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Water Use, Productivity and Socioeconomics of Farmer-managed Small Dam Irrigation Schemes in the Upper East Region of Ghana

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ABSTRACT

Food availability gaps caused by short-duration wet season and long dry spells marking semiarid regions of the world and the pivotal role irrigated agriculture plays in the economic sustenance of agrarian regions of developing countries, have informed the need to constantly monitor the performance of irrigation systems. The use of small reservoirs for dry season farming presents a viable alternative to medium and large-scale state agency-managed irrigation projects. This present study therefore evaluated the performance of two (2) small dam-based farmer-led irrigation schemes, at Baare and Winkongo, in the Upper East Region of Ghana. Performance indicators related to water availability and agricultural production, developed by the International Water Management Institute (IWMI) were used. Data were gathered through field surveys, laboratory analysis, and literature. The relative water supply (RWS) and relative irrigation supply (RIS) for Baare were 1.11 and 1.12, respectively, indicating crop water demand was marginally matched by water supply. The abundant water available to Winkongo crops, indicated by RWS and RIS values of 2.56 and 3.17, respectively, showed opportunity for water saving and/or bringing more land under cultivation. Doing this would cause better land productivity, which the output per cropped area (OPCA) indicator revealed was unexpectedly lower than Baare. The study concluded that demographic distribution, including age and gender of the irrigation farmers, plays a limited role in the efficient use of small reservoirs for dry season irrigation farming, compared to ready availability of farmland to willing irrigators and season-round water availability. If the significant youth populations involved in dry season farming at the studied schemes are maintained for farmer-led irrigation in other parts of northern Ghana, the crisis of labour shortage is not likely to occur. This is a positive sign in the drive to reaching food self-sufficiency level (SSL) and keeping afloat the agriculture-based rural economy.

INTRODUCTION

Crop water use accounts for a significant portion of the total available water consumption, especially in agrarian regions of the world, such as rural communities of developing countries. Agriculture, crop cultivation particularly, forms the core of the economy of these communities (Sidibe *et al.*, 2016; Bjornlund, *et al.*, 2016). Besides, agriculture contributes substantially to the gross domestic product (GDP) of developing countries and gainfully employs a large chunk of the population. In fact, to a large extent, the economic development of individual countries is tied to increased agricultural production (Namara *et al.*, 2010; FAO, 2014; Adelodun and Choi, 2018) and rainfed agriculture alone cannot guarantee that. A peculiar challenge is presented in agrarian semiarid climates with monomodal, short-duration, yet erratic rainfall pattern, such as the north of Ghana, where crop water demand for the most part of the year must be matched from irrigation. This offers the main reason why irrigation projects dot the landscape of semiarid West African communities. Ofosu (2011) remarked that irrigation development in sub-Saharan Africa (SSA) began during the colonial era. Nonetheless, other scholars such as Ugalahi *et al.* (2016) and Adelodun and Choi (2018) contended that serious governmental attempts at irrigation development in West Africa dates back to the 1950s, and became intensified after the Sahelian drought of the 1970s which ravaged the region.

Consequently, construction of dams began, purposefully for irrigation, but could serve other functions. State agencies were created to drive the irrigation development agenda of the respective governments. For instance, the River Basin Development Authorities (RBDAs) were created in Nigeria in 1976 and domiciled in the Federal Ministry of Water Resources (FMWR) and with defined mandates, chief of which is to harness water resources for irrigation, provision of roads and other enabling interventions for the country's agricultural development.

Similarly, the government of Ghana created the Ghana Irrigation Development Authority (GIDA) in 1977 to drive the government's irrigated agriculture initiatives vis-à-vis dam site identification, design, construction and operation of the irrigation scheme (Adongo *et al.,* 2015). Alongside these governmental efforts, nongovernmental organisations (NGOs) in Ghana led the construction of small reservoirs (SRs), which are intended for water supply for smallholder dry season farming and other purposes (Namara e*t al.,* 2010).

Farmer-led irrigation is one in which a farmer or a group of farmers takes full charge of their irrigated farming, that is, choosing the best-fit agricultural water management technology for their needs and within their financial capacity (Tushaar *et al.,* 2020). Small dam irrigation projects are a prominent type of farmer-led irrigation in Ghana and West Africa. Of all the smallholder irrigation initiatives, the small reservoir (SR) initiative has the most uses. Small reservoir irrigation practice in Ghana guarantees mostly leafy vegetable foods for the populace and livelihood sustenance for the resource constrained rural farmers, during dry season (Sidibe *et al.,* 2016). The reservoirs serve other purposes such as livestock watering, fishing and sanitation and domestic.

Farmer-led irrigation practices, notably the small reservoir-based type, in Ghana, have in recent times attracted special attention, example, the One Village One Dam (1V1D) policy of the government of Ghana. The major reason being that considerable output could come from the use of small reservoirs for crop production (Namara et. al, 2011). However, the performances of this irrigation typology are not constantly being evaluated to inform timely intervention where and when the need arises. Such challenges could include inefficient in-field water use, farm land and labour issues, amongst others (Tetteh et al., 2020).

Faulkner (2005) had earlier submitted that small reservoir irrigation projects in West Africa are important to the livelihoods of those who utilize these systems, and recommended the continuous study and understanding of the systems in order to position them for the agricultural development of the region. Acheampong *et al.* (2018) provided evidence on the effectiveness of small reservoirs for delivering multiple benefits related to improved agricultural production, enhanced food security and their impact on the livelihood of smallholder farm households in Ghana. Yet, there is a need for sufficient studies on irrigation management if agricultural development is to be sustained. An essential pre-requirement for irrigation management is the system's performance assessment, which gives an idea of the constraints and opportunities in the use of the system's limited resources, and generally the system's position relative to its management's set objectives (Degirmenci *et al.,* 2006) and service delivery when compared to other irrigated agricultural systems.

This paper's authors believe there are limited studies conducted to assess the performance of such irrigation schemes. In the author's opinion, even the existing studies on performance evaluation have not used indicators that address key aspects critical to the sustainability of these irrigated agricultural systems.

Against these backdrops, this present study therefore assessed two (2) of such an irrigation typology in the Upper East Region of Ghana, and compared their performances across a set of widely relatable indicators. The specific objectives include to estimate the adequacy of water available to crops, using Relative Water Supply (RWS) and Relative Irrigation Supply (RIS) as indicators; evaluate the output (in terms of water and land productivities) from each irrigation system, using the standardized gross value of production (SGVP)-based indicators; and investigate the influence of land accessibility and demographic distribution on the output from each irrigation system.

MATERIALS AND METHODS

Study Area

The study was conducted at the small dam irrigation sites in Baare (latitude N10.830^0 and longitude W -0.960^0) and Winkongo (latitude N10.710^0 and longitude W -0.850^0) in the Talensi District, Upper East Region of Ghana (Figure 1). The district has the following demographic details: 838 km2 area; 81, 194 inhabitants; 15,748 households and 78% of the population has agriculture as the main occupation while 91% of the households engage in agricultural activities (Sidibé *et al.*, 2016). The Upper East Region, like other regions in northern Ghana, has two seasons- wet and dry. These regions have similar climatic, geologic, agro-ecological and socioeconomic makeups. They are classified as semi-arid, and are marked by unimodal annual rainfall and long months of dryness. The rain which usually starts from April/May and ends in October, has its annual amount between 700–1100 mm, with the peak occurring in late August through September. Water storage reservoirs are heavily relied on for supply of water during the long dry spells. The region's temperatures vary markedly according to the season and can reach 39.1 ^{o} C the peak of the dry season, in April, causing low relative humidity and thus creates the warm-temperature condition needed for leafy and other vegetables like tomato, okra, pepper, onion and water melon, to thrive under irrigation (Adongo *et al.*, 2015; Sidibe *et al.*, 2016). The White Volta River of the Volta River system, majorly drains the Upper East Region.

Sandy loam appears to be the dominant soil textural class in the Upper East Region. The topography of the region places between flat and gently undulating. Generally speaking, soils in northern Ghana present susceptibility to flooding. Liebe et al. (2002) suggested that because of the low cumulative infiltration capacity of the soils in the region, excess rain water does not get to store in the soil. It rather runs off over the land surface. Surface runoff collected from different points, plus the water harvested during rainfall are what small dams and dugouts store and supply during dry season for agriculture and other uses. Two crops, namely; okro and amaranthus, were common to both schemes during the dry season. Others crops exclusive to the Winkongo irrigation scheme were roselle, cowpea and sweet potato, grown for their leaves.

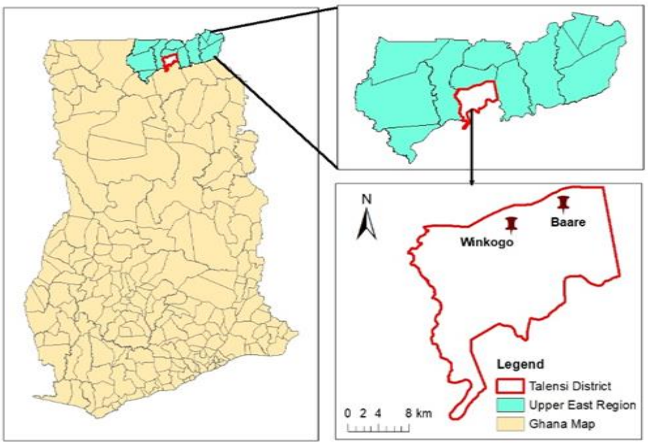

Figure 1: Map of Ghana showing Location of the Study Irrigation Schemes

Data Collection

Data collection is discussed under two (2) different headings relating to the study's specific objectives. Both secondary and primary data were used in this study. Primary data included canal discharge to estimate surface diversions/irrigation supply (m^3), soil data, and data on socioeconomics collected using questionnaires. Market survey and farmers' interviews were carried out to establish the prices of the crops. Secondary data included crop yield data from the Talensi District Agriculture Department (validated by a few on-farm measurements) and climate data required to run the CROPWAT model. The model requires data on climate, crop, and soil to execute. The planting and harvest dates and the length of growing period (in days) given by the farmers were used to adjust the typical values given in the CROPWAT. All other crop parameters used were from small vegetables, associated with the software.

Performance Measurement

Water Use Indicators

The indicators used were defined by Molden *et al.* (1998) as follows:

$$RWS = \frac{\text{Total water supply}}{\text{Crop water requirement}} \quad \ldots\ldots\ldots\ldots\ (1)$$

where: RWS is the relative water supply, Total water supply is the sum of reservoir supply

and effective rainfall.

$$RIS = \frac{\text{Irrigation supply}}{Irrigation\ requiremment} \quad \ldots\ldots\ldots\ldots\ (2)$$

Where: RIS the relative irrigation supply.

Effective rainfall, crop water requirement (ET_c) and irrigation requirement are computed by the CROPWAT. The effective rainfall, crop water requirement (or crop evapotranspiration, ETc), and the irrigation requirement (IR) were computed using the version CROPWAT 8.0, otherwise called CROPWAT (Basiri, 2009). The USDA-Soil Conservation method was chosen for effective rainfall estimation and irrigation requirement was computed as the difference between the crop water requirement and effective rainfall.

$$ETc = ETo \times Kc \quad \ldots\ldots\ldots\ldots\ldots\ldots\ (3)$$

The model uses the FAO recommended Penman-Monteith equation as presented in Equation 1 (Allen *et al.*, 1998) to estimate the reference evapotranspiration (ET_O).

$$ETo = \frac{0.408\,\Delta\,(R_n - G) + \gamma \frac{900}{T+273} U_2\,(e_s - e_a)}{\Delta + \gamma\,(1 + 0.34\,U_2)} \quad \ldots\ldots\ (4)$$

Where: *ETo* is the reference evapotranspiration in mm/day, *Rn* is the net radiation at the crop surface [MJ/ m^2/day], *G* is the soil heat flux density [MJ/m^2/day], *T* is the mean daily air temperature (^{o} C), U_2 is the wind speed at 2 m height (m/s), es is the saturation vapour pressure [kPa], e_a is the actual vapour pressure [kPa], $(e_s - e_a)$ is the saturation vapor pressure deficit (KPa), Δ is the slope vapor pressure curve (KPa/^{o} C), γ is the psychrometric constant (KPa/^{o} C).

Agricultural Performance Indicators

Equations 5 to 8 were used to determine the agricultural performance of the irrigation schemes:

Output per unit land cropped = $\frac{\text{SGVP}}{\text{Irrigated cropped area}} \left(\frac{\text{GH¢}}{\text{ha}}\right)$ ….(5)

Output per unit water consumed = $\frac{\text{SGVP}}{\text{Net ETcrop}} \left(\frac{\text{GH¢}}{m^3}\right)$ ……(6)

Output per unit irrigation supply = $\frac{\text{SGVP}}{\text{Diverted irrigation suppy}} \left(\frac{\text{GH¢}}{m^3}\right)$ …………….. (7)

Where: SGVP is the standardized gross value of production

$$\text{SGVP} = \left(\sum_{crops} \text{Ai Yi} \frac{Pi}{Pb}\right) P_{bm} \ldots\ldots\ldots\ldots (8)$$

Where: A_i is the area occupied by crop i (ha), Y_i is the yield of crop i (ton/ha), P_i is the local price of crop i (GH¢/kg), P_b is the local price of the base crop (GH¢/kg), and P_{bm} is the world market price of base crop (US$/ton) [price of the base crop in the region, (GH¢/ton) was used instead].

Demographics and Land Accessibility

Primary quantitative data were collected and the data collection instrument used was semi-structured questionnaire (that is, contained both open-ended and close-ended questions). The questionnaire was pre-tested and administered to irrigation farmers to gather information on how they access the plots they cultivated during the dry season and demographic information like gender and age, amongst others.

The Miller and Brewer method (2003) (Eq. 9) was used to determine the number of respondents (sample size) from each site.

$$n = \frac{N}{1+N\,(\propto)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (9)$$

Where: N = Sample frame, n = Sample size, α = Margin error (fixed at 5%).

Comparison of both schemes' individual results were done through the *t*-test.

RESULTS AND DISCUSSION

Water Availability and Use

The two (2) indicators, relative water supply (RWS) and relative irrigation supply (RIS), were used to relate water supply to water demand. This gives an idea of the sufficiency or otherwise of the water available to crops.

Relative Water Supply

Table 1 presents RWS values of 1.11 and 2.56 for the Baare and Winkongo schemes, respectively. The values are in the range of what have been obtained from previous similar study by Madhava Chandran and Ambili (2016) which recorded RWS values ranging between 1.15 and 2.34 for two (2) minor irrigation schemes in India. Molden et al. (1998) in their study of 18 irrigation systems of different typologies and in dissimilar agroclimatic regions of the world, obtained RWS values 0.8 (the least) for Muda Irrigation System, Malaysia, and 4.1 (the highest) for Salvatierra Irrigation System, Mexico. Şener *et al.* (2007) obtained 1.91 for the Haraybolu Scheme in Turkey.

Even though Levine (1999) reported that it is at an RWS value of 2.5 or more that crops failure or low yields could not be attributed to water stress, judging water availability based on RWS values might require a bit of caution. An RWS value of 1.0 means water supply is just equal to demand. For an irrigation scheme with no concern for irrigation farming being done downstream, that is just outside its proper command area, an RWS value slightly less than 1.0, for example 0.8, may mean that the farmers are practicing deficit irrigation (Molden et al., 1998) and poor yields less likely to occur because of the farmers' experience.

Generally, a large RWS value following from a relaxed management, removes the risk of water stress (if there's uniformity in water distribution across the field), and the 'drainage water' can cater to small land cultivation downstream. Meanwhile, if there exists a need for judicious use of water, strict management that would result in moderate RWS value is encouraged.

All things being equal, incorporating conveyance and application losses in the computation, not practicing deficit irrigation, and uninterested in irrigation going on in the downstream area just outside the irrigation system, RWS values much less than 1.0 indicate insufficiency in water available to crops; slightly less than or greater than or equal to 1.0, means just sufficient, that is supply tightly matches demand; much greater than 1.0 is indicative of water abundance. Water abundance may however come with the challenge of waterlogging. In such a situation, RWS values in the range of 1.3-1.5 are appropriate (Abernethy 1990).

Table 1: Water Use Performance Indicators

Performance Indicator	Irrigation Scheme	
	Baare	**Winkongo**
Relative Water Supply	1.11	2.56
Relative Irrigation Supply	1.12	3.17

Relative Irrigation Supply

The RIS, like the RWS, is a measure of the adequacy of water availability to crops. However, unlike the RWS, it does not regard rainfall contribution to crop water requirement and focuses on the water supply from the system alone (which in the study sites, are surface diversions). Computed value of RIS tells us the extent to which the irrigation system provides the portion of crop water demand not covered by rainfall. RIS values falling much less than 1.0 would mean the irrigation system isn't supplying enough of the water amount demanded of it, and that could put the crops on the route to water stress, ultimately resulting in poor yields. RIS values much higher than 1.0 may not be encouraged in a water-scarce catchment where there exists stiff competition between irrigation farming and other water uses. Table 2 shows RIS values of 1.12 and 3.17 for the Baare and Winkongo sites, respectively. The values fall within the range of those determined for irrigation schemes in past works. For instance, Molden *et al.* (1998) in their work on 18 irrigation systems obtained RIS values ranging from 0.4 to 4.8. Madhava Chandran and Ambili (2016) recorded the least RIS value (0.21), and highest RIS value (3.36) at the midstream of the canals at Kanniparamba and Vellannur irrigation schemes, respectively, in India. Şener *et al.* (2007) obtained 1.55 for the Haraybolu scheme in Turkey.

Agricultural Productivity/Output

Three (3) standardized gross value of production (SGVP)-based indicators were used to assess the output from each of the irrigation schemes. Water productivity and land productivity were measured in terms of SGVP per m^3 of water consumed/supplied and per unit hectare cultivated, respectively (Table 2).

Table 2: Agricultural Productivity Performance Indicators

Performance Indicator	Irrigation Scheme	
	Baare	Winkongo
SGVP (GH¢)	96,039	12,192
Output per unit water consumed (GH¢/m^3)	1.55	0.80
Output per unit irrigation supply (GH¢/m^3)	1.67	0.35
Output per unit cropped area (GH¢/ha)	8,003	4,190

(1 US Dollar = 5.74 Ghanaian Cedis as at May, 2021)

Water Productivity

The productivity of water supplied might be of paramount interest at an irrigation system, located in catchment or basin marked by general scarcity of water, so much so that irrigation actors are interested in the economic returns of crops produced with unit volume of water. The goal is to use minimal water to obtain maximum possible economic return on crops. Water productivity is assessed through the output per unit water consumed (for crop evapotranspiration) and output per unit irrigation supply.

Output Per Water Consumed

Table 2 presents OPWC values of GH¢1.55/m^3 (US$ 0.27/m^3) and GH¢0.80/m^3 (US$ 0.14/m^3) for the Baare and Winkongo irrigation schemes, respectively. The values are in the range of what were obtained from previous similar studies. Inadequate water supply, especially at moisture-sensitive crop growth stages can markedly depress crop yield, translating into little economic returns. Madhava Chandran and Ambili (2016) remarked that a high RWS value is indicative of adequate water availability, and will positively influence input use, for instance fertilizer. This may culminate in higher crop yield, as evaluated by the SGVP. Even though RWS and OPWC have in common, the net crop water requirement in their denominator component, the correlation between these indicators remains unclear. The following were a few observations to back this claim: the Winkongo site recorded RWS of 2.56, more than twice of the Baare site's value, but recorded OPWC value of half the Baare site. Molden et al. (1998) studied a set of irrigation systems of heterogenous typologies and agro-climates and reported the Mahi Kadana irrigation system, India, to have an RWS value of 3.9 but the least OPWC value US$ 0.03/m3; the Gorgo irrigation system, Burkina Faso, had an RWS value of 1.6 but the highest OPWC value US$ 0.91/m3. What this suggest is that efforts should be made to ensure water supply throughout the cropping season tightly matches crop water demand, in order to maximize water productivity.

Output Per Irrigation Supply

Table 2 shows OPIS values of GH¢1.67/m3 (US$ 0.29 /m3) and GH¢0.35/m3 (US$ 0.06 /m3) for the Baare and Winkongo schemes, respectively. Molden et al. (1998) reported values greater than US$ 0.20 /m3 for systems cultivating vegetables as do the Baare and Winkongo systems.

Low OPIS values may be excusable for systems in semiarid regions, because more water need be diverted to meet the high irrigation requirement. Notwithstanding, judging by the results, the Baare system, more than Winkongo, productively used irrigation water.

RIS has direct links with OPIS. High RIS value indicates that irrigation supply is in excess of irrigation demand. While one is unsure if that excess would translate into increased crop yield, it is certain one would obtain a relatively low OPIS when the large irrigation supply is used to divide the SGVP. This is true for the studied schemes. The irrigation supply at the Baare scheme is almost equal to irrigation requirement (RIS = 1.12), a value slightly above one-thirds of Winkongo's RIS value. Yet, the irrigation water productivity at Baare (OPIS = US$ 0.29 /m^3) is almost 5 times Winkongo's. The results clearly indicate the opportunity to bring more land under cultivation, as irrigation water seems abundant at the Winkongo site. If the current cultivated area must be maintained, then irrigation supply must be reduced to obtain high output per irrigation supply.

Generally, however, the values are in the range of what various researchers have obtained from past similar studies. Şener *et al.* (2007) obtained US$0.33/$m^3$ for the Haraybolu scheme in Turkey. Tanriverdi *et al.* (2011) in their study in Turkey, reported US$ 0.01 – 0.85/m^3 for the schemes operated by the state hydraulic waterworks (SHW), and US$ 0.03 – 0.56/m^3 for the irrigation schemes managed by the water user associations

(WUA). Degirmenci *et al.* (2003) studied twelve irrigation schemes in the Southeastern Anatolian Project in Turkey, and reported their OPIS values as ranging between US\$0.12/m^3 and \$2.16/m^3. Madhava Chandran and Ambili (2016) had OPIS values range between US\$ 0.07 and 0.41/m^3 for canal reaches of two minor irrigation schemes in India.

Land Productivity

Output Per Unit Cropped Area

Table 2 indicates that each cultivated hectare (ha) at the Baare irrigation scheme yielded GH¢8,003/ha (US\$ 1394/ha) and GH¢4,190/ha (US\$ 730/ha) at the Winkongo scheme. Even though land is the limiting resource at Winkongo, and thus land productivity is expected to be high due to strict land utilization, the Baare irrigation scheme with enough land, still had the higher land productivity during the study period. The cropping pattern is most likely responsible for this. On the average, a farmer at Winkongo cultivated three (3) different crops on tiny land fragments in different locations on the irrigation scheme.

Nevertheless, the calculated values are comparable to what were obtained in previous works. An irrigation scheme in Pakistan recorded the least of US\$ 384/ha, and another irrigation scheme in Mexico recorded the maximum of US\$ 3,626 /ha (Molden *et al.,* 1998). Tanriverdi et al. (2011) studied in Turkey, two sets irrigation schemes—one under agency and reported US\$ 449 – 5079/ha. The other set was composed of schemes managed by farmers, and values between US\$ 448 – 4938/ha were reported for them. Şener *et al.* (2007) obtained US\$2325/ha for the Haraybolu scheme in Turkey.

Socioeconomics of Small Dam-Based Irrigation Farming

Gender Distribution

Table 3 shows Winkongo was a female-dominated scheme (66%), with male farmers constituting about one-thirds of the total population. Male was the dominant gender, constituting 61% at the Baare scheme. The gender composition at the Winkongo site is in agreement with the insinuations by Gollin (2014) that agricultural activities in rural developing regions were mostly undertaken by women, and they play a key role in smallholder irrigated farming (FAO, 2007). The high population of women in Winkongo has however not translated into higher crop yield as indicated by Adongo *et al.* (2015) that women, given equal resources, tend to produce more crops than men, per cultivated hectare. This relatively low productivity has more to do with the cropping pattern at Winkongo, and less with the findings that women have poor agricultural water management skills than they manage domestic water use.

However, the *t-test* revealed there was no significant difference ($p > 0.05$) in the gender composition of farmers in the studied schemes. What this implies is that the gender composition between both schemes is physically different but not statistically different. The statistical implication is that small reservoir-based dry season farming is not restricted to a particular gender at the two sites.

Age Distribution

Table 3 shows the percentage age distribution of the farmers. Analyses revealed that approximately 90% of the farmers from each scheme fell in the economically active working age range (21-60 years). The t test result indicates that there was no significant difference ($p > 0.05$) in the age group of farmers in the studied schemes. What this mean is that dry season farming was being done by similar age groups in both schemes, and farming as whole is the mainstay of the economy of these rural communities (Sidibe et. al, 2016).

The high percentage (60% and 65% for Baare and Winkongo schemes, respectively) of youth population (21 – 40 years) engaged in irrigation farming is noteworthy. This has positive implications for addressing the shortfall in farm labour during the rainy season, which is as a result of the youth seeking greener pastures (north-south migration of the youth) during the dry season. The return of the migrant youth to their communities in the north, to undertake wet season farming, is not always guaranteed (Tetteh *et al.,* 2020), and this has negative implications for the quest to attaining food security in the region. It is important that dry season farming be made attractive, through inputs subsidies and extension services, to retain this youthful population.

Table 3: Demographic Distribution of Farmers

Demographic Parameter	Percentage (%)	
Gender	Baare	Winkongo
Male	61	34
Female	39	66
Age (years)		
21-30	21	15
31-40	39	50
41-60	31	29
Above 60	9	6
t stat ($p > 0.05$)		

Land Ownership and Allocation

Farmland Ownership

From Table 4, it can be seen that equal percentage of farmers owned and borrowed the plots they cultivated at the Baare scheme during the dry season, while only 30% of the irrigation farmers owned the Winkongo farmland. Even though there were no written or spoken agreements to the effect of land borrowers returning favour in cash or in kind, both forms of favour were reported by the farmers at the schemes. Generally, land ownership was by family inheritance and some female farmers owned land through marriages. These observations were corroborated by the submissions of Tetteh *et al.* (2020).

The t test showed insignificant difference at 95% level in the land ownership composition in the studied schemes. That is, the ownership composition between both schemes might differ physically but not statistically. The statistical implication is that, difference in land ownership composition was not necessarily the reason for any observed variations in the output from each of both schemes.

Land Allocation/Holding

In the spirit of communal cooperation, the farmland in each case was broken into fragments to grant access to non-land owners willing to do dry season cultivation. Though a land owner usually got a farm plot slightly higher in size than a non-owner, the average plot size per farmer were 0.055 ha and 0.038 ha at the Baare and Winkongo sites, respectively. Adongo *et al.* (2015) reported 0.06 ha as the average land size held by farmers on Doba irrigation scheme. However, Salami *et al.* (2010) expressed concerns about how excessive fragmentation could render farmlands uneconomic.

Effect of excessive land fragmentation was more pronounced at Winkongo, when combined with the effect of the cropping pattern there. An average Winkongo farmer cultivated three (3) different crops on tiny fragments in different locations on the scheme, making the productivity from the scheme to be relatively low.

Table 4: Land Attributes

Land Factor	Percentage (%)	
Accessibility	Baare	Winkongo
Owned	50	30
Lease	50	70
Holding (ha)		
Average size of land per farmer	0.055	0.038
t stat ($p > 0.05$)		

CONCLUSION

Water supply indicators revealed that water was marginally adequate for Baare crops. That is, the combined amount of water supplied from the reservoir and rainfall towards crops growth, tightly matched the amount actually required by the crops. The marginal adequacy of water (especially irrigation supply) available to Baare crops did not negatively impact yields. That notwithstanding, except that the farmers are experienced in deficit irrigation practice and/or can maintain the current supply, a slight upset in the current supply could easily lead to the crops being water stressed.

On the other hand, at Winkongo, RWS value of 2.56 means, approximately two-and-a-half times of the crop water requirement was supplied, and RIS value of 3.17 means irrigation supply was roughly three times irrigation demand, all of these values indicate an opportunity to irrigate more land.

Effect of excessive land fragmentation was more pronounced at Winkongo as the female dominance did not translate into higher productivity (output per unit cropped area, OPCA), even with a fairly high SGVP value. Another most likely factor for the relatively lower land productivity at Winkongo was the cropping pattern. The cropping pattern is the most likely cause of low land productivity. Pest incidence adaptation/control was another reason the farmers said they had stuck with the cropping pattern.

This study therefore recommended that the district's Department of Agriculture office should provide support to the Winkongo farmers in pest control efforts. Age distribution did not play a significant role in the output from the irrigation schemes, as older farmers are too weak to do much work and often sought the help of, or paid, younger people to do specific farming operations. Farm labour was not a limiting factor at the studied schemes, as a high percentage of the youth was engaged in dry season farming.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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