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The Value of Irrigation Water Reservoirs for Tomato Production in the Upper East Region of Ghana

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ABSTRACT

Improving crop water productivity is one among the strategies for addressing water scarcity in Sub-Saharan African countries. However, existing studies on water productivity rarely consider other factors of production such a labour and non-water inputs resulting to over estimation of the productivity of water. This study was conducted to assess the value of irrigation water for tomato production at Tono and Dorongo schemes. A residual imputation method was used to determine the value of irrigation water for tomato production. Semi-structured questionnaire was administered to 60 irrigator's households from each of the study sites to collect data on farm inputs (capital, labour and non-water inputs), crop yield and market price for dry season irrigated tomato. The agricultural asset price index (API) of five years (2000-2005) was constructed and used to estimate farmer's capital using the 2000 as base year. Labour and cost of labour was estimated using reported work hours and hired labour charge in the study area. Quantities and unit cost of inputs reported by farmers were used to estimate costs of farming inputs. The total revenue was estimated using farm gate prices and the quantity of tomato harvested. The return to management was assumed 5% of the total revenue. The estimates of irrigation water use from previous studies in the two sites were adopted and used to determine the value of water. The economic return to water represented 58% and 64% of the total revenue for tomato production at Tono and Dorongo schemes respectively. The high economic return underscored the importance of water for dry season irrigation in the two study sites respectively. Considering the different water use components, the value of water ranged from 0.20US$/m^3 to 0.38US$/m^3 at Tono and 0.31US$/m^3 to 0.48US$/m^{3}at Dorongo respectively. The water use under the actual evapotranspiration represented good indicator of the value of water at Tono because of potential reuse of surface and groundwater losses downstream of the scheme while the irrigation water use was a good indicator of the value of water at Dorongo. The value of water for tomato production in this study was far higher than the values of high water consumptive crops such as rice in the region. There is a potential to improve the value of water especially at Tono scheme through reduction of surface and ground water losses.

Keywords: Ghana, Reservoir irrigation water, Sub-Saharan Africa, Value of water, Water productivity

INTRODUCTION

Existing projections on global water availability indicate that most Sub-Saharan African (SSA) countries will experience economic rather than physical water scarcity by 2025 (IWMI, 2000, WWC 2000). A country with adequate water resources but lacking economic capacity to develop water infrastructure to supply water is referred as economically water scarce, whereas a country with insufficient water resources to support its population is regarded to experience physical water scarcity (IWMI, 2000). Ghana is one among the SSA countries which is likely to experience economic water scarcity by 2025. However, geographically disadvantaged settings within the country such as Upper East Region (UER) often face severe physical water scarcity far beyond what is suggested by the national average per capita water resources of

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2,489m^3/person/year (Namara *et al*., 2011). Environmental change, population increase and economic development under constant resource base are among the key drivers for increased water scarcity in developing countries (Qadir *et al*., 2007; Rijsberman and Manning, 2006).

Improving water productivity (WP) is identified as one among the important strategies for addressing water scarcity (Mdemu *et al.*, 2009). Increases in WP and expansion of irrigated areas are required to account for half of the long-term increase in global water requirements for a food supply to ensure food security of the projected population of 9 billion people by 2050 (Tropp *et al.*, 2006). However, poor performance of irrigation schemes and negative environmental impacts associated with irrigation investment in the past have discouraged investments on large scale irrigation schemes (Kadigi *et al*., 2012). Increases of water productivity by 30% and 60% in rain-fed and irrigated agriculture respectively are required in order to meet demands for food security by 2025 (Cook *et al.*, 2006; Rijsberman and Molden, 2001).

A number of studies on water productivity have been conducted in the Upper East Region (UER) (Mdemu *et al.*, 2009, Ofosu *et al.*, 2010, Faulkner *et al.*, 2008). However, these studies focused on understanding of the physical water productivity with less consideration of other factors that contribute to water productivity. It is further recognized that physical water productivity (WP) is a useful metric for identifying levels of water system performance and potential strategies for improved water management (Mdemu, 2008). The contribution of non-water input factors in irrigated agriculture, which are also important for WP improvement are not always explicit in most of physical WP expressions (Wichelns, 2002). Wichelns (2002) emphasize the importance of considering other factors such as labor, capital and management in the assessment of strategies for improving the value of water. The knowledge of factors contributing to the total value of production is important for understanding the value of water in irrigated agriculture. This study focuses on the assessment of the value of irrigation water from two contrasting irrigation schemes in terms of size, but with similarities in terms of crops produced and irrigation technologies applied.

DESCRIPTION OF THE STUDY AREA

Location

This study was conducted in the UER. The region is located on the north east corner of Ghana between latitudes 10°30' to 11° North and longitudes 0° to 1°30' West. The UER cover a land surface area of 8860 km^2 within the White Volta River Basin. Tono and Dorongo representing large and small scale irrigation schemes respectively were identified during the 2005/2006 dry season for determination of the value of water for tomato production. The two schemes are very distinct in terms of size (i.e., 2500 ha of irrigation for Tono versus 10 ha for Dorongo respectively) and management but have similarities in terms of types of crops grown and the irrigation technologies used.

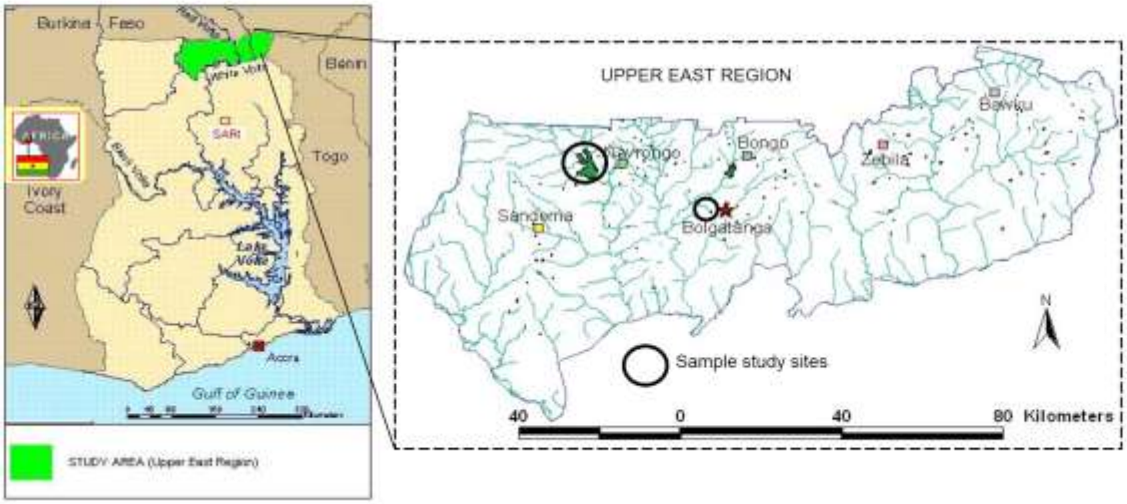

Figure 1: Location of the study area in the Upper East Region, Ghana (Source: Mdemu *et al.*, 2009).

Climate, soils and drainage

The study area is characterized by mono-modal rainfall pattern. The rainy season in the area is confined between May and September with peak rainfall occurring in late August or early September. Rainfall is erratic and spatially variable. Average annual rainfall ranges from 700 to 1010 mm per year. However, the annual evapotranspiration is generally twice the annual precipitation. Therefore, water storage reservoirs provide an important source of water supply during the dry season. Temperatures in the region are consistently high. March and April are the hottest months, while August is the coolest month in a year. Relative humidity is high during the rainy season and low during the dry season. Wind speed is low, varying between 0.4 and 3 m/s. The region is characterized by high sunshine from October to November and from February to May. Sandy clays, clay loam and sandy loam are the main soil types found in the study area. The area is drained by the White Volta River drainage basin.

Socioeconomic conditions

Agriculture employs more than 80% of the population in the UER, making the sector key to socio-economic growth in the region. The UER is one the three northern regions with highest poverty levels in Ghana (Sandoff, 2011, Gyasi, 2005). The irrigation schemes are vital for increasing food security and rural income by providing water for dry season farming, livestock use and fishery, which are the main sources of cash income for rural households in the region (Gyasi, 2005). Food crops and high-value crops such as rice, onions, tomatoes, pepper, and traditional leaf vegetables are produced during the dry season from the irrigation schemes in the area. The irrigation of tomato is the most extensive dry season farming in the area (Ofosu *et al.*, 2010).

Methodology

A total of 120 farmers, 60 from each scheme were interviewed using a semi-structured questionnaire between March and April in 2006 during the dry season crop production. A stratified random sampling approach was used to select the farmers from the famer's roster and other factors including farm location in schemes, irrigation technology and periods of planting. The agricultural asset price index (API) of five years (2000-2005) was constructed and used to estimate farmer's capital using the 2000 as base year. The fixed water levy per hectare paid by each farmer at the two sites was used as a proxy of the value of land.

The labour input in terms of mandays for irrigation activities were estimated from reported work hours. A labour charge of ¢5,000 (0.55US$)-¢10,000 (1.11US$) reported by farmers in the study area was used to estimate the cost of labor use for irrigation activities. Rental rates for agricultural machinery from machinery operators, and purchase of inputs such as seeds and agro-chemicals as reported by farmers were used to estimate the cost of farming inputs. The total revenue for each farmer was estimated by summation of the revenues obtained from the determined number of tomato harvests per season. The revenue for each tomato harvest was estimated as product of yield and farm get price reported by the farmers. Five percent of the total revenue was assumed to represent return to management (Young, 2005). The collected questionnaire data were analysed using SPSS statistical package version 14.0. The analysis included frequencies, descriptive statistics and the T-test for the value of water.

The value of irrigation water for tomato production was determined using the residual imputation method (Young, 2005, Kadigi *et al*., 2004). For a single product of tomatoes, *Y*, produced by the factors of production: capital (K), labor (L), other inputs (Z) and water (W), the production function can be defined (Eq. 1):

$$Y = f(K, L, Z, W) \qquad (1)$$

Assuming competitive factor and product markets, prices may be treated as constants (constant returns to scale). By the second postulate of the residual imputation method (Eq. 2) can be written:

$$TVP_Y = (VMP_K \times Q_K) + (VMP_L \times Q_L) + (VMP_Z \times Q_Z) + (VMP_W \times Q_W) \qquad (2)$$

Where:
TVP is the total value product Y, VMP is the value marginal product of resource *i* and Q is the quantity of resource *i*. The first postulate of the residual method, which states that $P_i = VMP_i$ allow the replacement of P_i into (Eq. 2), which after rearranging gives (Eq. 3):

$$TVP_Y - [(P_K \times Q_K) + (P_L \times Q_L) + (P_Z \times Q_Z)] = P_W \times Q_W \qquad (3)$$

When all the variables in (Eq. 3) are known, the unknown P_W can be solved to impute the value of the residual claimant (water) P_W (Eq. 4):

$$P_W = \frac{\{PVP_Y - [(P_K \times Q_K) + (P_L \times Q_L) + (P_Z \times Q_Z)]\}}{Q_W} \qquad (4)$$

Pw is the contribution of water to the total revenue of tomato production after exclusion of all other factors of production. It can also reflect the decisions on allocation of irrigation by the irrigation managers in the study area.

RESULTS AND DISCUSSIONS

Characteristics of farm plots

The average farmers plot size during the study period was 0.7 ha for Tono and 0.2 ha for Dorongo, respectively. At Tono, about 17% of the respondents had plots smaller than 0.4 ha, while 73% of the farmrs had plots varying from 0.4 to 1.42 ha (Table 1). Only 10% of the respondents had plots which were larger than 1.42 ha. At Dorongo, 62% of the farmers had plots varying between 0.09 and 0.28 ha while 28% of the farmers had plots which were smaller than 0.08 ha. Only 10% of the farmers farmed plots that were larger than 0.28 ha. Farmers with more than 1 ha plots in Tono represented 10% of the surveyed farmers. In Dorongo scheme, 10% of the farmers had farm plots which were above 0.3 ha.

Table 1: Distribution of irrigated plots at Tono and Dorongo

Tono		Dorongo	
Plot size (ha)	% of farmers	Plot size (ha)	% of farmers
<0.4	17	<0.08	28.3
0.4-1.42	73	0.09-0.28	61.7
1.43-2.44	5	0.29-0.49	6.7
2.45-3.47	3	0.5-0.69	3.3
>3.48	2	Total	100
Total	100		

Farm plots allocated for irrigation in the UER are generally small. Bacho and Bonye (2006) reported average plots for dry season irrigation to vary between 0.12 ha and 0.4 ha per household for small reservoirs in the region. Similarly average plot sizes from 0.2 to 2 ha were reported for Tono and Vea irrigation schemes (Dittoh, 1998). In this study, much smaller plot sizes of less than 0.2 ha were recorded at Dorongo irrigation scheme. The sub-division and sharing among farmers of 1 ha plot at Tono reflected the capital requirements for irrigated plots of 1 ha and above. Tomato production is one of the capital intensive enterprises in the UER (Clotey *et al*., 2009). The farmers also shared the water levy and the costs of machinery for land preparation. Plot size is one of the important characteristics for dry season irrigation in the study area. The irrigated plot size reflected the resources needed to manage the farms. The larger the plot size, the more resources was required to manage the irrigation farming in the area.

Irrigation technology and use of farm inputs

Majority of the farmers in the two study schemes depend on surface canal irrigation technology to irrigate their plots in the dry season. Ninety percent (90%) of the farmers at Tono depended on surface canal irrigation while 7% of the farmers used pumps to pump water for irrigation from the drainage canals in the scheme. Three percent (3%) of the farmers combined both surface canal irrigation and pumped water from drains to irrigate their plots. The plots which relied on pumped irrigation water were located in areas that do not have access to surface canal irrigation. These areas were not laid-out and leveled when the scheme was developed.

Sixty eight percent (68%) of the farmers at Dorongo used surface canal irrigation while 22% and 10% in the same scheme used pumps and a combination of surface and pumped irrigation water, respectively. Increased number of irrigation water pump users at Dorongo as compared to Tono was attributed by pump sharing practice among farmers as opposed to ownership of pumps. Mean fuel use for pump irrigation was 61.7 and 72 l/ha at Tono and Dorongo, respectively (Table 2). The mean fuel use was similar between the study sites because only 8.5% and 27% of the farmers at Tono and Dorongo respectivelty could afford pumping water for irrigation.

Table 2: Farming inputs at Tono and Dorongo schemes

Input	Tono			Dorongo		
	N	Mean	s.d.	N	Mean	s.d.
Plot size (ha)	59	0.75	0.78	60	0.16	0.13
Fuel use (l/ha)	5	61.75	37.83	18	72.45	21.12
Seed use (kg/ha)	58	0.20	0.05	60	0.24	0.04

Fertilizer use (kg/ha)	58	472.79	154.25	60	495.43	68.73
Pesticides (kg/ha)	57	4.04	2.25	60	4.08	1.57

The average tomato seed use was 0.20 kg/ha and 0.24 kg/ha at Tono and Dorongo respectively. The tomato variety *Pectomech VF* was the preferred variety at both sites, followed by a combination of *Pectomech* and a *no-name* variety at Tono, and only a *no-name* at Dorongo. "*No name*" is a common trade name of tomato variety in the study area which is also believed to be "*Pectomech* (Robinson and Kolavalli, 2010). The seeds were being purchased in packages (100 grams) from retailers at Bolgatanga Town.

The mean fertilizer application was 472.8 kg/ha and 495.4 kg/ha at Tono and Dorongo, respectively. A combination of NPK (15:15:15) and Sulphate of Ammonia (SA) was commonly applied by tomato farmers in the UER with a varying application frequencies per season. All surveyed farmers at Tono applied chemical fertilizer twice during the season. In Dorongo, 90% of the farmers applied the fertilizers twice while the remaining 10% applied the fertilizers once or thrice per crop season. The slightly higher application rate of fertilizer at Dorongo was mainly attributed to the problem of estimates and purchase of correct quantities of inputs on small plots by the farmers. The application of incorrect quantities of fertilizers was influenced by low level of knowledge among the farmers on fertilizer application.

Past recommended fertilizer application rates for irrigated tomato farming based on soil surveys at the Tono and Vea schemes were 50, 120, and 120 kg/ha for N, P_2O_5, and K_2O, respectively (Thalm, 1988). The results from the survey showed that farmers applied equal amounts of NPK and SA. From the average fertilizer use, the application rates are estimated at 89, 37, and 37 kg/ha for N, P_2O_5, and K_2O, respectively. The application rate for N was in excess compared to the recommended rate of 50 kg/kha, while P_2O_5, and K_2O application rates were far below compared to recommended rates of 120 kg/ha. The fact that majority of soils in the UER contain available P and available exchangeable K below the critical ranges (Thalm, 1998), the application of unbalanced quantities of fertilizers could have negative effects on the uptake of nutrients by crop plants resulting in lower crop yields and water productivity.

The mean pesticide application was 4.04 kg (or l/ha) and 4.08 kg/ha (or l/ha) for Tono and Dorongo schemes respectively. Common pests included *nematodes*, *amphids*, *whitefly* and *caterpillar*, while *early and late blight*, *fusarium*, *bacterial wilt*, and *fruit rot* were the major tomato diseases in the study areas (Asare-Bediako *et al.*, 2007). The pesticides applied in the study area were derivatives of Dichloro-Diphenyl-Trichloroethane (DDT) and were available under various trade marks (Table 3). The pesticides were applied in combination with foliar fertilizers such as Harvest-more, Cropmax and NPK (19:19:19) in order to boost production of crops.

Table 3: Brands of pesticides and foliar fertilizers applied in the study area

DDT Brands reported as insecticides	DDT Brands reported as fungicides	Commonly applied foliar fertilizers
PAWA 2.5EC	Diothine	Harvest-more
Karate	Saiden Supper	NPK 19:19:19
Supton	Coside	Cropmax
Super force/Grow force	Champion	
Tireness	TOPSON/W10	
	Diosere/ Dioxin	

About 82% of the respondents applied fungicides twice or thrice at Tono, while at Dorongo the majority (78%) applied the fungicides three times or more per farming season. The farmers applied insecticides three times or more due to high incidence and severity of pests and diseases.

Cost of production

The mean capital at Tono was twice than Dorongo. Although minimum capital for both sites was similar (i.e, 6700 ¢/ha), maximum capital at Tono was about four times that of Dorongo. This condition indicates that, there were more capital diverse farmers at Tono than Dorongo.

The costs of seeds, fertilizers, pesticides and fuel (for pumped water irrigated plots) were uniform among farmers within the study sites but higher costs were recorded in Dorongo compared to Tono. The high cost of inputs used at Dorongo reflected over application of farm inputs especially fertilizer. The problem of excessive input use was attributed to challenges of correct input management for small irrigated plots (<0.1 ha).

At Tono, the cost of tractor plowing during the study period was 500,000 ¢/ha (55US$/ha). The mean value of 441,000 ¢/ha (49US$/ha) was charged for tractor-and oxen- or bullock-plowing at Dorongo. The water levy was about 548,000 ¢/ha (61US$/ha) and 200,000 ¢/ha (22US$/ha) at Tono and Dorongo, respectively. The levy was meant to support operation and maintenance of the irrigation infrastructures especially the irrigation canals.

Table 4: Cost of farm inputs per ha at Tono and Dorongo

Variable	Tono			Dorongo		
	N	Mean (x 1000)	s.d (x 1000).	N	Mean (x 1000)	s.d. (x 1000)
Capital (cedis)	60	252	504	60	133	136
Seeds (cedis/ha)	58	210	53	60	247	36
Fertilizers (cedis/ha)	58	1702	555	60	1947	1220
Pesticides (cedis/ha)	57	364	197	60	405	145
Fuel (cedis/ha) +	5	497	305	18	507	148
Plowing (cedis/ha)	56	500	0	38	441	100
Water levy (cedis/ha) *	58	548	0	60	200	0

+All pumps are assumed to use petrol as fuel; price during the time of the study was 7000 cedis/l,
* Proxy value of land

The mean total labor use was 80.6 and 77.3 mandays/ha at Tono and Dorongo respectively. The equivalent costs of the labour input were 806,000¢/ha (89.3US$/ha) and 691,000¢/ha (76.5US$/ha) at Tono and Dorongo, respectively. Irrigation, harvesting, land preparation, transplanting, weeding and mulching were the main labour intensive activities at the two study sites. Irrigation and harvesting together accounted for 46% and 39% of the total labor costs for Tono and Dorongo schemes, respectively. The cost of these activities was lower at Dorongo compared to Tono scheme due to low labour charge per manday for harvesting at the former than the latter scheme. The labour charge at Dorongo was only 50% of the labour charge in Tono. The cost of labor for land preparation, transplanting, weeding and mulching together contributed 43% and 50% of the total cost at Tono and Dorongo respectively. Activities such as nursery raising, fertilizing, pesticide application and lifting of plants require less labor, all together accounting for 11% and 10% of the total labour use at Tono and Dorongo, respectively. The labour cost for nursery preparation, fertilizing, pesticide application, and lifting of plants accounted to 11% of the total labour cost in both sites.

Crop yield, revenue and share of production inputs

The average crop yield was 16 tons/ha and 12 tons/ha at Tono and Dorongo, respectively. Crop yield variation within the schemes was high (2 - 84 tons/ha for Tono and 2 - 42 tons/ha for Dorongo). The maximum crop yield at Tono was double the maximum crop yield at Dorongo. Crop yield varied between 2 tons/ha and 84 tons/ha at Tono and between 2 tons/ha and 42 tons/ha at Dorongo. The total revenue per hectare ranged from 2.03 to 129.5 million cedis at Tono and from 3.12 to 104.83 million cedis at Dorongo. The average revenue between the study sites was not different in spite of higher maximum revenue at Tono compared to Dorongo. The high maximum revenue at Tono reflected isolated cases of high crop yield within the scheme. The crop yield directly contributed to the total revenue from tomato farming in the study areas. Crop yield and total revenue were more variable at Tono compared to Dorongo due to the influence of factors such as levels of inputs, effects of pests and diseases, crop timing and market fluctuations of harvested tomatoes.

Table 5: Crop yield, total revenue and per hectare share of production inputs

Variable	Tono			Dorongo		
	N	mean	s.d	N	mean	s.d
Yield (tons)	58	15.93	15.53	60	11.96	8.69
Total revenue (million ¢)	58	24.41	25.26	60	23.13	21.38
Capital (million ¢)	58	2.70	2.79	60	1.13	1.04
Labor (million ¢)	58	1.72	1.78	60	1.39	1.28
Other Inputs (million ¢)	58	5.83	6.03	60	5.76	5.33
Return to water (million ¢)	58	14.16	14.65	60	14.85	13.73

The contribution of capital, labour and non-water inputs to the total revenue were 11%, 7% and 24% for Tono and 5%, 6% and 25% for Dorongo, respectively. The contribution of capital at Tono was two times higher compared to Dorongo. About 73% of the farmers at Tono had tomato plots with plot size of 0.4 ha to above 3.4 ha. The plots of these sizes required capital in terms of farm assets (e.g., tractor, oxen-ploughs, irrigation water pump) for irrigation farming. The contribution of labour to the total revenue was small at both sites because labour was highly under-paid for all farm activities that required labour input. The average labour charge was about one dollar per labourer a day which was less than the official minimum wage rate of ¢11,000 (1.22US$) for Ghana during the study period. The contribution of farm inputs to the total production was almost the same at the study sites. Economic returns to water at Tono and Dorongo were also similar but with a slightly increased spread at Tono compared to Dorongo. Overall, the return to water clearly underscores the contribution of water among the factors of production for tomato.

Estimated value of irrigation water

The economic return to water was about 58% and 64% of the mean total revenue at Tono and Dorongo, respectively (Table 6). A high economic return to water signified the importance of water for dry season tomato farming. The crop transpiration (T) water use recorded high estimates of the value of water at Tono (3442.69 ¢/m^3 or 0.38 US$/$m^3$) and Dorongo (4352.95 ¢/m^3 or 0.48 US$/$m^3$) respectively compared to values based on actual evapotranspiration (ETa), crop evapotranspiration (ETc), and irrigation (I) water use components. Although the value of water based on consumptive transpiration would have been economically favorable, the underlying assumption, that water supplied to crop plants will only meet transpiration is technically not feasible under most current surface canal irrigated schemes. This is because the groundwater losses, evaporation from soil surfaces constitutes a part of irrigation water requirements. Therefore, the estimate of the value of water based on T is theoretical which considers T as the only water flow in an agricultural field through the crop plant (Bowman, 2007). The estimated value of water based on consumptive ET is in general a primary target required to be attained by water management strategies under plot, farm and irrigation scheme scales. The values of water based on ET_a and ET_c were higher at Dorongo compared to Tono due to low return to water, prolonged crop cycle and high water use.

Table 6: Estimated value of water for tomato irrigation

Item		Tono		Dorongo	
		¢/ha	US$/ha	¢/ha	US$/ha
Total revenue		24,413,549	2704	23,126,008	2561
Cost of non-water inputs		10,253,777	1136	8,278,085	917
Return to water		14,159,771	1568	14,847,923	1644
*Average value of irrigation water per:		¢/m^3	US$/m^3	¢/m^3	US$/m^3
	T	3442.69	0.38	4352.95	0.48
	ET_a	2885.33	0.32	3127.85	0.35
	ET_c	2730.91	0.30	3076.01	0.34
	I	1796.93	0.20	2779.21	0.31

*T, ET_a, ET_c and I are average values adopted from Mdemu *et al*., (2009)

The exchange rate used was 1US$ =9030 ¢.

The irrigation water (I) for the tomato plot accounted for actual crop water consumption and groundwater losses to the ground, which were both regarded as depletive at plot scale. The increasing amount of irrigation use resulted to low values of water at Tono (1796.9 ¢/m^3 or 0.20 US$/m^3) and Dorongo (2779.21 ¢/m^3 or 0.31 US$/m^3) respectively.

In this study, irrigation water use was considered a good indicator of the estimated value of water at Dorongo, since part of the water lost due to groundwater percolation could not be reused within and downstream the scheme. Downstream flows in the scheme did not exist for more than half of the dry season farming period. Although such ground water losses could have been contributing to the main groundwater body that supplies, among others the domestic water in traditional and pumped boreholes, it was a lost resource from the individual farmer's point of view. However, at Tono, the value of water based on actual evapotranspiration was a good indicator because of potential reuse of surface and deep percolation losses occurring at field and farm levels. Apart from reuse, the drains also contribute to in-stream flows maintaining the river ecosystem functions in the downstream of the river. The estimated values of water for all water use components were not significantly different at the 5% significance level between Tono and Dorongo respectively. The values were significantly different at the 5% significance level within the schemes.

The obtained value of irrigation water in this study was relatively higher than values of water reported from literature under similar environmental conditions. The values of 0.14-0.18 US$/m^3 were obtained under tomato irrigation in the semi-arid areas of the southern highlands in semi-arid in Tanzania (Hermans et al., 2006). Values of 0.2 US$/m^3 and 0.4 US$/m^3 were obtained under surface and drip irrigated tomatoes semi-arid Mediterranean region (Laquet *et al*. 2004). The obtained values of water under this study were high compared to values of water consumptive crops such as rice. However, methodological differences from which the values of water are determined may seriously limit any meaningful comparison between the water valuation studies.

CONCLUSION

The economic returns to water at both sites were above 50% of the total production. This condition indicates the importance of irrigation water for dry season tomato farming. The value of water showed a decreasing trend from consumptive transpiration to the amount of irrigation water use. The values of water were not significantly different between the study sites at 5% significance level based on transpiration, actual and crop evapotranspiration and irrigation water uses. The values, however, significantly differed within sites under the same significance level and water use components. The slightly lower return at Tono as compared to Dorongo suggested that improvement in water use efficiency through improved water management would have positive contribution on the value of water at the former compared to the later.

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REFERENCES

Asare-Bediako A., Showemimo, F.A., Buah, J.N. and Ushawu, Y. (2007). Tomato Production Constraints at Bontanga Irrigation Project in the Northern Region of Ghana. *Journal of Applied Science* 7 (3) 459-461.

Bacho, Z.L. and Bonye, S. (2006). From public open access to common property: The prospects and challenges of institutionalizing boundaries for self-governance and management of community irrigation dams in the Upper East Region, Ghana. *Ghana Journal of Development Studies* 3(1):102-118.

Cook S., Gichuki, F. and Turral, H. (2006). Agricultural Water Productivity: Issues, Concepts and Approaches. *Basin Focal Project Working Paper No. 1*. http://waterandfood.org/.../CPWF_Documents/Documents/Basin_Focal_Projects/BFP_restricted/Paper_1_Final_14JY06.pdf. Cited on 3 March 2014.

Dittoh, S. (1998). Towards sustainable irrigated agriculture: The case of large and small systems in upper east Region, Ghana. *Condensed final research report submitted to African rural social sciences research networks (ARSSRN) and Winrock International*, Department of Agricultural Economics and Extension. University for Development Studies, Nyankpala Campus, Tamale, Ghana.

Faulkner, J.W., Steenhuis, T., van de Giesen, N., Andreini, M., Liebe, J.R., (2008). Water use and productivity of two small reservoir irrigation schemes in Ghana's upper east region. *Irrigation and Drainage* 57, 151–163.

Gyasi, K.O. (2005). Determinants of Success of Collective Actions on Local Commons: An Empirical Analysis of Community-Based Irrigation Management in Northern Ghana. *Peter Lang*, Vol. 49.

Hermans, .L. M., van Halsema, G. E. and Mahoo, H. F. (2006). Building a mosaic of values to support local water resources management. *Water Policy* 8 (2006) 415–434.

International Water Management Institute (IWMI) (2000). World Water Supply and Demand: 1995 to 2025. Colombo, Sri Lanka: International Water Management Institute. http://www.iwmi.cgiar.org/pubs/WWVisn/WWSDPdff.htm. Cited 25.03.2014.

Kadigi, R.M.J., Kashaigili, J. J. and Mdoe, N. S. (2004). The economics of irrigated paddy in Usangu Basin in Tanzania:water utilization, productivity, income and livelihood implications. *Physics and Chemistry of the Earth* 29: 1091–1100.

Kadigi, R.M.J., Tesfay, G., Bizoza, A. and Zinabou, G. (2012). Irrigation and water Use efficiency in Sub-saharan africa. Policy Research Paper 4. GDN, New Delthi.

Luquet, D., Vidal, A., Smith, M., Dauzat, J., (2004). More crop per drop: how to make it acceptable for farmers? *Project INCO-WADEMED*, Actes du Seminaire Modernisation de l'Agriculture Iriguee, Rabat.

Mdemu, M., (2008). Water Productivity in Medium and Small Reservoirs in the Upper East Region of Ghana. *PhD Dissertation*. Rheinischen Friedrich, Wilhelms, Universität zu Bonn, Bonn.

Mdemu, M.V.; Rodgers, C.; Vlek, P.L.G. and Borgadi, J.J. (2009). Water productivity (WP) in reservoir irrigated schemes in the Upper East Region (UER) of Ghana. *Physics and Chemistry of the Earth* 34(4-5): 324-28.

Ofosu, E.A., van der Zaag, P, van de Giesen, N.C. and Odai S.N. (2010). Productivity of irrigation technologies in the White Volta basin. *Physics and Chemistry of the Earth*, doi:10.1016/j.pce.2010.07.005.

Qadir, M., Sharma B.R., Bruggeman, A., Choukr-Allah, R. and Karajeh, F. (2007). Non-conventional water sources and opportunities for water augmentation to achieve food security in water scarce countries. *Agric. Water Manage*. 87: 2-22.

Namara, R., E., Horowitz, L., Nyamadi, B. and Barry, B. (2011). Irrigation Development in Ghana: Past experiences, emerging opportunities, and future directions. *Ghana Strategy Support Program Working Paper No. 0027*, IFPRI, Accra Ghana.

Rijsberman, F.R. and Molden, D. (2001). Balancing water uses: water for food and water for nature, thematic background paper. *International conference on freshwater*, Bonn.

Rijsberman, F.R. and Manning, N. (2006). Beyond More Crop per Drop: Water Management for Food and the Environment, *Posta presentation*, 4th World Water Forum, Mexico 16-22 2006.

Robinson, E.J.Z. and Kolavalli, S.L. (2010). Ghana Strategy Support Program (GSSP), The Case of Tomato in Ghana: Productivity, *GSSP Working Paper No. 19*, IFPRI, Washington, DC.

Sandoff, A. (2011). Small-scale agriculture in Bolgatanga, Ghana- a case study of how to make small-scale sustainable agriculture more profitable, *Handelshögskolan* vid Göteborgs Universitet.

Thalm, A. (1988). Report on the analysis, interpretation and fertilizer recommendations of the Tono and Vea Irrigation Projects. *Soil Research Institute*, Kumasi, Ghana

Tropp, H., Falkenmark, M. and Lundqvist, J. (2006). Water governance challenges: Managing competition and scarcity for hunger and poverty reduction and environmental sustainability. *Background paper: Human Development Report* 2006, Water for Human Development.

Wichelns, D. (2002). An economic perspective on the potential gains from improvement in irrigation water management. *Agricure Water Management*. 52: 233-248.

World Water Council (2000). World Water Vision: making water everybody's business. London, *Earthscan Publications*.

Young, R. A. (2005). Determining the Economic Value of Water Concepts and Methods. *Resources for the Future*, Washington, DC, USA.