing trees on a cocoa farm is not having enough of the desired tree seedlings available.”*

According to a key informant responsible for distributing seedlings to local communities, seedlings are allocated based on a needs assessment. This assessment considers two main factors: Farmer-Preferred Tree Species (FPTS), such as fruit trees, shade trees, and fodder species valued for their economic, cultural, or household utility, and Recommended Tree Species, which are identified by foresters, agronomists, or ecologists for their ecological benefits, including nitrogen fixation and carbon sequestration. The emphasis on FPTS helps increase farmer motivation and engagement, as they are more likely to plant trees, they personally value. However, the informant also emphasized the importance of ensuring that farmers include recommended species to enhance environmental outcomes. Despite current limitations in seedling availability, we are trying to scale up distribution starting this year, with the aim of promoting broader adoption of climate-smart cocoa agroforestry practices.

Tree tenure insecurity and pest and disease pressures were the second and third most frequently cited challenges, respectively. Tree tenure insecurity was mentioned by 85 respondents and pertains to uncertainties around ownership and rights over trees planted on farms. In Ghana, the legal framework dictates that all naturally occurring trees, including those on farms, are owned by the state. As one respondent explained: *"Organizations like Solidaridad encourage farmers to register trees with the Forestry Commission (FC), but the process is slow and discouraging. When I went to the Commission, they told me to return the next day, and when I returned, they delayed me again. It's hard for farmers to keep going back. Yet, if we cut down a tree, officials will fine us, claiming it belongs to the state."* Another farmer added: *"Even when we plant the trees ourselves, we have no ownership. The government grants concessions to others who then cut down our trees and damage our cocoa farms."* These highlight the systemic challenges associated with securing tree tenure and the disincentives they create for tree planting.

Pests and diseases were reported by 84 respondents as major threats to tree and crop productivity. The most cited issues included black pod disease (n = 74), swollen shoot disease (n = 66), termites, and rodents. One farmer described a widespread issue: *"There's a plant called mistletoe that grows on cocoa trees. Birds eat its berries and excrete the sticky seeds on branches, causing the mistletoe to grow and weaken the trees."* Another respondent noted that increasing tree cover creates a more humid microclimate, which can exacerbate black pod infections in cocoa. Labor constraints were cited by 82 respondents, reflecting the difficulty in accessing sufficient labour for agroforestry management. One respondent stated: *"Hiring labour is hard and expensive because most people have left to work in galamsey."*

Other notable challenges included, lack of technical knowledge ($n = 60$), Competition between trees and crops ($n = 53$) and long wait for returns on tree investments ($n = 52$). Land tenure issues, distinct from tree tenure, were the least frequently mentioned among the structured responses ($n = 26$). Additional challenges reported include environmental and climate-related stresses. Respondents cited difficulties such as: "*Watering trees during the dry season is hard," "Most trees die due to insufficient water in the dry season," "Climate change has reduced rainfall, and nearby rivers are polluted from mining, making irrigation impossible.*" Some farmers also noted that softwood species like *Ceiba pentandra* and *Terminalia superba* frequently drop large branches, damaging cocoa trees. These are the multifaceted challenges farmers face in integrating trees into cocoa systems.

Farmers who have not integrated cocoa agroforestry into their farms were asked to identify the barriers they faced, and the most frequently cited barrier was limited access to seedlings and farm inputs, reported by 30 respondents. The second most common barrier was lack of knowledge or information, mentioned by 18 respondents. Labor constraints were reported by 12 respondents indicating the challenge of securing adequate human resources for the labour-intensive activities associated with agroforestry. Additional barriers reported by respondents included financial constraints ($n = 9$), scepticism regarding the benefits of agroforestry ($n = 7$), and the long-time horizon required to realize returns on investment ($n = 3$). A smaller number of respondents cited land tenure issues ($n = 2$), while one individual expressed a preference for traditional cocoa cultivation over the adoption of agroforestry systems.

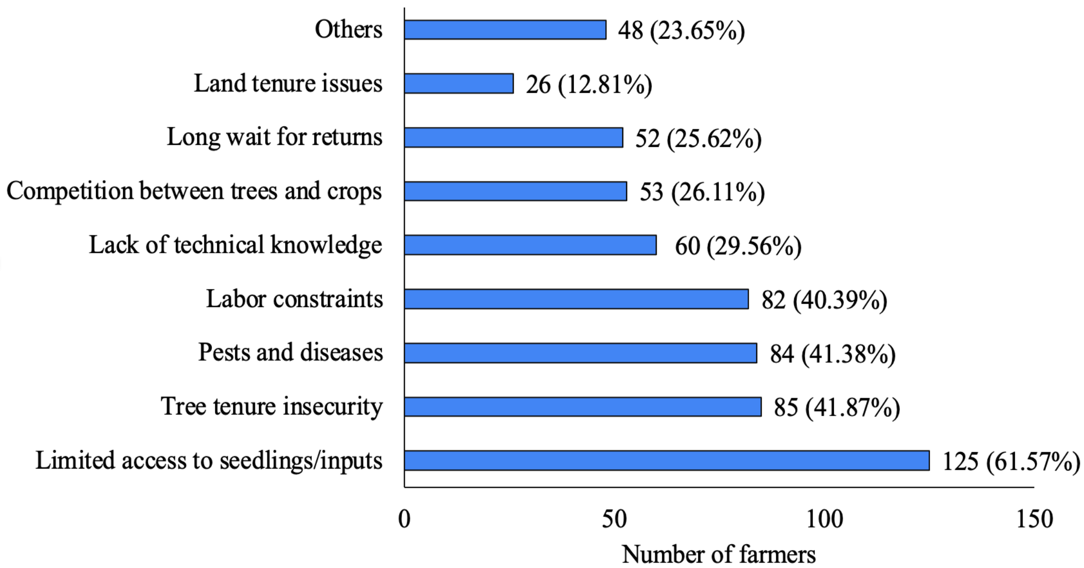

Figure 12: *Showing the challenges of having an agroforestry system*

5. Discussion

5.1 VSLA Membership as a Driver of Agroforestry Adoption

This study's findings strongly support Hypothesis 1, indicating a significant positive association between VSLA membership and the adoption of climate-smart cocoa agroforestry practices. Firstly, VSLA membership was strongly associated with a significantly higher likelihood of adopting agroforestry practices. Results from the logistic regression model showed that VSLA members were 7.08 times more likely to adopt agroforestry compared to non-members, after adjusting for covariates through propensity score matching and controlling for observed confounding (Table 7). These findings directly fulfil Specific Objective 1, which aimed to compare adoption rates of agroforestry between members and non-members of VSLAs, demonstrating significantly higher adoption rates among VSLA members ($\chi2 = 18.68, p < 0.001$) (Table 5). This aligns with existing research indicating that VSLA participation enhances farmers' capacity to invest in sustainable agriculture by providing them with access to savings and credit (Agyapong et al., 2024). Another research on Average treatment effects of impacts of VSLA on SAPs indicated that on average the mean number of sustainable agricultural practices (SAPs) adopted by participants of VSLA is approximately 2.097 times higher than the mean number of SAPs adopted by individuals who are not participants (Alhassan et al., 2023). The findings further corroborate studies showing that in Taiama, Kori Chiefdom, Moyamba District, VSLA-facilitated access to microfinance enables farmers to overcome upfront investment barriers such as acquiring tree seedlings, fencing materials, or labour required for agroforestry establishment (Gassama et al., 2023). Farmers did mention using VSLA funds in this study to purchase tree seedlings, hire labour, and expand cocoa plots as well. These activities are strongly tied to agroforestry implementation.

5.2 Strengthening Financial Capital and Overcoming Investment Barriers

Secondly, VSLA members exhibited significantly greater access to credit than non-members. While 55.9% of VSLA members had accessed loans, only 14.9% of non-members did so (Figure 8). Most of the loans obtained by members came from their own VSLAs, highlighting these groups as critical financial institutions in rural areas with limited formal banking infrastructure. This finding directly addresses Specific Objective 2, which sought to analyse the impact of VSLA membership on cocoa farmers' access to finance and its influence on agroforestry adoption, demonstrating that VSLA membership substantially improved access to finance and linking this enhanced financial capacity directly to agroforestry investments. The ability to mobilize funds through group savings has not only significantly increased smallholder investment in sustainable agricultural practices but also improvement in household business outcomes and women's empowerment. (Beaman et al., 2014; Karlan et al., 2017).

In contexts where there is limited participation and geographic reach of microcredit institutions, especially among the rural poor, informal groups like VSLAs can play a catalytic role in enabling capital-intensive transitions like agroforestry. The results of this study corroborate the tenets of the Sustainable Livelihoods Framework (Ellis, 2000; Scoones, 2015), which explains that access to assets like financial and social capital can improve livelihood outcomes and enhance resilience. VSLAs effectively enhanced farmers' financial capital through accessible loans and savings mechanisms, enabling investments in agroforestry inputs such as seedlings, labour, and tools. This finding aligns with the literature on financial inclusion and agricultural investment. Studies by Ksoll et al. (2016) and Karlan et al. (2017) demonstrated that VSLAs can significantly increase household savings and productive investment. In this context, cocoa farmers utilized VSLA funds to expand their farms, purchase agro-inputs, and implement sustainable practices. Furthermore, the study reinforces the theoretical framework surrounding poverty traps (Barrett & Carter, 2006). Farmers outside VSLAs, often older and wealthier, may rely on accumulated capital, whereas younger, lower-income farmers use VSLAs to incrementally escape poverty through collective mechanisms (Yi et al., 2023). This dual-path dynamic underlines the importance of social institutions in disrupting intergenerational poverty cycles. Also, adopting agroforestry can be risky due to delayed economic benefits and ecological uncertainties. VSLAs provide a financial safety net that allows members to buffer against short-term losses or crop failures (Ksoll et al., 2016). This risk-pooling effect reduces individual exposure and incentivizes long-term investment in climate-smart practices (Ksoll et al., 2016).

Moreover, the significance of VSLAs in overcoming financial barriers is further emphasized by the finding that VSLAs constituted the primary source of credit for rural farmers, with 56 individuals (27.6% of all respondents) obtaining loans through their VSLA compared to only 14 (6.9%) who accessed credit from formal financial institutions. This pattern reflects the broader challenges of financial inclusion in rural Sub-Saharan Africa, where only 23% of adults have access to formal financial services (Demirgüç-Kunt et al., 2018).

5.3 Knowledge Sharing, Social Capital, and Inclusive Participation

Thirdly, VSLA members were more engaged in knowledge-sharing practices. Although the difference in receiving formal training was not statistically significant, the qualitative and quantitative data confirmed that VSLA meetings served as vital platforms for sharing agricultural knowledge, including agroforestry practices (Table 8). These findings accomplish Specific Objective 3, which aimed to assess how participation in VSLAs supports knowledge transfer and capacity building for adopting cocoa agroforestry practices, establishing VSLAs as vital knowledge-sharing platforms and informal extension networks that facilitate horizontal knowledge transfer for agroforestry practices. Research has shown that social learning significantly enhances agricultural technology adoption, particularly when facilitated through trusted peers (Conley & Udry, 2010). In this study, VSLA members were more likely to report sharing and receiving agroforestry-related knowledge, supporting the idea that VSLAs act as informal extension networks. Moreover, the finding that training knowledge is disseminated within VSLA meetings amplifies their role as 'knowledge multipliers', a concept critical to scaling sustainable agriculture in low-resource settings. The role of VSLAs in promoting knowledge sharing also supports literature on social capital and innovation diffusion theory (Bandiera & Rasul, 2006). The institutionalized practice of sharing training insights during VSLA meetings exemplifies horizontal knowledge transfer, reinforcing the VSLA as a vehicle not only for finance but for community learning. Social capital derived from such networks is critical in influencing behaviour, especially where innovation adoption involves risk and uncertainty (Pretty & Ward, 2001; Woolcock & Narayan, 2000). The shared norms and obligations within VSLAs reduce the transaction costs of information exchange and help create an enabling environment for sustainable practices. Participation in VSLAs fosters regular engagement, financial discipline, and long-term planning. These behavioural shifts are consistent with findings from behavioural economics, which suggest that structured financial commitments can improve future-oriented decision-making (Ashraf et al., 2006). For agroforestry, which entails delayed returns and long-term land management, such behavioural transformation is an important component.

VSLA Members demonstrated significantly higher informal knowledge dissemination behaviours (peer sharing and neighbour), suggesting that VSLAs facilitate participatory learning, even when formal training coverage is equivalent (Pamuk et al., 2022). Contrary to expectations, gender, land tenure security, and education level did not significantly affect VSLA participation or agroforestry adoption in this study. While education and gender are often cited as determinants of technology adoption (Amponsah et al., 2023), this may reflect the inclusive nature of VSLAs, which are intentionally designed to accommodate women and less-educated participants (VSL Associates, 2024). It also suggests that financial access, peer support, and a strong sense of belonging in a group may outweigh individual level demographic factors in influencing agroforestry decisions (Leduc & Hansson 2024; Briamonte et al., 2023). This supports findings from Alhassan et al. (2023), who noted that group-based dynamics in VSLAs create enabling environments that reduce the need for individual-level assets or credentials.

Interestingly, the study revealed that VSLA members were significantly younger than non-members yet had substantially lower annual incomes and cocoa season incomes (Table 4). This paradoxical finding suggests that VSLAs may particularly attract younger, resource-constrained farmers who face greater barriers to accessing formal financial services. This pattern aligns with previous studies indicating that VSLAs disproportionately serve poor, financially excluded populations in rural areas, who often lack access to formal banking services or collateral for loans (Brannen & Sheehan-Connor, 2016; Agyapong et al., 2024). Also, according to SAVIX (2025), VSLAs have transformed marginalised communities worldwide, mobilising local savings, which provide members with a means to cope with emergencies, help to manage household cash-flow, build a capital base and, crucially, re-build social networks, solidarity and trust.

The lower income levels among VSLA members, despite their higher adoption of agroforestry practices, may reflect several factors. First, the adoption of agroforestry represents a long-term investment that may temporarily reduce income as farmers allocate resources to tree planting and management before realizing returns (Franzel et al., 2001). Secondly, the self-selection of lower-income farmers into VSLAs suggests these associations effectively target financially marginalized populations who stand to benefit most from collective savings and lending mechanisms (Bwalya Zulu, 2021).

Also, members tended to be located farther from buyers and agriculture extension compared to non-members, although not always significantly so. This distance might partially explain their reliance on VSLAs for knowledge and financial services. Remote farmers may lack access to government or NGO-run training and financial institutions and thus rely on VSLAs as critical service delivery platforms (Sienso et al., 2021). These spatial dynamics further emphasize that VSLAs help bridge rural service gaps, especially where geography or infrastructure impedes formal extension outreach. Though VSLA members were generally further from extension services and markets, this spatial gap was not statistically significant. Nevertheless, distance also remains an important contextual barrier, especially in the rainy season, as noted during focus group discussions. While not statistically significant, this practical reality warrants intervention, such as integrating VSLA groups into decentralized service delivery platforms (Rubyutsa et al., 2024).

5.4 Structural, Demographic, and Contextual Challenges

Despite the findings affirm the positive impact of VSLAs on agroforestry adoption, several challenges persist that could threaten the sustainability and scalability of these interventions. A consistent concern among members was that available loan sizes were too small for high-input investments like agroforestry, which may require bulk purchases of seedlings, fencing, or labour. Additionally, short loan repayment cycles (typically 3 months) may not align with the long gestation periods of agroforestry returns (Allen & Panetta, 2010). This structural mismatch between VSLA loan design and agroforestry timelines echoes concern in other contexts, where seasonal cash flows in agriculture do not synchronize with rigid repayment schedules (Jumpah et al., 2019; Ksoll et al., 2022; Amponsah et al., 2023). Thus, while VSLAs improve access to capital, they may need external support or innovation in loan structuring to truly support agroecological transformations. Empirical evidence from Northern Ghana supports these findings, stating that the small amount of available loans and short-term loan period were major challenges faced by the VSLA programmes and these limited investments in long-term activities (Antwi et al., 2022). Also, the standard VSLA methodology compounds this limitation by restricting loan amounts to up to three times the value of their savings with repayment periods for a maximum period of three months (VSL Associates, 2024). While some flexibility exists within the operation of VSLA with groups documented to adjust loan terms following poor harvests, to help members recover without jeopardizing their financial standing (Osei et al., 2024) yet systematic adaptation mechanisms for long-term investments remain underdeveloped. Thus, while VSLAs demonstrably improve access to capital, they require external support or fundamental innovation in loan structuring to genuinely support agroecological transformations.

The study revealed that many youths are opting out of VSLAs in favor of illegal mining due to faster returns. This has long-term implications for agroforestry adoption, which demands long-term land stewardship, often from the next generation. This concern is reflected in similar findings by Rubyutsa et al. (2024), who argue that without targeted youth engagement strategies, rural sustainability initiatives like VSLAs may age out of its effectiveness. This youth-mining dynamic represents a particularly acute threat to agroforestry sustainability. Research across resource-rich Sub-Saharan Africa demonstrates that large-scale extractive industries create few jobs for youth, and, as a result, drive individuals to pursue employment in informal sector activities (Ackah-Baidoo, 2016), including artisanal and small-scale mining. This phenomenon reflects broader challenges in rural development where short-term economic opportunities can undermine investments in sustainable livelihoods (Hilson, 2016). The same author further reveals that artisanal and small-scale mining provides countless numbers of jobs and supports the livelihoods of millions of people in a landscape where employment opportunities remain severely constrained. However, this comes at significant environmental cost, with evidence from Ghana indicating that mining activities can lead to indiscriminate deterioration of the environment through unorthodox mining practices creating direct competition with agroforestry conservation objectives (Ofosu et al., 2020).

Qualitative data from surveys, FGDs and KIIs highlighted that during the rainy season, access to VSLA meetings becomes difficult due to poor road conditions and farming demands. Additionally, conflicting schedules, household responsibilities, and lack of trained facilitators further limit engagement. These challenges, along with the structural mismatches between VSLA loan terms and agroforestry investment timelines and youth migration to illegal mining, fulfil Specific Objective 4, which aimed to identify challenges that limit joining VSLAs and limiting factors in promoting adoption of agroforestry. According to Gray et al., (2012), these accessibility challenges represent systemic barriers extending beyond individual VSLA operations. Rural communities face a range of challenges associated with accessibility and connectivity which apply in both the physical and virtual sphere, with constraints in rural transport infrastructure and services often compounded by limitations in the development and resilience of technological infrastructures (Gray et al., 2012). Another study from Northern Ghana specifically documented how VSLA members might find selling their goods or services challenging, reducing their income and ability to repay loans due to fluctuating market conditions exacerbated by poor accessibility infrastructure (Osei et al., 2024). These logistical issues underscore the importance of flexible programming, localized coordination, and technology use (e.g., mobile meetings or digital savings platforms) to strengthen VSLA resilience. Yet in the African context digital literacy is often lower in rural areas than in urban ones, which makes it even more difficult to activate such solutions (Salemink et al., 2017).

6. Policy Relevance

The findings have several important implications for policies and programs aimed at promoting sustainable cocoa production and rural development. First, the strong association between VSLA membership and agroforestry adoption suggests that expanding VSLA coverage could be an effective strategy for scaling climate-smart agriculture. However, this expansion must address identified constraints, including improving road infrastructure to facilitate access during rainy seasons and adapting meeting schedules to accommodate agricultural labour demands.

Second, the critical role of VSLAs in knowledge dissemination suggests that agricultural extension programs could achieve greater impact by explicitly partnering with VSLAs as delivery channels. Training VSLA leaders as para extension agents or establishing formal linkages between extension services and VSLA networks could enhance the efficiency and reach of technical support for agroforestry adoption.

Third, addressing the tree seedling constraint requires coordinated efforts to strengthen seedling production and distribution systems. The current approach of balancing farmer-preferred tree species with ecologically recommended species appears sound, but implementation capacity needs significant expansion. Public-private partnerships could help establish community nurseries linked to VSLA networks, creating both seedling access and income-generating opportunities for members.

Finally, the tree tenure insecurity issue demands policy reform to clarify and strengthen farmers' rights over planted trees. Streamlining the tree registration process and ensuring farmers can benefit from trees they plant would remove a significant disincentive to agroforestry adoption.

7. Limitation of study and future research

Several limitations constrain the interpretation and generalizability of these findings. The cross-sectional design limits our ability to establish definitive causal relationships, despite the use of propensity score matching to address selection bias. The study focused on a single district in Ghana, and findings may not translate directly to other contexts with different agroecological conditions, cultural norms, or institutional landscapes. Additionally, the research relied primarily on farmer self-reports of agroforestry adoption without independent verification of practices or measurement of their environmental outcomes.

The challenges identified in this study point toward several important areas for future research. Longitudinal studies tracking farmers over multiple seasons would provide stronger evidence of causal relationships and allow researchers to observe the dynamic interactions between VSLA participation, financial behaviour, and agricultural decision-making over time. Comparative research across different agroecological zones and countries would help identify the contextual factors that influence the effectiveness of VSLAs in promoting sustainable agriculture. There is also a critical need for studies that measure the actual environmental and productivity outcomes of VSLA-supported agroforestry, rather than focusing solely on adoption rates.

Moreover, although this study employed rigorous matching and regression techniques to adjust for observed confounding factors, the possibility of unmeasured confounders influencing the relationship between VSLA membership and agroforestry adoption cannot be completely ruled out. Future research could incorporate sensitivity analyses or alternative study designs to further assess the robustness of these findings.

8. Conclusion

This study examined how membership in VSLAs influences the adoption of climate-resilient agroforestry practices among cocoa farmers in Ghana's Wassa Amenfi West District. The research sought to understand whether VSLAs, as informal financial and social institutions, could serve as an enabler for sustainable agricultural transformation in rural communities facing climate pressures.

The findings provide strong evidence that VSLA membership significantly enhances farmers' likelihood of adopting agroforestry practices. VSLA members were 7.08 times more likely to integrate trees into their cocoa systems compared to non-members, even after controlling for observable differences through propensity score matching. This positive association is driven primarily by two interlinked mechanisms; enhanced financial access and strengthened social capital. VSLAs effectively addressed key barriers to agroforestry adoption by offering accessible credit with 55.9% of members accessing loans compared to only 14.9% of non-members and serving as platforms for agricultural knowledge exchange. Remarkably, 27.6% of all respondents obtained loans specifically through VSLAs, making these associations the predominant source of rural credit in communities where formal banking services remain limited or inaccessible.

The knowledge-sharing function of VSLAs proved to be as influential as their financial function. Through routine practices such as post-meeting discussions and peer-to-peer interactions, VSLAs fostered informal extension networks that effectively extended the impact of formal training programs. Members exhibited significantly greater involvement in disseminating agroforestry knowledge to neighbours and peers, indicating that VSLAs function as ‘knowledge multipliers’ within rural communities. This combination of financial support and peer-based knowledge exchange positions VSLAs as an effective institution for advancing climate-smart cocoa agroforestry at the grassroots level.

Building on this work, the future research should explore on unmeasured confounders that influences the relationship between VSLA membership and agroforestry adoption. Such evidence would provide more robust insights into how VSLA facilitate agroforestry uptake, mititgating impact of climate change, curb deforestation and deliver mutual benefits to both human and biodiversity.

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10. Appendix

10.1 Questionnaire

The Role of Village Savings and Loan Associations (VSLAs) In Promoting Climate-Resilient Agroforestry Practices Among Cocoa Farmers in Wassa Amenfi District, Ghana.

Note: *This research is part of the Wassa Amenfi Cocoa Landscape Initiative in Ghana. All information collected through this questionnaire is strictly confidential and will be used solely for research purposes. Respondents' comments, suggestions, and personal information will not be shared beyond this study. The findings will be shared with project partners to support sustainable cocoa farming and benefit the community. This survey explores the role of social networks in adopting climate-smart cocoa practices.*

Section A: Demographic and Household Characteristics
Respondent ID: ________________
Age: _______ years
Gender:

- Male
- Female
- Other/Prefer not to say

Highest level of education:

- No formal education
- Primary
- Junior High School
- Senior High School
- Secondary High School
- Tertiary
- Other (specify): ________

Household size: _______ (number of people living in your household)
Primary occupation: ________________
Secondary occupation(s): ________________
Total farm size: _______ (hectares/acres)
Land dedicated to cocoa production: _______ (hectares/acres)
Land tenure status:

- Own land with title deed
- Own land without formal documentation
- Family land
- Rented/Leased
- Other (specify): ________

Distance from your home to the nearest agricultural extension service: _______ km
Are you a member of a Village Savings and Loan Association (VSLA)?

- Yes → Continue to Section B1 (VSLA Members)
- No → Skip to Section B2 (Non-VSLA Members)

Section B1: **VSLA Membership and Activities** ***(For VSLA Members Only)***
How long have you been a VSLA member? _______ years/months
How many VSLA cycles have you completed? _______
What is your position in the VSLA?

- Chairperson
- Secretary

- Treasurer
- Ordinary member
- Other (specify): ________

How much do you typically save per month in your VSLA? _______ (local currency)

How much do you typically earn per month:

- Cocoa Seasons: ________________
- Other seasons: ________________

What percentage of your household income is saved through VSLA? _______%

Have you taken loans from your VSLA?

- Yes
- No

If yes, how many loans have you taken in the last 1 year? _______

What was the average loan amount? _______ (local currency)

What were the loans primarily used for? (Select all that apply)

- Investing in cocoa farm
- Investing in agroforestry
- Household expenses
- Education
- Health
- Business
- Other (specify): ________

After the VSLA cycle is completed, what do you typically use your share-out money for? (Select all that apply)

- Investing in cocoa farm
- Investing in agroforestry
- Household expenses
- Education
- Health
- Business
- Other (specify): ________

Before joining the VSLA, did you have access to any formal financial services

- Bank account
- Microfinance
- Cooperative
- None
- Other (specify): ________

Has joining the VSLA improved your ability to access other financial services?

- Yes
- No

Distance from your home to the nearest VSLA meeting point: _______ km

Continue to Section C

Section B2: Financial Access and Savings ***(For Non-VSLA Members Only)***

Are you aware of VSLAs operating in your community?

- Yes
- No

Distance from your home to the nearest VSLA meeting point (if known): _______ km

Do you have access to any formal financial services?
- Bank account
- Microfinance
- Cooperative
- None
- Other (specify): ________

Do you save money regularly?
- Yes
- No

If yes, where?
- At home
- With friends/family
- Bank
- Mobile money
- Other (specify): ________

How much do you typically save per month? _______ (local currency)
Cocoa Season: ________________
Other season: ________________
How much is your income per month: ___________ (local currency)
What percentage of your household income is saved? _______%
Have you taken any loans in the last 2 years?
- Yes
- No

If yes, from where?
- Bank
- Microfinance
- Friends/family
- Money lender
- Other (specify): ________

If yes, what was the average loan amount? _______ (local currency)
What were the loans primarily used for? (Select all that apply)
- Investing in cocoa farm
- Investing in agroforestry
- Household expenses
- Education
- Health
- Business
- Other (specify): ________

Continue to Section C

Section C: Agroforestry Practice Screening ***(For All Respondents)***
Do you practice cocoa agroforestry on your farm?
- Yes → Continue to Section D
- No → Skip to Section G

Section D: Agroforestry Adoption ***(For All Adopters)***
When did you start implementing agroforestry practices? _______ (year)

How many acres/ha of land do you have under agroforestry: ________(Acre/Hectar)
Did you start agroforestry practices before or after joining the VSLA? *(For VSLA Members Only)*

- Before
- After
- N/A (Non-VSLA member)

Which agroforestry practices have you implemented? (Select all that apply)

- Shade trees with cocoa
- Fruit trees with cocoa
- Timber trees with cocoa
- Nitrogen-fixing trees
- Intercropping/Alley cropping
- Boundary planting
- Other (specify): ________

What tree species have you incorporated in your agroforestry system? (List up to five)

a. ________________
b. ________________
c. ________________
d. ________________
e. ________________

What motivated you to adopt agroforestry practices? (Select all that apply)

- Additional income
- Improved cocoa yields
- Climate resilience
- Soil improvement
- Training received
- Access to finance through VSLA *(VSLA members only)*
- Access to finance *(non-VSLA members)*
- Seeing successful examples
- Other (specify): ________

(For VSLA Members Only) **On a scale of 1-5 (1=not important, 5=extremely important), how important was your VSLA membership in your decision to adopt agroforestry? _______**

(For VSLA Members Only) **On a scale of 1-5 (1=strongly disagree, 5=strongly agree), rate your agreement with the following statement: "VSLA membership provided the financial means necessary to implement agroforestry." _______**

Continue to Section E

Section E: Benefits and Challenges of Agroforestry *(For All Adopters)*

What benefits have you experienced from implementing agroforestry? (Select all that apply)

- Increased cocoa yield
- Additional income sources
- Improved soil fertility
- Better climate resilience
- Enhanced food security
- Access to fuelwood
- Other (specify): ________

What challenges have you faced in implementing agroforestry? (Select all that apply)

- Lack of technical knowledge
- Limited access to seedlings/inputs
- Financial constraints
- Labor constraints
- Land tenure issues

- Long wait for returns
- Competition between trees and crops
- Pests and diseases
- Other (specify): ________

(For VSLA Members Only) **Have you been able to address any of these challenges through your VSLA membership?**

- Yes
- No

If yes, how? ________________

(For Non-VSLA Members Only) **How have you addressed these challenges without VSLA support? ________________**

What additional support would help you to better implement or expand agroforestry practices? ________________

Continue to Section F

Section F: Training and Knowledge Transfer *(For All Adopters)*

Have you received training on agroforestry practices?

- Yes
- No

If yes, who provided the training? (Select all that apply)

- Government extension
- NGO (specify): ________
- Private company (specify): ________
- VSLA facilitator *(VSLA members only)*
- Fellow farmers
- Other (specify): ________

How many agroforestry training sessions have you attended in the last 2 years? _______

(For VSLA Members Only) **Did you receive any training specifically because of your VSLA membership?**

- Yes
- No

If yes, what kind of training? ________________

(For VSLA Members Only) **Do VSLA meetings include knowledge sharing about agricultural practices?**

- Yes
- No

If yes, how often?

- Every meeting
- Monthly
- Occasionally
- Rarely

(For Non-VSLA Members Only) **From where do you typically get information about farming practices?** (Select all that apply)

- Government extension
- NGOs
- Radio/TV

- Other farmers
- Family members
- Internet/mobile phone
- Other (specify): ________

Have you shared knowledge about agroforestry with others?

- Yes
- No

If yes, with whom? (Select all that apply)

- Family members
- Neighbours
- Other VSLA members *(VSLA members only)*
- Other farmers
- Other (specify): ________

(For VSLA Members Only) **On a scale of 1-5 (1=not at all, 5=very much), to what extent has VSLA membership improved your:**

- Knowledge about agroforestry: _______
- Skills in implementing agroforestry: _______
-Access to resources for agroforestry: _______
- Confidence in managing agroforestry systems: _______

(For Non-VSLA Members Only) **Do you feel you have adequate knowledge about agroforestry practices?**

- Yes
- No
- Partially

Do you feel capable of maintaining your agroforestry system independently?

- Yes
- No
- Partially

(For VSLA Members Only) **Do you feel capable of maintaining your agroforestry system independently after project support ends?**

- Yes
- No
- Partially

Skip to Section H

Section G: Non-Adoption of Agroforestry ***(For All Non-Adopters)***

Are you familiar with cocoa agroforestry practices?

- Yes
- No
- Partially

Have you ever considered implementing agroforestry on your cocoa farm?

- Yes
- No

What are the main reasons you haven't adopted agroforestry practices? (Select all that apply)

- Lack of knowledge/information
- Limited access to seedlings/inputs
- Financial constraints
- Labor constraints
- Land tenure issues

- Long wait for returns
- Not convinced of benefits
- Prefer traditional cocoa cultivation
- Other (specify): ________

On a scale of 1-5 (1=strongly disagree, 5=strongly agree), rate your agreement with this statement: "I would implement agroforestry if I had the right support." _______

What kind of support would you need to adopt agroforestry practices? (Select all that apply)

- Technical training
- Access to quality seedlings
- Financial support
- Labor assistance
- Land security
- Guaranteed markets for products
- Other (specify): ________

(For VSLA Members Only) **Have you received any training on agroforestry through your VSLA membership?**

- Yes
- No

(For VSLA Members Only) **Has anyone in your VSLA shared knowledge about agroforestry with you?**

- Yes
- No

(For VSLA Members Only) **Would you be interested in learning more about agroforestry through your VSLA?**

- Yes
- No
- Maybe

(For Non-VSLA Members Only) **Do you think membership in a VSLA would help you to adopt agroforestry practices?**

- Yes
- No
- Maybe

If yes, how? ________________

Continue to Section H

Section H: Household Decision-Making and Gender Aspects *(For All Respondents)*

Who makes decisions about farm management in your household?

- Male head of household
- Female head of household
- Joint decision
- Other (specify): ________

(For VSLA Members Only) **Who makes decisions about VSLA participation in your household?**

- Male head of household
- Female head of household
- Joint decision
- Other (specify): ________

(For Non-VSLA Members Only) **Who makes decisions about financial matters in your household?**

- Male head of household
- Female head of household
- Joint decision
- Other (specify): ________

(For VSLA Members Only) **Since joining the VSLA, has your role in household financial decision-making changed?**

- Yes
- No

If yes, how? ________________

(For VSLA Members Only) **On a scale of 1-5 (1=strongly disagree, 5=strongly agree), rate your agreement with this statement: "VSLA membership has improved women's participation in farm management decisions." _______**

(For Non-VSLA Members Only) **On a scale of 1-5 (1=strongly disagree, 5=strongly agree), rate your agreement with this statement: "Women in my household have equal say in farm management decisions." _______**

(For VSLA Members Only) **On a scale of 1-5 (1=strongly disagree, 5=strongly agree), rate your agreement with this statement: "VSLA membership has created opportunities for youth to engage in agroforestry." _______**

(For Non-VSLA Members Only) **On a scale of 1-5 (1=strongly disagree, 5=strongly agree), rate your agreement with this statement: "Youth in my household have opportunities to participate in farm management decisions." _______**

(For VSLA Members Only) **If you are a woman or youth member: Has VSLA membership helped you overcome any specific challenges related to farming or agroforestry?**

- Yes
- No
- Not applicable

If yes, please explain: **________________**

VSLA Members: Survey Complete
Non-VSLA Members: Continue to Section I

Section I: Perceptions of VSLAs *(For Non-VSLA Members Only)*
Are you familiar with how VSLAs operate?

- Yes
- No
- Partially

Have you ever been invited to join a VSLA?

- Yes
- No

Would you be interested in joining a VSLA?

- Yes
- No
- Maybe

What would motivate you to join a VSLA? (Select all that apply)

- Access to loans
- Safe place to save
- Financial discipline
- Social support
- Learning new skills
- Support for agroforestry
- Other (specify): ________

What factors have prevented you from joining a VSLA? (Select all that apply)

- Lack of awareness
- VSLA not available nearby
- Meeting times not convenient
- Cannot afford minimum savings
- Distrust in group saving
- Prior negative experience
- Not interested
- Other (specify): ________

Trust Statements

Please indicate your level of agreement with the following statements related to trust in your community:

Most people in my community who are VSLA members can be trusted.

- Strongly Disagree
- Partly Disagree
- Neither agree nor disagree
- Partly Agree
- Strongly Agree

Most people in my community/VSLAs have trust in me.

- Strongly Disagree
- Partly Disagree
- Neither agree nor disagree
- Partly Agree
- Strongly Agree

Thank you for participating in this survey!

10.2 Agroforestry system

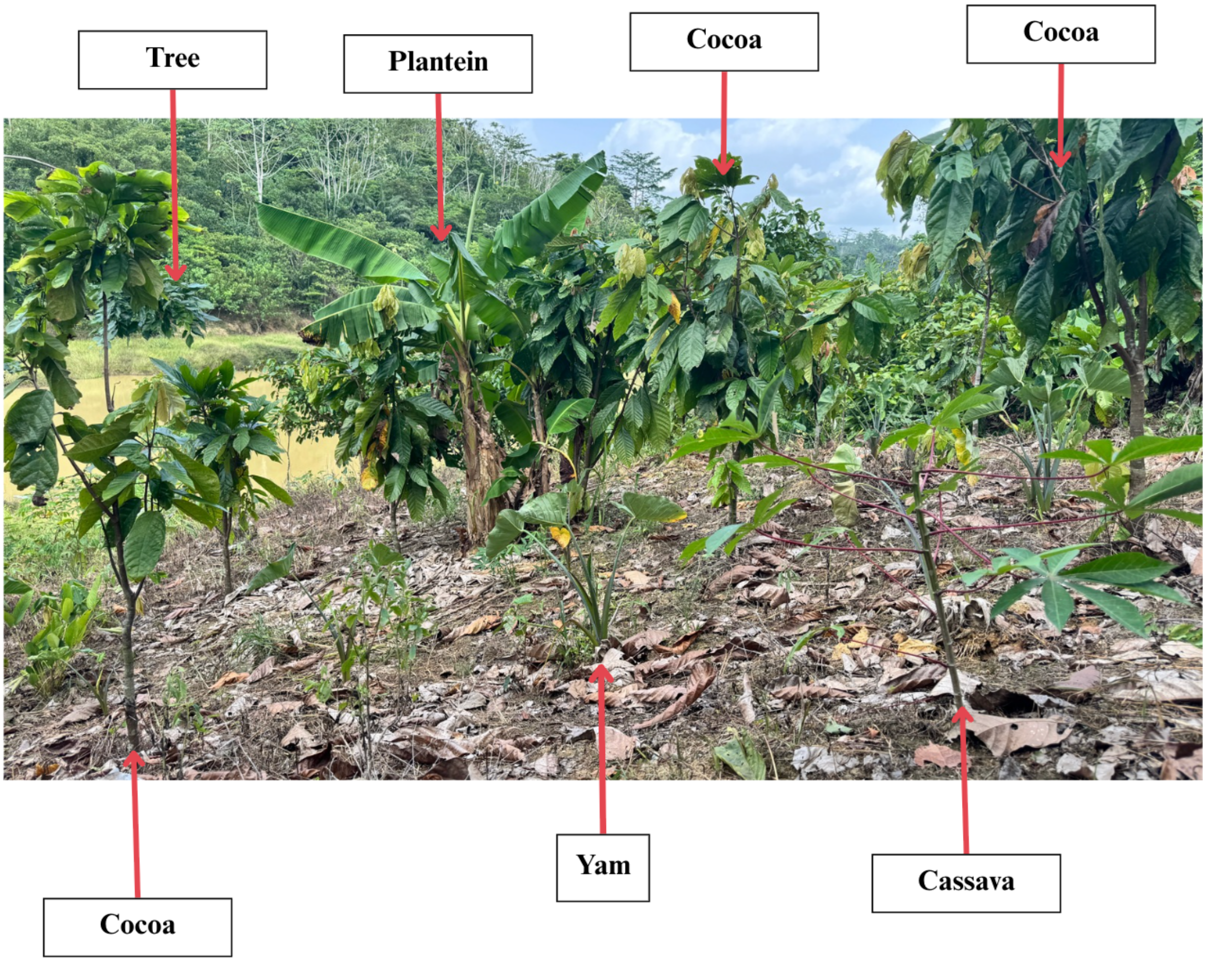

Figure 13: *Cocoa agroforestry with integration of crops, trees and cocoa.*

10.3 Test of Multicollinearity

Table 9: *Test of Multicollinearity*

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 age	1.00															
2 gender	0.15	1.00														
3 education_level	-0.04	0.31	1.00													
4 hh_size	0.00	0.10	-0.04	1.00												
5 total_farm_size	0.18	0.20	0.17	0.25	1.00											
6 cocoa_land	0.06	0.18	0.23	0.23	**0.77**	1.00										
7 land_tenure	0.03	0.08	0.18	0.07	0.17	0.16	1.00									
8 hire_labor	0.05	-0.07	0.01	-0.01	0.02	0.06	-0.01	1.00								
9 avg_annual_income	0.12	0.15	0.14	0.05	0.34	0.38	0.15	0.12	1.00							
10 distance_extension	0.02	0.07	-0.17	0.06	0.13	-0.02	0.02	0.04	-0.01	1.00						
11 farmer_org_membership	0.16	0.21	0.21	-0.13	0.08	0.11	-0.05	0.02	0.04	0.00	1.00					
12 climate_change_impact	0.12	0.01	-0.05	-0.02	0.00	-0.01	0.11	0.13	0.03	0.07	-0.03	1.00				
13 receive_agroforestry_training	0.12	0.10	0.04	0.00	0.06	0.09	0.02	-0.04	0.02	0.05	0.17	0.06	1.00			
14 agroforestry_training_session	0.08	0.10	-0.01	-0.04	0.07	0.07	-0.08	-0.15	-0.04	0.07	0.26	-0.04	0.68	1.00		
15 credit.access	-0.12	0.01	-0.01	-0.06	0.02	0.05	0.12	-0.03	-0.03	0.14	0.09	-0.13	0.18	0.22	1.00	
16 asset_score	-0.14	0.37	0.34	0.10	0.27	0.39	0.13	-0.04	0.26	-0.09	0.19	-0.07	0.15	0.10	0.21	1.00

The correlation matrix, presented in Table 9, displays the Pearson correlation coefficients for all pairs of variables included in the subsequent analyses (propensity score matching and logistic regression modelling). Generally, a correlation coefficient with an absolute value greater than 0.8 or 0.9 is often considered indicative of potentially problematic multicollinearity (Hair et al., 2014; James et al., 2013).

10.4 List of Tables

Table 10: *Different crops grown by the respondents.*

Crop Grown	*n*	%
Cassava	190,00	93,60
Plantain	116,00	57,14
Cocoyam	157,00	77,34
Maize	136,00	67,00
Rice	40,00	19,70
Garden Eggs	136,00	67,00
Tomatoes	115,00	56,65
Rubber	9,00	4,43
Pepper	55,00	27,09
Yam	24,00	11,82
Okro	13,00	6,40
Beans	6,00	2,96
Ginger	1,00	0,49
Banana	5,00	2,46

Table 11: *Loan usage from all respondents availed loan*

Loan Usage	n	%
Investing in cocoa farm	30.00	41.10
Education	27.00	36.99
Agroforestry	17.00	23.29
Household expenses	16.00	21.92
Business	12.00	16.44
Health	6.00	8.22
others	7.00	9.59

Figure 14: *Fieldwork Experiences*