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Interceding role of village saving groups on the welfare impact of agricultural technology adoption in the Upper East Region, Ghana

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ABSTRACT

For most developing countries like Ghana, the adoption of productive agricultural technologies in the quest to achieve food security and improve farmers' welfare cannot be overemphasized. Hence, interventions that have the potential to enhance the impact of the adoption of these technologies are critical for development planning and policy. This study investigates whether or not village saving groups enhance the welfare impact of agricultural technology adoption using farm-level data collected from the Garu and Tempane districts in the Upper East Region, Ghana. We applied an instrumental variable regression model that incorporates an endogenous interaction term to estimate the interceding role of village saving groups on the welfare impact of agricultural technology adoption. The empirical results reveal that participation in village savings groups further enhances the welfare impact of agricultural technology adoption (proxy by *Zai* technology). The factors that influence farmer's participation in village saving groups include the number of extension contacts, membership of farmer-based organizations (FBOs) and access to farm credit. Other factors such as the age of the farmer, household size and years of education were also found to influence farmers' decisions to adopt *Zai* technology. The study recommends the promotion of village saving groups as they build rural farmers' capacity to save for farm investment, which further enhances their adoption of agrarian technology in the quest to improve farmers' welfare. Moreover, policy instruments like the revitalization of extension services, the formation of FBOs, and access to farm credits should be strengthened in this pursuit.

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Abbreviations: ATA, Agricultural Technology Adoption; VSLA, Village Savings and Loan Associations; CMP, Conditional Mixed-Process; 3SLS, Three-stage Least Square and FBOs, Farmer-based Organizations.

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Introduction

Over the past decade, most policies of Ghana's agricultural sector have mainly focused on modernizing the agrarian economy through the adoption of new and productivity-enhancing technologies such as the use of improved seeds, mechanized farming, farm irrigation and adoption of climate-smart technologies, among others. Prominent among these policies include the Ghana Poverty Reduction Strategy (GPRS I & II), Food and Agricultural Sector Development Policy (FASDEP I & II) and the current Planting for Food and Jobs (PFJ) programme, which all sought to achieve rural and inclusive development by transforming and modernizing the agricultural sector. One of the challenges in implementing these policies is how to internally finance these programmes and projects. The need to finance the agricultural sector has long been recognized, after independence where agricultural credit and cooperative banks were established to finance agricultural activities and services in Ghana [26]. Hence, for most agricultural dependent economies like Ghana, innovative ways of financing projects and programmes are very crucial for the expansion of production through the adoption of improved technologies. Financial services such as credit, savings, and insurance penetration in the economy can foster the impact of agricultural technology adoption [9]. Sekyi [32] indicated that agricultural financing accelerates the adoption of new technologies, which improves welfare through an increase in farm output and household income. Hence, several policies and projects by the Central Bank of Ghana in each reform process of the banking sector aimed at increasing financial penetration and deepening in the agricultural sector. Some of these policies are Rural Financial Service Projects, Shareholder Credit, Input Supply and Marketing Project (SCIMP), Grains Bill Financing Scheme and Cocoa Bill Financing Schemes [20,26].

The agricultural sector in Ghana is characterized by peasant farmers whose farms are scattered with an average of about two hectares. These farmers employ rudimentary farming systems and are challenged with inadequate access to formal financial services to modernized farming practices through the adoption of improved technologies [1]. Advancing credit to these peasant farmers is highly risky due to the reported frequent crop failure, which stems from their over-dependence on rainfall. As a result, formal financial institutions are not willing to provide loans to the sector making them the least preferred lending sector in Ghana [20]. Studies by Henning and Jordaan [17] reported that the formal financial sector has failed to provide adequate credit to smallholder farmers for fear of default in repayment. In Ghana, about 5–6% of the population has access to formal financial institutions with about 81% of the holders from urban centres while the remaining 19% is from rural communities who are mainly the farmers [14]. So the question then remains: what are the options for the rural smallholder farmer given this limitation?

A major alternative that could be employed to finance most rural and urban poor is microfinance. Scheurle [31] indicated that microfinance made waves as a major instrument in the achievement of the Millennium Development Goal as it enables the poor to have access to finance for investment purposes to improve their livelihood. It is said to play an important role in achieving the Sustainable Development Goals (SDGs) specifically the goal of reducing poverty (SDG1) through a decrease in inequality [38]. Perron [29] further opined that microfinance will serve as a significant lever in the implementation of the agenda 2030 (i.e., SDGs) through the provision of access to services in various dimensions such as health (SDG3), food security (SDG2), education (SDG4) and energy (SDG7). Microfinance plays an important role in financial intermediation and as such its expansion is highly recommended in many studies (e.g., [32]). As a result, several Non-governmental Organizations (NGOs) have offered an alternative innovative mechanism of mobilizing small savings of the resource-poor by group formation, mostly called Village Savings and Loan Associations (VSLAs). VSLAs have gained a lot of grounds in most rural communities in Ghana and beyond. In Ghana for instance, most local NGOs such as Presbyterian Agricultural Station and Jaksally Youth Group have partnered with CARE International to diffuse this initiative, especially in rural areas including the Garu and Tempane districts of Ghana. The primary aim of this intervention is to improve welfare by providing limited formal financial services to the people, particularly those living in rural areas.

These village savings groups are primarily a built-up of Rotating Savings and Credit Association (ROSCAs). However, VSLAs are more flexible and functional than ROSCAs, which have formal financial characteristics that include savings, loans, insurance and interest earned on savings [18,28]. Village savings groups are noted for their effectiveness in accelerating growth and capacity building [33]. It is said to improve food security and increase the volume of savings and total household expenditure [33]. An evaluation conducted in Ghana, Malawi and Uganda by Innovation for Poverty Action and Care International concluded that village saving groups have a significant impact on financial service usage, coping with unexpected events such as droughts, expansion of business activities, and smoothen of income [18]. In Zambia, the main motive for participating in village saving groups is the expected improvement in welfare, as household economic activities increase through savings mobilization and loan availability. Participation in village saving groups has a positive and significant effect on consumption and hence improvements in the welfare of people in Western and Eastern Zambia [28]. Financial intermediation provided through village saving groups enhance agricultural production and productivity. This is because it increases the probability of farmers getting a loan for agricultural investment [17].

Despite the expansion and popularity of village saving group formations among rural communities and the evidence of its impact documented in many parts of Sub-Saharan Africa, there has not been any study in Ghana to assess how village saving groups could improve rural welfare through the enhancement of agricultural technology adoption. The study hypothesized that stimulating village savings has the potential to enhance the impact of farm innovations on the welfare of rural households. This is partly because the adoption of one farm technology often requires complementary technology to achieve the expected results. Moreover, some other farm technologies require more labor to implement. In this study, *Zai* technology was used as a proxy for agricultural technology adoption. The term *Zai* is what farmers in Burkina-Faso referred to small planting pits of about 20–30 cm in width, 10–20 cm deep, and filled with manure. The pits are spaced 70–80 cm apart, resulting in approximately 10,000 holes per hectare. Hence, *Zai* technology refers to small planting pits in which organic matter (manure, compost, or dry biomass) is buried before planting seeds in those pits (Mottis et al., 2013). It is a traditional rehabilitation technology that helps to recover degraded land, cope with drought and conserve soil moisture amidst the existing climate change. Thus, *Zai* technology has the ability of water retention for about seven to ten days after rainfall and boost infiltration [10]. Moreover, unlike other location-specific technologies, *Zai* technology has proven to be an effective agricultural technology for increased food production not only in the upper east region of Ghana but also in other dryland areas of Africa including Niger, Mali, Ethiopia, Burkina Faso and Kenya [11]. *Zai*, unlike other farm technologies like mineral fertilizer that only enhances soil fertility, it also reduces soil erosion and serves as a water-harvesting technique [25]. The World Bank [36] report indicated that *Zai* technology could increase farm output by 500% if well managed while Koome [19] indicated that the practice of the technology leads to a substantial improvement in the welfare of farmers through an increase in yield. Moreover, Ehiakpor et al. [13] revealed that *Zai* technology in northern Ghana leads to significant gains in consumption expenditure, consumption expenditure per capita, and household income. These numerous benefits of the technology coupled with the fact that it is widely promoted in most parts of northern Ghana including the study area makes it reliable for use as a proxy for agricultural technology. Hence, agricultural technology, hereafter referred to as *Zai* technology in this study.

It is indisputable that the effectiveness of farm management practices such as *Zai* technology is often adversely affected by lack of financial liquidity to purchase the required inputs which therefore hinders productivity and pushes farmers into the whips of poverty. Engaging in VSLAs has the likelihood of building farmers' financial capacity to invest in their farms and improve their welfare through an increase in productivity. Hence, a clear understanding of the intermediary role of VSLAs on farmers' welfare through such a multifaceted technology like *Zai* is essential for rural farm-level policy designs and implementations. The study, therefore, examines the interceding role of VSLAs on the welfare impact of *Zai* technology adoption in Garu and Tempene districts in the Upper East Region of Ghana.

The nature of village savings and loans associations in Ghana

The VSLA models drew on community-based groups offering savings and micro-credits which have a long history in Africa and Asia. Community-based microfinance programmes like VSLA have since been promoted in many parts of the globe especially in many parts of Africa. In Ghana, CARE international is noted to have first initiated the idea of VSLA in 1991 to improve financial access in most rural communities [7]. The VSLA programme has three primary components: (i) a group-based commitment savings mechanism, (ii) loan acquisition by members of the group, and (iii) an emergency or social fund financed by members with their regular contributions. The group is not formally registered with the government and is composed of 15–30 members. Members of the groups are trained on group dynamics, governance and financial management, after which a box is provided to the group by the agent of the NGO (usually CARE) managing the group. The standard mode of operations of the VSLA in Ghana is as follows: Group members meet at a regular interval (weekly) where decisions on the contribution are made (usually maximum shares or contributions individuals can purchase determine share value). The savings are kept in the box provided which is fitted with three padlocks and the keys kept with different leaders of the group. The contributions are made up of savings, loans fund and social fund or solidarity fund. The savings and loan funds are used to provide short-term loans to members upon request, up to 300% of their contribution with interest. The social or solidarity fund is given out to members in emergency events such as the death of a family member or accidents in order to cushion the member from the shock. At the end of an annual cycle, the sum of accumulated savings and the interest charged on loans minus any outstanding debts are shared proportionately among the group and another cycle begins. The VSLA has now been patronized in many areas of the country including the Garu and Tempane Districts. It is also implemented by different NGOs such as the Presbyterian Agricultural Stations, Jaksaly youth group, among others.

Evidence of the impact of VSLA on many facets of life has been documented by many studies. For instance, Cameron and Ananga [8] revealed that village saving groups help poor rural households pay for education in some contexts as well as raise income for investment in farm operations. Beamen et al. [6] showed that savings have a significant increase in livestock holdings for participants and helps to smoothen their consumption throughout the year. Beamen et al. [6] further indicated a slight increase in education expenses for saving group members than their counterparts.

Materials and methods

Study area and sampling procedure

The study was carried out in the Garu-Tempane District (now Garu and Tempane districts) in the Upper East Region of Ghana. The District lies in the south-eastern part of the Upper East Region of Ghana. It covers an area of 1060.91 square km. It lies approximately at latitude $11^{0}38^{1}N$ and$11^{0}N$ longitude $0^{0}06^{1}E$and $0^{0}23^{1}E$.The District shares boundaries with Bawku Municipal to the north; Bunkpurugu-Yunyoo District to the south; Bawku West District to the west; and the Republic of Togo to the east. Unskilled agriculture, forestry, and fishery workers are the dominant occupations in the District recording 85.2%, followed by small-scale industrialization, fishing and trading. The output in these areas is however low and income levels are equally low. The majority (84.4%) of males find themselves within the unskilled agriculture, forestry and fishery compared with 82.8% of females engaged in the same sector. About 95.4% of households in the District engage in agriculture. In the rural localities, nine out of ten households (97.2%) are agricultural households while in the urban localities, approximately 70% of households are into agriculture. Crop production is the mainstay of the district economy with vast potential in maize, millet, sorghum, onion, watermelon, Soya bean, mango, groundnuts, among others.

The Garu and Tempane Districts were predefined for this study. Simple random sampling was used to select 10 communities from each district of which 20 farm households within each community were selected by simple random sampling giving a total sample size of 400. The methods of data collection were through questionnaire administration, observation and personal interviews.

Empirical model and estimation technique

Following Makate and Makate [23], the empirical model starts with formulating the welfare function which is expressed as follows;

$$Welfare = \alpha_0 + \alpha_1 Zai_i + \alpha_2 VSLA_i + \alpha_3 ATA_i \times VSLA_i + \delta X + \varepsilon \tag{1}$$

where Zai_i is the proxy for agricultural technology adoption as indicated earlier, $VSLA_i$ is village savings and loan associations,$Zai_i \times VSLA_i$ is the interaction term between *Zai* and *VSLA*, *X* is a vector of institutional, socioeconomic characteristics of the farm households and social network variables such as contact with agricultural extension agent and farmer-based organization that offer learning and knowledge opportunities to farmers to enhance their managerial and technical abilities [24]; while εis the error term. Our primary focus is to estimate the potential impact of *Zai* on the welfare of farm households. Many studies estimating the impact of a treatment on any outcome have used a propensity score matching technique [13]. However, we adopted a slightly different approach employed by Makate and Makate [23], which uses the instrumental variable (IV) methodology to address the challenge of endogeneity that may emanate from correlations among the error terms of the outcome and treated variables. The endogeneity of *Zai* adoption may come as a result of the voluntary decisions of farmers to adopt the technology. Farm households may not have access to information about the technology and its intended benefits and hence cannot adopt it. The study used three-stage least square (3SLS) instead of a two-stage least square (2SLS) estimator employed by Makate and Makate [23]. The principal drawback with the use of 2SLS is that the distribution of error terms is not efficient [15]. Hence, we employed 3SLS to ensure the efficiency of the estimates and address the endogenous relationship between membership of VSLA and farmers' welfare through the adoption of *Zai*. Since there are many methods used to estimate causal effects, Wooldridge [35] recommends the use of several approaches to ascertain the robustness of the magnitude and the direction of the estimates. Hence, we employed a conditional mixed-process framework recently proposed by Roodman [30] to check the robustness of the estimates. The following subsections describe the two estimations used to achieve the primary objective of our study.

The three-stage least squares (3SLS)

The structural equations for the first and second stages of the IV estimation are given as;

$$Zai_i = \beta_0 + \beta_1 VSLA + \beta_3 X + \delta Z + u_i \tag{2}$$

$$Zai_i \times VSLA = \beta_0 + \beta_1 VSLA + \beta_3 X + \delta Z + u_i \tag{3}$$

where *Z* is an instrument that is correlated with the error term but uncorrelated with the outcome variables. A critical requirement in IV estimation is to ensure that the equations are identified (i.e. there is sufficient information to consistently estimate the structural parameters of interest in the models), so we needed to include identifying variables such as FBO membership and field demonstrations. Identification is ensured when the number of exogenous variables omitted from a particular equation is equal to or greater than the number of endogenous variables less one [16]. Since we have two structural equations with two endogenous variables, we necessarily need at least one exogenous variable not appearing in either equation; this is the so-called exclusion restriction principle or rank condition for identification [35]. Hence, if a structural equation meets the rank condition, it is both necessary and sufficient for the parameters to be consistently estimated [3].

The endogenous variables in Eqs. (2) and (3) are then estimated over the set of exogenous variables. We then predict theZai_i and the interaction term ($Zai_i \times VSLA_i$) to formulate the reduced form model as;

$$Welfare = b_0 + b_1\, Zai + b_2 VSLA + b_3\, VSLA \times Zai + \delta X + e \tag{4}$$

Hence, the main parameter of interest is b_3 which captures the intermediary effect of VSLA on farmer's welfare through *Zai* technology adoption, where a positive and statistically significant coefficient implies that participation in VSLAs further enhances the welfare impact of *Zai* technology adoption.

Conditional Mixed-Process (CMP)

As stated earlier, the study applied the CMP framework as a robustness check of the results obtained from our primary model, 3SLS. The CMP is an empire of multi-equation systems with the ability to take a different format of dependent variables. The word "mixed-process" suggests that different equations can have different response types. Thus, the dependent variable may be binary (logit or probit), ordered (logit), categorical (multinomial probit), censored (Tobit), 2SLS or Heckman two-stage model, among others [30]. It can also control for both simultaneity and endogeneity where consistent estimates are produced for a recursive system in which all endogenous variables are observed on the right-hand side of the equation and correct for selectivity bias that may arise from unobserved characteristics [4]. Moreover, the CMP has its foundation from the seemingly unrelated regression (SUR) framework where the cross-equations of the error terms are correlated [24]. The recursive nature of our objective, where we want to estimate the effect of VSLA on *Zai*, and *Zai* on welfare with a different format of the dependent variable suggests that the CMP is the most appropriate estimation framework to complement our primary estimator, 3SLS.

The recursive equations estimated within the framework of CMP can be expressed as follows;

$$VSLA = \beta X + \varepsilon \tag{5}$$

$$Zai = \beta X + VSLA + u \tag{6}$$

$$Welfare = \beta X + Zai + VSLA + VSLA \times Zai + e \tag{7}$$

Where X is a vector of explanatory variables to be estimated.

Considering the endogeneity of participation in VSLA and *Zai* in the outcome equation, the joint marginal likelihood can be expressed as;

$$\iint_{\eta_7\eta_6\eta_5} \left[\prod L_7(\eta_7) \prod L_6(\eta_6) \prod L_5(\eta_5)\right] f(\eta_7, \eta_6, \eta_5) d\eta_7 d\eta_6 d\eta_5 \tag{8}$$

where L_5, $L_6$and L_7 are conditional likelihood functions of Eqs. (5), (6) and (7), respectively, $f(\eta_7, \eta_6, \eta_5)$is the joint estimation of the unobserved heterogeneity components. The joint distribution of the unobserved effects$f(\eta_7, \eta_6, \eta_5)$is assumed to be a three-dimensional normal distribution.

As stated earlier, the primary purpose of estimating Eq. (5), (6) and (7) is to deal with potential self-selection bias. As noted by Maitra [22], the objective of joint estimation is to explore the possibility of non-zero covariance between the error terms of Eqs. (5) and (6), thus, $\text{cov}(\eta_5, \eta_6) \neq 0$. Nevertheless, since the heterogeneity terms are conditioned, Eqs. (5) and (6) become independent. In this case, the likelihood function in Eq. (8) can be estimated by multiplying the individual conditional likelihood functions of Eq. (5)–(7) (Chamberlain et al., 1975). Estimating Eqs. (5)–(7) jointly allows the selection bias estimates for the outcome variables to be derived as long as Eqs. (5), (6) and (7) are identified. Thus, identification is made possible by the recursive nature of the CMP structure, where the outcome variable (welfare) measures household consumption expenditure per capita.

Selection of variables and measurement

The study followed empirical literature such as Makate and Makate [23] and Mahama et al. [21] to select a set of farmer-specific and institutional factors hypothesized to influence participation in village savings groups, technology adoption as well as welfare.

Dependent variable: The study first estimated the determinants of participation in village saving groups and *Zai* technology adoption using the membership of VSLA and adoption of *Zai* as dependent variables, respectively.[1] Both VSLA membership and *Zai* are measured as dummy variables where a farmer is assigned a value of 1 if a member of VSLA and 0 otherwise. Hence, both participation of VSLA and adoption of *Zai* technology were estimated using probit models which are the first and second stages of the CMP framework, respectively. The welfare variable was measured as the annual consumption expenditure per capita of the household in Ghanaian Cedis (GH¢). The consumption expenditure was calculated from the household expenditure for the preceding year covering 12 months. This was based on the cost of food (households' consumption of home-produced food + purchased food + gift food) and non-food expenditure (medication + education, among others) during each month and aggregated to annual level. The annual consumption expenditure was then adjusted per adult equivalent to obtaining the consumption expenditure per capita. The consumption expenditure per capita was then logged transformed to reduce the potential bias that may arise from the skewness of the data.

Independent variables: Many farmer-specific, socioeconomic and institutional variables were postulated to influence participation in VSLA, *Zai* technology adoption, and farmers' welfare. Farmer-specific factors include the age of the farmer, household size, years of education, the primary occupation of the farmer and the total farm size. The experience of a farmer (measured in years of farming) could inform the risk perception of the farmer about innovations and, hence his decision to adopt the *Zai* technology. Members of the household can also supply family labour for the adoption of improved technologies such as *Zai*, which is said to be labour intensive [19]. The educational attainment of the respondent is relevant as it helps in the evaluation of the technology and its subsequent adoption. Farming as the primary occupation can influence the level of commitment to farming as a family business, which can influence the adoption of *Zai* technology as well as the

[1] Note two key things of this study: 1. Membership of VSLA and village saving groups are used interchangeably. 2. Agricultural technology and *Zai* technology are also used interchangeably.

Table 1
Summary statistics of variables used in the analysis.

Variable	Full Sample ($N = 400$) Mean (SD)	*Zai* technology adopters ($N = 178$) VSLA Participants ($N = 125$) Mean (SD)	*Zai* technology adopters ($N = 178$) Non-participants VSLA ($N = 53$) Mean (SD)	*Zai* technology Non-adopters (222) VSLA Participants ($N = 120$) Mean (SD)	*Zai* technology Non-adopters (222) Non-participants of VSLA ($N = 102$) Mean (SD)
Dependent Variables					
VSLA Participation (Yes = 1)	0.513				
Zai technology (Yes = 1)	0.445				
Consumption expenditure	862.21 (465.34)	902.16(150.50)	712.48(234.10)	822.34(252.25)	705.50(202.28)
Farmer specific-factors					
Age (years)	43.84(14.36)	45.65(4.30)	40.2(6.50)	43.5(4.20)	42.4(2.50)
Household size	9.88(5.34)	9(2.10)	6.5(3.20)	5.4(2.30)	6.4(2.40)
Years of education	4.57(4.08)	6.5(1.50)	4(0.50)	4.5(0.45)	4(2.10)
Farming as main occupation	0.93	0.95	0.21	0.89	0.32
Total farm size (Acres)	4.78(2.52)	8.6(1.20)	4.5(2.40)	6.5(1.50)	3.45(1.20)
Institutional factors					
FBO membership	0.35	0.65	0.34	0.32	0.20
Extension contact	4.34(2.85)	5.65(0.65)	4.5(1.5)	3.2(1.40)	3.67(1.80)
Visit of field demonstration	0.26	0.54	0.34	0.35	0.15
Accessibility to farm credits	0.40	0.49	0.42	0.32	0.24

Note: SD shown by the values in brackets represents the standard deviation from the mean.

VSLA. The total farm size of the farmer can also determine the acreage that would be allocated for the practice of *Zai* technology. Farmers with large farm sizes are more likely to diversify into cropland than those with smaller farm sizes, ceteris paribus.

Furthermore, institutional factors such as membership of FBOs, number of agricultural extension contacts, attendance of field demonstrations and access to farm credits are also hypothesized to influence participation in VSLA programme and adoption of *Zai* technology. Each of these variables was measured as a dummy, where a farmer is assigned a value of 1 if yes and 0 otherwise. These institutional structures are relevant in exposing farming to relevant agricultural innovations, which can influence farmers' decision to adopt *Zai* and participate in village savings groups. The number of extension contacts was measured as the number of extension visits during the farming season. This is also postulated to influence farmers' participation in VSLAs and *Zai* technology adoption.

Results and discussions

Summary statistics of socioeconomic and institutional variables

The results from Table 1 reveal that about 45% of the farmers adopted *Zai* technology while about 51% participated in the VSLA. The household consumption expenditure per capita (welfare) was estimated to be about GH¢862.21 (US$ 190.75).[2] The participants of VSLAs who adopted the *Zai* technology had an average amount of GH¢902.16 (US$ 199.59) while non-participants who did not adopt the technology had a consumption expenditure per capita of GH¢705.50 (US$156.08). Moreover, farmers who adopted the technology and participated in VSLA were found to have a relatively more uniform distribution in terms of welfare with each farmer's consumption expenditure differing by GH¢150.50 (US$ 33.30) from the average. The average age of the sampled farmers was about 44 years with the adopters that are members of VSLA groups being about 46 years. The average age of adopters who did not participate in VSLA was about 40 years, which is slightly lower than the non-adopters that either participated or did not participate in VSLA. Donkoh et al. [12] found that the average age of farmers in Northern Ghana to be 38 years, which is slightly lower than the average found in this study. The average household size was about 10 members with the technology adopters that are members of the VSLA having the highest average household membership of nine people while the non-adopters of *Zai* technology who are members of the VSLAs have an average of five people in the household.

Generally, both adopters and non-adopters of the technology who are members or non-members of the VSLA have a basic educational level. This low level of education for the majority of farmers is in congruence with the findings of Mahama et al. [21] who found the average years of education in northern Ghana to be about two years with a standard deviation of four. Thus, an average farmer in this study is only educated up to primary five. About 93% of the respondents had farming as their primary occupation. Meanwhile, about 95% of the *Zai* technology adopters that participated in the VSLAs were primarily farmers while 21% of the adopters that are not members of VSLA engage in other economic activities including

[2] The average exchange rate as at data collection (2017) was GH¢1.00: US$4.52

Table 2
Determinants of participation in VSLA and adoption of *Zai* technology.

Variables	Participation in VSLA		*Zai* technology adoption	
	Coeff	Std. Err	Coeff.	Std. Err
Farmer-specific factors				
Age	0.0134	0.0153	0.0188*	0.0098
Household size	−0.0565	0.0345	0.0474**	0.0235
Farming as main employment	0.0002	0.0221	0.0551	0.0148
Education (years)	−0.0116	0.0374	0.0551**	0.0262
Total farm size	−0.0560	0.0533	−0.0091	0.0315
Institutional factors				
Number of extension contacts	0.6697**	0.3016	−0.0080	0.2353
FBO membership	1.1584**	0.4699	1.086***	0.3496
Farm demonstrations	0.0731	0.0884	0.0340	0.0622
Credit access	2.3872***	0.3098	0.9905***	0.3263
VSLA			1.737***	0.2735
Constant	−1.6927***	0.7031	−1.489***	0.4516
Number of observation	*400*			
Pseudo R-square	*0.6944*		*0.7241*	
LR Chi2	*189.71*		*191.42*	
Prob>chi2	*0.0000*		*0.000*	

***, ** and * indicates significant levels at 1%, 5% and 10%, respectively.

farming. The average farm size for adopters that are members of VSLAs was higher (8.6 acres) than the sample average (4.78 acres) with a relatively low standard deviation of 1.2 acres.[3]

Danso-Abbeam et al. [10] also found the average farm size of farmers in the Upper East region to be about 4 acres which is similar to the average for the pooled sample in this study. The results in this study however suggest that most of the adopters that participated in village saving groups had a higher average farm size.

The study results also revealed that about 35%, 26%, and 40% are members of FBOs, attended field demonstrations and had access to farm credits, respectively. The average number of times farmers received extension services was about 4. The average number of times of extension services received by the adopters who participated in village saving groups was relatively higher than the non-adopters and the adopters who did not participate in village saving groups. The results further revealed that the proportion of farmers who had access to credit (whether in kind or cash) was relatively higher for *Zai* adopters than the non-adopters.

Determinants of participation in VSLA and Zai technology adoption

Table 2 shows the results from the probit estimates of the determinants of participation in VSLA and *Zai* adoption. The joint significance as indicated by the value of the *LR Chi*^{2} was significant at 1% indicating a good fit of the probit model. Participation in VSLA is influenced by several institutional factors including the number of extension contacts, membership of FBOs and access to credit. The positive effect of the number of extension contacts on participation in VSLA is in accordance with the empirical results obtained by Anang et al. [2], who also found that the number of extension contacts had a positive influence on the accessibility of rural microcredit in northern Ghana. This is because access to agricultural extension services is expected to enrich rural farmers with information about what is happening in their environment, which has the potential to improve their lives. Most often, extension agents can convince rural farmers to participate in such programmes due to the trust these farmers have for them. Another critical area of information sharing is farmer groups (FBOs). Farmer groups play an essential role in the dissemination of information through farmer-to-farmer extension. Farmers learn from each other, and will usually join a particular group or even adopt a technology when they see their neighbours benefiting from such programmes or innovations. Thus, information about village savings groups can easily diffuse among people when the benefits derived are shared during extension and FBO meetings. Access to credit is another critical determinant of participating in VSLA, which is also consistent with Amariyono [27] who opined that access to micro-credit empowers farmers to engage in productive alternative enterprises. This is because VSLA provides a source of credit for its members within the sampled communities where most of the farmers were linked to financial institutions using their membership of the VSLA as collateral. This, therefore, encourages continual participation in VSLA as it acts as insurance against which farmers obtained credit both in cash or as inputs.

The last two columns in Table 2 represent the results on the determinants of *Zai* technology adoption. These include both farmer-specific characteristics such as age, household size and education, and institutional factors such as FBO membership and credit access. Additionally, membership of VSLA was also found to have a positive and significant influence on the adoption of *Zai* technology. Age significantly enhances farmers' propensity to adopt *Zai* technology. This result agrees with Awuni

[3] In Northern Ghana, farm sizes are measured in acres rather than hectares. Hence, the study maintained the indigenous unit of measurement. 1 acre: 0.405 ha.

Table 3
Intermediary Role of VSLA on the Welfare Impact of *Zai* technology Adoption.

Variable	3SLS Welfare		CMP Welfare	
	Coef.	Std. Err	Coef.	Std. Err
Farmer-specific factors				
Age	0.0048	0.0031	−0.0031	0.0015
Education(Years)	0.0066	0.0086	0.0017	0.0046
Household size	0.0562	0.0025	0.0134*	0.0072
Farming as primary occupation	0.0063	0.0852	−0.0279*	0.0154
Total farm size	0.0441*	0.0231	0.0230***	0.0054
Institutional Factors				
FBO membership	0.3686***	0.1178	0.0693*	0.0395
Extension services	0.1438**	0.0732	0.2254*	0.1327
Field demonstrations	0.2450	0.0012	0.0096	0.0100
Credit	0.5780	0.3425	−0.0479	0.0498
VSLA	0.8992**	0.3789	1.0335***	0.0916
Zai technology	0.4591**	0.2346	0.2792***	0.0339
VSLA × *Zai*	1.5709***	0.5064	0.4353***	0.1125
Constant	6.3907***	0.1368	3.4818***	0.0737
Rho12			*0.1453****	*0.0265*
Rho13			*0.7345*	*0.4760*
Rho23			*0.9876**	*0.5134*
Sig_3			*1.5025****	*0.0506*

***, ** and * indicates significant levels at 1%, 5% and 10%, respectively.

et al. [5] who found that age positively influences the adoption of improved agricultural technologies among rice farmers in northern Ghana. It thus implies that older farmers are more likely to adopt technology compared with younger farmers. This may be because older farmers are more experience and understand their environment better and hence, recognizes the need to adopt relevant innovations to improve output and adapt to climate change. Household size had a positive effect on the probability of *Zai* technology adoption. This was expected because *Zai* technology is said to be labour intensive [11]. Hence, households with more members are more likely to supply family labour for farming, which increases their probability to adopt the technology. Education improves farmer's ability to adopt agricultural technology. From the descriptive statistics where the majority of the farmers have a lower educational, one would expect that such a low level of education would not be relevant in explaining their decision to adopt. However, the quantitative results indicate that a short period of formal education is sufficient to encourage adoption.

The results on education agree with other studies such as Uaiene et al. [34] who found that farmers with less than 4 years of formal education are more likely to adopt pesticide use and mechanization practices. FBO membership increases the farmer's capacity to adopt the *Zai* technology. This finding is consistent with that of Wossen et al. [37] where cooperative membership significantly influences technology adoption.

Access to credit by farmers significantly enhances their ability to adopt agricultural technologies. Most agricultural technologies are expensive for rural farmers with limited savings and, hence accessibility to farm credits will eliminate the cash constraints to agricultural technology adoption. This is in line with the results of Uaiene et al. [34] who argued that credit accessibility enables farmers to purchase expensive technologies but can also make farmers switch to higher productive crops. Participation in VSLA had a significant positive effect on agricultural technology adoption. VSLA participation provides farmers with credit, savings and insurance which makes it relatively easy for members to purchase farm technology. Thus, participants can use their share out (returns from their savings) to employ technologies such as *Zai*, which is labour intensive.

Interceding role of VSLA on the welfare impact of agricultural technology adoption

Table 3 presents the results of the 3SLS model and CMP framework indicating the intermediary effects of membership of VSLA in improving the welfare impact of *Zai* technology adoption. The cross-sectional correlation of the error terms of the recursive equations (indicated by the *rho*) of the CMP is reported at the bottom of the table in the CMP section. The estimated *rho* shows a primary measure of endogeneity emanating from self-selection bias. A significant coefficient of the *rho* shows the presence of self-selection bias. A significant positive value of *rho* indicates that some unobserved variables positively influence both the endogenous and the outcome variables. The reverse applies to a negative and significant value of the *rho*. Thus, the significant values of the *rho* justify the use of the CMP. Here, we are much interested in the coefficients of three variables: the VSLA, *Zai*, and VSLA × *Zai* (indicating the intermediary contribution of membership of VSLA on the welfare impacts of *Zai* adoption). The results from the 3SLS and CMP are highly comparable with regard to the interceding role of VSLA on the welfare impacts of *Zai* adoption. Results from the 3SLS showed a positive and statistically significant effect of VSLA on farmer's welfare through *Zai* technology adoption at 1% level of significance. Similarly, the interaction term *VSLA* × *Zai* in the CMP model has a positive and statistically significant effect on welfare implying that participation in VSLA impacts positively on welfare by further enhancing the adoption of *Zai* technology. More precisely, membership of VSLA improves the welfare impacts of *Zai* technology by about 1.57 and 0.044 percentage points in the 3SLS and CMP models, respectively. Thus, the positive effect of the interaction term implies that membership of VSLA enhances the impact of *Zai* technology adoption on household welfare. This could be because members of VSLA can acquire income from their savings and micro-loans, which can be used to purchase agricultural inputs and boost production, and subsequently smoothen their consumption.

The differences in the magnitude of the estimates of the interaction term from the two models could be due to differences in the data processing generation of the 3SLS and CMP. Other studies such as Uaiene et al. [34] used different estimation techniques as a robustness check but obtained similar results in terms of direction. However, they had divergent results concerning the magnitude of the estimates. Table 3 further indicates that membership of VSLA and *Zai* technology independently have a positive and significant impact on welfare in both models. Ehiakpor et al. [13] reported that the adoption of *Zai* technology increases the welfare of adopters through an increase household consumption expenditure and total household income.

However, the total farm size under cultivation had a significant positive effect on the farmer's welfare in both models. Also, both models showed that farmers who are members of FBOs and had a relatively good number of contacts with extension agents had better welfare. FBOs take collective decisions on several activities such as linking its members to extension services, getting information on new technologies, linking farmers to markets and financial resources, among others. These activities enhance farmers' access to information, improve farmers' managerial and technical skills, and subsequently improves their welfare. The result agrees with the study of Wossen et al. [37], where farmers who are members of cooperatives had improved welfare compared with farmers were not. Through extension services, farmers learn to adopt technologies that will help them overcome the risk associated with farming, and hence, enhance their welfare. Makate and Makate [23] and Uaiene et al. [34] confirmed this result where access to extension services has significant impacts on welfare.

Conclusions and recommendations

The study estimated the interceding role of VSLAs on the welfare impact of *Zai* technology adoption in the Garu and Tempane districts of the Upper East Region, Ghana. We employed two econometric techniques viz; three-stage least squares (3SLS) and the conditional mixed-process (CMP) to check the robustness of the results. The probit estimates of the CMP were used to identify the determinants of participation in VSLA and the adoption of *Zai* technology. The results showed that the same institutional factors including the number of extension contacts a farmer receives, membership of FBOs, and access to farm credits (kind or cash) significantly influence the participation in VSLA and the adoption of *Zai* technology. Moreover, farmer-specific factors such as the age of the farmer, the household size, and years of formal education were also identified as significant determinants of *Zai* technology adoption. The study further reveals that membership of VSLA and the adoption of *Zai* technology independently improve farmers' welfare. More importantly, the findings of the study bring to the conclusion that membership of village saving groups such as VSLA encourages the welfare impacts of agrarian technology adoption such as *Zai*.

The findings of the study call for the strengthening of farm-level institutional and policy efforts that seek to promote village saving groups such as VSLA. These saving groups can help build the financial capacity of rural farm households, thereby encouraging the financial inclusiveness of rural farm dwellers, which is one of the critical goals of the Central Bank of Ghana. Moreover, through the VSLA model, farmers have the flexibility of planning for future investment in their farms because they are sure of reliable savings and micro-credit. Thus, farmers can reduce the burden of credit constraints, invest in farm operations through the adoption of farm technology and boost productivity. The promotion of village savings groups and their subsequent effects on the adoption of agricultural technology and welfare could be achieved by strengthening the existing supply-side policy instruments such as access to extension services and farmer-based organizations. There should be a conscious effort to encourage farmers' participation in village savings groups through FBOs such as offering incentives to communities with well-functioning farmer groups as well as strengthening extension service delivery.

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Contributors

Gilbert Dagunga administered the questionnaires and did the analysis. Abigail Amoakowaa discussed the results of the study. Gideon Danso-Abbeam provided the guidelines for the analysis and wrote the methodology. Dennis Sedem Ehiakpor proofread the manuscript and offered significant contributions while Franklin Nantui Mabe wrote the introduction and guided the data collection process.

Declaration of Competing Interests

The authors declare that they have no competing interests.

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