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SMALLHOLDER RICE AND VEGETABLE FARMERS' CONSTRAINTS TO ADOPT SMALL-SCALE IRRIGATION IN SOUTH TONGU DISTRICT, GHANA

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ABSTRACT

Past studies agree that small-scale irrigation can be accessible in remote regions and significantly improve smallholder farmers' agricultural productivity, food security, income growth, and poverty alleviation. However, many of Africa's smallholder farmers do not appear to be enjoying the expected benefits of irrigation for some reason. This study aimed to investigate the constraints faced by smallholder farmers when adopting small-scale irrigation for crops production with the focus on highly irrigable fertile areas of Ghana. A structured questionnaire survey was administered from September to November 2020 among 120 smallholder farmers in six irrigation communities to better understand their perspective about challenges of small-scale irrigation adoption. We found that despite good irrigation source availability and District policy to make more arable lands available for irrigation farmers, the respondents had relied mainly on rainfall. These smallholder farmers faced the following major constraints: a lack of credit access (100%), erratic rainfall (76%), limited water supply (54%), and unreliable water distribution (53%). They had also experienced such physical constraints as flooding (77%), droughts (93%), and a lack of technical expertise (65%). They showed good interests in adopting irrigation practices with the expectation of higher farm productivity. For this investment, land ownership, age and income were key for their decision-making.

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1. INTRODUCTION

Small-scale irrigation has been widely adopted in Sub-Saharan African countries partly to replace volatile rainfed farming (Sakaki and Koga, 2011) and increase productivity (Bjornlund *et al.*, 2017). However, it has not always brought expected benefits for some reasons. In some communities, farmers experienced low yields and increasing poverty (GIZ, 2012). In Ghana, small-scale irrigation was promoted by international organizations for the purpose of enhancing rice production (Balana *et al.*, 2020), but a shortage of capital, poor supply chains, and financial management capacity were reported as impediments in constructing, improving, and maintaining physical irrigation infrastructures (Kadigi *et al.*, 2019; Namara *et al.*, 2011; Kyei-Baffour and Ofori, 2006). As a result, many farmers had left irrigated fields after the end of a project period (Adiku *et al.*, 2017; Alhassan, 2012).

Past studies on the impact of small-scale irrigation appear to be divided in terms of benefits it gave to smallholders. Some emphasized its positive contribution to productivity, income, and food security in developing countries (De Fraiture and Giordano, 2014; Namara *et al.*, 2014; Wichelns, 2014; Xie *et al.*, 2014). These benefits were predominantly reported about cases in China, India, and the United States. On the contrary, some highlighted negative benefits of irrigation. In Ghana small-scale irrigation projects were seen as failures arguably due to small household farm sizes (Delinthe and Zwart, 2022; Schoengold and Zilberman, 2007), poor irrigation infrastructure (Van Den Berg and Ruben, 2006), unreliable water delivery services (Kolleh, 2015), and a limited irrigation service availability (Francois *et al.*, 2015; Ahmed and Gasparatos, 2020; Azumah *et al.*, 2021).

In relatively water abundant areas of Ghana, such as South Tongu District near Volta Lake, irrigation is a reasonable and feasible choice; thus, international irrigation projects have focused on this area. Here smallholder vegetable farmers could potentially obtain 30% yield improvement and 20% income growth. According to the Ghana Ministry of Food and Agriculture (2019), the rice yield of 5.7 mt/ha could be improved up to 6.9 mt/ha annually. However, the project was postponed and never implemented because of COVID-19 restrictions (Ministry of Food and Agriculture, 2021). These farmers still rely on rainfalls. Even those farmers who had willingly participated in international irrigation projects tend to go back to rainfed practices soon after the end of the project period. It is difficult to be convinced that poor infrastructure and unreliable water services were the main reasons that discouraged South Tongu farmers to adopt a long-term small-scale irrigation practice. This paper, therefore, attempts to (1) investigate what constraints smallholder rice and vegetable farmers face in South Tongu District in adopting small-scale

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irrigation for a long term; and (2) determine smallholder farmers' constraints in drawing irrigation water to their farms.

2. METHODOLOGY

2.1 Study Area

South Tongu District of the Volta Region, our study area, lies between latitudes 6°10' and 5°45' N and longitudes 30°30' and 0°45' E, covering a total land area of 665 km^2 (South Tongu District Assembly, 2021; Ghana Statistical Service, 2021b). It had a population of 113,114, of which 60,626 were females in 2021 (Ghana Statistical Service, 2021b; South Tongu District Assembly, 2021). The population has shown a general growing trend since 2010. An average household size was four persons. About 69% lived in rural areas, and about 91% were engaged in agriculture (South Tongu District Assembly, 2021; Ghana Statistical Service, 2021b; Agbi *et al*., 2018).

The District is situated in the Coastal Savannah Vegetation Zone with swampy areas that are suitable for farming (Amponsah *et al.*, 2018; Koku, 2001). The soil types are largely heavy clayey loam with good particle-size distribution (Allotey *et al.*, 2008). As a result, the grounds respond well to water content changes. Clays retain nutrients against leaching and react with hydrogen and aluminum ions while buffering the soil against extreme pH changes (Newman, 1984; Gazey and Davies, 2009). The existing climate is characterized by Southwest Monsoon winds twice annually (Ghana Statistical Service, 2021b; South Tongu District Assembly, 2021; Wondergem, 2016).

Rice is cultivated twice annually in the District due largely to rainfall availability. The major rainy season begins in late March or early April and continues through July. From May to June, 195 mm of rains fall on daily average. From October to November a daily average rainfall is 73mm. August is the driest month with a temperature ranging from 22.6°C to 33°C with a mean annual temperature of 27°C and an average humidity of 80% (Ghana Statistical Service, 2014; South Tongu District Assembly, 2021; Wondergem, 2016). Smallholder farmers start planting rice in late April and early May. In mid-August, they start harvesting. The second season begins with farmers planting rice in early September. Then they harvest from late November to early December.

South Tongu District had enough water sources to sustain any agricultural ventures, but a small portion of arable land is under irrigation (South Tongu District Assembly, 2021; MOFA, 2011; Ghana Statistical Service, 2021; Ablo and Boadu, 2020). According to Namara *et al.* (2011), only about 2% of cultivated land was under irrigation in Ghana. The World Bank (2018) had reported an estimated regional average of 30,000 ha of irrigated area in the Volta Region. Out of Ghana's 1.9 million hectares of potentially arable land, only about 30,000 ha to 31,000 ha was cultivated in the Volta Region (Mendes *et al.*, 2014; World Bank, 2018). The commonly used irrigation

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practices in the District include traditional flood recession, pumping water from rivers, gravity irrigation, fields bunding, sprinkler systems, and furrow irrigation. Among these, flood recession is the most common method. Some farmers have constructed diversion ditches, but ditches were often collapsed after heavy rainstorms and fell into disuse. Smallholder farmers do not draw water from the Lower Volta River, Avu lagoon, streams, wells, dugouts, even though these water sources are located relatively in a close distance (Bidzakin *et al.*, 2018; Nakawuka *et al.*, 2018).

The Volta Region has gained much attention from the national government and international organizations for its great potential to practice both small-scale and large-scale irrigation farming. As early as the 1980s, the World Bank spent US$29.5 million on smallholder agricultural development to increase production, farm incomes, and welfare (World Bank, 1990). This regional focus was partly in response to Ghana's new policy in the late 1970s, which aimed to decentralize agricultural development planning and practices among smallholders.

In the last twenty years, South Tongu District has been recognized for its high irrigation farming potential because of its abundant water sources, including the Volta and Tordzi rivers and tributaries. However, the Department of Agriculture, the District Assembly, and the Ghana Irrigation Development Authority have not observed meaningful progress in irrigation infrastructure development for smallholder farmers despite the implementation of several projects (Nalumu *et al.*, 2021). For example, the District Assembly under village infrastructure projects introduced catchment planning and small-scale irrigation programs among some selected local farming communities to alleviate rural poverty, but it faced significant challenges due largely to land ownership conflicts (Koku and Gustafsson, 2003) and insufficient financial resources (South Tongu District Assembly, 2021).

In 2001, the Japan International Cooperation Agency (JICA) and African Development Bank (AfDB) funded a project that aimed to turn 80 hectares under irrigation. The Ghana Irrigation Development Authority (GIDA) undertook this project by mobilizing about 300 farmers at Dordoekope. At the time about 103 hectares were estimated to be potentially irrigable. In 2006, when the project period was ending, many components of construction works remained uncompleted. About 23 hectares were placed under irrigation, serving some vegetable farmers. After the project period, several farmlands were found unused without pump units and secondary canals. At the time, the reasons were attributed to poor construction supervision, a lack of technical expertise, and poor financial support (JICA Report, 2010).

The Ghana Peri-urban Vegetables Value Chain Project (GPVVCP) and a Ghana Commercial Agriculture Project (GCAP) attempted to improve existing small-scale riverine irrigation systems for resource poor farmers. It was funded by the Japan Social Development Fund (JSDF) through

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a trust fund arrangement with the World Bank and implemented by the Ministry of Food and Agriculture. It was to receive a technical support on irrigation from the GIDA. Smallholder vegetable farmers at Hikpo in South Tongu District were the main target groups. They were expected to obtain 30% yield improvement and 20% increment in income growth. However, the project was postponed and never implemented because of COVID-19 restrictions (Ministry of Food and Agriculture, 2021).

The government of Ghana instituted the flagship program called "One-village One-dam" initiative across the country to encourage private investment in the construction and rehabilitation of abandoned irrigation facilities (Bernard *et al.*, 2014; Baldwin and Stwalley, 2022). It envisioned to have more dams, dug-outs, canals, and reservoirs to capture and store surface water and rainwater for controlled distribution to farming communities during dry seasons (John *et al.*, 2012; Kemeze, 2020; Balana and Akudugu, 2023). However, these goals have not been accomplished arguably due to budget constraints and bureaucratic hurdles (Giordano and de Fraiture, 2014; Namara *et al.*, 2011).

2.2 Data Collection and Analysis

In order to better understand this delay in irrigation progress, we engaged in an extensive discussion with local extension workers at the South Tongu District Agriculture Directorate to identify important communities for this study. The selection criteria were based on their farming systems, soils, water resources, cultivated crops, irrigation activities, and culture. We obtained the cooperation of trained enumerators from the district directorate of agriculture, and six irrigation communities were purposively sampled. These communities were Gbenorkope, Hikpo, Dorkploame, Agbakope, Tordzinu, and Dordoekope.

A structured questionnaire was designed and administered among farmers in South Tongu District from September to November 2020. We used a simple random sampling technique to select 120 respondents from 17,505 rural farm households. Our sample reflects about 102,933 farmers in the entire district. It accounts for 0.12% of the district's farmer population. To validate our responses, a focus group interview was conducted with the district agriculture directorate and some opinion leaders in the District concerning challenges smallholder farmers had faced in adopting small-scale irrigation on their farms. In the same year, we conducted field visits among some farmers in the study area to better understand their farming involvement or engagement. We conducted interviews, discussions, and observations in their homes. Our field visits gave us a firsthand perspective on the actual farming practices and conditions. We concentrated on their roles, responsibilities, challenges, and contributions in the agricultural sector.

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The questionnaire was divided into two thematic sections. The first section covered the socio-demographic characteristics of smallholder farmers in the study area, including gender, age, education, experience, and years of residence in the District. The second section dealt with small-scale irrigation development constraints that smallholder farmers faced. It includes Likert-scale questions that offered a range of response options to understand the level of respondents' agreement. In presenting our findings, we used descriptive statistics (frequencies and percentages).

The study further examined the factors that influence farmers' irrigation adoption. The factors were age, gender, education, experience, farmland ownership, farm size, access to extension services, and income. In analyzing our data, SPSS software version 27 was used to find the significant correlation between irrigation adoption and socio-demographic characteristics. We applied the binary logistic model because the farmers' irrigation adoption is being either yes or otherwise. Moreover, we obtained a significant log-likelihood ratio of 145.753 at the 1%, 5% and 10% significance levels and a pseudo R^2 of 0.186. This illustrated the data were well-fitted as well as the overall model used. The socio-demographic characteristics of the farmers were among the explanatory variables. We also identify a binary variable, namely the farmers' adoption of irrigation=1, and 0=otherwise, where the characteristics of the farmers are represented by the set of explanatory variables. Equation (1) below illustrates the general logit model:

$$\text{logit}(p_i) = \ln(p_i/1-p_i) = \beta_0 + \beta_1 X_{1,i} + \ldots + \beta_n X_{n,i} \quad (1)$$

Where:

p_i = depicts the probability of the farmer being associated with the observation, i, and has adopted irrigation in the time period.

$X_{n,i}$ = depicts the value of the n-th independent variable for the observation, i.

β_1 = vector of parameters to be estimated.

Past econometric studies used the logit model to examine the influence of predictor variables (e.g., age, gender, experience, education) on a given binary dependent variable, such as technology adoption, willingness to pay for irrigation water, and information accessibility (Nikam *et al.*, 2022; Nonvide, 2021; Bavorová *et al.*, 2020; Linh *et al.*, 2016). Similarly, we used the logit regression model to understand factors that influence irrigation adoption. Here those farmers who adopted irrigation was coded as 1, those without as 0. An odds ratio indicates the probability of an outcome resulting from a one-unit increase in the predictor variable with greater than 1, less than one, or no impact. Dependent variable's logit (log-odds) and predictor variables had a linear relationship. Past studies showed that the relationship between predictors and outcomes does not have to be

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necessarily linear (Ho and Cole, 2023; Mittal and Gautam, 2023), and the logit model corresponds with this condition. Information about farmers' irrigation adoption decision does not have to influence the decisions of other farmers. This notion allows us to treat each observation as a unique data set. There are no extreme outliers in predictor variables that may bias the results.

3. RESULTS AND DISCUSSION

3.1 Socio-Demographic Characteristics of the Respondents

The first section of our questionnaire survey tried to identify the socio-demographic characteristics of the respondents (Table1). The results showed that about 66% of the respondents were in 40-49 and 50-59 age groups. Considering Ghana's average life expectancy of 64 years old (World Bank Group, 2020), this result indicates an aging trend. As current farming practices depend largely on manual labor with the use of simple implements, farm works place heavy physical strain on older farmers. This possibly implies declined productivity and decreased farm income. Additionally, older farmers may be less likely to accept new and costly technology like irrigation. Similar aging trends were discussed in case studies among smallholder farmers in other parts of Ghana (Abdulai and Matsui, 2022; Kyei and Matsui, 2019; Nuhu and Matsui, 2022). In the study area, males tend to have lower life expectancy.

In terms of gender distribution, our results have shown that males (62%) were represented slightly more. In our field survey, we found that female farmers in the study area were not fully engaged in farming due largely to other household responsibilities, such as childcare, cooking, and water collection. The 2021 population and housing census showed that females consisted of 54% in the study area with a mean household size of four persons (Ghana Statistical Service, 2021a). The regional and national census records showed a similar trend of gender distribution and average household size (Ghana Statistical Service, 2021a).

Regarding the educational attainment of the respondents, about 60% of them had completed primary education which is lower than the district average of 69% (Dorm-Adzobu and Ampomah, 2014; Ghana Statistical Service, 2014). Here literacy means their ability to comprehend English as it is Ghana's official language. Farmers learn of new agricultural technologies in English from government agencies, NGOs, and other stakeholders. Dauda *et al.* (2009) found that in Nigeria's southwestern region literacy was linked to technology accessibility. Asfaw and Admassie (2004) found that in Ethiopia education improved farmers' ability to respond to innovations.

To understand how much experience matters for farmers in the study area, we asked the respondents about the duration of their residency. We found that almost 60% of the respondents had lived in the study area for more than 25 years, suggesting their substantial knowledge about

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the area, including local customs and irrigation practices. To note here, small-scale irrigation practices were introduced here in the 1980s (Namara *et al.*, 2011; Venot *et al.*, 2012). A modern large-scale irrigation technology was introduced to Ghana as early as the 1960s (Sakaki and Koga, 2013) although the national irrigation promotion policy failed to disseminate irrigation to smallholder farmers.

Our field survey among smallholder farmers found that a handful of them had come to the study area from the surrounding towns and villages to acquire land to farm. The motivation behind this migration stemmed from such factors as land availability, soil quality, access to water sources, and the suitability of environmental conditions for cultivating specific crops. The decision to seek land elsewhere might also be driven by desire to access more affordable agricultural land. Moreover, there was some perceived or tangible economic advantages linked to farming in new locations.

Our questionnaire survey results have shown that a correlation exists between irrigation experience and the number of years spent by smallholder farmers. We found that 40% of the respondents had spent more than 15 years in irrigation farming. These farmers might have experienced or observed one or more of the above-mentioned irrigation projects in South Tongu District. Awunyo-Vitor *et al.* (2016) in Ghana and Zongoma *et al.* (2015) in Nigeria similarly found that irrigation experience positively affected smallholder farmers' productivity. Mabohlo *et al.* (2021) found that in South Africa farmers with more than ten years of farming experience were likely to adopt irrigation technologies.

Table 1: Socio-Demographic Characteristics of the Respondents

Socio-demography	Category	Frequency	Percentage (%)
Gender	Male	74	62
	Female	46	38
Age	18-29	4	3
	30-39	13	11
	40-49	45	38
	50-59	34	28
	60-69	24	20
Education completed	No formal	17	14
	Primary/Basic	72	60
	Secondary	29	24
	Tertiary	2	2

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Years of residence in the District	< 5 years	10	8
	5-14	18	15
	15-24	22	18
	25-34	18	15
	35-44	17	14
	Above 44	35	30
Irrigation experience (Years)	< 5 years	46	38
	5-14	48	40
	15-24	10	8
	25-34	8	7
	35-44	7	6
	Above 44	1	1

3.2 Constraints that farmers experience with farm irrigation

In the second part of our survey, we attempted to identify constraints smallholder farmers faced in an attempt to draw water to their farms. From our preliminary field observation and literature review, we identified the following constraints: irrigation water availability (quantity), flood, drought, water/land rights conflicts, salt-water intrusion, credit support for constructing an irrigation canal, maintenance support, and technical know-how. Considering these constraints, the respondents were asked to make applicable choices (Likert-scale questions), where 1 indicates strong disagreement and 5 being strong agreement.

We found that the most serious constraint for the respondents was inadequate credit support. All the respondents agreed or strongly agreed (Figure 1). The next serious constraint was flood damages, with which 93% agreed or strongly agreed. Akatsi Dam spillage and the Tordzi river occasionally flood the study area and destroy farms near the dam and riverside. In the upper stream of the Volta River Basin, Zakaria and Matsui (2021) found a similar flood damage issue partly because of the spillage from Bagre Dam. In addition, farmers located near the Dam did not have sufficient information sometimes about the spillage (Joy News, 2023; South Tongu District Assembly, 2023). The 2023 heavy rain event in the Lower Volta area caused the worst flood damages in the region's history. Parts of the study area were severely impacted. The flooding was arguably caused by a spillage from Akosombo Dam, country's largest hydroelectric dam. More than 26,000 people were displaced, and farms and infrastructures were destroyed. However, there were no official death reports. The last recorded spill was in 2010 (Joy News, 2023).

Crop failure was identified by about 77% of the respondents due largely to drought conditions. High temperatures in the study area affected crop yields as evaporation rates were accelerated and heat stress changed crop physiology. Similarly, Nuhu and Matsui (2019) found that smallholder

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farmers in the Upper East Region of Ghana experienced reduced yield in July 2017 (unimodal rainy season) and March 2018 (long dry period). Zakaria and Matsui (2018) found that smallholder rice farmers in the same Region experienced reduced yield due to decreased rainfall and increased temperature. In the Upper East Region and the Volta Region, climate change reduced the quantity of yams that threatened food security (Wahab, 2014).

Regarding technology related constraints, our respondents identified inadequate irrigation support (59%) and a lack of technical know-how (65%). These are related to irrigation equipment installation, pump maintenance, valve repairs and canal construction. These results imply that extension services or farmer based organization's supports was not readily available. Jonah and Dawda (2014) showed that in the northeastern part of Ghana's Garu and Tempane districts smallholder farmers had limited technical knowledge about pump maintenance, repairs, and irrigation infrastructure construction.

Regarding irrigation water availability, only 33% of the respondents agreed or strongly agreed (5%). This means that these respondents had reliable irrigation supplies. Those who remained neutral were probably not involved in irrigation activities partly due to their farms' remote location from water sources. Koku and Gustafsson (2003) found that South Tongu District was endowed with rich water sources for irrigation farming. Despite this good water availability, our respondents tend not to rely on irrigation.

Fair access to water resources and sustainability depend on effective management. Regulating who can use water, how much, and for what purposes depends on water use rights. These rights are distributed in accordance with the institutional and legal framework that is in place through licenses, permits, and regulations. We, therefore, attempted to find out about the study area's water rights enforcement. The result showed that 70% did not consider water rights as constraints. This means that the respondents can freely draw water from water sources. Adams *et al.* (2019) discovered that farmers were more concerned about land dispossession and agro-chemical threats to water quality than water rights violations. In Ghana, the Water Resources Commission Act of 1996 empowers the Ministry of Food and Agriculture, Ghana Irrigation Development Authority, and local governments to manage water resources for irrigation and domestic purposes (Adombire *et al.*, 2013; Monney and Ocloo, 2017; Government of Ghana, 1996). However, these agencies do not appear to have strictly enforced water law or resolved conflicts among farmers (Williams *et al.*, 2012; Nalumu *et al.*, 2021).

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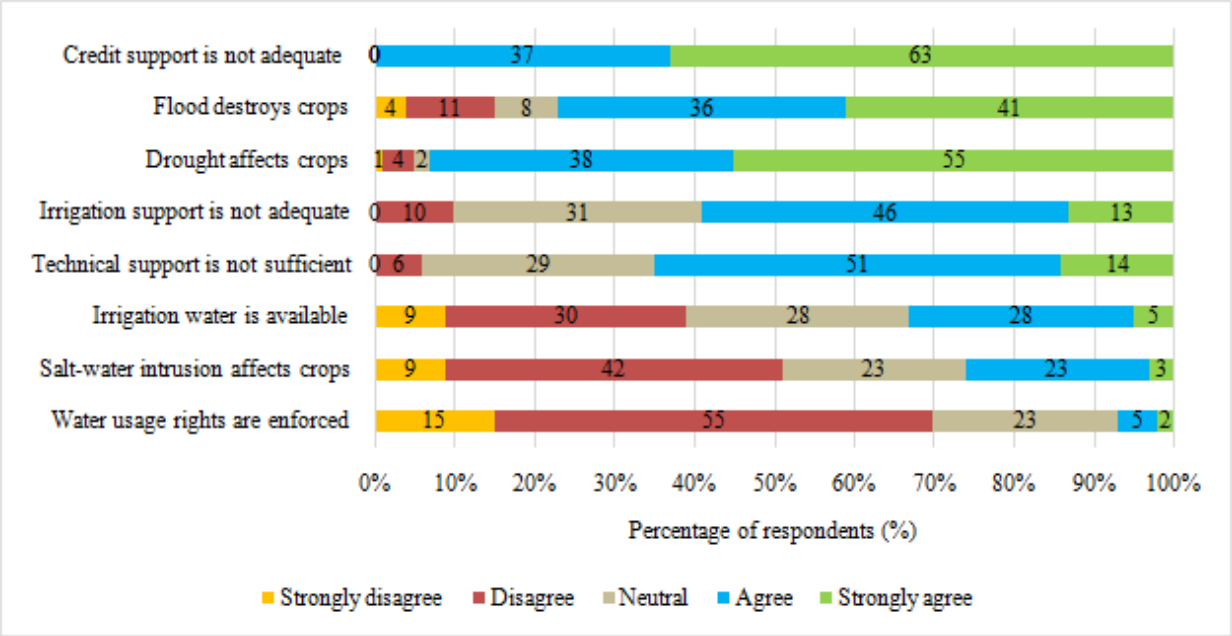

Figure 1: Smallholder farmers' constraints in drawing irrigation water

3.3 Challenges Smallholder Farmers Faced in Cultivating Crops

In another Likert-scale question, we tried to understand challenges smallholder farmers faced in cultivating their crops. This question was based on the level of agreement among the respondents, where 1 indicates strong disagreement and 5 indicates strong agreement. The following options were presented: (1) water supply is not enough; (2) water delivery is not reliable; (3) labor cost is high; (4) not enough experienced labor is available; (5) rainfall is not reliable for production; (6) seeds are not good for high yield; (7) I need better access to credit facilities; (8) water salinity reduced productivity; and (9) land tenure system affects production.

The result shows that, corresponding with the results of the previous section, all our respondents agreed or strongly agreed that they needed better access to credit facilities like bank loans (Figure 2). In terms of water supplies, the respondents had faced tremendous challenges from unreliable rainfalls (76%). About a half of the respondents had experienced challenges of unreliable water delivery (53%) and insufficient water availability (54%). Those respondents who irrigated their farms told us that their water withdrawal and delivery were unreliable partly because their farms were located in upland areas without pumping equipment. In the study area PVC (polyvinyl chloride) irrigation pipes are typically used as these are relatively cost-effective, flexible, and safe compared to metal ones (Gupta, 2016). However, the installation of these pipes requires

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underground placement and fittings. These pipes were reported for failure (e.g., leakage, fracture) more often than other types of irrigation pipes (Ariyoshi *et al.*, 2018).

In connection to irrigation, the impact of water salinity was investigated. The result showed that about 40% of the respondents had experienced reduced yield due to salinity. In the study area, salts from Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, and Ca^{2+} ions could have come from household wastewater runoff, industrial wastewater released from upstream, runoff from small-scale brick and tile factories, and irrigation activities. Salts could also come from oil spills from outboard motors on fishing canoes. Organic and inorganic wastes, fertilizers and agro-chemicals from residential areas and farms enter the water source through runoffs and erosion.

Another substantial challenge the respondents experienced in the study area was complex land tenure systems (44%). As our respondents did not own farmlands, they rented or leased from traditional owners or family heads. These rent or lease agreements can be done without legal authentication. Things get complicated when landowners decide to lease the same land to others or land boundaries are not clearly defined (Boamah *et al.*, 2020; Nyasulu, 2012). This vulnerable situation discouraged smallholder farmers' choice of making further investments in irrigation equipment and soil improvement (e.g., fertilizer). Ayamga *et al.* (2016) similarly found in Ghana that tenure security was an incentive for smallholder farmers to invest in irrigation developments.

In terms of inadequate skilled labor availability, about 49% agreed or strongly agreed. This result corresponds with the aging trend of the agriculture workforce, including our respondents. As experienced farmers retire and younger generations tend to choose other occupations, there is a significant gap in transferring knowledge and skills to younger generations. This result means that smallholder farmers will have to hire experienced labor at a fee to carry out certain farm activities. This labor hiring cost was concerned by 89% of our respondents.

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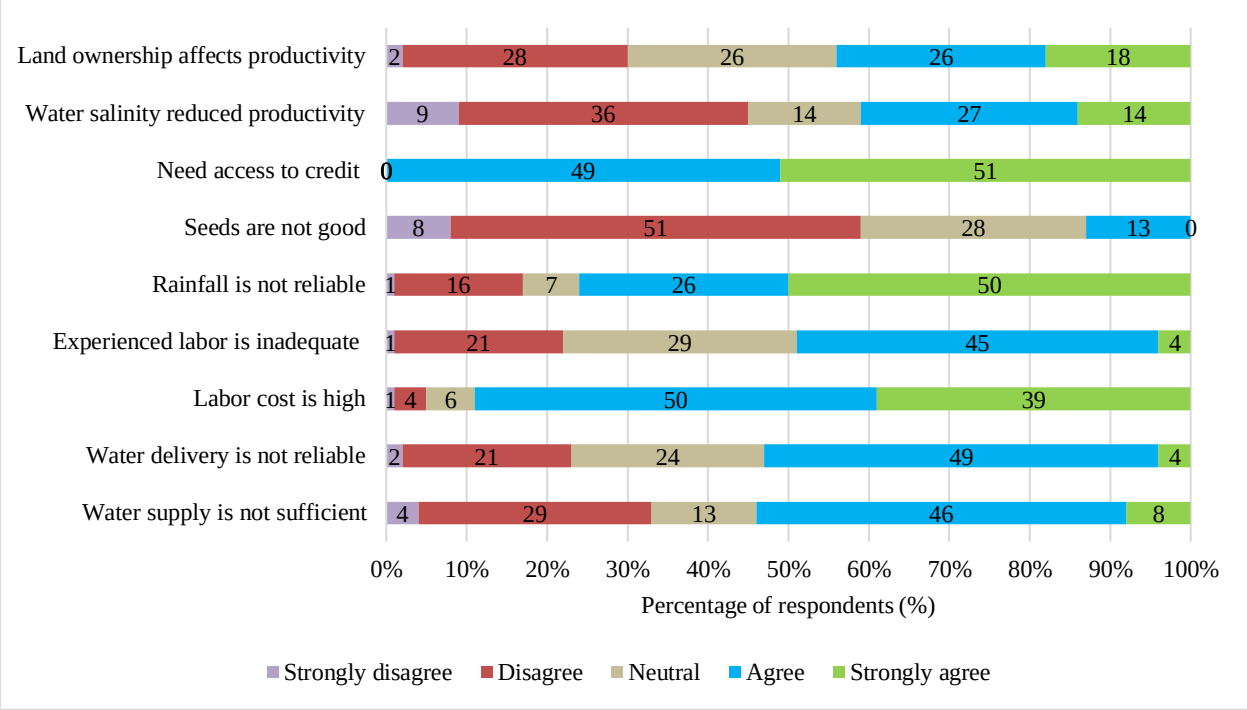

Figure 2: Smallholder farmers' cultivation challenges under irrigation

3.4 A logistic regression analysis on factors influencing irrigation adoption among respondents

Finally, we correlated smallholder farmers' socio-demographic characteristics to irrigation adoption in the study area. The results show that age, average income, and farmland ownership were statistically significant and negatively correlated with irrigation adoption. An aging trend among the respondents negatively influenced irrigation adoption. Mango *et al.* (2018) similarly found that in the Chinyanja Triangle of Southern Africa, farmers' age negatively influenced their irrigation adoption.

Regarding income, we found that smallholders with low income tend to be unwilling to adopt irrigation. It also means that simply they could not afford to pay regularly for irrigation services. Gebregziabher *et al.* (2014) found that farmers with additional sources of income were more likely to adopt modern irrigation technologies.

Farmland ownership also significantly influenced farmers' irrigation adoption. This means that those farmers who had adopted irrigation were those who owned farmlands. In other words, farmers who operate on rented or leased farm lands would not be able to adopt irrigation. This further means that Ghanaian farmers in the study area are more likely to invest in irrigation

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infrastructure on their own farmlands (Table 2). This result corroborates the findings of Martey (2013) on rice development projects in northern Ghana.

Table 2: A logistic regression analysis on the factors influencing irrigation adoption

Variable	B	Standard error	Wald	Sig	Exp(B)
Gender	−0.070	0.464	0.023	0.880	0.932
Age	−0.389	0.226	2.959	0.085*	0.678
Education	−0.191	0.340	0.315	0.575	0.826
Farm size	0.450	0.355	1.606	0.205	1.569
Average income	−0.750	0.212	12.470	0.001***	0.472
Extension services	0.469	0.754	0.386	0.534	1.598
Farmland ownership	−0.5480	0.518	4.120	0.032**	0.578
Constant	2.867	1.735	2.730	0.098	17.592
−2 Log-likelihood	=145.753				
Pseudo R^2	=0.186				
Prob>Chi2	=0.022				
N	=120				

***1%; **5%; *10% Significance levels (Source: Field survey, 2020)

4. CONCLUSION

This paper investigated constraints that smallholder farmers encountered when adopting small-scale irrigation in the Volta Region of Ghana. In doing so, we identified several interconnected factors to explain low irrigation adoption despite the area's high irrigation potential. Our socio-demographic analysis found that our respondents' aging trend, low education, and farmland ownership status were significantly related to the slow adoption of new farming technologies. Most respondents were experienced farmers with at least 25 years of residence in the locality and more than 15 years of experience in irrigation farming.

Among several constraints for irrigation adoption and crop cultivation, the responded smallholder farmers perceived that insufficient credit support had most seriously prevented them from adopting irrigation. They also faced climate change related challenges in drawing water to their farms, such as unpredictable floods (93%) and droughts (77%). Their technological challenges to adopting irrigation included a lack of knowledge (65%) and insufficient technical support (59%). In cultivating crop, other than credit access problems, the respondents emphasized unreliable rainfall patterns (76%). This point clearly corresponds with drought problems they identified in drawing water. Labor cost (89%) and skilled labor shortage (49%) posed additional challenges. Water rights

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issues were not critical impediment for them. This means that irrigation adoption was more about supply service and management problems rather than water scarcity or competition ones.

For decades, irrigation has been promoted in Sub-Saharan African countries without achieving substantial improvement to food security, poverty alleviation, and productivity. Past studies emphasized many different factors without much in-depth knowledge about farmers' perceptions. One of the most important areas to be addressed by policymakers in the near future is the extent to which an inclusive green growth for the agricultural sector can minimize inequality issues that have plagued smallholders due to traditional social norms and complex land tenure systems. As this paper demonstrated, irrigation facilities are needed despite the cost, and government agencies at all levels are recommended to find ways to invest more fully in irrigation facility installment and make it accessible to all smallholders regardless of land ownership. In another word, irrigation can be made available at least initially as government enterprise and use a right-of-way land acquisition for securing canal routes. A right to irrigation water should be considered in connection to arable land plots rather than ownership. Although these policy options for future smallholders are beyond the scope of this paper, possible ways to expedite a full access to irrigation can be an essential future study topic. In connection to this point, more case studies are needed to find interconnection among inhibiting factors for smallholders to adopt irrigation practices.

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