Beyond yields: multidimensional livelihood outcomes of conservation agriculture among smallholder farmers in northern Ghana

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Abstract

Conservation agriculture (CA) is promoted globally as climate-smart, yet studies on its broader livelihood outcomes remain fragmented. This study evaluates the multidimensional livelihood impacts of CA promoted under the Ghana Agricultural Sector Investment Program (GASIP) across the five capitals in the Upper West Region. Using a mixed-methods approach, the study conducted 300 surveys, 10 key informant interviews, and 6 focus group discussions with farmers and the project implementation team. The results indicate significant gains in agronomic knowledge, psychosocial well-being, social cohesion, soil fertility, food access, productive assets, income, savings, and financial inclusion, supported by strong farmer-to-farmer knowledge diffusion and Village Savings and Loans Associations. At the same time, youth under-representation, persistent gendered land constraints, and varied financial and asset gains reveal important distributional limitations. We argue that integrated CA interventions linking training, mechanisation, irrigation, and local financial institutions can strengthen resilience, but must address targeting, equity, and long-term sustainability.

Keywords: Conservation agriculture, Ghana, Rural livelihoods, Smallholder farmers, Sustainable livelihoods approach

Introduction

Globally, conservation agriculture (CA) has been recognised as a climate-smart approach for sustainable agricultural production, considering the mounting challenges emanating from climate change and resource constraints, especially for smallholder systems [1, 2]. With the goal of improving and sustaining productivity while preserving and regenerating the environment, CA is defined as a farming system built around three interdependent principles: minimal soil disturbance (typically through no-till or reduced tillage practices), maintaining a continuous soil cover (through mulching), and the diversification of crops via rotation or intercropping [2, 3]. CA is argued to enhance biophysical conditions, including biodiversity, water efficiency, and nutrient cycling, while increasing yield and food security over time [4, 5]. These outcomes position CA's as both an adaptation and mitigation strategy whose effectiveness is further enhanced when integrated with complementary best practices such as integrated pest management and the use of high-quality planting materials [6, 7].

Globally, CA diffusion and adoption have seen a steady increase, growing from ~157 million ha in 2013/14 (11% of cropland) to ~180 million ha in 2015/16 (12.5%), which has been attributed to reduced cost of production and improved profitability, greater factor productivity and farm output, minimal soil erosion degradation, greater resilience to biotic and abiotic stresses, and improved soil health (Farooq & Siddique, 2015; Kassam *et al*., 2019). Nevertheless, this growth has not been uniform across regions. Adoption rates in sub-Saharan Africa (SSA) remain low (≈1 million ha, ~1% of the global CA area), with mechanised farms in South Africa being substantially higher than other parts of the region [1, 8]. The limited adoption rate in the region has been attributed to several factors, such as the inability of farmers to immediately assess the benefits of CA, which materialize over time despite immediate household food needs; weak input and output markets, lack of access to herbicides, quality seed, and no-till equipment, as well as credit constraints [1, 9]. Ghana was among the first few countries in West Africa to conduct research trials on CA, with initial experiments dating back to the late 1960s [10]. However, with strong political support, it was first introduced to smallholders in 1993 through a collaboration between SG 2000 Monsanto, Ghana Crop Research Institute, and the Ministry of Food and Agriculture (Ekboir *et al*., 2002). Studies on the livelihood effects of CA on smallholder farmers are mixed across different geographical contexts and outcomes. Regarding food security outcomes, there are reports of positive, null, and area-specific effects depending on the methods used for measuring food security. In Zimbabwe, CA was found to improve the duration of grain self-sufficiency but not the Food Consumption Score (FCS) measure (11). Other studies in Ghana and elsewhere found positive or minimal effects on food security (12–15). In a multi-country study in Malawi, Mozambique, and Zimbabwe, Mango *et al*. (2017) found heterogeneity with a positive impact in Mozambique and no significant impact in Malawi and Zimbabwe. This difference was attributed to some of the farmers implementing all CA principles in addition to good crop management practices. CA Studies in Ghana show improvements in food access and dietary diversity [17–19]. Regarding income, the results are also mixed, with improvements found in Tanzania, Zambia, South Africa, and Ghana [18, 20–22], which differ from studies in which higher yields did not translate into higher household income [23]. With regards to CA effects on natural resources or ecological sustainability, many studies find improvement in soil organic matter, soil organisms, water infiltration, and reduced runoff/erosion with residue retention and no-till [4, 24–26]. The effects of CA on these outcomes appear context-dependent based on conditions such as the local conditions of production and complementary practices, the duration of adoption, and labour dynamics [27–29]. These mixed results partly reflect the narrow conceptualisation of impacts of CA on livelihoods, mainly focusing on biophysical or economic indicators such as yields and income rather than broader livelihood effects, including knowledge, health, social relations, infrastructure access, and financial inclusion.

In Ghana, where rural livelihoods mainly depend on agriculture and remain highly vulnerable to climate change, the need for such multidimensional analysis is especially critical. The Upper West Region (UWR), for instance, has one of the highest poverty rates in Ghana, with a rate of 70.9% (30), which implies that seven (7) out of ten (10) people in the UWR are poor by the income measure of poverty. The agriculture sector of Ghana has been identified as one of the major sectors that could bring about socio-economic development in poor communities that are engaged in agriculture through employment creation, food access, and income improvements (National Development Planning Commission (NDPC) 2022, 2024). In line with this, the Ghana Agriculture Investment Program (GASIP) has promoted CA as a strategy for sustainable poverty reduction through improving resilience, productivity, and incomes of smallholder farmers (33). However, despite the huge financial commitment of US$71.6 million towards GASIP, there has not been a comprehensive assessment of its multidimensional livelihood effects on beneficiaries.

Existing studies in Ghana on CA effects on livelihoods give valuable but incomplete insights, as they are mostly concentrated on income, yields, food security, and soil quality outcomes, without capturing the multidimensional nature of smallholder livelihoods [12, 13, 17, 19, 24, 34, 35]. This study, therefore, examines the multidimensional livelihood effects of CA under GASIP in the UWR of Ghana using the lens of the sustainable livelihood approach (SLA) [36, 37]. Specifically, it assesses how CA contributes human, social, natural, physical, and financial capitals among smallholder farmers, incorporating dimensions often overlooked in previous studies, including knowledge, health, social cohesion, household power dynamics, and financial inclusion, and local agency. By adopting this approach, the study contributes new empirical evidence to the broader discourse on the livelihood implications of CA in SSA while informing policy decisions on the design and implementation of agricultural interventions.

Conceptual framework: Sustainable Livelihoods Approach (SLA)

The study uses the SLA as its overarching conceptual framework for assessing the multidimensional effects of CA. Having originated from the seminal work of Chambers and Conway (1992) and institutionalised by DFID (1999), SLA has represented a marked shift from sector-based to people-centred development with emphases on participation, contextual understanding, and the lived experiences of the poor. As Serrat (2017) and Tambe (2022) noted, this approach is particularly befitting for the study because it conceives poverty as multidimensional, highlights the interactions amongst the various livelihood assets, situates livelihoods in vulnerability and institutional context, and directly informs pro-poor programme design and evaluation.

Following the DFID's (1999) framework, SLA is composed of five interlinked components: vulnerability context, livelihood assets, transforming structures and processes, livelihood strategies, and livelihood outcomes. The rural households in northern Ghana face a vulnerability context driven by seasonality, demographic and environmental trends, as well as shocks, including drought, crop failure, or health crises (40). According to SLA's assets Pentagon, there are complementarities and dynamic interactions between all five forms of capital: human, social, natural, physical, and financial. All of these have been targeted directly or indirectly by GASIP-CA through training, group formation, improved agricultural practices, infrastructure support, and financial inclusion mechanisms. However, access to these assets and the returns from them will be further shaped by the Transforming Structures and Processes, including organisations, policies, cultural norms, and power relations, which mediate the benefit that households derive from CA interventions. These assets and structures influence the livelihood strategies that households pursue, from production and diversification to off-farm work and investment decisions (DFID, 1999; Serrat, 2017). CA can reshape these strategies by changing labour demands, input use, risk profiles, and opportunities for cropping diversification. SLA identifies several livelihood outcomes, such as increased income, improved well-being, reduced vulnerability, enhanced food security, and sustainable natural resource management (DFID, 1999; Serrat, 2017). Importantly, outcomes also function as feedback that can reinforce or erode asset portfolios, such as income improving savings or improved soil quality sustaining productivity, producing dynamic livelihood trajectories over time. This systems-oriented approach is in line with the aim of this study, which is to assess CA's multidimensional and interactive impacts across livelihood capitals.

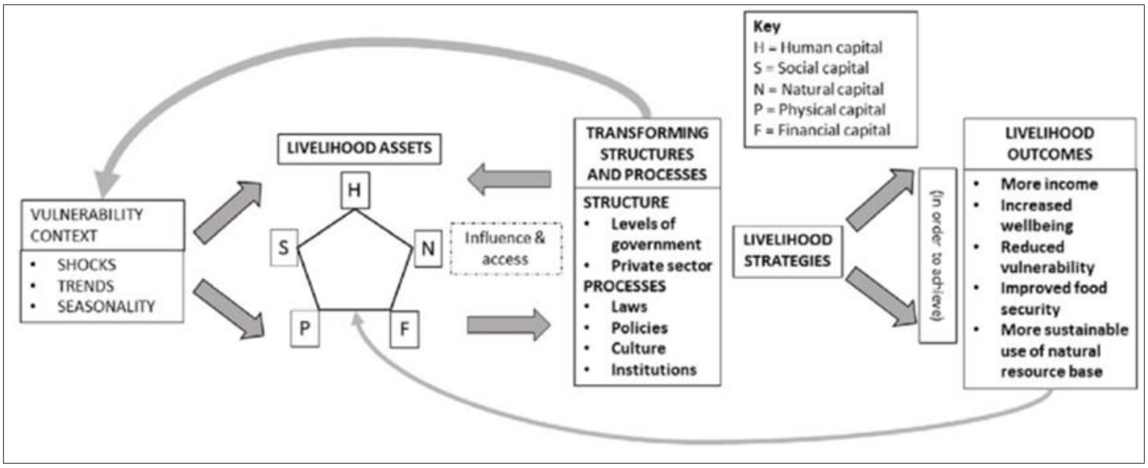


Fig 1: DIFID SLA Framework: Source: (41)

Linking CA to multidimensional livelihood outcomes

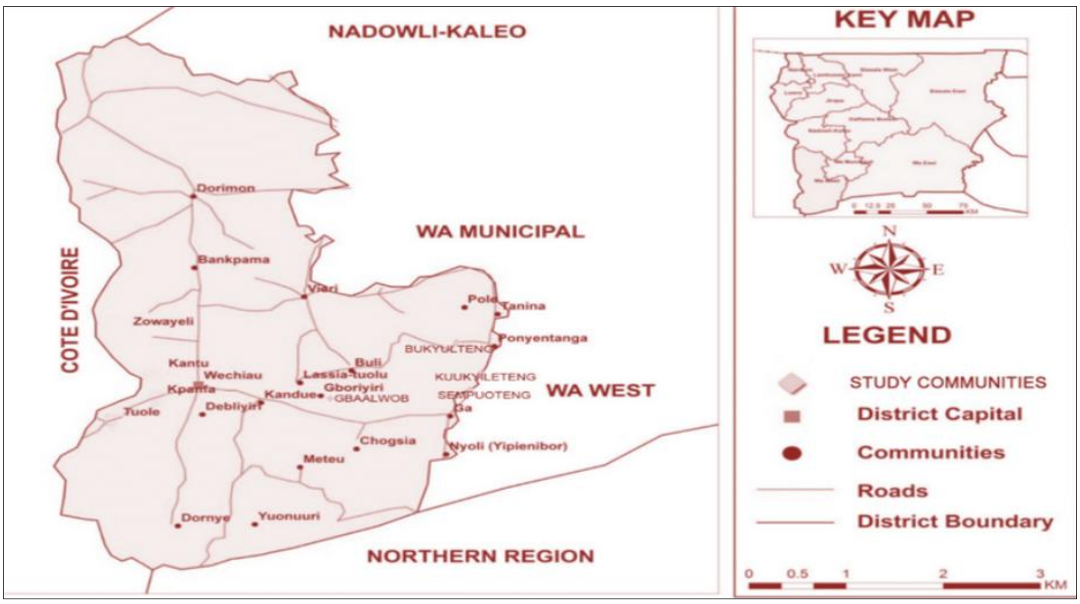
Bringing these strands together, our conceptualisation is as follows:

- Intervention pathway. GASIP promotes CA through training, extension, input facilitation, and group-based arrangements.
- Asset effects. Participation is expected to enhance human capital (skills/knowledge, self-esteem, health), strengthen social capital (networks, trust, collective action), improve natural capital (soil fertility, access to land), expand physical capital (tools, infrastructure access), and increase financial capital (income, savings, credit access).
- Feedback and Resilience. These multidimensional effects on capitals interact dynamically, creating reinforcing feedback, and building adaptive capacity and resilience over time.

Materials and Methods

Study areas

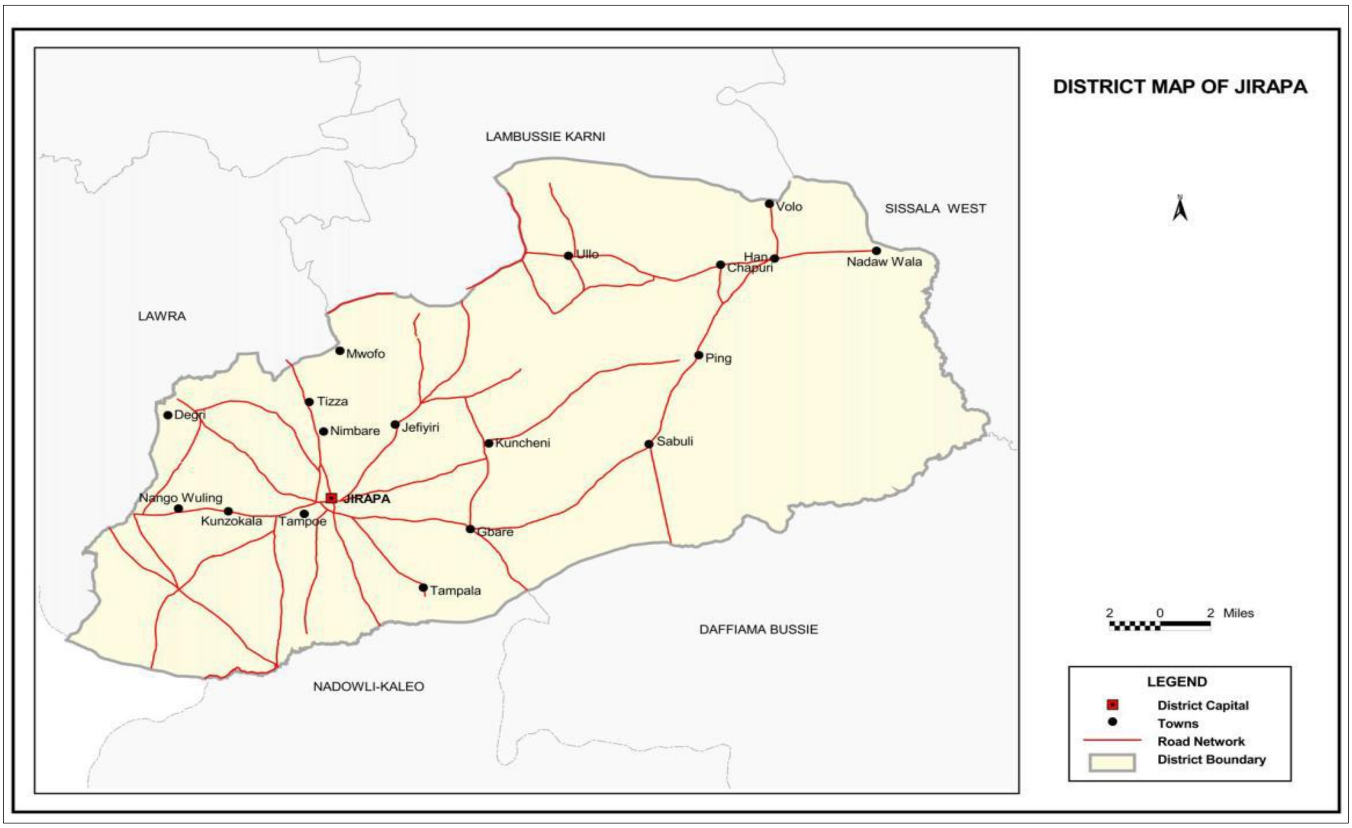
The study was conducted in the UWR of Ghana, specifically in the Wa West district and Jirapa municipality, where the GASIP CA component was implemented among smallholder farmers. The Wa West District was created in 2014, with Wechiau as the capital and more than 200 rural communities. It has a land area of roughly 1,458 km², which represents roughly 10% of the UWR land mass. The population of the district in 2021 was 96,957, out of which 52.7% were female [42]. The district continues to experience widespread poverty and food security, constituting 92.4% and 43.6% of the population, respectively [43, 44]. The district is located in the Guinea Savanna ecological zone, where the climate conditions include unimodal seasonal rains, occurring between the months of May and September, with annual levels ranging between 840 and 1,400 mm [45]. Temperatures range between 22°C and as high as 45°C. Moreover, land degradation is prevalent in the district, resulting mainly from charcoal burning, overgrazing, and frequent bush fires. Agriculture is the main economic activity in the district, employing over 90% of the people, mainly in crop and livestock systems. Residents are into the production of cereals, pulses, root and tubers, and vegetable farming, which is supplemented by fishing, as well as agro-processing of shea butter and pito brewing.



Source: Yiridomoh *et al*. (2022)

Fig 2: Wa West District Map

On the other hand, Jirapa Municipality, the second study area, was established in 2007 with Jirapa as the administrative capital. The municipality occupies approximately 1,189 km² (6.4% of the land area of UWR). In 2021, the population of the municipality stood at 91,279 people, with up to 79% of people residing in rural settlements (GSS, 2021). It has a male population of 47.1% and a greater female population of 52.9%. Approximately 71% of the population is classified as poor, and over 60% are food insecure. These represents are the largest proportions of food insecurity and poverty in the region (GSS, 2015; GSS & MOFA, 2022). The climate of the Municipality is unimodal with annual rainfall of 1,000-1,100 millimetres (mm), and is primarily characterised by smallholder agriculture, featuring food crops, such as cereals, legumes, roots, tubers, and tree crops like shea and cashew. Other agricultural practices involve livestock production and small-scale agro-processing. The area is primarily Guinea Savanna woodlands that is intensively degraded through bush burning, harvesting of fuelwood for energy and unsustainable agricultural practices [46].



Source: (GSS, 2014)

Fig 3: Jirapa District Map

Research approach and Design

A mixed-methods research approach was employed, which combines quantitative and qualitative data to attain both breadth and depth [47]. This approach allows triangulation and enhances the validity of findings through the corroboration of diverse sources of data. Among the three principal mixed-method designs—convergent, explanatory sequential, and exploratory sequential—the convergent design was employed. This involves the simultaneous collection and analysis of quantitative and qualitative data, followed by merging and comparing the results to produce integrated interpretations (Creswell & Clark, 2017). The efficiency and complementarity of this design made it particularly suitable for this study, allowing for the concurrent examination of quantitative outcomes and participant voice.

Sampling of study participants

The GASIP-CA intervention was implemented in 10 and 11 communities in the Wa West District and Jirapa Municipality, respectively. The total number of beneficiaries in each district/municipality is 240, making it a total of 480 beneficiary smallholder farmers in UWR, which is the study population, in addition to 10 key informants, including district desk officers, Agriculture Extension Agents (AEAs), and zonal and head office staff.

The study used the total number of beneficiary farmers in each district/municipality as the sampling frame, which is 240 for each. Determination of the sample size for the survey was done using the statistical formula provided by Yamane (1967), which is as follows:

$$n = \frac{N}{1 + N(\alpha)^2}$$

Where n =Sample size, N= Sample frame, α=margin of error, which is 0.05

The sample size for each district is calculated as follows;

$$n = \frac{240}{1+240(0.05)^2} = 150$$

This implies that the sample size for the quantitative strand for each district is 150 beneficiary farmers. Therefore, these 150 beneficiaries were selected using simple random sampling from the beneficiary communities in each district, making up 300 study participants in total for the survey. However, the 10 key informants were selected using purposive sampling technique.

Data collection methods

The study employed three complementary qualitative data collection methods. A total of ten (10) key informant interviews were carried out with AEAs, district desk officers, zonal, and head office staff engaged in GASIP-CA implementation. These respondents were selected using purposive sampling techniques due to their operational knowledge of the intervention. Additionally, we also conducted six (6) Focus Group discussions, consisting of three (3) per district, with varying groups of farmers, including one (1) women-only FGD session to promote gender-sensitive conversations. Finally, we employed participant observation and reviewed documents such as official reports and M&E documents, which helped us to capture socio-cultural and infrastructural conditions of participants and to contextually triangulate our findings.

For the quantitative aspect, the study used Computer-Assisted Personal Interviewing (CAPI) method to administer a structured survey to the 300 sampled farmers. The main data gathered comprised socio-demographic characteristics, participation in GASIP-CA, and livelihood outcomes.

Data analysis

Interviews and FGDs were transcribed verbatim and analysed using a thematic analysis approach, following the six-stage process developed by Creswell (2014). Coding was undertaken deductively, guided by the five capitals of the SLF (human, social, natural, physical, and financial) as well as inductively, using emergent codes and themes. Dedoose software was used to manage the data analysis process. Themes were validated through member checking, peer debriefing, and triangulation with quantitative findings, to increase dependability and confirmability [49].

The quantitative data were analysed using SPSS v19. Descriptive statistics, including frequencies, percentages, and means, were calculated to summarise the socio-demographic characteristics of the participants and livelihood indicators.

Ethical considerations

The study seriously took into consideration ethical integrity. Formal approval was received from the Department of Development Studies, SDD-UBIDS, prior to data collection. Participants received clear communication of the purpose of the study and were informed that the study was voluntary and that they could withdraw from the study at any time. Informed consent was obtained verbally from all participants. Confidentiality of participant information was strictly maintained through the exclusion of names and other identifying information, and all data was securely stored. Respect for cultural norms and reliance on community leaders were used to build trust and reciprocity.

Results and Discussion

Background characteristics of participants

The socio-demographic results from Table 1 indicate a higher female representation of 59.3%, while 40.7% were male. In terms of age distribution, 70.7% of participants were in the age group of 35-54 years, who are economically active adults, while 15.6% constitute the youth (18-34 years). Just 13% were 55 years and above. This age distribution signifies the availability of economically active adults for agricultural activities, while the youth are less represented. In terms of marital status, most participants reported being married (84.3%), while widows comprised 11.7%, and those who were never married represented 3.3%. Those separated/divorced were just 0.7%. The educational levels of the participants are generally low. Almost two-thirds (63.7%) received no education, while 19.7% received primary education. Secondary, tertiary, and other forms of education constitute 9.3%, 5.3%, and 2%, respectively. The distribution of the educational attainment of the participants generally shows a lower exposure to formal training, which could affect agricultural technology adoption and awareness of livelihood opportunities. The results on household size demonstrate that over half (54%) of participants had middle-sized households (6-10 members), 35% had smaller households (1-5 members), while 11% had large households of 11+ members. These household size compositions reflect typical rural demographic patterns and may influence labour availability and livelihood diversification potential.

Table 1: Demographic characteristics of respondents

Variable		Number of Respondents	Percentage (%)
Gender	Male	122	40.7
	Female	178	59.3
Age	18-34	47	15.6
	35-54	212	70.7
	55 and above	39	13.0
	Missing	2	0.7
Marital Status	Married	253	84.3
	Never Married	10	3.3

	Widowed	35	11.7
	Separated/Divorce	2	0.7
Level of formal education	No formal education	191	63.7
	Primary	59	19.7
	Secondary	28	9.3
	Tertiary	16	5.3
	others	6	2.0
Number of household members	1-5	105	35.0
	6-10	162	54.0
	11 and above	33	11.0

Source: Survey data, 2023

Human and social capital: knowledge, well-being, and social cohesion

The GASIP-CA intervention has improved the human and social capital of smallholder farmers. In terms of human capital, Table 2 shows that the vast majority of farmers reported receiving training from AEAs on various CA and other practices, including crop rotation (99.7%), cover crops (99.3%), minimum tillage (98%), and no-till seeding (77%). This training improved their knowledge and skills, as 53% and 45% reported high and average levels of mastery of the skills they learned during the training. This was confirmed during the interviews, in which farmers not only practised the new skills on their own farms but also transferred them to non-CA beneficiary farmers, indicating farmer-to-farmer diffusion. A female farmer from Wa West district noted, *"It is not only this community that has adopted the CA principles… When we go to other communities, we educate them on the benefits and teach them how to practice CA. I have taught many people in my paternal home."* Similar to existing evidence, these results emphasise the importance of structured training, farmer-field schools, as well as peer-to-peer learning in agricultural technology adoption and diffusion [18, 34, 50].

Table 2: Training coverage and mastery of CA practices among beneficiaries

CA Practice / Indicator	Number of Farmers	Percentage (%)
Training coverage		
Crop rotation/association	299	99.7
Use of cover crops	298	99.3
No-till/Minimum tillage	294	98.0
No-till seeding	232	77.3
Others: Row planting, fertiliser application, pesticide application, residue management, live fencing, and fire-belt creation	231	77.0
Level of mastery/understanding of CA		
High mastery	157	53.0
Average mastery	135	45.0
Low mastery	9	3.0

Source: Authors' survey (2023).

Moreover, the intervention also enhanced various aspects of participants' well-being (human capital), which are mostly not captured in CA impact studies. Nearly all participants reported improved self-esteem and happiness (99%) and healthcare access (98%). On the other hand, qualitative accounts confirm improved health care access and reduced drudgery through the use of jack planters, especially for women. A female participant explained, *"On the aspect of the planting… we were provided with jack planters. So instead of using our cutlasses, we are now using the jack planters. We do not bow down the way we used to… and as a result, we are no longer experiencing waist pains."* Another participant added, *"Those days, when they came to renew our health insurance, we didn't have money to pay for it, but now, we are able to renew our health insurance, including our children. Now, if any of our children complain about illness, you just take their health insurance card and go to the clinic for treatment."*

These results extend the typical assessments of CA impacts, which are mostly focused on productivity and income gains, and support previous studies that show that improvement in agricultural productivity can lead to improved healthcare access [51] and that agricultural mechanisation improves sustainable intensification [52]. However, it contradicts studies such as Descheemaeker (2020) and Montt & Luu (2020), which indicate that CA increases women's workload and labour burdens. This study shows that the use of tools such as jack planters under GASIP-CA, instead, reduces physical strain, especially for women.

The contributions to social capital were similarly high. In Table 3, almost all participants reported improved household cohesion (98%), group participation (99%), and a sense of inclusion (99%). These were corroborated during the interviews as one participant indicated, *"It (GASIP) gives us social prestige and family unity. When food was not available before GASIP, I used to fight with my wife over lack of food. But now that food is available, there are no more quarrels."* Another participant added, *"I feel empowered by GASIP. Even as a woman, sometimes a man would come to me to teach him how to practice CA on their farm."*

Table 3: Reported Improvements in Human and Social Well-Being

Indicator	No. of Farmers	Improved (%)
Self-esteem & happiness	297	99
Health access	294	98
Household cohesion	294	98
Group participation	297	99
Sense of Inclusion	297	99

Source: Authors' survey (2023)

Furthermore, the group structure adopted by GASIP, which focused on vulnerable households and women, promoted trust, cooperation, and learning, aligning with findings that group-based approaches promoted CA adoption [53, 54]. Not only were social networks reinforced, but new ones were created through peer-to-peer training and community demonstrations, aligning with studies that argue that such agricultural interventions create and enhance social cohesion [55]. Despite these outcomes, there was underrepresentation (15%) among the youth, and some households that are more affluent were included, indicative of elite capture and unequal access noted in previous studies [56]. These gaps emphasise the need to improve targeting mechanisms in CA interventions to make them more inclusive to ensure the benefits of CA are distributed equitably.

Natural and physical capital: soil health, productivity, and productive assets

Table 4 shows that the GASIP-CA intervention has also contributed significantly to improving farmers' natural capital through improved soil fertility (98.3%), better access to food through higher yields (98.7%), and improved land access, especially for women. These findings were supported during the interviews. For instance, improvement in soil fertility was widely reported during the interviews, which the participants attributed to retaining farm residues, controlled burning, mulching, and crop rotation. A farmer recounted, *"We were taught to ensure crop residues remain on the field, without being burnt. Because of that, the land is regaining its fertility."* This perception is consistent with several studies in Ghana, which demonstrated that no-till, retention of farm residue, and crop rotation were effective in enhancing soil organic carbon and soil health (Naab *et al*., 2017; Dagunga *et al*., 2021). Moreover, studies in Zambia and Malawi have also documented improvement in soil fauna under CA systems (Ngwira *et al*., 2013; Thierfelder & Wall, 2010). These findings also contribute to the debate on CA's contribution to ecological outcomes, which remain mixed. While several studies show improvements in water retention, soil carbon, and biodiversity (Araya *et al*., 2012; Thierfelder & Wall, 2009), others noted that such outcomes depend on the availability of residue or may involve trade-offs such as elevated nitrate levels or nitrous oxide emissions [1, 57]. This study offers methodological value by using farmers' observations, an approach rarely used but consistent with experimental findings.

Table 4: Natural and physical capital contributions of CA

Indicator	No. of Farmers	Improved (%)
Soil fertility	294	98
Farm Yields	297	99
Farm and household assets	291	97

Source: Authors' survey (2023)

The study also revealed improved access to land, an important natural capital, especially for women, who traditionally do not have land ownership. Women remained disproportionately affected by access constraints, which is consistent with gendered land inequities in Ghana (58). A female participant noted, *"Our husbands gave us the lands on which we are farming, and we do not have lands of our own. Because we both benefited from the land, we did not face any challenges in getting our farmlands.* While this indicates improved intra-household dynamics because of the shared benefits of food access, women still need their husbands to allocate them land to produce. This implies that CA did lead to a complete transformation of land ownership for women, but an incremental improvement.

Additionally, farmers' access to food has improved through increased yields as a result of the CA intervention. A female farmer said, *"We used to go to Kumasi to work as 'kayaye' to earn money in order to buy food for our children, but this has changed as a result of GASIP-CA. I harvest plenty of food from my GASIP farm, which is enough to feed my family for a long time."* These findings align with Altieri *et al*. (2012), who noted that agroecological interventions help reduce household vulnerability by enhancing local food sufficiency. It also echoes Yahaya *et al*. (2018) and Setsoafia *et al*. (2022), whose work in Ghana found a positive impact of CA adoption on access to food among practising farmers.

In terms of physical capital contributions, the study revealed that an overwhelming majority (97%) of farmers reported improvements in farm and household assets. Income gains from the sale of surplus produce from CA plots enabled farmers to acquire assets such as bicycles, knapsack sprayers, and to renovate their houses. A farmer said, *"I was able to buy cement from my farm income to renovate my old building. Is this not beneficial?"* and another farmer added that *"I sold some of my maize and bought a knapsack sprayer, fertiliser, and seeds."* While many farmers acquired new tools or household goods, others reported only being able to purchase fertiliser for the next season. As one farmer admitted, *"If not only fertiliser I can buy, I don't think I can buy something like a bicycle."* This indicates an uneven physical capital outcome. Overall, these results align with livelihood literature emphasising how agricultural income supports the accumulation of physical capital (DFID, 1999).

Financial capital: income, saving, and financial inclusion

CA under GASIP significantly improved financial capital among participants, as shown in Table 5. The majority of these farmers have reported enhanced farm income (99.7%), purchasing power (99%), and savings (96.7%) as a result of higher sales of surplus maize and diversification of income through dry-season vegetable farming. These findings were confirmed during the interviews. A farmer elaborated, *"In one of the years, when we were only 20 members of GASIP, we loaded a full truck of maize to down south (southern Ghana). This fetched us huge money, which we used to meet our personal expenses. Before GASIP, we had never had this amount of income from our farms because we used to get very low yields"*. This aligns with several studies in Ghana and other countries, which demonstrate that CA improves farm income and profitability when practised with appropriate institutional support [18, 20, 22, 60].

Table 5: Financial capital contributions of CA

Indicator	Improved (%)	Key Change
Crop farm income	99.7	Increased income
Purchasing capacity	99	Greater ability to buy inputs and household goods
Savings capacity	96.7	Financial inclusion
Overall financial capital	98.7	Strengthened income stability and liquidity

Source: Authors' survey (2023)

One of the major contributions of this study is the effect of GASIP-CA intervention on financial inclusion, particularly with respect to the establishment of Village Savings and Loans Associations (VLSAs). An AEA stated that *"They now have this thing they call 'Dagi Bile'. That is village savings and loans association. The project helped them to form this, and now they have huge money in their accounts"*. Noting that most of the respondents reported improvement in their savings, VLSAs provide a platform for collective mobilisation of resources, lending, and reinvestment in their farms, which aligns with the assertion of Lanidune (2021) that such groups offer financial services to rural farmers who cannot access formal banking services.

Despite these improved outcomes, not all households benefited equally, as some reported small impacts. This is attributed to poor market access, limited income, or the high cost of inputs, which are consistent with studies such as Nkala *et al*. (2011) and Descheemaeker (2020). The mixed results of CA emphasise the ongoing debates on the profitability of CA, especially where income gains are needed for herbicide, high costs of inputs, and poor market access (Araya *et al*., 2024; Corbeels *et al*., 2014). From an SLA viewpoint, gains in financial capital reinforce improvements in the other types of capital, including natural, human, physical, and social capital, thereby mutually enhancing the resilience of the farmers (38)

Cross-capital linkages

The study demonstrated that there are complex interactions between capitals that mutually reinforce one another. Human capital improvement through training, health access, and psychological outcome enhanced soil management (Natural capital). Improvement in Natural capital leads to improved yields, increasing farm income (Financial capital), which allows the purchase of assets (physical capital) and enhances social and household cohesion (social capital). This positive feedback loop captures the system's logic in SLA, and, therefore, enables the multidimensional outcome assessment of CA (van Rijn *et al*., 2012; Serrat, 2017).

The holistic approach of GASIP-CA, encompassing agronomic training, mechanisation, gender inclusion, and financial services, shows that integrated agriculture programs can promote adoption. The study also offers empirical support to the assertion that CA success can be enhanced by investing simultaneously across knowledge, resources, and institutional domains (Kassam *et al*., 2019; Farooq & Siddique, 2014).

Conclusion

The study concludes that CA, promoted under GASIP, delivered multidimensional outcomes beyond the usual biophysical and economic impacts assessment. It has improved human and social capital through imparting knowledge and skills, psychosocial well-being, health access, and household and social cohesion. Natural and physical capital improved through enhancements in soil fertility, land access for women, food access, and household and farm assets. Financial capital outcomes improved through gains in farm income, savings, purchasing power, and financial inclusion as a result of VSLAs. The study fills three gaps in the literature by empirically linking these dynamic and interdependent outcomes. First, it extends CA outcomes evaluations beyond biophysical or economic indicators to account for human, psychosocial, and gender dimensions of smallholder livelihoods. Second, it demonstrates that sustained adoption occurs not only because of technical training but also because of social learning processes and financial inclusion. Third, this study demonstrates how the SLF can be used as a dynamic framework to explore how CA shapes capabilities, institutions, and agency under climate risk conditions.

Practical implications

- Incorporate capacity building with empowerment efforts: Training programs need to cover not only agronomy but also psychosocial and gender perspectives. The enhancements in self-esteem, health, and household cohesion show that human capital outcomes of CA are as important as its productivity and food security impacts.

- Support peer-to-peer learning and local institutions: The diffusion among farmers was critical for adoption. Future projects should institutionalise farmer trainers and inter-community learning to embed learning beyond project cycles.
- Promote more inclusive targeting of beneficiaries: Policy reforms should institutionalise an inclusive targeting procedure that prevents elite capture and promotes more equitable inclusion of vulnerable groups such as youth, women, and landless farmers.
- Provide equal access to mechanisation and infrastructure. Jack planters and boreholes improved labour efficiency and enhanced productivity. Clear mechanisms for delivery and maintenance can avoid disparity among beneficiaries
- Integrate ecological gains with rural finance and markets: The success of VSLA shows how conservation and finance can support and leverage each other. Incorporating CA into community-based financial systems will help enhance resilience.

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