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Sustainable Irrigation Water Management Practices and Their Effects on Farm-Level Water Use Efficiency in Northern Ghana

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Abstract

This study examined sustainable irrigation water management practices and their effects on farm-level irrigation water-use efficiency in the Tono Irrigation Scheme of Northern Ghana. A mixed-methods research design was employed, combining a cross-sectional survey of 300 randomly selected irrigation farmers with key informant interviews. Quantitative data were analysed using descriptive statistics, Kendall's coefficient of concordance, stochastic frontier analysis, and Tobit regression, while qualitative data were analysed through verbatim narratives. The results revealed that erratic rainfall (Mean = 4.07), labour unavailability and high labour costs (Mean = 4.13), poor market access (Mean = 4.76), and lack of institutional support (Mean = 4.80) were the most critical production constraints. The mean irrigation water-use efficiency was 42.23%, with values ranging from 0.67% to 85.24%; 42.3% of farmers operated below 40% efficiency, while only 2.0% exceeded 80%. Stochastic frontier estimates indicated that farm size, seed quantity, labour, fertilizer application, and irrigation water significantly influenced rice output. Tobit results showed that conservation agriculture, bunding, integrated pest management,

drought-resistant crop varieties, membership in farmer-based organizations, and extension services significantly improved water-use efficiency, whereas excessive water application reduced it. The study concludes that strengthening extension services, promoting climate-smart irrigation technologies, improving market access, and scaling up sustainable water management practices are essential for enhancing water productivity and ensuring the sustainability of irrigated agriculture under increasing climate variability.

Keywords: Sustainable, Water Resource Management, Water Use, Efficiency, Farmers, Tono, Irrigation, Ghana

1. Introduction

Agriculture is one of the most vital sectors of Ghana's economy. Until 2006, the agricultural sector contributed the largest portion to the Gross Domestic Product (GDP) of the country. The structural transformation since then has led to a continuous decline in the percentage contribution of the agriculture sector to GDP. Recent national estimates show that agriculture contributed about 19% to GDP in 2016 and this declined to 18.3% in 2017 (ISSER, 2017). On average, the sector contributes 21.9% to GDP between the period of 2011-2016 (ISSER, 2017). However, the sector has recorded positive growth over the years, with an average growth of 3.5% for the period of 2010-2016. Equally, agriculture is one of the major sources of export commodities for Ghana, thereby relevant in improving the foreign exchange reserve of the country. The sector employs the largest proportion (44.7%) of the country's workforce (Factbook, 2018), making it an essential sector that must be considered to improve the livelihood

of the majority of Ghanaians. This notwithstanding, there are challenges to the development of the country.

One of such challenges is climate change and variability. Ghana's high vulnerability to climate change is heightened due to the high reliance on natural resources, including rainfall for agriculture and other purposes. Arndt et al. (2015) found that climate change could lead to as high as 1.9% reduction of agriculture's share of Ghana's GDP by 2050. One of the major adaptation strategies to the changing climate among farmers is irrigation. However, irrigation development is low in Ghana and hence considered one of the major challenges to agricultural development in the country. This is not an isolated conclusion on Ghana, as FAO (2012) noted that most sub-Saharan African countries have failed in coping with climate change and variability.

In Ghana, only 0.4% of the total land is under irrigation (MoFA, 2013). In recent times, farming under irrigation is becoming more relevant to supplement the decline in rainfall and to meet the water requirements of plants for growth. While irrigation water can be obtained from surface and groundwater, irrigation can generally be classified into two types: formal and informal irrigation systems (Donkoh et al., 2016). There are formal irrigation schemes established mostly by the government across the country. For instance, the present government of Ghana envisaged establishing irrigation dams in every village of the northern regions of the country. This is aimed at reducing crop losses due to drought and ensuring an all-year-round crop production in these areas where rainfall is unimodal. The success of these policies is to ensure that Ghana attains universal food security.

Various empirical studies revealed that the provision of irrigation to farmers could improve crop production, income of farmers and the welfare of the farm households. According to Dinye (2013), the investment in the development of irrigation infrastructure is crucial in reducing poverty in sub-Saharan Africa since it would offset the limited rainfalls, thereby increasing agricultural productivity.

Considering the importance of irrigation in economic development, a number of studies have been conducted on the subject. Mumin (2017) classified studies on production under irrigation into three as those that examine the adoption of irrigation farming, those that estimate the impact of irrigation farming and those that address the two simultaneously. For instance, Donkoh et al. (2016) analyzed the adoption and effects of dry season irrigation farming and found that dry season vegetable production has a positive impact on farm income. A similar estimate was obtained by Mumin (2017) as irrigation was found relevant for improving farm incomes among households. Although these studies are policy relevant, they do not address the fundamental issue of sustainable water management in the country. However, the latter remained the most crucial for sustaining the positive outcomes from irrigation. Agodzo, et al. (2014), for instance, explained that ensuring water productivity reduces water requirement for agricultural purposes and frees up water for sustaining the general ecosystem. Consistently, the authors recommended that effective and efficient water management in irrigation schemes should be ensured in order to realize the needed benefits of the schemes.

While previous studies in Ghana have examined the income and productivity effects of irrigation adoption, limited empirical evidence exists on how specific sustainable water management

practices influence irrigation water-use efficiency at the farm level. This study addresses this gap by integrating sustainable water management indicators into a stochastic frontier framework. The objective of this study is to; a) Analyze the challenges to crop production and access to the Tono irrigation scheme among farmers. b) Examine the sustainable water management strategies adopted by farmers in the Tono irrigation scheme. c) Estimate the level of water use efficiency of the farmers in the Tono irrigation. d) Estimate the effect of sustainable water management on water use efficiency of farmers in the Tono irrigation scheme.

2. Conceptual Framework

The conceptual framework for this study explains the pathways through which sustainable water management practices influence irrigation water-use efficiency among farmers in the Tono Irrigation Scheme. The framework is grounded in Resource Use Efficiency Theory, which posits that agricultural productivity can be enhanced when production inputs are utilized optimally to maximize output while minimizing waste (Farrell, 1957). It is further informed by Climate Change Adaptation Theory, which emphasizes farmers' adoption of adaptive strategies to reduce vulnerability to climatic stresses (IPCC, 2023), the Integrated Water Resources Management (IWRM) Framework, which advocates the efficient and sustainable use of water resources across sectors (Global Water Partnership, 2000), and the Agricultural Water Productivity Framework, which focuses on increasing crop output per unit of water consumed (Molden et al., 2010). Together, these theoretical perspectives provide a comprehensive explanation of how sustainable water management practices contribute to improved irrigation performance and agricultural sustainability.

The framework recognizes climate change and variability as important external drivers influencing agricultural production and water management decisions. In northern Ghana, changing rainfall patterns, prolonged dry spells, and increasing temperatures have heightened the importance of irrigation as a climate adaptation strategy (Arndt et al., 2015). Climate-related challenges create the need for farmers to adopt sustainable water management practices that can reduce water losses, improve water productivity, and maintain crop production under conditions of water stress (Chartzoulakis & Bertaki, 2015).

Beyond climatic factors, the framework recognizes the importance of institutional conditions in shaping farmers' adoption of sustainable water management practices. Access to agricultural extension services, credit facilities, irrigation management structures, and farmer organizations influences farmers' capacity to implement improved water management strategies (Dong et al., 2010; Ansah et al., 2016). According to the Sustainable Livelihood Framework, institutional support constitutes an important form of livelihood capital that enhances farmers' ability to adapt to environmental and economic challenges (Scoones, 1998).

Within this context, farmers may adopt a range of sustainable water management practices to improve the efficiency of irrigation water use. These practices may include row planting, conservation agriculture, terracing, mulching, integrated pest management (IPM), integrated soil fertility management (ISFM), and the use of drought-resistant crop varieties. These interventions represent the primary independent variables in the framework and are expected to directly influence irrigation water-use efficiency. Previous studies have shown that sustainable land and water management practices improve water retention, reduce soil degradation, and enhance

agricultural productivity under water-limited conditions (Anley et al., 2007; Bewket, 2007; Clarke-Sather et al., 2017).

The framework further proposes that sustainable water management practices improve irrigation water-use efficiency through several interrelated mechanisms. First, these practices enhance water conservation by reducing runoff, limiting evaporation losses, increasing water infiltration, and improving soil moisture retention. Conservation agriculture, mulching, and terracing have been widely recognized for their ability to improve soil-water relationships and increase water availability for crop growth (Chartzoulakis & Bertaki, 2015). Improved soil moisture retention allows crops to utilize available water more effectively, thereby reducing the amount of irrigation water required to sustain production.

Second, sustainable water management practices improve crop productivity and water productivity. Practices such as integrated soil fertility management, drought-resistant varieties, and integrated pest management enhance nutrient uptake, crop health, root development, and resistance to environmental stress. Consequently, crops are able to produce higher yields with the same quantity of water, thereby increasing water productivity (Molden et al., 2010). Enhanced crop productivity is a critical pathway through which sustainable water management contributes to improved water-use efficiency because efficiency is ultimately measured by the amount of output generated per unit of water applied.

Third, sustainable water management practices strengthen farmers' adaptive capacity and resilience to climate variability. Climate Change Adaptation Theory suggests that adaptation measures reduce exposure and sensitivity to climate-related risks while enhancing the ability of farming systems to withstand shocks (IPCC, 2023). By improving soil moisture conservation and

reducing water losses, sustainable water management practices enable farmers to maintain crop production during periods of rainfall variability and water scarcity. This contributes to greater stability in agricultural production and reduces the risks associated with climate-induced water stress.

The framework also recognizes the role of socio-economic characteristics as moderating factors influencing both the adoption and effectiveness of sustainable water management practices. Variables such as education, farming experience, farmer-based organization membership, extension access, credit access, and off-farm income opportunities affect farmers' knowledge, financial capacity, and willingness to invest in improved water management practices. Empirical studies have consistently shown that access to information, institutional support, and financial resources positively influence the adoption of sustainable agricultural technologies and resource management practices (Ali et al., 2014; Ansah et al., 2016). These factors, therefore, strengthen or weaken the relationship between sustainable water management practices and irrigation water-use efficiency.

The combined effects of improved water conservation, enhanced crop productivity, and increased adaptive capacity ultimately lead to higher irrigation water-use efficiency. Water-use efficiency refers to the ability of farmers to maximize agricultural output from a given quantity of irrigation water while minimizing losses and wastage (Chebil et al., 2014). When sustainable water management practices are effectively implemented, farmers are able to produce more output with less water, improve irrigation performance, and reduce pressure on scarce water resources. This aligns with the principles of resource-use efficiency and sustainable water management advocated by the IWRM framework (Global Water Partnership, 2000).

Finally, the framework suggests that improved irrigation water-use efficiency generates broader agricultural and livelihood benefits. Increased efficiency contributes to higher crop yields, improved household income, enhanced food security, greater resilience to climate change, and the long-term sustainability of irrigation systems. Sustainable use of irrigation water also supports ecosystem conservation by reducing unnecessary water abstraction and promoting the equitable allocation of water resources among competing users (Agodzo et al., 2014). Consequently, sustainable water management practices serve as a critical mechanism through which irrigation schemes can simultaneously achieve agricultural productivity, environmental sustainability, and rural livelihood improvement.

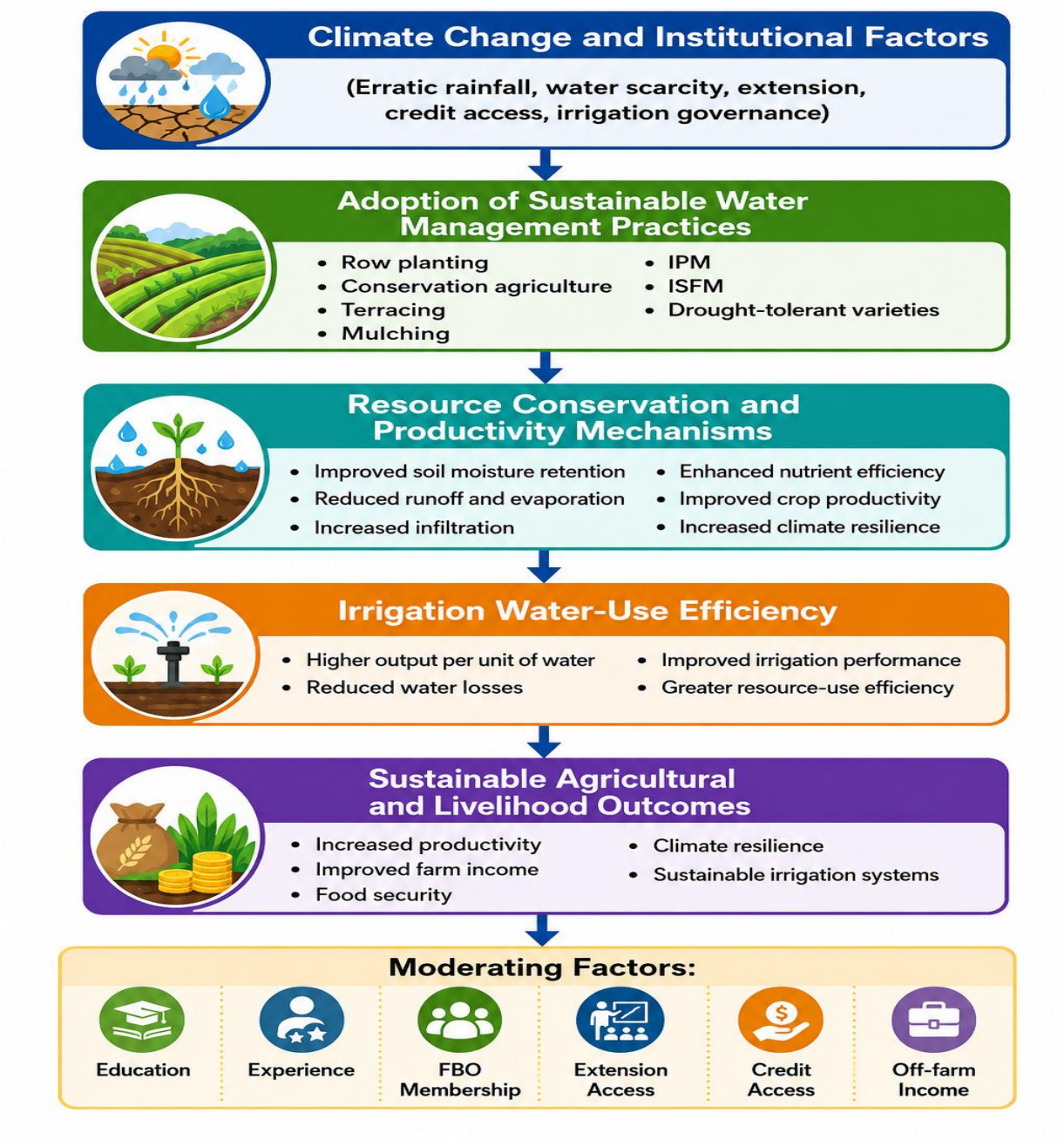
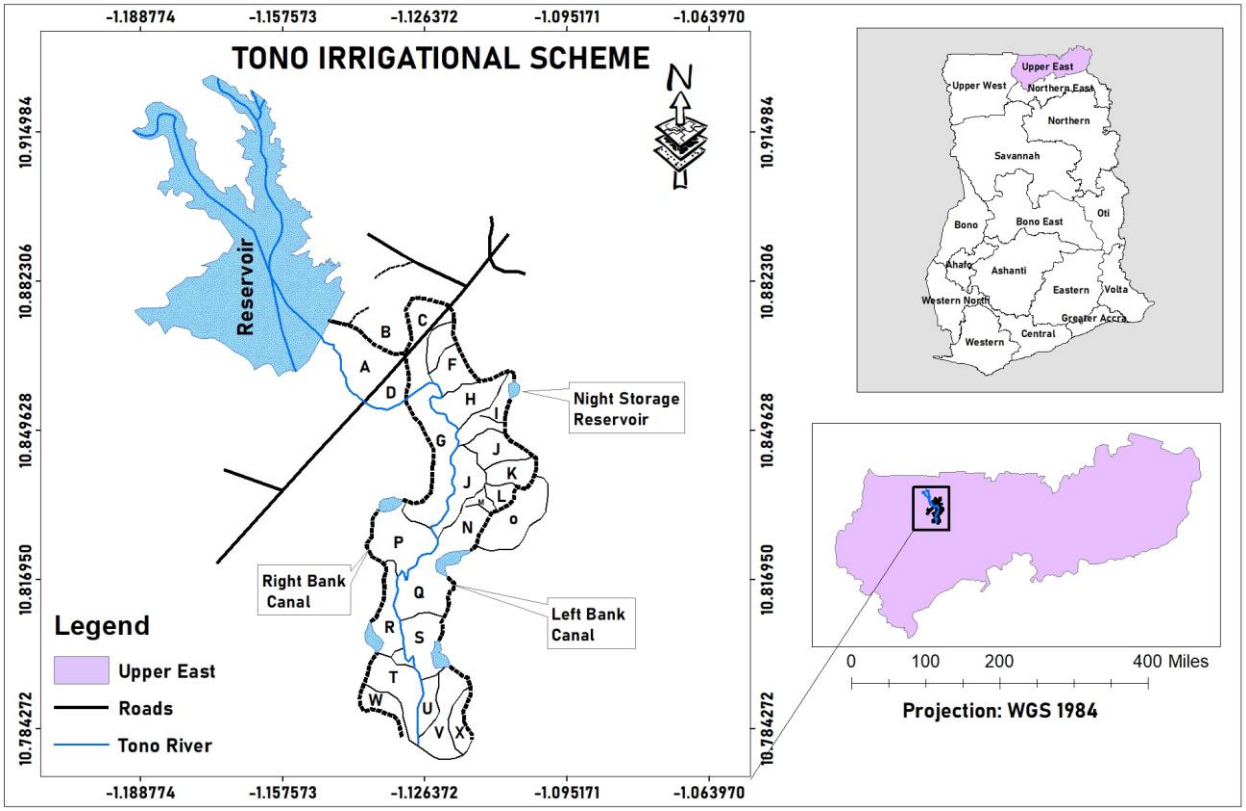


Figure 1. Conceptual framework illustrating the pathways through which sustainable water management practices influence irrigation water-use efficiency.

3 Study Area and Methodology

3.1 Study Location

The study was conducted in Tono, Navrongo. The construction of the Tono irrigation scheme started in 1975 and was completed in 1985. Geographically, the Tono irrigation scheme is located in the Kassena-Nankana Municipal of the Upper East Region of Ghana. It lies at 10 ºC 45” N and longitude 1 °C W. The objective of the establishment of the irrigation scheme is to promote food crop production among small-scale farmers. The major crops cultivated in the area include rice and vegetables. The irrigation system is the gravity method and the water for the irrigation system is obtained from the Tono River. The irrigation scheme has an irrigation potential area of 3840ha, but an irrigable area of 2,490 ha. It is the largest irrigation scheme in the Upper East region. According to Dinye (2013), the water storage capacity of the Tono dam is 93 million cubic meters, out of which less than half can be used for irrigation of the irrigable lands. The irrigable lands are connected with the left and right banks of the dam. Overall, the total length of the irrigable channel is about 42 km.



Study Area Map

Source: Authors Construct, 2026, using ArcGIS 10.7.1

3.2 Research Design

This study adopted a mixed-methods research design, specifically a convergent parallel design, to examine sustainable irrigation water management strategies and their effects on farm-level water-use efficiency within the Tono Irrigation Scheme in Northern Ghana. The mixed-methods approach was selected because sustainable water management is a multidimensional phenomenon that encompasses both measurable production outcomes and farmers' experiential knowledge, perceptions, and management decisions. Integrating quantitative and qualitative data, therefore, provided a more comprehensive understanding of irrigation water management practices and their implications for agricultural productivity and water-use efficiency (Creswell & Plano Clark, 2018).

The quantitative component employed a cross-sectional survey of irrigation farmers to generate empirical evidence on production characteristics, adoption of sustainable water management practices, determinants of rice production, and levels of irrigation water-use efficiency (Saunders et al., 2019). The survey data enabled the estimation of production functions and efficiency models using econometric techniques, thereby facilitating the identification of factors influencing water-use efficiency.

The qualitative component complemented the survey by exploring farmers' perceptions of irrigation farming, their understanding of sustainable water management, production constraints, and experiences with irrigation water allocation and management (Denzin & Lincoln, 2018). Qualitative data were obtained through key informant interviews and farmer consultations involving irrigation scheme managers, agricultural extension officers, leaders of farmer-based organizations, and experienced irrigation farmers. These stakeholder perspectives provided contextual explanations for observed quantitative relationships and enhanced the interpretation of empirical findings.

The study was underpinned by Resource Use Efficiency Theory (Farrell, 1957) and the principles of Integrated Water Resources Management (IWRM), which emphasize the efficient and sustainable utilization of water resources to maximize agricultural productivity while safeguarding long-term resource availability (Molden et al., 2010). The mixed-methods design was therefore considered particularly appropriate because it enabled the simultaneous

examination of technical efficiency outcomes and the behavioural, institutional, and management factors influencing sustainable water use.

Data for both components were collected during the same study period and analysed independently before being integrated during the interpretation stage. Quantitative findings provided evidence on the magnitude and direction of relationships among variables, while qualitative findings offered explanatory insights into farmers' decision-making processes and water management behaviours. The integration of both strands of evidence enhanced the validity, reliability, and policy relevance of the study findings (Fetters et al., 2013).

3.3 Sampling Procedure and Sampling Selection

A multistage sampling procedure was employed to select irrigation farmers from the Tono Irrigation Scheme for the study. The use of a multistage sampling approach was considered appropriate because the irrigation scheme comprises several operational blocks with varying numbers of registered farmers. The approach ensured adequate representation of farmers across the scheme while minimizing sampling bias.

In the first stage, the Tono Irrigation Scheme was purposively selected because it is the largest formal irrigation scheme in Ghana and plays a significant role in dry-season crop production in northern Ghana. The scheme was also selected because of its strategic importance in promoting irrigation development and sustainable water resource management in the country.

In the second stage, the irrigation blocks within the scheme constituted the primary sampling units. A complete list of operational irrigation blocks and 1200 registered farmers was obtained

from the management of the Tono Irrigation Scheme. This list served as the sampling frame for the study.

In the third stage, the sample size for the study was determined using the statistical procedure outlined by Yamane (1967), at 95% confidence level, assuming a margin of error of 0.05 for the study.

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

Where *n* is the expected sample size, *N* is the population and *e* is the margin of error. Therefore, the sample size is calculated as:

$$n = \frac{1200}{1 + 1200(0.05^2)} = 300$$

Therefore, a total of 300 farmers were selected for this study.

In the final stage, simple random sampling was employed to select individual farmers. Registered farmers within the scheme were assigned identification numbers and random numbers were generated to select respondents. Every farmer within the scheme therefore, had an equal probability of being included in the study. The multistage sampling design improved the representativeness of the sample by ensuring coverage of farmers across different blocks of the irrigation scheme while reducing selection bias and enhancing the reliability of the study findings.

3.4 Data Collection

Data was collected through the use of a questionnaire. The questionnaire was designed through consultations with various stakeholders within the irrigation schemes of the region, including the Ministry of Food Agriculture, the Tono irrigation management, water users' associations and individual farmers. The questionnaire includes both open-ended and closed-ended questions. The questionnaire was pretested on a few farmers and corrections were made before the final main data was collected. This ensured that the questionnaire was valid in addressing the objectives of the study.

3.5 Data Analysis

Objective one was analysed using Kendall's coefficient of concordance, and objective two was analysed using descriptive statistics. Objective three was analysed using a stochastic production frontier model to estimate the effect of sustainable water management on the efficiency of the farmers, while objective four was analysed using a Tobit regression model.

3.5.1 Kendall's coefficient of concordance

The Kendall's coefficient of concordance involves the ranking of a set of predetermined parameters by a number of observations and finding the level of agreement in the ranking among the observations. The constraints of production as well as access to irrigable land were ranked from the least constraint to the most severe constraint. Thus, the ranks used was based on 1, 2, 3…, n where n is the most severe constraint. The coefficient of concordance ranges from 0 to 1. It is 1 if the ranking assigned by an individual observation is the same for all other observations and 0 if the rank assigned by an individual observation is completely different from that assigned by all other observations.

$$Var_T = \frac{\left(\sum T^2 - \sum T^2\right)/_n}{n}$$

Thus, the maximum variance of T is $m^2\,(n^2-1)/_{12}$.

Where T is the sum of ranks of each constraint, m is the set of rankers and n is the number of constraints.

Therefore, the Kendall's coefficient of concordance (W) is given as;

$$W = \frac{\left[\left(\sum T^2 - \sum T^2\right)/_n\right]n}{m^2\,(n^2-1)/_{12}}$$

$$= \frac{12\left[\left(\sum T^2 - \sum T^2\right)/_n\right]n}{nm^2(n^2-1)}$$

However, the sum of squares, s, can be defined as

$$\left(\sum T^2 - \sum T^2\right)/_n$$

Therefore,

$$\frac{12sn}{nm^2(n^2-1)}$$

The F ratio of W is obtained as;

$$F - ratio = \frac{(m-1)w}{1-w}$$

Where w is the estimated Kendall's coefficient of concordance.

3.5.2 Stochastic frontier analysis

Stochastic frontier has been used extensively to analyse the efficiency of a production or a production system. In this study, the objective was to estimate the efficiency levels of farmers

under the Tono irrigation scheme and the effect of sustainable water management strategies on the water use efficiency of the farmers. Therefore, the study followed the stochastic frontier approach by (Farrell, 1957). Farrell (1957) assumed that firms/farms operate on a frontier (an outer bound function) that is considered as the maximum possible output and any deviation from this is considered to be inefficient production. This approach has since been applied to a number of decision units, including water management and use. The importance of efficiency analysis is to ensure that wastage of resources is eliminated to their minimum. Efficiency is generally given as: $Y_i = f(X_i) + v_i - u_i$

Where Y is the observed output and X is a vector of inputs that are exogenous to the system. Unlike the classical regression model, where the error term is assumed to be completely random, frontier models assume that the error term is composed of two, $v_i - u_i$. While the v_i is the random error component that explains measurement and specification error, the u_i is non-random and measures the error due to inefficiency of the individual observation. Hence, $v_i - u_i$ is described as a composite error term. From this theoretical formation, water use efficiency can be measured as; $Y_i = f(X_i, \alpha) + v_i - u_i$

Where Y_i is the water use efficiency of the farmer and is defined as the ratio of the level of output to the amount of irrigation water used for a production. α is the vector of parameters to be estimated on the vector of X_i.

The problem is to identify a suitable functional form for the stochastic frontier model. Generally, Cobb-Douglas and translog functional forms are widely used. The translog production function specification for k number of inputs is:

$$InY = \alpha + \sum_{k=1}^{k} \beta_k InX_k + {}^1/_2 \sum_{k=1}^{k} \sum_{m=1}^{k} \gamma_{km}\, InX_k InX_m$$

This can be reduced to the Cobb-Douglas specification if only the first component, $\sum_{k=1}^{k} \beta_k InX_k$ is assumed. The water use efficiency levels can be obtained by estimating the ratio of the stochastic output to the observed output;

$$TE = \frac{Y_i}{Y_{i*}} = \frac{f(X_i;\beta)exp(v_i - u_i)}{f(X_i;\beta)exp\ v_i} = exp(-u_i)$$

where the numerator is the frontier output and the denominator is the observed output of the farm.

Specifically, the following empirical model was estimated.

$$Output = \beta_1 Farm\ size + \beta_2 Family\ labour + \beta_3 Hired\ labour + \beta_4 Seed + \beta_5 Fertiliser + \beta_6 Herbicides + \beta_7 Water\ quantity$$

3.5.3 Tobit regression

To estimate the effect of sustainable water management strategies on the water use efficiency (WUE) of the farmers, a Tobit model is estimated. This follows the work of Hong & Yabe (2016). The Tobit model assumed that the latent variable is observed if irrigation water use efficiency is between zero and the upper bound.

Therefore, the model can be specified as;

$$WUE = \sum_{i=1}^{I} \gamma_0 + \gamma_i W_i + Z_i + e_i$$

Where WUE is the water used efficiency of the *ith* farmer, W_i is a vector of sustainable water management strategies, Z_i is a vector of socioeconomic characteristics of the farmer, γ are the parameters to be estimated and $e_i$is a random error term.

Specifically, the model estimated is;

$$WUE = \delta_1 CA + \delta_2 Bonding + \delta_3 ISFM + \delta_4 IPM + \delta_5 Drough\ resistant + \delta_6 Row\ planting + \delta_7 terracing + \delta_8 FBO + \delta_9 Off - farm + \delta_{10} Household\ size + \delta_{11} Education + \delta_{12} Extension + \delta_{13} Social\ assets + \delta_{14} Credit\ access + \delta_{15} Experience$$

4. Results and Discussion

4.1 Descriptive statistics of farmers

Table 2 shows the descriptive statistics of the respondents. From the result, the mean age of a farmer is 47.5 years. This means that the average irrigation farmer is within the active working age group and could potentially lead to an increased production and sustainability of the irrigation scheme. Considering the high innovation potential of younger farmers, it is expected that the irrigation farmers would be willing to adopt sustainable water management strategies, as noted in the study of Wang et al. (2023).

The mean value for sex is 0.67, which means that 67% of the sampled farmers were males, while the remaining 33% are females. This is consistent with Addison et al. (2026), that the general and traditional notion is that farming is a male-dominated activity in northern Ghana. The national statistics on the region also showed that while 75.8% of the employed male farmers engaged in agricultural-related activities, only 67.2% of the employed females (GSS, 2021). Farmer group membership is low, considering that only 47% of the sampled farmers belonged to a farmer group. Considering the importance of groups in enhancing access to production inputs and incentives, it is rather unexpected that only a few farmers would be members of a farmer-

based association. The number of farmers who engaged in off-farm activity was low since only 26% of the respondents affirmed this. Generally, off-farm opportunities are less in the farming communities; therefore, it is unusual that nearly two of every three farmers do not engage in any off-farm activity in addition to crop farming (Adzawla et al., 2022).

The household size was estimated to be 10.5. Thus, there are about 11 people in each selected farmer's household. This is high considering that the average household size of the Upper East region is 5.8 (GSS, 2021). However, considering the important role of family labour in rural farming communities, the high household size of the farmers could be an essential labour resource for them.

Regarding level of education, a farmer had spent only 3.68 years in formal education. Thus, on average, a farmer has not completed four years of formal education. Although this could have a negative implication for the human capacity development of the farmers and their abilities to adopt efficient and sustainable water management strategies, it is also a reflection of the characteristics of farmers in Ghana (GSS, 2021). Also, about 41% of the selected farmers had access to extension services. Indicating that more than half of the farmers had no access to extension services in the last cropping season. Extension services are crucial for the development of the agricultural sector. In addition to providing technical advice to the farmers, they are able to link farmers to input supply agencies. Extension service can also be vital in improving the farmers' understanding of sustainable irrigation water management. Access to credit is low among farmers. Only 26% of the farmers accessed credit for agricultural purposes in the last cropping season.

Table 2. Descriptive statistics of farmers

Variable	Mean	Std. Dev.	Min.	Max.
Age	47.47	13.21	20	80
Sex	0.67[a]	0.47	0	1
FBO	0.47[a]	0.50	0	1
Off-farm	0.26[a]	0.44	0	1
Household size	10.54	5.26	2	32
Education	3.68	5.06	0	16
Extension	0.41[a]	0.49	0	1
Credit access	0.26[a]	0.44	0	1
Experience	21.17	14.33	0	80

Note: Mean values with 'a' are proportions obtained from dummy variables

Source: field survey, 2018

4.2 Production Challenges Affecting Irrigation Farming

The results presented in Table 3 reveal that irrigation farmers face multiple production challenges that collectively undermine agricultural productivity and the sustainability of irrigation farming. Erratic rainfall emerged as the most critical challenge, with 27% of farmers ranking it as the foremost challenge. Despite the availability of irrigation infrastructure, the finding suggests that agricultural production remains highly vulnerable to climate variability, particularly because rainfall influences reservoir recharge and overall water availability. This result corroborates growing evidence that climate change and rainfall uncertainty continue to threaten agricultural production across sub-Saharan Africa (Arndt et al., 2015; IPCC, 2023; Aduko, 2025).

Some key informants detailed that,

"Over the years, the rainfall pattern has become increasingly unpredictable. Farmers can no longer rely on the onset and duration of the rainy season, which is why irrigation has become

essential for sustaining crop production in this area." (An Agricultural Extension Officer, KII, 2018).

"Sometimes the rains cease right after planting, and farmers lose whole fields. Without irrigation, many of us would be unable to grow crops constantly." (A Farmer-Based Organization Leader, KII, 2018)

Labour unavailability and high labour costs constituted the second most important challenge identified by farmers, with 18% of respondents ranking it first and an additional 15% and 16% ranking it second and third, respectively. The prominence of this challenge reflects increasing labour shortages in rural areas, driven by rural-urban migration and declining youth participation in agriculture. Given the labour-intensive nature of irrigation farming, labour scarcity can significantly increase production costs and constrain farm productivity (Jayne et al., 2019).

For instance, some respondent during a key informant interview had this to say:

"The cost of hiring labour has increased significantly. Many young people are moving to urban areas, making it difficult to find workers during critical farming periods." (KII, 2018)

"Even when labour is available, the cost is too high. This affects our profitability because labour accounts for a large share of production costs." (Rice Farmer, KII, 2018)

Lack of institutional support was another major concern, with 19% of farmers ranking it as the most important constraint and 22% ranking it third. This finding underscores the importance of extension services, technical assistance, and institutional interventions in enhancing irrigation

performance. Weak institutional support can limit farmers' access to information, innovation, and sustainable water management practices, thereby constraining productivity and efficiency improvements. Poor access to markets also emerged as a significant challenge, with 20% of respondents ranking it fifth and 17% ranking it seventh. This suggests that although irrigation enhances production opportunities, farmers may face difficulties in translating increased output into improved incomes due to market inefficiencies. Limited market access reduces incentives for investment and restricts the commercialization potential of irrigated agriculture.

Soil infertility remains an important production challenge, with 23% of respondents ranking it fifth and 18% ranking it fourth. The finding highlights the persistent problem of soil nutrient depletion, which can limit productivity gains even under improved irrigation conditions. Sustainable irrigation development therefore requires the integration of effective soil fertility management practices alongside water management interventions. Pests and diseases were similarly identified as major constraints, with 13% and 17% of farmers ranking them first and second, respectively, while 19% ranked them sixth. The prevalence of pest and disease challenges may be linked to intensified cultivation under irrigation systems and changing climatic conditions that favour pest proliferation. This finding reinforces the need for integrated pest management strategies to sustain agricultural productivity.

Although the lack of external production incentives, lack and high cost of inputs, and low capital availability received comparatively lower first-place rankings, they remain important barriers to agricultural development. For instance, 25% of farmers ranked the lack and high cost of inputs as the sixth most important challenge, while 22% ranked low capital availability sixth. These

findings indicate that financial and input-related constraints continue to limit farmers' ability to adopt improved technologies and sustainable production practices.

Table 3: Production Challenges Affecting Irrigation Farming

	Rank (%)								
Challenge	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
Erratic rainfall	27	10	11	4	23	4	0	17	4
Labour unavailability and prices	18	15	16	21	0	5	9	4	12
Soil infertility	5	4	16	18	23	0	15	9	10
Low capital	0	11	5	14	5	22	19	5	19
Lack of external production incentives	5	9	10	5	21	11	11	9	19
Lack of and high cost of inputs	9	10	0	17	0	25	4	19	16
Poor access to market	4	14	11	16	20	10	17	4	4
Pests and diseases	13	17	4	0	9	19	14	18	6
Lack of institutional support	19	5	22	5	4	10	5	20	10

Source: field survey, 2018

Table 4 presents the mean rankings of the major production challenges confronting farmers within the Tono Irrigation Scheme. The results reveal statistically significant agreement among respondents regarding the severity of the identified constraints, as evidenced by Kendall's coefficient of concordance ($W = 0.591$, $\chi^2 = 141.856$, $p < 0.001$). The relatively high Kendall's W value indicates a moderate to strong level of consensus among farmers in ranking the challenges affecting irrigation production, suggesting that the identified constraints are widely experienced across the scheme. Erratic rainfall emerged as the most critical production challenge, recording the lowest mean score (Mean = 4.07; SD = 2.659) and ranking first among all constraints. Although irrigation is intended to reduce farmers' dependence on rainfall, the finding suggests that agricultural production within the scheme remains vulnerable to climate

variability. Rainfall fluctuations can affect reservoir recharge, water availability, and irrigation scheduling, thereby influencing overall farm productivity.

This result reinforces growing concerns that climate change and increasing rainfall uncertainty continue to threaten agricultural production systems across sub-Saharan Africa despite investments in irrigation infrastructure. Labour unavailability and high labour costs ranked as the second most important challenge (Mean = 4.13; SD = 2.653). The prominence of this constraint highlights the growing difficulties farmers face in accessing affordable labour for irrigation activities, which are generally more labour-intensive than rain-fed agriculture. Rising labour costs and shortages may be attributed to rural-urban migration and the declining participation of young people in agriculture, factors that have increasingly constrained agricultural intensification across many developing countries. Makuvaro et al. (2017) also found that labour constraint is one of the major challenges to crop production and argued that this is due to migration and diversification by the youth into off-farm activities. The author (Makuvaro et al., 2017) therefore recommended the development of innovations that are less labour-intensive for crop production.
Poor access to markets was ranked as the third most important challenge (Mean = 4.76; SD = 2.058). This finding suggests that despite the production advantages associated with irrigation farming, farmers continue to face challenges in marketing their produce and accessing profitable markets. Limited market access may reduce farm profitability, discourage investment in productivity-enhancing technologies, and constrain the commercialization potential of irrigated agriculture. Buckmaster (2012) explained that the higher the distance from the farmer to the market, the higher the input cost, the higher the transportation cost, while the lower the output price.

Lack of institutional support emerged as the fourth most important production challenge (Mean = 4.80; SD = 2.847). Notably, the relatively high standard deviation indicates variation in farmers' experiences with institutional services. Nevertheless, the ranking underscores the importance of extension services, technical support, training programmes, and other institutional interventions in improving irrigation performance and promoting sustainable water management practices. Ali et al. (2014) estimated that removing credit constraints could increase output by 17%. Ansah et al. (2016) noted that although many farmers do apply for financial credit, only a few are granted and that the reasons are best known to the financial institutions.

Pests and diseases constituted the fifth most important challenge (Mean = 5.14; SD = 2.665), closely followed by soil infertility (Mean = 5.15; SD = 2.233), which ranked sixth. These findings highlight the continuing importance of agronomic constraints in irrigated production systems. While irrigation improves water availability, productivity gains may be limited where pest infestations and declining soil fertility are not adequately addressed through integrated crop and soil management strategies.

Lack of external production incentives (Mean = 5.64; SD = 2.464) and the lack or high cost of agricultural inputs (Mean = 5.71; SD = 2.590) ranked seventh and eighth, respectively. Although these constraints were perceived as relatively less severe than climatic and institutional challenges, they remain important barriers to technology adoption and productivity enhancement. High input costs can discourage farmers from adopting improved seeds, fertilizers, and other yield-enhancing technologies necessary for sustainable agricultural intensification. Low capital

availability was ranked as the least severe challenge (Mean = 5.94; SD = 2.221). However, this should not be interpreted as indicating that financial constraints are unimportant. Rather, the finding suggests that farmers perceive climatic, labour, market, and institutional constraints as more immediate impediments to production. Limited capital may still indirectly constrain productivity by restricting farmers' ability to invest in improved technologies and sustainable water management practices.

Table 4: Mean ranks and Kendall's coefficient of concordance of Production Challenges

Challenge	Mean Score	Standard deviation	Rank
Erratic rainfall	4.07	2.659	1st
Labour unavailability and prices	4.13	2.653	2nd
Soil infertility	5.15	2.233	6th
Low capital	5.94	2.221	9th
Lack of external production incentives	5.64	2.464	7th
Lack of and high cost of inputs	5.71	2.590	8th
Poor access to market	4.76	2.058	3rd
Pests and diseases	5.14	2.665	5th
Lack of institutional support	4.80	2.847	4th
Kendall's W		0.591	
Chi-Square		141.856	
Df		8	
Asymp. Sig.		0.000	

Source: field survey, 2018

4.5 Farmers' Adoption of Sustainable Water Management Strategies

Table 6 indicates that the majority of farmers adopt row planting as a more sustainable water management strategy than the other strategies. Thus, while 59.7% of the sampled farmers planted in rows in order to ensure that water is used judiciously on the farms, the remaining 40.3% of the farmers did not. Row planting involves planting of seedlings or seeds in a single direction or in a distinct direction. It is one of the promoted soil and water conservation and climate-smart production strategies since it enhances light exposure, visibility, access and the ease of determining the plant population on the farm. Consistent with this study, Zhou et al.

(2010) estimated that not only does planting in rows increase crop yield, but also water use efficiency. However, studies such as Yang et al. (2016) indicated that the spacing of crops in rows is crucial to obtain higher yields under row-planting fields. The qualitative results further agree with the survey findings and this was revealed during some key informant interviews.

"Row planting helps us control water movement and improve crop spacing. It also makes farm management easier and reduces unnecessary water losses." (An Agricultural Extension Officer, KII, 2018)

"When crops are planted in rows, irrigation water is distributed more evenly across the field." (Rice Farmer, KII, 2018)

The second major sustainable water management strategy adopted by the farmers is the use of drought-resistant varieties. Because irrigated agriculture is done in the dry season, farmers would want to use drought-resistant varieties to offset any potential challenge in the water supply from the irrigation scheme. The advantage of the drought-resistant seed varieties used by the farmers is that they are early maturing. Therefore, the total water requirement or use by these varieties is less, hence, sustainable management of the irrigation water. Consistently, Napasintuwong & Pray (2014) estimated that the adoption of drought-resistant rice varieties is high among farmers in Thailand.

In an interview, one respondents remarked that,

"The drought-resistant varieties mature earlier and require less water. Farmers prefer them because they reduce the risks associated with water shortages." (Seed Specialist, KII, 2018)

The third sustainable water management strategy adopted by most farmers is terracing. This involved the cultivation of crops along slopes. From the result, 28% of the farmers explained that their lands are gently sloped. Therefore, to ensure that the water is effectively used, they prepare and plant their fields on graduated terraces that are built into the slopes. The advantage is that water does not easily run off the farms. This, therefore, ensures an efficient management of the irrigation water. Waraich et al. (2011) explained that planting in terraces helps prevent soil erosion and enhance crop yield.

While 27.7% of farmers adopted conservative agriculture, 27% used integrated pest management (IPM) strategies. Conservative agriculture requires little disturbance to the soil, especially during land preparation. Thus, from little tillage to zero tilling of the soil before planting. This helps maintain the structure of the soil and prevents excessive degradation of the soil and keeps the soil properties, including water holding capacity, intact. According to FAO (2011), zero tillage is crucial for water management under rainfed agriculture as well as irrigated farming. In recent times, pests and disease infestation have been a major challenge to crop production in Ghana; therefore, farmers have resorted to the use of different approaches simultaneously to control the pests and diseases. The least adopted strategy is integrated soil fertility management (ISFM).

In an interview, one extension officer mentioned that,

"Many farmers know about integrated soil fertility management, but implementation remains low because the practice requires additional knowledge, labour, and investment." (KII, 2023)

Table 6: Farmers Adoption of Sustainable water management strategies

	Non-Adopters		Adopters	
Strategy	**Freq.**	**%**	**Freq.**	**%**
Conservation Agric	217	72.3	83	27.7
Bunding	221	73.7	79	26.3
ISFM	270	90.0	30	10.0
IPM	219	73.0	81	27.0
Terracing	216	72.0	84	28.0

Row planting	121	40.3	179	59.7
Drought resistant	184	61.3	116	38.7

Source: field survey, 2018

4.5 Factors influencing rice production under Tono irrigation scheme

The result in Table 7 shows that all variables except herbicides usage have significant influence on rice production. From the result, farm size had a positive significant effect in rice output at 1% significance level. The estimated coefficient is 0.692 implying that a 100% increase in farm size would lead to 69.2% increase in the output of the farmer. The implication is that farmers under their current characteristics can increase their farm sizes and still obtain higher yields. This is an important finding that justified the need for commuting more lands under irrigation farming in order to improve the food security condition of Ghana and attain second SDGs that seeks to eliminate food insecurity in all forms by 2030. The positive effect is consistent with the findings of Dhehibi et al. (2007).

Both hired and family labours were significant at 5% and had a negative elasticity. This implies that an increase in labour supply would reduce output. For instance, a 100% increase in family labour into the farm can lead to a reduction of 21.6% of rice output. Similarly, a 100% increase in hired labour would lead to a reduction of 15.2% of rice output. This can be due to an overuse of labour on the farms. Thus, farmers are employing labours that do not do productive work on the farms and this have a negative implication on crop output. The estimated negative effect of labour is consistent with theoretical explanation that labour is subject to diminishing returns. Contrary to this study, Chebil et al. (2010) estimated a positive effect of labour on irrigated output. The seed quantity used has a positive effect on output, with an estimated elasticity of 0.126. This means that if the quantity of seed used by farmers increased by 100%, output would

also increase by 12.6%. considering that seed is the basic unit for production, this positive estimate suggests that farmers have to increase the level of seeds they plant on their farms and this can ensure that water transferred to these farms are efficiently used.

Fertiliser also had a positive effect on output and this is significant at 5%. The elasticity estimate suggests that a 100% increase in fertiliser usage would increase output by 12.3%. it is important to recall that one of the major constraints to rice production as mentioned by the respondents is declining soil fertility. Therefore, it is expected that with the use of external fertiliser, the level of output would increase. Consistently, Chebil et al. (2010) also estimated a positive effect of fertiliser on output.

The elasticity on water is -0.072 and this is significant at 10% significant level. This implies that if the quantity of irrigation water supplied to a farmer's farm increase by 100%, the output of the farmer would decrease by 7.2%. This is due to the fact that plants have their water requirement levels; therefore, water supply beyond this threshold can have a negative effect on the growth and yield of the crop. The negative estimate also justified support for irrigation expansion in the country since the water requirement for increasing crop output is less. Contrary to this study, Dhehibi et al. (2007) estimated a positive effect of irrigation water on output.

Table 7: Factors influencing rice production under Tono irrigation scheme

Variable	Coef.	Std. Err.	z	P>z
Ln Farm size	0.692	0.095	7.270	0.000
Ln Family labour	-0.216	0.108	-2.010	0.044
Ln Hired labour	-0.152	0.059	-2.570	0.010
Ln Seed	0.126	0.075	1.680	0.093
Ln Fertiliser	0.123	0.062	1.980	0.047
Ln Herbicides	0.092	0.085	1.080	0.279
Ln Water quantity	-0.072	0.040	-1.8	0.071

Constant	-0.909	0.288	-3.15	0.002

Source: field survey, 2018

4.6 Irrigation water use efficiency levels among farmers

Table 8 presents the distribution of irrigation water-use efficiency levels among farmers within the Tono Irrigation Scheme. The results reveal generally low levels of irrigation water-use efficiency, with an average efficiency score of 42.23%, indicating that farmers, on average, achieve less than half of the potential output obtainable from the volume of irrigation water applied. Efficiency scores ranged from a minimum of 0.67% to a maximum of 85.24%, suggesting substantial variation in farmers' ability to utilize irrigation water effectively.

The distribution further shows that 21.3% of farmers recorded efficiency levels below 21%, representing the largest proportion of respondents. An additional 10.0% and 11.0% of farmers achieved efficiency levels within the 21-30% and 31-40% categories, respectively. Collectively, 42.3% of farmers operated below 40% efficiency, highlighting significant inefficiencies in irrigation water utilization across the scheme.

Approximately 14.7% of farmers achieved efficiency levels between 41% and 50%, while 17.0% fell within the 51-60% category. Furthermore, 13.0% and 11.0% of respondents recorded efficiency levels ranging from 61-70% and 71-80%, respectively. Only 2.0% of farmers attained efficiency levels above 80%, indicating that relatively few farmers are operating near the efficiency frontier.

The low average efficiency level suggests considerable potential for improving irrigation water productivity within the scheme. From a resource-use efficiency perspective, the findings imply that substantial output gains could be achieved without increasing water withdrawals if existing

farmers adopted more efficient irrigation and farm management practices. The wide variation in efficiency scores further indicates that differences in management practices, access to institutional support, technical knowledge, and adoption of sustainable water management strategies may play an important role in determining irrigation performance.

The predominance of farmers within the lower efficiency categories may reflect challenges associated with inappropriate water application practices, weak extension support, inadequate irrigation scheduling, and limited adoption of water-conserving technologies. Similar findings have been reported in irrigation schemes across sub-Saharan Africa, where inefficient water allocation and management practices often constrain agricultural productivity despite substantial investments in irrigation infrastructure (Molden et al., 2010; Asres, 2016).

Table 8: Irrigation water use efficiency levels among farmers

Efficiency category	Frequency	Percentage
<21	64	21.3
21-30	30	10.0
31-40	33	11.0
41-50	44	14.7
51-60	51	17.0
61-70	39	13.0
71-80	33	11.0
81-90	6	2.0
Total	300	100.0
Mean	42.23%	
Minimum	0.67%	
Maximum	85.24%	

Source: field survey, 2018

4.7 Effect of sustainable water management strategies on water use efficiency

Table 9 provides empirical results on sustainable water management practices that have a significant effect on water use efficiency. Socioeconomic factors significantly influenced the water use efficiency of the farmers. These include farmer group membership, off-farm,

extension access and experience in crop production. It is important to note that a negative coefficient means the variable have a negative effect on water use inefficiency but a positive effect on water use efficiency, and vice versa. Conservative agriculture had a negative effect on water use inefficiency and thus, a positive effect on water use efficiency. This means that farmers who engaged in conservative agriculture are more water-use efficient than those who did not practice conservative agriculture. This justified the primary principle of conservation agriculture, which seeks to maintain the water level of soils by retaining the structure of the soil. Bonding had a negative effect on water use efficiency. This implies that farmers who practiced bonding have higher water use efficiency than those who did not practice bonding. Bonding involves the creation of bonds around farms to ensure that water supplied to the farms is retained on the farm and does not run off. It is therefore expected that with high water retention on the farms, the water use efficiency of the farmers would be high. Hong & Yabe (2016) also estimated that farmers who engage in soil and water conservation strategies such as conservation agriculture have higher irrigation efficiency than those who do not.

Contrary to the researcher's expectation, integrated soil fertility management (ISFM) had a positive coefficient, which means that farmers who adopt ISFM have lower water use efficiency. However, ISFM requires a high understanding in order to obtain higher returns from its adoption. Therefore, with its complexity, it is likely that its adoption may interfere with the farmers' ability to effectively manage their farms and irrigation water. Waraich et al. (2011) revealed that a good strategy to enhance water use efficiency is through proper plant nutrition. The result also shows that integrated pest management (IPM) have a negative effect on water use efficiency, hence a positive effect on water use efficiency. This means that farmers who adopt

IPM have higher water use efficiency than those who do not. This is plausible considering the effect of pests and diseases on crop production. Therefore, with effective IPM, farmers may be able to efficiently use the irrigation water.

The adoption of drought-resistant seed varieties has a negative relationship with water use efficiency. This means that farmers who adopt drought-resistant seed varieties have higher water use efficiency than those who use less drought-resistant varieties. It is therefore not surprising that the adoption of drought-resistant varieties is the second sustainable water management strategy adopted by most of the farmers. Chebil et al. (2014) also estimated a positive effect of the adoption of a more productive and promoted seed variety on irrigation water use efficiency. Fang and Waraich et al. (2011) indicated that increasing the drought tolerance of crops is a means of effective and efficient water use.

Farmer group membership (FBO) had a negative effect on water use efficiency. Therefore, it can be concluded that farmers who belong to FBO have a higher water use efficiency than those who do not belong to any FBO. FBO is generally a platform used by farmers to discuss production issues such as input sources and use, farm management, as well as irrigation water use and management. It is also used as a medium by development practitioners, including NGOs in the agriculture sector, to reach farmers. Therefore, it is possible that knowledge from these FBOs is effective in improving the water use efficiency level of the farmers. Again, this demonstrated the need for enhancing the participation of farmers in FBOs. Consistently, Chebil et al. (2014) also estimated that farmers who belonged to a water user association have higher irrigation water use efficiency than those who do not.

Off-farm also had a negative coefficient, suggesting that it has a positive effect on water use efficiency. Thus, farmers who engage in off-farm activities in addition to irrigation farming have higher water use efficiency than those who engage solely in crop production. It is possible that farmers who engage in off-farm activities are able to invest the extra income from these activities in their irrigation farms and, therefore, would be able to effectively manage their farms. Hong & Yabe (2016) also estimated that with increase income share from off-farm, farmers can obtain higher irrigation efficiency.

Extension access has a negative effect on water use efficiency. Thus, farmers who had access to extension services have higher water use efficiency than those who had no access to extension services. This is justifiable considering the important role extension officers play in providing information and education to the farmers. According to the farmers, there is a general respect and trust for extension officers, therefore, the information provided by these extension officers is highly accepted by the farmers. This also calls for the need to improve extension service delivery under irrigation farming in order to ensure the sustainable use of water resources. Hong & Yabe (2016) also estimated a positive effect of extension access on irrigation efficiency.

The effect of experience is significant at 5% and negative. Thus, farmers with high experience in irrigation farming have higher water use efficiency than those with less experience in irrigation farming. With high experience, it is expected that farmers would understand irrigation water management and use water more efficiently. Similarly, with higher experience, farmers can

adopt other efficient agronomic practices that would generally ensure efficient water use. Chebil et al. (2014) also estimated a positive effect of experience on irrigation water use efficiency.

Table 9: Effect of sustainable water management strategies on water use efficiency

Variable	Coeff.	Std. Err.	z	P>z
Conservation Agric	-0.585	0.246	-2.38	0.017
Bunding	-0.493	0.237	-2.08	0.038
ISFM	0.894	0.499	1.79	0.073
IPM	-0.438	0.258	-1.70	0.090
Drought resistant	-0.439	0.251	-1.75	0.081
Row planting	-0.220	0.231	-0.96	0.340
Terracing	-4.149	5.067	-0.82	0.413
FBO	-0.499	0.210	-2.37	0.018
Off-farm	-0.843	0.283	-2.98	0.003
Household size	-0.003	0.020	-0.13	0.900
Education	0.006	0.022	0.25	0.799
Extension	-0.266	0.101	-2.64	0.008
Social asset	0.237	0.226	1.05	0.295
Credit access	-0.336	0.242	-1.39	0.166
Experience	-0.018	0.008	-2.22	0.026
_cons	1.996	0.348	5.74	0.000
Sigma v2	-1.306	0.255	-5.12	0.000

Source: field survey, 2018

6 Conclusions

This study examined the sustainable water management strategies adopted by Tono irrigation farmers and their effects on the water use efficiency of the farmers. The study seeks to explore means of improving and maintaining a sustainable use of the irrigation scheme. The study concludes that the farmers adopt several sustainable management practices that are well documented in literature as sustainable production methods. It can also be concluded that these sustainable management practices are necessary for ensuring sustainable irrigation water use efficiency of the farmers. The result of irrigation water use efficiency levels is rather low and needs to be addressed. In addition to sustainable water management strategies, socioeconomic factors are also crucial for attaining efficient irrigation water usage. The study also concluded

that farmers have to reconsider their input usage; while some inputs must be increased, others must be decreased in order to obtain higher production outputs under the irrigation scheme. Generally, increasing irrigation water to farms is not ideal for increasing crop output.

9 Recommendations

Based on the findings and conclusions from the study, the following recommendations are made:

1. There must be an understanding of the water requirement of the various plants planted under the irrigation scheme. This would ensure that appropriate water quantities are distributed to each farm. For rice farmers however, this study recommends that the level of water supply to rice farms must be reduce to increase the farmers' output. There would be the need for authorities at the irrigation scheme to work with development partners such as iDE and IFDC to develop and adapt the Alternate Wetting and Drying (AWD) techniques to conserve water.
2. Irrigation farming should be promoted in the region since farmers outlined erratic rainfall as the major challenge but explained that irrigated farms provide higher yields and income than the conventional rain fed farms. The government's one village one dam policy should be hastened and implemented to provide substantial benefits to the farmers. The implementation of this policy should also integrate measures to ensure that farmers adopt sustainable irrigation water management strategies on their farms.
3. The provision of extension services and other institutional supports should be improved in order to improve the irrigation water use efficiency among the farmers.
4. Since the adoption of sustainable water management practices was low among the farmers, there must be a renewed effort by the appropriate stakeholders including the

irrigation scheme management to educate, train and encourage farmers to adopt sustainable water management strategies.

5. A further study is recommended to critically examine the cost-benefit of each sustainable water management strategy in order to ensure that the farmers do not only improve their water use efficiency but also, maximise their profit from the adoption of the various strategies.

Declarations

Human Ethics and Consent to Participate

Verbal informed consent was obtained from all participants after explaining to them the objective of the study. They were also assured of confidentiality and made to understand participation was strictly voluntary, with the option to withdraw at any stage without consequence.

Conflict of Interest

The authors express no conflict of interest in any form regarding the publication of this work.

Data Availability

Data for this study will be made available when requested.

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Clinical Trial Number

Not Applicable

Ethical Statement

The study received approval from the University of Technology and Applied Science (UTAS) Ethical Clearance Committee (ECC) in Navorongo, Ghana. And the study was carried out in

strict accordance with the stated guidelines and regulations outline by the ethical committee board.

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