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The Effects of Participation in Smallholder Irrigated Agriculture on Livelihoods in the Bawku Area of Ghana

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ABSTRACT

Irrigation is one of the key strategies for agricultural transformation and commercialization processes in Ghana and elsewhere in the developing world. This is because irrigation provides opportunity for extended agricultural production, particularly in areas characterized by short duration and low intensity rainfall regimes. Thus, irrigation provides a unique opportunity for the poor, who are mostly smallholder farmers to urge themselves out of poverty. In order to enhance and sustain the benefits from irrigation, there is the need for careful and rigorous study to understand the socio-economic underpinnings of irrigation participation. This paper sought to investigate the factors that influence participation in irrigated agriculture and its effects on livelihoods. The method of analysis involved an estimation of treatment effect model. The study relied mainly on primary data collected from 304 respondents randomly sampled across four irrigating communities in the Bawku West District of Ghana. The empirical results show that age, marital status, market availability, extension contact and farm size significantly influence farmers' decision to participate in irrigated agriculture. Participation in irrigation positively affects livelihoods development. However, the benefits of irrigation are likely to be offset by large household sizes, source of water for irrigation and education. The study recommends that farmers must be assisted with improved technologies in irrigated agriculture supported by gender sensitive extension services to ensure effective technology use. There is also the need for improved access to markets.

Keywords: Irrigation, Treatment Effect Model, Livelihoods, Bawku West, Ghana

INTRODUCTION

Globally, irrigation farming plays a crucial role in not only food production but also, livelihood improvement. Although current irrigated land area is less, irrigation farming provides more than one-fifth of the world's food (Sebastian, 2014). Thus, irrigation can compensate for inadequate precipitation, especially in semi-arid regions like Sub-Saharan Africa where vagaries in weather patterns, limiting water supply and growing population continue to threaten food security. There has been massive development in irrigation infrastructure with corresponding expansion in irrigated area, increasing from 139 million hectares in 1961 to 277 million hectares in 2003 (FAO, 2003 in Fraiture *et al.,* 2010). This led to remarkable improvement in irrigation infrastructure across continents with irrigation accounting for 95 percent of all water withdrawal in most parts of developing countries. The importance of this expansion is improved food security (Siebert *et al.,* 2013). A global map on irrigation for 2013 indicates the total area equipped for irrigation is estimated at 307.6 million hectares 83 percent of which is irrigated. This is an increase of 33.6 million hectares over that of the year 2000 (Siebert and Doll, 2007; Siebert *et al.,* 2013). The area equipped for irrigation in Ghana stands at 59, 000 hectares, out of which 56, 000 hectares is actually irrigated (Siebert *et al,* 2013).

Irrigation farming have been identified as significant aspect of rural agriculture with some documented effects on livelihoods of rural folks including income, health, nutrition, food security, and employment (Hussain and Biltonen, 2001; Hussain and Hanjra, 2003; Mangisoni, 2003; Namara *et al.,* 2005; Namara *et al.,* 2011; Dittoh *et al.,* 2013). The poverty effects of irrigation are significant, especially in settings where communities and households depend on agriculture for their livelihoods because of limited non-agricultural livelihood opportunities. For instance, Namara *et al.* (2005) reports that irrigation technologies lead to poverty reduction through substantial increase in farm income. The authors further noted that micro irrigation has significant effect on cropping patterns and intensity, improved access to income, food and nutrition security and decision-making power of women adopters. Similarly, Hussain and Hanjra (2003) revealed that irrigation affects poverty through cropping intensity, land and water productivity, labour employment and household income. Cropping intensity ranges from 111-242 percent for production under irrigation compared to 100-168 percent for production under rainfed conditions. For example, irrigated lands have higher productivity (3.0-5.5 t/ha) of rice paddy compared to 4.0 t/ha under rainfed conditions. Furthermore, income inequality in irrigated areas is lower than that of rainfed areas (Hussain and Hanjra, 2003). In another study, Namara *et al.* (2011) found out that, irrigation farmers had either lower poverty or fewer food shortages as compared to rainfed farmers. By employing the Foster-Greer-Thorbecke (FGT) indices with consumption expenditure as a proxy to measure poverty and inequality indices, the authors suggested that, although poverty levels are generally higher (57 %) in the study area than the national average, poverty indices is lower (0.46 - 0.58) in irrigating households compared to rainfed households (0.62).

The livelihoods effects of irrigation must however, be interpreted with caution because they are not the same across areas. For instance, a study conducted in the Tono Irrigation Scheme in Ghana by Dinye and Ayitio (2013) found that the effects of irrigation on the income levels of farmers were moderate. Although majority of farmers in the irrigation fall under middle-income brackets, most of the farmers were not satisfied with the effect on their economic status and their general livelihood. Findings from their research also revealed that, irrigation has no positive effect on food security. This is because farmers are not able to store their perishable products hence compelled to sell them early with normally low prices making food scarce at other times of the year. The livelihoods impacts of irrigation are therefore context specific. This assertion is consistent with that of Hussain and Hanjra (2003) and Ofosu *et al.* (2013) who noted that poverty impacts of irrigation is dependent on predictable and stable input/outputs markets, favourable policies and effective institution, reliable support systems for farmers, access to improved production technology, cropping patterns and diversification and equity in land distribution.

Many of the earlier studies mentioned above focused on specific livelihood outcomes such as income, employment and productivity, which are not holistic assessment of the livelihood effects of irrigation. This is because livelihood extends beyond economic outcomes to social and ecological factors (Krantz, 2001). This paper therefore employed a multi-dimensional index in measuring the livelihood effects of participation in irrigation. The use of a multi-dimensional index is not only important but also necessary in extending existing knowledge on how participation in irrigation affects the livelihoods of irrigators and non-irrigators in rural Ghana. The paper therefore determined the socio-economic and farm characteristics that influence smallholder participation in irrigated agriculture and the effects of their participation on farmers' livelihood.

MATERIALS AND METHODS

The Study Setting

The study was carried out in four irrigating communities in the Bawku West District of the Upper East Region of Ghana. The Upper East Region covers 8,842 km^2 representing about 7 percent of the total land area of Ghana. The total population is about 1 million (GSS, 2014). With a population density of approximately 113 people per square kilometer, it is one of the densely populated regions of Ghana.

Agriculture plays an important role in the socio-economic development of the Bawku West District. It provides incomes and employment for over 80 percent of the population. The total cultivable area is 58,406 ha and uncultivable area of 33,687 ha. The types of irrigation dominant in the area include river, used primarily by communities living along the White Volta banks, groundwater and dams.

Theoretical and Analytical Framework

Primarily, estimating the determinants of irrigation farming is an adoption model since it involved a decision making. Adoption models have been studied in the framework of discrete choice modelling where farmers' decision to adopt a particular technology is dependent on several factors including resource endowment, socio-economic characteristics, expectations (Ansah *et al.,* 2015). The variables which have been used in the study for the model definition are presented in Table 1. As cited in Ansah *et al*. (2015), Feder *et al.* (1985) demonstrated that a technology can only be adopted if and only if one of the components of the technology is benefiting the client. In such a case like agriculture, the decision to use a particular technology is discrete; either adopt or do not adopt. Such discrete decisions are often motivated by the random utility theoretical underpinnings, which falls under the theory of utility maximization (Becerril and Abdulai, 2010). Within the context of utility maximization, farmers face a choice among *j* alternative actions, thus adoption or non-adoption. This is because they (farmers) would derive a level of utility from each alternative action chosen.

Thus, the utility (u) that the *ith* farmer derives from choosing alternative *j* is given by u_{ij} whereas the utility for not adopting the technology is given by u_{ik}. According to Becerril and Abdulai (2010), a farmer will only choose *jth* technology if and only if the maximum utility or benefit derived from such option is greater than the maximum utility or benefit from the alternate technology. In other words, the utility maximizing farmer will adopt irrigation farming if and only if, at least, the benefit (be it economic, financial, managerial, easiness of work, etc.) from the adoption is greater than the costs of adopting the technology. Probit and logit models are the commonly used estimation techniques for things of this nature (Greene, 2003; Udoh *et al.,* 2008). However, using binary in a stage-two regression model, probit models are used because they assume error terms that follow standard normal distribution. The probit model is specialized regression model of binomial response variables. For instance, the authors sought to understand why some farmers decide to participate in irrigated agriculture and others do not. This means that there are only two categories of farmers: irrigators and non-irrigators, leading to a dichotomous situation. The probit model allows for estimating this choice situation. According to Sienso *et al.* (2014), many researchers have adopted discrete choice models to identify and explain factors influencing the individual's choices between two or more alternatives. The purpose of the discrete choice model is to estimate the probability that an observation with particular characteristics would fall into one specific category or the other, which is mathematically represented as:

$$y_i = \beta' x_i + u_i \qquad (1)$$

Where y_i is a binary response variable with the basic assumption that the u_i will show the same dispersion around the mean (Koutsoyiannis, 2003) violated (Maddala, 1983). Under this circumstance, it is no longer appropriate to use the Ordinary Least Squared (OLS) for these estimations since it would produce inefficient β_s (Maddala, 1983).

Stating the underlying response variable as y^*, equation (1) is specified as:

$$y_i^* = \beta' x_i + u_i \qquad (2)$$

Where x_i is a vector of exogenous variables that influence y_i, β_i is vector of parameters and u_i is the noise term having constant variance and zero mean. In practice, y^* is not observed, instead a dummy variable that is defined as below is observed:

$$y = 1 \; if \; y_i^* > 0 \quad or \quad y = 0 \; if \; otherwise \qquad (3)$$

The respective probability of these events becomes $-\beta' x_i$ and $1 - \beta' x_i$. In this case $\beta' x_i$ is no longer the $E(y_i/x_i)$ as in OLS (y_i^*/x_i).

From equation 2 and 3

$$Prob(y = 1) = Prob(u_i > -\beta' x_i) = 1 - F(-\beta' x_i) \qquad (4)$$

Where F is the cumulative distributive function u_i. Depending on x_i, the probabilities given in equation 4 may vary, hence the likelihood function is:

$$L = \prod_{u_i=0} F\,(-\beta' x_i) \prod_{y_i=1} [1 - F(-\beta' x_i)] \quad (5)$$

Since the probit model assumes that u_i is normally distributed $[N(0, \sigma^2)]$, we have:

$$F = (-\beta' x_i) = \int_{-\infty}^{-\beta' x_i/\sigma} \frac{1}{(2\pi)^{1/2}} exp\left(\frac{-t^2}{2}\right) dt \quad (6)$$

From equations 5 and 6, we can now estimate $-\beta' x_i/\sigma$ instead of β_s and σ separately.

The marginal effect of x_i is estimated as:

$$\frac{\partial}{\partial x_{ij}} \Phi(x_i \beta') = \emptyset(x_i \beta')\beta_j \quad (7)$$

In estimating factors influencing farmer's participation in irrigation and the effect of participation on livelihoods, it is expected that sample selection bias will arise for two reasons: (1) there may be self-selection by the individuals being investigated; (2) when some respondents do not have observable values for dependent variables (Heckman, 1979). For instance, irrigation output is only observed for irrigators but not for non-irrigators. Also, there may be certain characteristics that affect participation that are not observable, for example entrepreneurial abilities and fertility of soil thereby leading to selectivity bias. This means that irrigators may have unmeasured characteristics that themselves are related to their livelihoods and so estimating the effects of participation in irrigation on livelihoods with adoption as one of the explanatory variables is inappropriate. According to Heckman (1976), this would result in biased parameter estimates and this would mean that the true effect of participation in irrigation on livelihood would not be known. Assuming there was no selection bias, the effects of participation in irrigation on livelihoods could be estimated through Ordinary Least Squares (OLS) as:

$$Livelihood = X_l' \beta + \delta A_i \quad (8)$$

Where X_l' is a set of factors that influence livelihoods, A_i is a dummy variable capturing adoption (i.e. participation in irrigation). This means that δ will measure the effects of participation in irrigation on livelihoods. However, because of the selection bias, δ will not be a true estimate of the effects of participation in irrigation. To remedy this, the Heckman (1979) treatment effect model is used and specified following Greene (2003) as:

$$A_i^* = w_i' + u_i \quad (9)$$
$$A_i = 1 = if\ A_i^* > 0, 0\ if\ otherwise$$

However, the ε_i and u_i are correlated. To correct this, we first estimate the selection equation (2) before estimating outcome equation (1). Therefore, the two equations (1 and 2) are extrapolated as:

$$E\left[\frac{y_i}{A_i} = 1, x_i, \quad z_i\right] = X_l' \beta + \delta + E\left[\frac{\varepsilon_i}{A_i} = 1, \ x_i, \ z_i\right]$$

$$Livelihood = x_i' \beta + \delta + \rho \sigma_\varepsilon \lambda(-w_i' \gamma) \quad (10)$$

$$\lambda = \frac{-\phi(w_i' \gamma)}{1 - \phi(w_i' \gamma)}\ is\ the\ Inverse\ Mills\ Ratio\ (IMR)$$

or treatment problem. It should be observed that equation (3) is only defined as $A_i = 1$. In the case of the non-participants:

The two-step estimator provides a follow-up result of δ which accounts for the self-selection

$$E\left[\frac{y_i}{A_i}=1, x_i, \quad z_i\right]-E\left[\frac{y_i}{A_i}=0, \ x_i, \ z_i\right]=\delta+\rho\sigma_\varepsilon\left[\frac{\emptyset_i}{\Phi_i(1-\Phi_i)}\right] \quad (11)$$

The omitted λ is what OLS would have estimated to measure the value on the treatment A_i and this would likely overestimate the treatment. Empirically, the selection and outcome models are specified as:

$$Participate = \beta_0 + \beta_1 Age + \beta_2 AgeSqd + \beta_3 Marital\ Status + \beta_4 Household\ head + \beta_5 Market\ Availabilty + \beta_6 Extension\ Contact + \beta_7 Rainfed\ Income + \beta_8 Farmsize + u_1 \quad (12)$$

$$lnALS^1 = \alpha_0 + \alpha_1 lnTotal\ Income + \alpha_2 lnHousehold\ size + \alpha_3 Location + \alpha_4 Remittances + \alpha_5 Educatio + \alpha_6 Irrigation + u_2 \quad (13)$$

Table 1: Definition of Variables Used in the Study

Variable	Description	A priori Expectation
Selection model		
Age	Age of the farmers in years	-/+
Gender	Dummy; 1 if farmer is male; 0 if otherwise	-/+
Marital status	Dummy; 1 if farmer is married, 0 if otherwise	-/+
Household head	Dummy; 1 if male; 0 otherwise	+
Market availability	Dummy; 1 if farmer have access to market; 0 if otherwise	+
Extension contact	The number of visits by an extension staff in a cropping year	+
Farm size	Size of rain-fed land cultivated in acres	+
Rain fed income	Total revenue from rain-fed farm in Ghana cedi	+
Outcome model		
Participation	Dummy; 1 if farmer participates in irrigated agriculture; 0 if otherwise	+
Education	Dummy; 1 if farmer has formal education; 0 if otherwise	+
Household size	Number of people in farmer's house eating in the same bowl	+
Location	Dummy; 1 if source is river; 0 if dam for irrigation	-/+
Remittances	Dummy; 1 if farmer's have received any external support; 0 if otherwise	+
Total income	Total revenue in the previous cropping season in Ghana cedi	+

[1] In determining the livelihood score, the eight dimensions or indicators of livelihoods namely food availability, housing condition, health situation, water facility, sanitation, participation in social activities, decision making in cash expenditure and health of ecosystems. To develop the average livelihood score, a two-stage procedure is employed. In the first stage, a percentage score for each of the eight livelihood indicators was determined and at the second stage the average livelihood score was computed based on the scores of the eight indicators. The percentage score for an individual farmer is computed as the individual farmer field score divided by the corresponding possible maximum score and expressed as a percentage. The following formula was used to determine the individual rural woman's percentage score:

$$ALS = \frac{\sum IFPS_i}{LD}$$

Where ALS = Average Livelihood Score; LD = Livelihood Dimensions; $IFPS_i = \frac{IFFS_i}{IFPMS_i} \times 1$; IFPS = Individual farmers percentage score, IFFS = Individual farmers' field score, IFPMS = Individual farmers' possible maximum score. The average livelihood score was calculated by dividing the sum of individual percentage field score of livelihood indicators by the number of dimensions.

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RESULTS AND DISCUSSIONS

The study considered equal number of male and female farmers. From the results in Table 2, majority (74 %) of respondents were married with a mean age of about 40 years and 46 years for irrigators and non-irrigators respectively. Given that people between the ages of 18 and 35 are recognized as youth in Ghana, it means that on the average, the youth are not involved in irrigated and non-irrigated agriculture in the study area. This re-echoes the growing concern that, agriculture in Ghana is facing aging population of farmers (Bruce, 2015). This also highlights lack of interest in farming by the youth. Again, the study recorded low level of education among farmers in the study area. Specifically, about 68 percent and 72 percent had no formal education for irrigators and non-irrigators respectively, while only about 2 percent of irrigators and 4 percent of non-irrigators had tertiary education. This further confirms the widely held notion in Ghana that farming is a preserve for the less educated. The mean household size in the study area was 6 compared to the national average of 4. Specifically, the household size for irrigators was found to be 6 compared to 5 for non-irrigators. The average farm size for irrigators and non-irrigators was found to be 4.1 acres and 3.6 acres, respectively is lower as compared to the national average of 5.0 acres. Furthermore, 47 percent of farmers had access to extension services. Finally, about 83 percent of famers revealed they have access to market for their crops with average income of GHS 7959.90 and GHS 3310.0 for irrigators and non-irrigators respectively.

Table 2: Socioeconomic Characteristics of Study

Variables	Irrigation				Rainfed			
	Mean	**S.D**	**Min**	**Max**	**Mean**	**S.D**	**Min**	**Max**
Age	39.6	13.9	18.0	72.0	45.7	19.5	17.0	93.0
Household size	6.4	3.1	1.0	13.0	5.3	2.8	1.0	13.0
Farm size	4.1	2.3	0.5	13.0	3.6	2.1	0.5	12.0
Extension visits	1.5	1.9	0.0	12.0	1.0	1.5	0.0	10.0
Rainfed income	993.7	1047.5	0	6370	943.7	907.8	20	5870
Total Income	7956.9	18506.0	300.0	130800.0	3310.0	5660.8	50.0	36700.0

Determinants of Smallholder Irrigation Participation

From results in Table 3, the probability of a farmer participating in irrigated agriculture was 0.48 and the Wald chi square was significant at 1 percent. The results indicate that the factors that significantly determine farmers' participation in irrigation are age, household size, marital status, market availability, extension contact and farm size. Age was found to be significant at 10 percent and have positive relationship with participation in irrigation. This may be due to the economic prospects of irrigation. The results also show that younger farmers have higher probability of participating in irrigated agriculture than older farmers i.e. as a farmer grows to a certain age the probability of participation in irrigation reduces. This may be due to the labour-intensive nature of irrigated agriculture in the study area and therefore older farmers have less vigour for farming. Irrigated sites in all the study areas do not have properly constructed canals and so manual water lifting is practised. In this case, younger farmers may have energy required to perform these tasks than their older counterparts. Additionally, youth may be more enterprising and are willing to commercialize agriculture for economic gains as compared to older farmers who are more conservative.

Table 3: Maximum Likelihood Estimates of Treatment Effect Model-Two Step Estimates

Variable	Coefficients	Standard Error	Z-Value	P>Z	[95% Conf. Interval]	
Average livelihood score						
Constant	4.214	0.034	125.68	0.000	4.148	4.279
lnTotal income	0.006	0.004	1.4	0.161	-0.002	0.013
lnHousehold size	-0.016	0.009	-1.72	0.086	-0.034	.0002
Water source	-0.034	0.010	-3.47	0.001	-0.053	-0.014
Remittances	-0.011	0.014	-0.78	0.436	-0.039	0.017
Education	-0.022	0.011	-1.95	0.052	-0.044	0.000
Participation	0.089	0.028	3.21	0.001	0.034	0.143

Source: Field Survey. Significant at 1%, 5% and 10%. Dependent variable: Participation in irrigated agriculture. Number of Observation = 304. Pr (participation) = .482. Wald chi^2 (6) = 31.95. Prob > chi^2 = 0.000.

Marital status was found to be a significant factor of farmers' participation in irrigation. This is possibly because access to some productive resources such as land is tied to marriage, which gives the right to use of family lands. This is particularly so for women who have to rely on husbands for land for farming. Also, market availability significantly influences smallholder participation in irrigated agriculture. This is because crops cultivated under irrigation are highly perishable cash crops and hence farmers are only motivated to produce when there are demands for them in the market. Hence, demand for cultivated products increases probability of participation in irrigated agricultural production. This finding is consistent with that of Ofosu *et al.* (2014) who noted that predictable and reliable produce markets enhance the economic viability of irrigation farming.

Extension contact also significantly influences smallholder participation in irrigation. Access to extension services allows farmers to be able to access improved technologies and good agronomic practices that increase the gains from irrigations. This finding supports the view of Deressa *et al.* (2008) that extension outreach had a positive and significant effect on the adoption of new technologies. Ansah *et al.* (2015) and Amankwah *et al.* (2011) in their respective findings found out that, extension positively influences the adoption of technology. Also, increased farm size (rainfed) positively influence participation in irrigation, which is capital intensive and one of the major source of capital is income from sales of produce from rainfed agriculture. Hence, increase farm size will translate to increased revenue of which part could be invested in irrigated agriculture. Increase in farm size have two implications for participating in irrigation: 1) there is enough foodstuff in the household hence any additional income will be invested in irrigated agriculture and 2) increases in farm size means increase in farm revenue, *ceteris paribus* which can be used to support irrigated agriculture. Amankwah and Egyir (2013) also found that, farm size influence flooding irrigation technology among urban vegetable farmers' in Ghana.

Effects of Irrigation Participation on Livelihood

In examining whether engagement in irrigated agriculture leads to improved livelihoods, *ceteris paribus,* from the results in Table 4, lamda (λ) was significant at 1 percent. Similarly, Wald chi square was also significant at 1 percent. The significance of the lambda (λ) implies that selectivity bias was present in the model and that if it was not corrected, the effects of participation in irrigation on livelihoods would have been bias. This means that the true effects would not have been measured. The use of Heckman model in this paper is therefore appropriate.

Table 4: Marginal Effects Estimates for Parameters after Probit Participation Model

Variable	dy/dx	Standard error	Z	P> [Z]	[95% Conf. Interval]	
Participation						
Gender	0.022	0.076	0.29	0.772	-0.126	0.170
Age	0.020	0.012	1.69	0.091	-0.003	0.042
Age Squared	-0.000	0.000	-2.16	0.030	-0.000	-0.000
Marital Status	0.158	0.070	2.25	0.025	0.020	0.296
Household Head	-0.099	0.076	-1.31	0.189	-0.249	0.049
Market Availability	0.328	0.073	4.53	0.000	0.186	0.471
Extension Contacts	0.114	0.062	1.85	0.064	-0.006	0.234
Rain-fed Income	-0.000	0.000	-1.23	0.219	-0.000	0.000
Farm Size	0.035	0.016	2.23	0.026	0.004	0.065
λ	-0.064	0.017	-3.52	0.000	-0.096	-0.846
Rho	-0.644					

Source: Field Survey. Significant at 1%, 5% and 10%. Dependent variable: Participation in irrigated agriculture. Number of Observation = 304. Pr (participation) = .482. Wald chi^2 (6) = 31.95. Prob > chi^2 = 0.000.

Furthermore, results indicates that participation in irrigation has positive and significant effects on livelihoods. This finding justifies the importance of irrigation in contributing to the livelihood of smallholder farmers. It was also observed that apart from total income and remittances, all other variables were significant but with a negative sign. Household size was used as a proxy for family labour availability. The negative coefficient means that increase in household size will lead to a reduction in livelihood or wellbeing of households. Although larger household size provides labour for irrigated agriculture, it is important to note that larger household size constraints household resources such as food and water. This means that, the per capita consumption of these households may be smaller.

Contrary to a priori expectation in Table 1, education had a negative effect on livelihoods of farmers. It was expected that those with some level of education would have improved livelihood than those without. The opposite is this case; farmers who did not have any form of education have higher livelihood score than those who have some level of education. This may be because educated individuals are perceived to be 'well to do' in most rural areas and hence have a lot of dependents. This put pressure on individual resources thereby reducing their livelihood status. Also, farmers using dams for irrigation were found to have better livelihoods than their counterpart-using the White Volta river as source of water for irrigation. This maybe because farmers using the White Volta experience perennial flooding as a result of the spilling of the dam from neighbouring Burkina Faso. This periodic disaster often leads to loss of lives and assets including destruction of farmlands of households that took them long years to build living most households vulnerable. This significantly affects the livelihoods of farmers in these communities.

CONCLUSION

The paper provides sufficient evidence that smallholder irrigation contributes significantly to rural livelihoods. Participation in irrigation was found to have significant effects on livelihoods. This finding provides a strong motivation for continued investment in irrigation farming in the Upper East Region and Bawku West District in particular as part of strategy to improve rural livelihoods and grow the local economy. However, the benefits from irrigation do not accrue equally to all households and therefore they are not equally beneficial. In order to enhance the benefits of irrigation to rural livelihoods, there is the need to focus on policies that provide incentives for female and youth participation in irrigated agriculture, increase access to improved and sustainable technologies in irrigated agriculture supported by gender sensitive extension services, improved access to markets and equip farmers with entrepreneurial skills. Such policies must be integrated into the overall agricultural development policy of Ghana.

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CONFLICT OF INTEREST

There is no conflict of interest situation.

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