Examining Smallholder Farmers' Perceptions of Irrigation Access in the Volta Region, Ghana

Michael Kossivi Tamekloe, University of Tsukuba, Japan

The IAFOR International Conference on Arts & Humanities in Hawaii 2025
Official Conference Proceedings

Abstract
Past studies that emphasized the importance of irrigation access for smallholder farmers focused on different sets of factors for irrigation adoption. Some emphasized cultural norms, local practices, and personal experiences. Some others examined geographical locations, farm size, access to water sources, and socio-economic status. This study attempted to find what factors above or others actually influence smallholder farmers' perceptions of irrigation access and needs. A structured questionnaire survey was randomly administered among 282 smallholder farmers in South and North Tongu districts of Ghana from January to February 2024. The data were analyzed using SPSS and Excel. It was found that among 94% of the respondents who needed to irrigate their farms, 68% could not because of water scarcity. About 93% found that the cost of connecting irrigation ditches to their farms was inhibiting. Another cost-related factor was energy/electricity for pumping water (89%) and maintenance (89%). About 55% blamed neighboring farmlands for blocking canal routes to their farms. Some neighbors diverted more water than their fair share, causing shortages for those downstream. Others blamed a lack of irrigation water access on start-up capital (95%), technical support (44%), and infrastructure (74%).

Keywords: Smallholder Farmers, Irrigation Access, Perceptions, Ghana

iafor
The International Academic Forum
www.iafor.org

Introduction

Smallholder farmers in Sub-Saharan Africa perceive irrigation access as involving more than physical infrastructure for irrigation water access (Burney et al., 2013). Their perception of irrigation is based on education level and how much exposure they have with irrigation. Nguyen and colleagues (2016) determined that farmers' perception of irrigation access was influenced by cultural norms and socio-economic conditions. Other studies found that farmers' views of irrigation access were influenced by the topography of the area, level of socio-economic development, and local farming practices (Chuchird et al., 2017; Udmale et al., 2014).

In Ghana, smallholder farmers' perception of irrigation access significantly depends on the geographical location of their farms, proximity to water sources, and rainfall amount (Akrofi et al., 2019; Limantol et al., 2016). Some farmers perceived that to have access to irrigation, their farms must be located near water sources (Ayamga et al., 2016; Dakpalah et al., 2018). Past studies have shown that farms were not close enough to water sources (Agodzo et al., 2023; Atiah et al., 2019), and this situation negatively influenced farmers' perceptions of irrigation access (Kyei-Baffour & Ofori, 2006). In the drier and semi-arid environments in Ghana's Northern, Upper East, and Upper West regions, farmers tend to view irrigation access as an essential tool for their production (Sekyi-Annan et al., 2018). Similarly, Akudugu and colleagues (2021) found that those farmers who lived in areas with inconsistent rainfalls tended to have a more positive perception of irrigation access. These farmers believed that they could rely on irrigation to mitigate the effects of climate change on their farms and to improve yields (Ankrah, 2024; Fagariba et al., 2018).

Some irrigation projects and initiatives were made available to farmers by the Ghanaian government and international agencies like JICA to support farming (Nalumu et al., 2021; Woodhouse et al., 2017). However, not every region, district, or community had benefited equally from these irrigation initiatives (Dziwornu et al., 2024; Namara et al., 2011). Farmers who had access to these irrigation projects had more positive perceptions of irrigation due to their firsthand experience with the benefits (Zakaria et al., 2020). On the contrary, in those regions where irrigation projects are not available, farmers are less likely to prioritize irrigation access (Boateng et al., 2024). These farmers do not seem to fully appreciate irrigation benefits because traditional rain-fed agriculture is dominant in the area and requires no irrigation expenses (Dakurah et al., 2024). Therefore, with rain-fed farming practices, these farmers experienced insufficient water access, which resulted in low productivity and yields (Assan et al., 2020; Balana et al., 2020).

Past studies on smallholder farmers' irrigation activities demonstrate that income levels, access to credit, and education influenced their perceptions of irrigation access (Derkyi et al., 2018; Kudadze et al., 2019). A study conducted by Castillo and colleagues (2021) in Maule and O'Higgins regions of Chile found that farmers with more financial resources, education, and knowledge about modern irrigation technologies had a more positive view of irrigation access. Other studies also found that farmers saw irrigation as expensive and difficult (Fagariba et al., 2018; Kyei-Baffour & Ofori, 2006; Nalumu et al., 2021). Asiedu and Gross (2017) found in Northern Ghana that farmers tended to perceive that irrigation was only for the wealthy and the privileged in society. On the contrary, some studies showed that farmers with limited financial resources and knowledge perceived irrigation as less accessible or non-beneficial and were skeptical about irrigation access (Lefore et al., 2019; Ndamani & Watanabe, 2015). These factors seem to be convincing to some extent regarding farmers' perceptions of irrigation access. In the Volta region, where this study is situated, previous studies examined farmers'

irrigation infrastructure and water management constraints. However, there are limited studies on the perceptions of farmers who are directly affected by a lack of irrigation facilities on their farms. In order to bridge this gap and meet farmers' needs, it is important to understand how these farmers perceive access to irrigation. Therefore, this study aims to examine smallholder farmers' perceptions of irrigation access in Ghana's South and North Tongu districts. The findings of this study will help stakeholders and policy to integrate farmers' perspectives into irrigation development programs and improve infrastructure and water management practices.

Methodology

Study Location

This study was carried out in South and North Tongu districts of Ghana's Volta Region (Figure 1). The Volta region has 18 administrative districts in operation. According to the Ghana Statistical Service (2021), the Volta region's total population is approximately 1,659,040 individuals, accounting for 5.4% of the national population of 30,832,019 people. Of this total, 790,685 were men. South Tongu District had 113,114 inhabitants, accounting for 6.8% of the Volta region's total population of 1,659,040. Males make up approximately 52,488 (46.2%) of the total population of South Tongu district, while females make up 60,626 (53.6%). The North Tongu District had a population of 110,891, which accounted for 6.7% of the Volta population. Males make up around 52,996 (48%) of the total population of North Tongu district, while females make up 57,895 (52%). A population of 68.9% and 56% in the South and North Tongu districts, respectively, live in rural areas and rely heavily on agriculture for a living. Both districts have household sizes of four people apiece. The selected communities in South Tongu for this study had a farmer population of approximately 1484 farmers, whereas those communities chosen in North Tongu had 1860 farmers (Ghana Statistical Service, 2021).

South Tongu District has a total land area of 665 km^2, which accounts for 7% of the Volta region's size (9,504 km^2). South Tongu sits 75 meters above sea level. However, North Tongu District has a total land area of 1,154 km^2, which is 12% of the size of the Volta region. North Tongu District is situated at a slightly higher elevation of 85 meters above sea level compared to South Tongu. Despite the differences in size and elevation, both districts share a border with the Volta River, providing important water resources for the region. The diverse landscapes of both districts, including fertile farmland and lush forests, which contribute to the overall beauty and natural resources of the Volta region (Ghana Statistical Service, 2014).

Farmers in the South and North Tongu Districts rely primarily on agriculture for their livelihoods. The sector contributes significantly to both districts' efforts to improve food security, alleviate poverty, and create jobs. However, low productivity and yields have reduced the sector's contribution to Ghana's GDP. This is frequently ascribed to insufficient investment in irrigation facilities and land tenure insecurities. Agriculture output is often small-scale in the selected localities. Farmers rely more on traditional rain-fed farming, which frequently produces low yields. The smaller farm sizes, high costs of land, fragmentation of lands, and ownership agreements often influence farmers' perception of irrigation. Farmers in the selected communities lack suitable irrigation infrastructure, such as streams and well-developed canal systems (Ghana Statistical Service, 2014).
These two districts are situated in the Coastal Savannah Vegetation Zone. They both have swampy areas that are conducive to agricultural cultivation (Amponsah et al., 2018; Koku, 2001). The Southwest Monsoon Wind creates a distinct climate pattern for these districts. This occurs twice a year and frequently results in a two-fold maximum rainfall regime (Braimah et

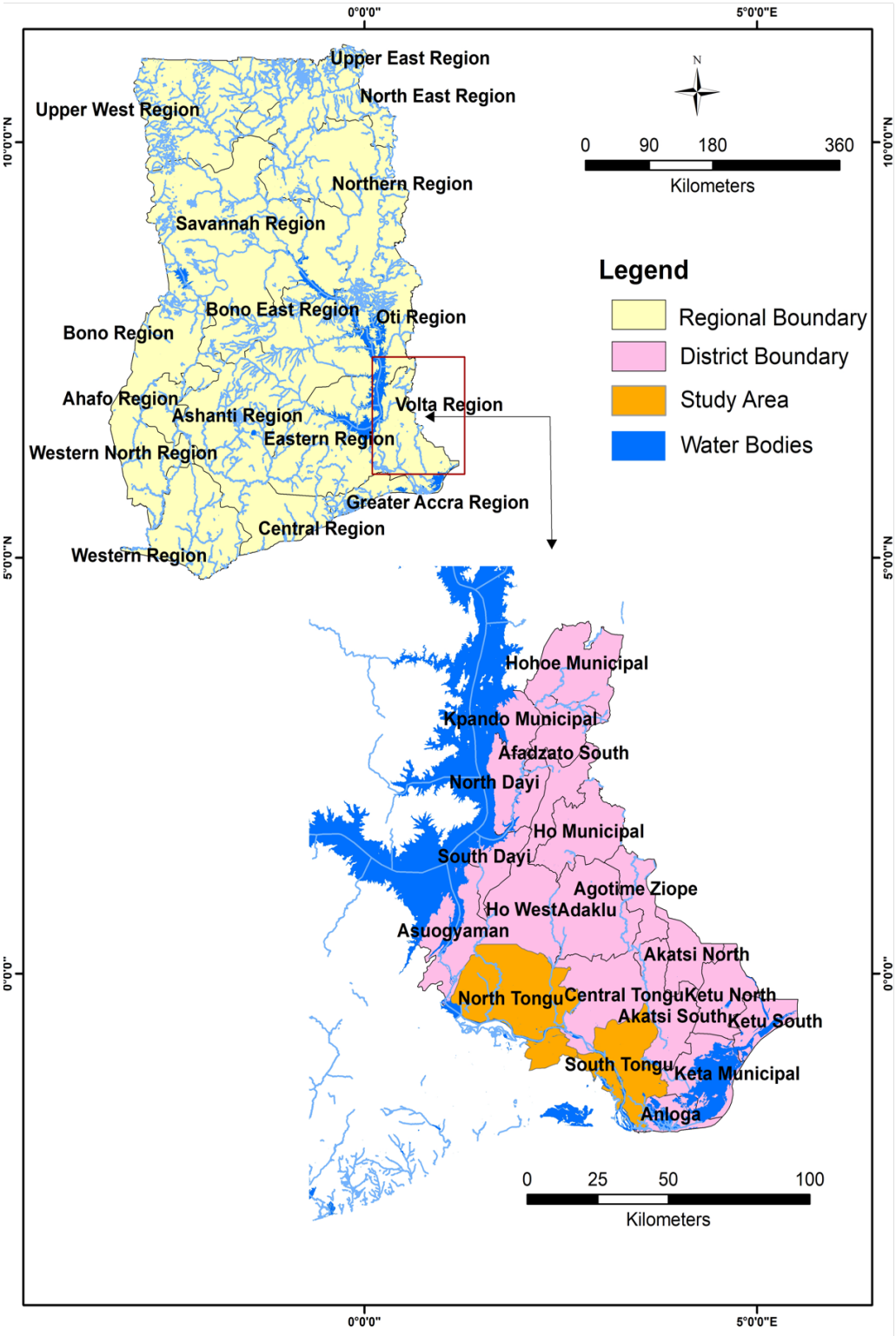
al., 2022; Ghana Statistics Service, 2014; Israelsson et al., 2020; Wondergem, 2016). The rainfall from the Southwest Monsoon Wind contributes to the success of agriculture in both South Tongu and North Tongu Districts. It provides the necessary water for crops to thrive. Farmers in these districts have learned to adapt to the unique climate pattern, utilizing it to their advantage in their cultivation practices. However, farmers in these rural communities faced challenges such as limited access to irrigation water and infrastructure, which hindered their productivity. Despite these obstacles, the agricultural sector remains the backbone of the local economy, providing employment and sustenance for the majority of residents.

Smallholder farmers who irrigate their farms produce more rice and vegetables than those who depend on rainfalls. Irrigated farms exhibit better technical, allocative, and economic efficiency than rain-fed farms (Bidzakin et al., 2018). Crop yields, on the other hand, are frequently low due to the poor status of irrigation, irrigable fields, and irrigation infrastructure in the area.

Moreso, the combination of swampy areas, water sources, and the distinct districts' climate patterns makes both districts prime locations for agricultural production. However, farmers' perceptions of irrigation access greatly impacted their decisions on what crops to grow and how much to produce. Some farmers choose to focus on crops that require less water in order to minimize their reliance on irrigation systems. Others also invest in irrigation technology to maximize their yields. Additionally, soil quality and market demand also play a role in determining the types and quantities of crops that farmers choose to cultivate in these districts (Ghana Statistical Service, 2014).

The success of agriculture in the communities in the study area is dependent on farmers' ability to adapt to changing conditions and make strategic decisions based on their individual circumstances. The rich soil in these districts, combined with the consistent rainfall from the Southwest Monsoon Wind, allows for a variety of crops to be grown successfully, including staples like maize, cassava, and rice. The farmers in the selected communities in these districts have honed their skills over generations, passing down traditional farming techniques that take advantage of the unique climate conditions. By understanding and working with the natural environment, the farmers have been able to sustainably produce food and support their local economy for years. However, the harsh effects of climate change in the forms of long spells of drought and erratic rainfall negatively affected farmers' productivity and yield in recent years. This highlights the need for irrigation access to prevent future crop damages and promote food security.

Figure 1: Study Area Map



Source: UNOCHA, 2024

Data Collection and Analysis

In this survey, two potential irrigation districts were chosen on purpose from the Volta Region. In December 2023, an initial household survey was carried out in Tordzinu and Dorfor-Adidome in the study area. Throughout this initial survey, useful data was gathered on the perceptions of smallholder farmers about access to irrigation and their needs for irrigation

system development. Subsequently, a questionnaire was carefully designed and uploaded unto the digital data collection platform known as Kobotool Box. This simplified the data collection process and eventual storing and retrieving it. The survey was carried out with the use of informed consent forms, ensuring that respondents were fully aware of and agreed to take part. Additionally, careful measures were taken to guarantee the anonymity and confidentiality of the respondents.

The Yamane sample size formula has been widely used in previous studies as a reliable method for obtaining an appropriate sample size when a population size is known. Studies have used this method because it ensures that the selected sample appropriately represents the target population without requiring a full census. In these past studies, the process involves determining the total number of individuals within the population and selecting a permissible margin of error, typically set at 0.05 or 0.10, as shown in equation 1 below (Alor et al., 2023; Awuku et al., 2023; Hasan & Kumar, 2024; Ikehi et al., 2019).

This study uses the Yamane sample size calculation with a 0.05 margin of error to determine the sample size for the study. The sample size was 357 household farmers. However, 75 individuals failed to respond to the questionnaire due to their unavailability, time constraints, and other personal reasons. Some farmers had busy schedules and prioritized other activities over participating in the survey. Therefore, the responses from 282 household farmers were used in the survey. The Yamane formula is expressed as:

$$n=N/(1+N(e)^2) \quad (1)$$

Where:
n = required sample size
N = population size (farmer population in the selected communities, 3344)
e = margin of error expressed in decimal (0.05)

Therefore,

$$n=N/(1+N(e)^2)$$
$$=3344/(1+3344(0.05)^2)$$
$$=357 \text{ respondents (farmers)}$$

Using trained enumerators, the questionnaire was administered randomly to 282 household farmers in the selected communities from January to February 2024. The selected communities included Tordzinu, Hikpo, Sokpoe from South Tongu, and Agorveme, Korsive, and Dorfor-Adidome from North Tongu with a total farmer population of about 3344 farmers. The selection of these study communities was purposeful, as they exhibited a lack of irrigation usage and inadequate construction of irrigation infrastructure among smallholder farmers. To verify the results of the questionnaire, interviews were conducted with extension officers from the directorate of agriculture in both districts.

Here the questionnaire was divided into two main sections. The first section focused on the socio-demographic factors of smallholder farmers in the study area, including gender, age, education, farm size, and farmlands ownership. The second section examined smallholder farmers' perceptions of irrigation access in the study area. The survey consists of Likert-scale questions with a range of responses provided to understand the extent of agreement among respondents regarding their perceptions of irrigation access and needs. In the analysis of data,

SPSS software version 27 and Excel were used to generate tables and figures that present descriptive statistics, specifically frequencies and percentages.

Results and Discussion

Socio-Demographic Factors of the Respondents

To understand smallholder farmers' perceptions of irrigation access, several socio-demographic factors, including age, gender, education level, farm size, and farmland ownership were considered (Table 1). The results showed that males (61%) in the study area were involved in agriculture than females. This result is slightly higher than the 2021 population and housing census figure of 50.1% males in rural areas. It is also slightly above the national average household size of 4. In rural agricultural communities, male dominance in farming activities influence perceptions about irrigation facilities, including access, usage, and decision-making regarding adopting irrigation systems. In contrast, the 2021 population and housing census revealed that females (54%) slightly outnumbered males in the study area with an average household size of 4 (Ghana Statistical Service, 2021). The census data indicated a comparable pattern of gender distribution in both regional and national contexts, with an average household size of 3 and 4 individuals correspondingly (Ghana Statistical Service, 2021). This highlights gender-specific roles or barriers affecting females' active involvement in agriculture as they may face unequal access to resources like irrigation facilities. For instance, women might view irrigation as less accessible due to socio-cultural, financial, or labor constraints.

In terms of age, it was found that 71% of the respondents belonged to 40 – 49 and 50 – 59 year groups, with an average age of 50 years. This shows an aging trend that may be a factor to explain the low irrigation adoption rate among farmers. Brown and colleagues (2019) found that farmers who are older tend to be less adventurous and more risk averse. Similarly, Wang and colleagues (2015) found that farmers' possibility of adopting irrigation technologies declines with increasing age. However, other studies indicated otherwise. Studies by Bunyasiri and colleagues (2024) in Thailand demonstrated that aged farmers tend to adopt labor-saving technologies like irrigation.

Regarding education, 75% of the respondents had completed primary and secondary education (Table 1). It means that the respondents were literate. Farmers' literacy influenced their perceptions of irrigation access, as those with higher levels of education will more likely understand and implement irrigation. It also means that farmers with higher levels of education are more likely to be aware of and understand the benefits of irrigation. They can also use and maintain irrigation systems well. Moges and Taye (2017) found that the educational level of farmers had a positive and very significant association with their perception.

Regarding farm size, 50% operated on small farm sizes of less than 5 acres (Table 1). They had farms at different locations. It means that farmers with smaller plots of land may not be interested in irrigation access due to the high initial costs of implementation. Asrat and Simane (2018) found that farm size influences farmers' decisions to implement technologies such as irrigation.

Regarding farmland ownership, 76% of the respondents did not own farmlands (Table 1). It means that these farmers may be unwilling to invest in and develop the farmland, with irrigation

facilities, on which they operate. Koirala and colleagues (2016) found that farmers who do not own farmland were less likely to invest in land improvement and in irrigation.

Table 1: Socio-Demographic Factors of the Respondents

Socio-demography	Category	Frequency	Percentage (%)
Gender	Male	173	61
	Female	109	39
Age (Years)	18-29	12	4
	30-39	45	16
	40-49	133	47
	50-59	66	24
	60-69	22	8
	Above 69	4	1
Education level	No formal Education	53	19
	Primary/Basic	86	31
	Secondary	124	44
	Tertiary	19	7
Farm size (Acreage)	< 5	140	50
	5-9	58	21
	10-14	38	13
	15-19	25	9
	More than 20	21	7
Farmland ownership status	Owned	69	24
	Not owned	213	76

Smallholder Farmers' View of Irrigation Merits and Demerits

This survey used a Likert-scale question to tried to understand respondents' perceptions about irrigation benefits (Figure 2). This question was based on the level of agreement among the respondents, where 1 indicates strong agreement and 5 indicates strong disagreement. The following options were presented: (1) It minimizes risks of drought; (2) It improves crop yield; (3) It saves time; (4) It reduces the cost of labor; (5) It increases cost of farm produce.

The results show that all respondents agreed or strongly agreed that irrigation minimizes risks of drought (Figure 2). It means that the respondents recognize or might have experienced the negative impacts of drought on their farms. It further means that farmers are aware of the importance of irrigation in maintaining their crop yields during periods of limited rainfall. This acknowledgment of the benefits of irrigation could lead to increased positive perception of irrigation adoption among farmers in the future, highlighting the significance of irrigation in mitigating the effects of drought.

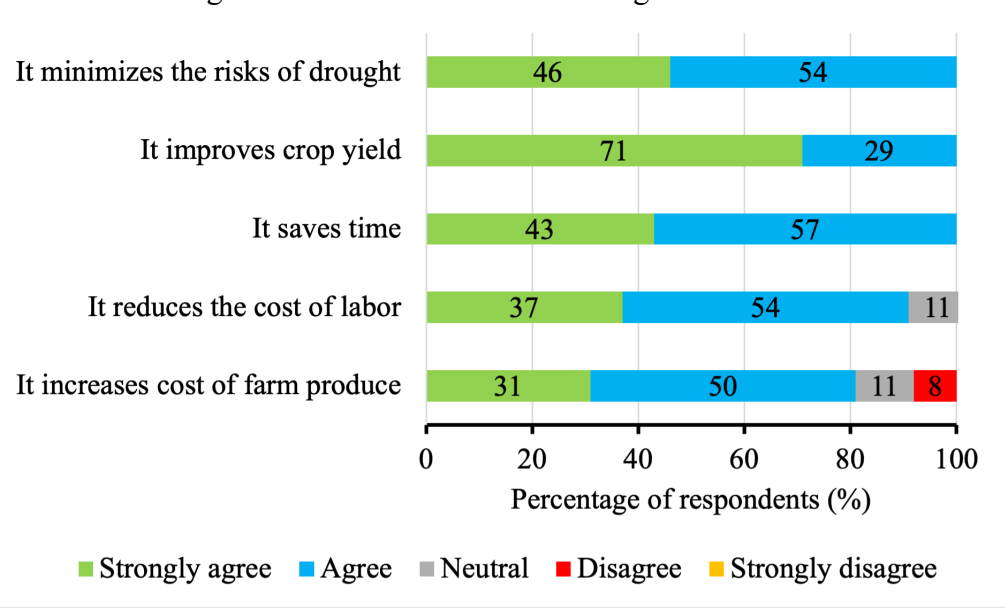
All respondents agreed (29%) or strongly agreed (71%) that irrigation improves yield (Figure 2). It means the respondents were aware of the effects of water on crops. They might have also participated in the field demonstrations organized by the directorate of agriculture on irrigation. This may have served as valuable educational opportunities for farmers to learn about irrigation benefits.

The respondents agreed (55%) or stronly agreed (44%) that irrigation saves time (Figure 2). This positive perception indicates that farmers with access to irrigation are likely to consider it as a good choice for managing their farming activities. However, it could also mean that those farmers who lack irrigation access may view time constraints as a significant challenge, which could affect their readiness to adopt irrigation technologies. This highlights a positive impact that irrigation can have on both farmers' time management and the overall health of plants.

In terms of labor cost, the results show that the respondents agreed (54%) and strongly agreed (37%) that irrigation reduces labor cost (Figure 2). It means that the respondents believe that irrigation systems help to streamline the farming process. It reduces the need for manual labor and saves time. In addition, when the watering process is automated, farmers can focus their efforts on other important tasks. Therefore, investing in irrigation technology can lead to significant cost savings in terms of labor.

Regarding the cost of farm produce, all respondents agreed (59%) or strongly agreed (49%) that irrigation increases the cost of farm produce (Figure 2). It means that farmers with irrigation access have enhanced confidence in consistent production, improved yield and good price. Though irrigation can improve productivity and yield, it could possibly affect market price, affecting farmers' perceptions of irrigation access. For instance, the expenses that farmers incur on irrigation during the production period might be passed on to the market price to enhance profit. This may lead to higher produce costs for the consumer. As a result, farmers might lose profits in the event that consumers fail to purchase the produce at the setted market price.

Figure 2: Smallholder Farmers' Irrigation Benefits



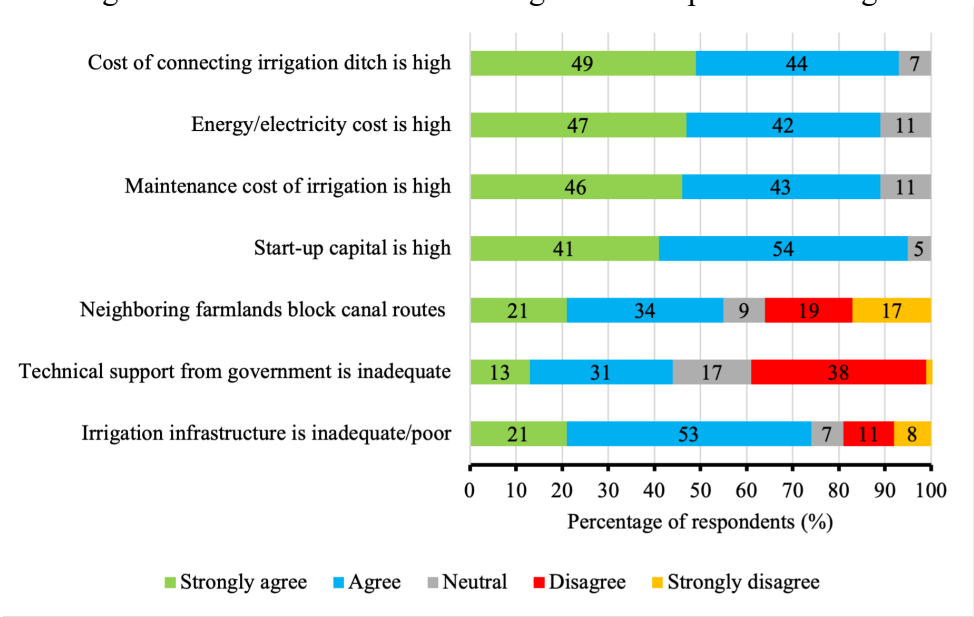
Smallholder Farmers' Irrigation Access Challenges

The survey attempted to identify responding farmers constraints with a Likert-scale question. From the preliminary field observation and literature review, the following challenges were identified: (1) Cost of connecting irrigation ditch is high; (2) Energy/electricity cost is high; (3) Maintenance cost of irrigation is high; (4) Start-up capital is high); (5) Neighboring farmlands obstruct canal routes; (6) Technical support from government is inadequate; (7) Irrigation

infrastructure is inadequate/poor. Considering these challenges, the respondents were asked to make applicable choices (Likert-scale questions), where 1 indicates strong agreement and 5 being strong disagreement (Figure 3).

The result shows that about 93% of the respondents agreed or strongly agreed that the cost of connecting irrigation ditches was high (Figure 3). In terms of energy/electricity cost for pumping water, the result showed that almost 89% agreed or strongly agreed. Other challenging physical installation cost were for canal and pump maintenance (89%). Responding farmers (95%) blamed a lack of start-up capital for their inability to access irrigation water to their farms. About 55% blamed neighboring farmlands obstructing canal routes. It was found that responding farmers (44%) lacked technical support from the government. They also strongly lacked adequate irrigation infrastructure (74%) around their farms (Figure 3).

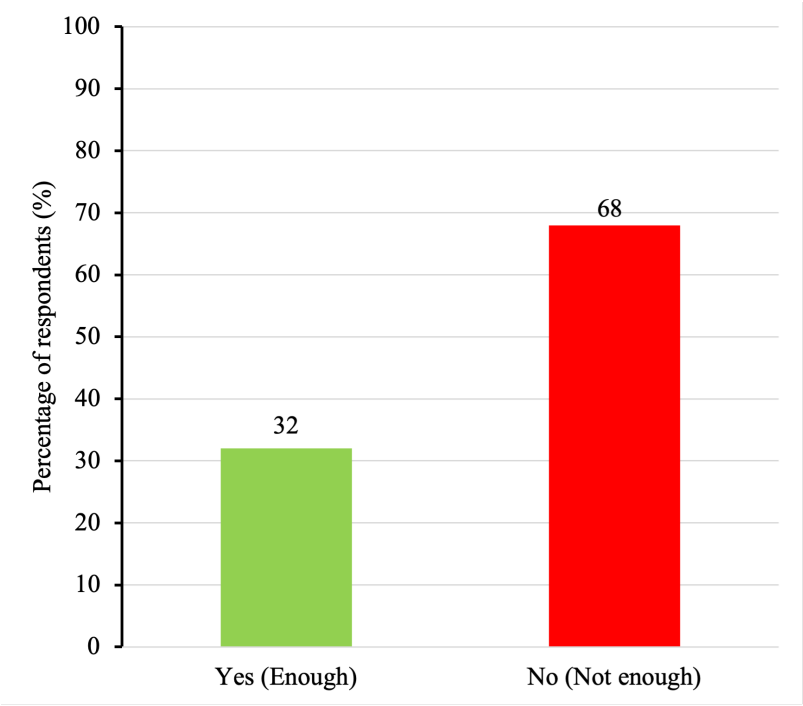
Figure 3: Smallholder Farmers' Irrigation Perception Challenges



Volume of Irrigation Water for Crop Production

In connection with the above section, the survey tried to understand from irrigators' physical observations if the volume of irrigation water that they accessed was enough to grow their crops. The results have shown that 68% did not have sufficient volume of water to grow their crops to their desired level (Figure 4). It means that it was difficult for these farmers to bring water to their farms. This further means that the farmers experienced a shortage of irrigation water which resulted in lower crop yields and decreased profits. Many of them expressed frustration with the low volume of water available and the impact it had on their yield. A further investigation showed that farmers had to resort to rainfall to supplement their irrigation needs. Responding farmers also had to reduce the scale of production. The impact of inadequate volume of irrigation water has become a pressing issue for farmers in the study area and cannot be ignored.

Figure 4: Smallholder Farmers' Satisfaction With Irrigation Water for Crops



Conclusion

This study examines smallholder farmers' perceptions of irrigation access in Ghana's South and North Tongu districts. Several factors including physical and financial constraints were identified. The Socio-demographic factors showed that responding smallholder farmers operated on small farm sizes at different locations, making it difficult for them to invest in irrigation access technologies. Customarily, female farmers had less decision-making power, and this influenced their perceptions of irrigation access. The responding farmers were literate, indicating that educated farmers, whether formal or informal, may have a better understanding of the technical and economic aspects of irrigation systems. Other than that, they could understand the benefits of irrigation, manage and maintain irrigation facilities with ease. However, they blamed a lack of farmland ownership for the inability to access irrigation.

A lack of access to irrigation water is a common challenge among the surveyed communities. Responding farmers encountered financial constraints, such as the cost of maintenance (89%), energy/electricity (89%) and irrigation ditch construction (93%), highlighting the need for irrigation training and capacity building among farmers. Respondents further blamed start-up capital (95%) for their inability to access irrigation, highlighting the need for credit and irrigation infrastructure supports for farmers from government. It was difficult for responding farmers (68%) to bring water to their farms as they expressed frustration with the low volume of water available and the impact it had on their yield. This highlights the need to support farmers with the construction of reservoirs and canals in the area to access irrigation water.

In order to increase irrigation access among farmers, efforts should be made to improve access to water sources and provide support for implementing irrigation technology. Irrigation can first be established as an administrative enterprise, leveraging right-of-way land acquisition to secure canal routes for farmers. Farmers' entitlement to irrigation water should be associated with arable land areas rather than the rights to land ownership. This would make it possible for all farmers to equally access irriagtion water for their farms. In connection with education level or literacy, all responding farmers were positive that irrigation can mitigate drought effects,

improve yield, save time and contribute to high produce cost, indicating that this broad consensus could be leveraged to encourage adoption in areas where irrigation access is currently limited. The results of this study might guide policy interventions to support women farmers, training and capacity building for all farmers with lower levels of education.

Author's Note

This conference proceeding paper is related to one of my thesis chapters at the Graduate School of Science and Technology, University of Tsukuba, Japan, 2024.

Acknowledgements

I extend a heartfelt gratitude to my supervisor, Professor Kenichi Matsui, for his continuous academic support and guidance throughout my doctoral program.

I am grateful to the Directorates of Agriculture in the South and North Tongu Districts of Ghana for their invaluable assistance in facilitating the data collection for this paper. My sincere appreciation also goes to the dedicated farmers, whose willingness to participate in the questionnaire interview and share their experiences played an important role in enriching this study.

I am grateful for the scholarship from the Japan Science and Technology Agency: Support for Pioneering Research Initiated by the Next Generation—JST SPRING Fellowship, for funding my doctoral studies in my final year at the University of Tsukuba, Japan.

Finally, I express my heartfelt gratitude to Klenam Venus Tamekloe and Setornam Ferguson Tamekloe (children) for their understanding during my time in Japan. I have not forgotten your unflinching support, Nagamatsu Hiroko.

Dōmo Arigatō gozaimasu!!!

References

Agodzo, S. K., Bessah, E., & Nyatuame, M. (2023). A review of the water resources of Ghana in a changing climate and anthropogenic stresses. *Frontiers in Water*, *4*(2023), 1-20. https://doi.org/10.3389/frwa.2022.973825

Akrofi, N. A., Sarpong, D. B., Somuah, H. A. S., & Osei-Owusu, Y. (2019). Paying for privately installed irrigation services in Northern Ghana: The case of the smallholder Bhungroo irrigation technology. *Agricultural Water Management*, *216*(2019), 284-293. https://doi.org/10.1016/j.agwat.2019.02.010

Akudugu, M. A., Millar, K. K.-N.-D., & Akuriba, M. A. (2021). The livelihoods impacts of irrigation in Western Africa: The Ghana Experience. *Sustainability*, *13*(10), 1-13. https://doi.org/10.3390/su13105677

Alor, S. K., Kretchy, I. M. A., Glozah, F. N., & Adongo, P. B. (2023). Factors associated with glycaemic control among patients with type 2 diabetes mellitus in Ho, Ghana: A cross-sectional study. *Metabolism Open, 20*(2023), 1-7. https://doi.org/10.1016/j.metop.2023.100265

Amponsah, S. K., Addo, A., Dzisi, K., Asante, B., & Afona, D. (2018). Assessment of rice farmers' knowledge and perception of harvest and postharvest losses in Ghana. *Cogent Food & Agriculture*, *4*(1), 1-14. https://doi.org/10.1080/23311932.2018.1471782

Ankrah, J. (2024). Climate risks and adaptation strategies: The perspectives of farmers in coastal Ghana. *Journal of Environmental Studies and Sciences, 1*(2024), 1-29. https://doi.org/10.1007/s13412-024-00970-w

Asiedu, E., & Gross, E. (2017). Can differences in benefits affect group investment into irrigation projects? Experimental evidence from Northern Ghana. Discussion papers. Available at https://www.econstor.eu/handle/10419/157266

Asrat, P., & Simane, B. (2018). Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. *Ecological Processes*, *7*(1), 1-13. https://doi.org/10.1186/s13717-018-0118-8

Assan, E., Suvedi, M., Olabisi, L. S., & Bansah, K. J. (2020). Climate change perceptions and challenges to adaptation among smallholder farmers in semi-arid Ghana: A gender analysis. *Journal of Arid Environments*, *182*(2020), 1-9. https://doi.org/10.1016/j.jaridenv.2020.104247

Atiah, W. A., Amekudzi, L. K., Quansah, E., & Preko, K. (2019). The spatio-temporal variability of rainfall over the agro-ecological zones of Ghana. *Atmospheric and Climate Sciences*, *9*(03), 527.

Awuku, M. S., Benjamin Yao, F., Kweku, S. F., Samuel, M., & Akosua, A. T. (2023). The dynamics of mobile phone usage among small-scale oil palm processors: Evidence from the Eastern Region, Ghana. *Cogent Social Sciences, 9*(1), 1-17. https://doi.org/10.1080/23311886.2023.2222570

Ayamga, M., Yeboah, R. W. N., & Ayambila, S. N. (2016). An analysis of household farm investment decisions under varying land tenure arrangements in Ghana. *Journal of Agriculture and Rural Development in the Tropics and Subtropics, 117*(1), 21-34. Available at https://urn.fi/urn:nbn:de:hebis:34-2015120349476

Balana, B. B., Bizimana, J. C., Richardson, J. W., Lefore, N., Adimassu, Z., & Herbst, B. K. (2020). Economic and food security effects of small-scale irrigation technologies in Northern Ghana. *Water Resources and Economics*, *29*(2020), 1-18. https://doi.org/10.1016/j.wre.2019.03.001

Bidzakin, J. K., Fialor, S. C., Awunyo-Vitor, D., & Yahaya, I. (2018). Impact of irrigation ecology on rice production efficiency in Ghana. *Advances in Agriculture*, *2018*(1), 1-10. https://doi.org/10.1155/2018/5287138

Boateng, E. N., Atampugre, G., Mariwah, S., Mensah, I., Johnson, F. A., Furst, C., & Nyarko, B. K. (2024). Spatial and multivariate assessment of access to water for sustainable agriculture intensification in semi-arid Ghana. *PLOS Water*, *3*(10), 1-23. https://doi.org/10.1371/journal.pwat.0000283

Braimah, M. M., Asante, V. A., Ahiataku, M. A., Ansah, S. O., Otu-Larbi, F., Yahaya, B., Ayabilah, J. B., & Nkrumah, F. (2022). Variability of the Minor Season Rainfall over Southern Ghana (1981–2018). *Advances in Meteorology*, *2022*, 1–14. https://doi.org/10.1155/2022/1861130

Brown, P., Daigneault, A., & Dawson, J. (2019). Age, values, farming objectives, past management decisions, and future intentions in New Zealand agriculture. *Journal of Environmental Management*, *231*(2019), 110–120. https://doi.org/10.1016/j.jenvman.2018.10.018

Bunyasiri, I., Suchato, R., & Sirisupluxana, P. (2024). Adaptation of rice farmers to aging in Thailand. *Open Agriculture*, *9*(1), 1-10. https://doi.org/10.1515/opag-2022-0364

Burney, J. A., Naylor, R. L., & Postel, S. L. (2013). The case for distributed irrigation as a development priority in Sub-Saharan Africa. *Proceedings of the National Academy of Sciences*, *110*(31), 12513–12517. https://doi.org/10.1073/pnas.1203597110

Castillo, G. M. L., Engler, A., & Wollni, M. (2021). Planned behavior and social capital: Understanding farmers' behavior toward pressurized irrigation technologies. *Agricultural Water Management*, *243*(2021), 1-12. https://doi.org/10.1016/j.agwat.2020.106524

Chuchird, R., Sasaki, N., & Abe, I. (2017). Influencing factors of the adoption of agricultural irrigation technologies and the economic returns: A case study in Chaiyaphum Province, Thailand. *Sustainability*, *9*(9), 1-16. https://doi.org/10.3390/su9091524

Dakpalah, S. S., Anornu, G. K., & Ofosu, E. A. (2018). Small scale irrigation development in Upper West region, Ghana; challenges, potentials and solutions. *International Journal of Civil and Structural Engineering*, *10*(3), 1-14. Available at https://www.researchgate.net/publication/338777971

Dakurah, G., Osbahr, H., & Arnall, A. (2024). Smallholder farmers' cropping decisions in rural North-west Ghana under climate variability and change. *Regional Environmental Change*, *24*(1), 1-22. https://doi.org/10.1007/s10113-023-02168-2

Derkyi, M., Adiku, S. G., Nelson, V., Delali Dovie, B., Codjoe, S., & Awuah, E. (2018). Smallholder farmers' perception of climatic and socio-economic factors influencing livelihoods in the transition zone of Ghana. *AAS Open Research*. http://gala.gre.ac.uk/id/eprint/24269

Dziwornu, M. G., Mponela, P., Inusah, S. S., Agyarko, F. F., Yeboah, S., Damba, O. T., Akpatsu, I. B., & Abera, W. (2024). Institutional efforts and regional distribution of climate-smart agriculture initiatives in Ghana. *Climate Smart Agriculture, 2*(2025), 1-13. https://doi.org/10.1016/j.csag.2024.100038

Fagariba, C. J., Song, S., & Soule, S. (2018). Factors influencing farmers' climate change adaptation in Northern Ghana: Evidence from subsistence farmers in Sissala West, Ghana. *Journal of Environmental Science and Management*, *21*(1), 61-73 Available at https://ovcre.uplb.edu.ph/journals-uplb/index.php/JESAM/article/view/

Ghana Statistical Service. (2014). 2010 Population & housing census report: District analytical report. South Tongu District. Ghana statistical service. Available at http://www.statsghana.gov.gh/

Ghana Statistical Service. (2021). Ghana 2021 population and housing census. General report volume 3A: Population of Regions and Districts. Available at https://statsghana.gov.gh/gssmain/fileUpload/pressrelease/2021%20PHC%20General%20Report%20Vol%203A_Population%20of%20Regions%20and%20Districts_181121.pdf

Hasan, M. K. H., & Kumar, L. K. (2024). Determining adequate sample size for social survey research: sample size for social survey research. *Journal of the Bangladesh Agricultural University*, *22*(2), 146-157. https://doi.org/10.3329/jbau.v22i2.74547

Ikehi, M. E., Onu, F. M., Ifeanyieze, F. O., Paradang, P. S., Nwakpadolu, M. G., Ekenta, L. U., & Nwankwo, C. U. (2019). Survey on sample sizes of postgraduate theses in agricultural education and extension in Universities of Nigeria. *Journal of Extension Education*, *31*(1), 1-9. https://doi.org/10.26725/JEE.2019.1.31.6200-6208

Israelsson, J., Black, E., Neves, C., Torgbor, F., Greatrex, H., Tanu, M., & Lamptey, P. N. L. (2020). The spatial correlation structure of rainfall at the local scale over southern Ghana. *Journal of Hydrology: Regional Studies*, *31*, 100720. https://doi.org/10.1016/J.EJRH.2020.100720

Koirala, K. H., Mishra, A., & Mohanty, S. (2016). Impact of land ownership on productivity and efficiency of rice farmers: The case of the Philippines. *Land Use Policy*, *50*(2016), 371–378. https://doi.org/10.1016/j.landusepol.2015.10.001

Koku, J. E. (2001). Socio-cultural factors and land degradation in the South Tongu District of Ghana: Some implications for resource protection and environmental health. *Journal of Environmental Planning and Management, 44*(3), 309-330. https://doi.org/10.1080/09640560120046089

Kudadze, S., Imoru, A. J., & Adzawla, W. (2019). Farmers' perception on irrigation farming and the factors influencing access to and size of irrigable lands in Northern Region, Ghana. *Asian Food Science Journal*, *8*(3), 1–14.

Kyei-Baffour, N., & Ofori, E. (2006). Irrigation development and management in Ghana: Prospects and challenges. *Journal of Science and Technology, 26*(2), 148-159. https://doi.org/10.4314/just.v26i2.32996

Lefore, N., Giordano, M. A., Ringler, C., & Barron, J. (2019). Sustainable and equitable growth in farmer-led irrigation in Sub-Saharan Africa: What will it take?. *Water Alternatives*. *12*(1), 156-168. Avaialble at https://pub.epsilon.slu.se/34304/1/lefore-n-et-al-20240529.pdf

Limantol, A. M., Keith, B. E., Azabre, B. A., & Lennartz, B. (2016). Farmers' perception and adaptation practice to climate variability and change: A case study of the Vea catchment in Ghana. *SpringerPlus*, *5*(1), 1-38. https://doi.org/10.1186/s40064-016-2433-9

Moges, D. M., & Taye, A. A. (2017). Determinants of farmers' perception to invest in soil and water conservation technologies in the North-Western Highlands of Ethiopia. *International Soil and Water Conservation Research*, *5*(1), 56–61. https://doi.org/10.1016/j.iswcr.2017.02.003

Nalumu, D. J., Mensah, H., Amponsah, O., & Takyi, S. A. (2021). Stakeholder collaboration and irrigation practices in Ghana: issues, challenges, and the way forward. *SN Applied Sciences, 3*(5), 1-16. https://doi.org/10.1007/s42452-021-04407-9

Namara, R. E., Horowitz, L., Nyamadi, B. & Barry, B. (2011). Irrigation development in Ghana: Past experiences, emerging opportunities, and future directions. IFPRI Ghana strategy support program (GSSP), GSSP Working paper No. 0027. Accra and Washington, D.C.: International Food Policy Research Institute. Available at https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/124870/filename/124871.pdf

Ndamani, F., & Watanabe, T. (2015). Farmers' perceptions about adaptation practices to climate change and barriers to adaptation: A micro-level study in Ghana. *Water*, *7*(9), 4593–4604. https://doi.org/10.3390/w7094593

Nguyen, T. P. L., Seddaiu, G., Virdis, S. G. P., Tidore, C., Pasqui, M., & Roggero, P. P. (2016). Perceiving to learn or learning to perceive? Understanding farmers' perceptions and adaptation to climate uncertainties. *Agricultural Systems*, *143*(2016), 205–216. https://doi.org/10.1016/j.agsy.2016.01.001

Sekyi-Annan, E., Tischbein, B., Diekkrüger, B., & Khamzina, A. (2018). Performance evaluation of reservoir-based irrigation schemes in the Upper East Region of Ghana. *Agricultural Water Management*, *202*(2018), 134–145. https://doi.org/10.1016/j.agwat.2018.02.023

Udmale, P., Ichikawa, Y., Manandhar, S., Ishidaira, H., & Kiem, A. S. (2014). Farmers' perception of drought impacts, local adaptation and administrative mitigation measures in Maharashtra State, India. *International Journal of Disaster Risk Reduction*, *10*(2014), 250–269. https://doi.org/10.1016/j.ijdrr.2014.09.011

UNOCHA. (2024). United nations office for the coordination of humanitarian affairs, humanitarian data exchange. Available at https://data.humdata.org/dataset

Wang, J., Klein, K. K., Bjornlund, H., Zhang, L., & Zhang, W. (2015). Adoption of improved irrigation scheduling methods in Alberta: An empirical analysis. *Canadian Water Resources Journal/Revue canadienne des ressources hydriques*, *40*(1), 47-61. https://doi.org/10.1080/07011784.2014.975748

Wondergem, S. (2016). Environmental and social management framework. World Bank.

Woodhouse, P., Veldwisch, G. J., Venot, J. P., Brockington, D., Komakech, H., & Manjichi, Â. (2017). African farmer-led irrigation development: Re-framing agricultural policy and investment?. *The Journal of Peasant Studies*, *44*(1), 213-233. https://doi.org/10.1080/03066150.2016.1219719

Zakaria, A., Alhassan, S. I., Kuwornu, J. K., Azumah, S. B., & Derkyi, M. A. (2020). Factors influencing the adoption of climate-smart agricultural technologies among rice farmers in Northern Ghana. *Earth Systems and Environment*, *4*(2020), 257–271. https://doi.org/10.1007/s41748-020-00146-w

Contact email: mickyay@yahoo.com