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Research Article

Willingness to Pay for Improved Water for Farming in the Upper East Region of Ghana

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ABSTRACT

This study examined the irrigation systems practiced in the Upper East Region of Ghana. It also estimated the farmers' willingness to pay for improved access to water for irrigation. Descriptive statistics were used to assess the expenditure incurred in the irrigation systems. Logistic regression approach was used to estimate willingness to pay for improvement in these systems of irrigation. Gravity motorized pumps was used to distribute water and hand-watering with bucket. Were the systems of irrigation practised in the rainy season? Hand watering was also done in the dry season. About 80% expressed willingness to pay for an improvement in their system of irrigation. For recommendation, government should subsidize the price of fertilizer in the study area since the respondents used the input alongside irrigation. Also other bodies and agencies should help improve the system of irrigation in the area by upgrading the existing ones and gradually deducting as part of the cost of water since the respondents were willing to pay for such an improvement.

INTRODUCTION

Water is an essential resource, and the most abundant resource on planet earth. It covers about 70% of the total surface area of the earth. The sources of water are oceans, lagoons, rivers, streams, lakes, wells and boreholes. There are, however, two main classifications of water sources, namely, fresh and salty water bodies. Though it is abundance, access to freshwater is emerging as one of the most critical natural resource issues facing humanity (Helmer, 1992; Falkenmark, 1993 and Feldmann, 1993). From the year 2000 and beyond, the world's population will expand rapidly yet there is no more fresh water on earth now than there was 2,000 years ago, when the population was less than 3% of its current size (PLCPD, 1994).

Ghana is endowed with both ground and surface water resources. The surface water resources are the Volta river system, the South-western river system and the Coastal river system. The Volta river system covers 70% of the total surface area of Ghana. The total annual runoff is about 54.4 billion m^3 of which 38.3 billion m^3 is accounted for by the Volta river system (GWRM, 1998). The Volta River is an international watercourse which is shared by six West African states, namely Ghana, Burkina Faso, Togo, Mali, Cote D'Ivoire and Benin. The economies of Ghana and Burkina Faso depend on the Volta River to a high degree and there is an increase in demand for water for agriculture, domestic use, mining and industrial purposes. Ghana has two hydroelectric power stations on the Volta River. There is an increasing water use by the riparian countries. This is known to cause conflicts amongst themselves; there is the need for countries to cooperate and also establish joint institutions in order to solve the problem. This cooperation is yet to be realized (GWRM, 1998).

It is estimated that there is an excess demand of water of about 655 million m^3 over supply in Ghana currently; this will increase to 46449 million m^3 by the year 2020 (GWRM, 1998). It has also been documented that fresh water is becoming a scarce commodity in Ghana. Also, in the mid fifties per capita available renewable fresh water was 9204 m^3; this declined to 3529 m^3 in 1990 (Karikari, 1996).

The watershed of the Volta basin is one of the poorest areas in Africa (ZEF, 2004). It is known that the average annual per capita income in the region is about $450 though there are some precious minerals found in the basin (Osei-Asare, 2001). Majority of the population depends largely on rainfed and some irrigated agriculture for their living. There is an increasing pressure on the land and water resources because of a high population growth rate of about 3% per annum (*ibid.*).

The Volta basin constitutes a very important national asset of inestimable value. Majority of the country's population live in this area and abounds in natural resources, including the lakes behind the Akosombo and Kpong dams which were constructed to generate hydroelectric power to sustain the national economy (Gordon and Amatekpor, 1999).

Agricultural activities in the Volta basin are coming under siege (Titriku, 1999); the major problems affecting agricultural production in the basin are those related to land degradation resulting from poor land and water management. It is likely that significant amounts of water will be reallocated from agriculture to higher valued domestic and industrial demands; this will lead to a competition among water-using sectors in the Volta basin (Ghana web).

The average annual rainfall in the region is about 430mm compared to 1800mm in the south. There has been a rainfall shortage in the whole basin sometime now leading to a quantitative reduction in water resources (GCI, 2001).

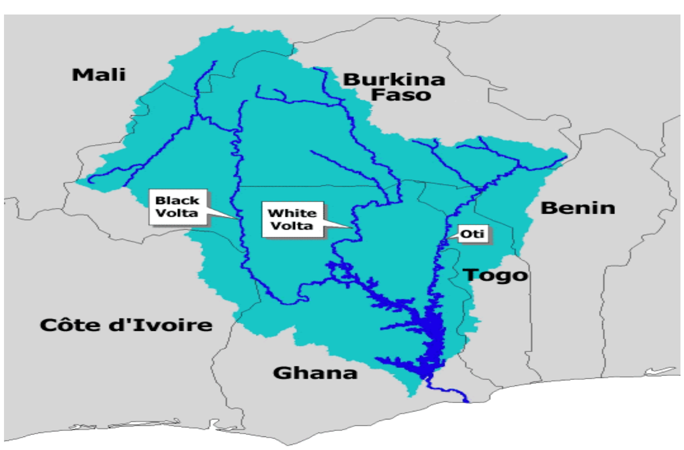

Fig. 1 Map of Ghana showing the Volta Basin.

The basin is in the tropics and has a direct impact of the sun's energy, which causes high evaporation from water bodies and other organic and inorganic matter and also transpiration from plants (GCI, 2001).There is high vulnerability of Basin Rivers to drought because of the high incidence of evaporation and transpiration. Consequently, water availability in the basin is declined drastically. From the foregoing discussion, the following research questions arise:

1 What are the systems of irrigation that farmers in the Upper Volta basin apply?
2 Are farmers willing to pay for strategies that will improve their access to water in the basin for irrigation?

Objectives of the Study

1 Identify the systems of irrigation farmers in the Volta basin in the Upper East Region apply.
2 To estimate farmers' willingness to pay for improved access to water for irrigation

The Concept of Willingness to Pay using Contingent Valuation Method

Willingness to pay for an improved water supply system can be estimated by means of Contingent Valuation Method (CVM). This is done by means of questionnaire administration or by means of interviews in order to gather information from targeted respondents about how much they are willing to pay for the use of an improved system and a specific amount of water for agricultural activities.

Valuation is done for various reasons; one aspect is to know viability and to enable allocation to be at optimum. This is supposed to be done even during implementation and operation period. Valuation of, for example, irrigation water is done so that water charges are introduced to its users. There are many ways of doing this, but it is economically prudent for the economic agents to be allowed to value the goods at stake. Estimation of the value of irrigation water provides evidence on the farmers' ability to pay in implementing cost recovery programmes for such projects (Young and Gray, 1996).

In a perfectly competitive market, the price of a good is taken as the expression of willingness to pay for that particular good by the economic agent. In the absence of a market and hence market prices, the value of a product or an input would be the amount a rational, fully informed user would be willing to pay (Young and Gray, 1996,). In such a situation respondents are offered conditions simulating a hypothetical market.

CVM provides estimates for total economic value of an environmental good or service and the expected revenue from providing a specified level of the commodity. CVM therefore is the most direct approach to get at the willingness to pay for the total value. It captures both use values and non-use values of an environmental good (Tsegabirhan 2004).

CVM is also an ideal approach for generating the value of a good, provided respondents understand and realize the importance of the provision of the good in question fully and answer the willingness to pay (WTP) questions truthfully. This leads to a valid and reliable estimation of an individual's strength of preference for the proposed environmental change.

Study Area

The Upper East Region which harbours the White Volta is situated at the North-Eastern corner of Ghana. The region is bordered to the south by the Northern region, to the north by Burkina Faso, to the east by Togo and to the west by the Upper west region. The region lies between $10^0 15'$ north and within longitude 0^0 and $1^0 40'$ west. It has eight administrative districts which are Bawku East, Bawku West, Bawku Central, Bongo, Talensi Namdam, Bolgatanga, Kassena- Nankana and Builsa. The region covers land area of about 8.842 sq km.

The region is characterized by wet and dry season. The wet season starts from May and ends in October whiles the dry season lasts from November to April. The minimum temperature is about $12.8^0 C$ and it is recorded between December and January, while the maximum temperature is about $42^0 C$ which is recorded between March and May. The mean annual rainfall is between 950mm and 1100mm, occurring between May and October. The rainfall is erratic with irregular spells occurring between June and July. There is a considerable variability in mean annual rainfall and so the region frequently suffers prolong periods of drought with dry season characterized by dry "harmattan winds".

The land in the region is generally flat with gradient ranging between 1% to 5% with few inselberg outcrops and upland with about 10% slope in the eastern and southern parts. The White Volta and the Sissili are the main rivers which form the drainage system in the region. There are dugouts, and dams in the area. The vegetation in the region is mainly Guinea savannah with a small area north of Bawku which fall under Sudan Savanna. The main soil type is Savannah ochrosol and ground water laterite, that are porous, well drained, and loamy with clayey soils.

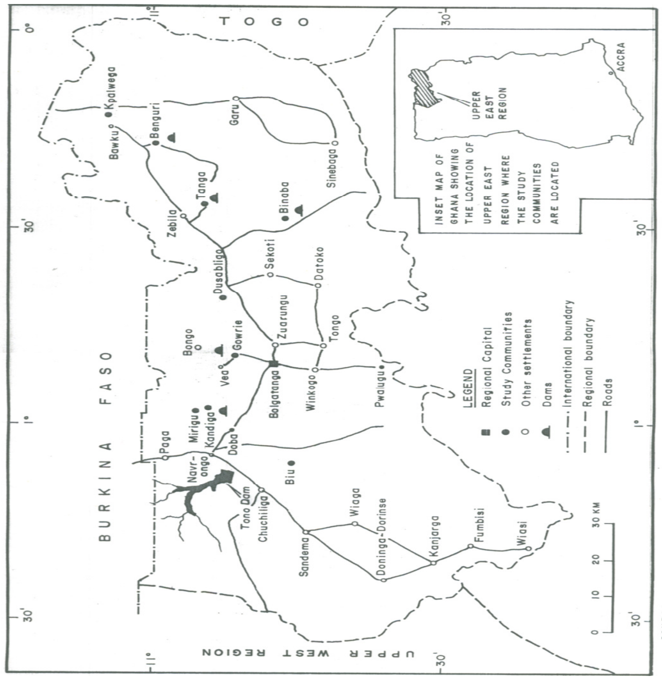

FIG. A MAP SHOWING UPPER EAST REGION, LOCATING THE STUDY COMMUNITIES.

SOURCE: SURVEY OF GHANA – ACCRA

Fig. 2 Map showing the study Area

Theoretical Framework for the Estimation of Willingness to Pay

From the theory of firm behaviour, farmers derive their profit function from the use of inputs such as water for the production of output. Consider that utility function of the farmer is given as:

$$U = u(a, q, z) \tag{1}$$

Here u(.) is the farmer's utility function; a is the vector of probabilities of obtaining higher crop yield as a result of an improved water supply for crop production, q is other inputs used by the farmers. Z is a row vector of background variables (socioeconomic factors). The probability of obtaining a high yield is given as:

$$a = B(w) \tag{2}$$

Where w is the amount of water used. For a single farmer, the objective is to

$$Max\, U = u(q, z)$$
$$st.$$
$$a = B(w)$$
$$p_w w + p_q q = y$$

Where $p_w w$ is the expenditure on water, $p_q q$ is the expenditure on other inputs, y is the farm budget of farmer. Forming the Lagrangian

$$L = u(.) + \lambda_i (a - B(w)) + \lambda_j (p_w w + p_q q - y) = 0 \tag{3}$$

Where λ is Lagrange multiplier. Assuming that the first and second differentials hold then the demand functions for improved water and other resources are as follows:

$$W = w(p_w, p_q, y) \tag{4}$$

$$Q = q(p_w, p_q, y) \quad (5)$$
$$A = a(p_w, P_q, y) \quad (6)$$

Where A (.) is the Marshallian demand function for using improved water; Q (.) is the vector of demand function for all other input except W. Substituting the above equations in (1)

$$V = V(p_w, p_{q,} y) = U[A(W(p_w, p_{q,} y), Q((p_w, p_{q,} y)] \quad (7)$$

Where V is the indirect utility function of a farmer, W(.) is the farmers Marshallian demand function for the use of improved water and Q(.) is the demand function for other inputs. If the farmer is faced with the situation where he has to select from a hypothetical situation with probability a^0 which corresponds with some level of water (improved) use w^0, then the utility can only be maximized over the other inputs q.

The new utility function becomes

$$v^0 = V(b^0, p_{q,}\ y - p_w w^0) \quad (8)$$

Now assuming there is a change from b^0 to b^1, there is a corresponding change of water use from w^0 to w^1 with equivalent cost of water $p_w w$. The utility function changes from v^0 to v^1. This implies that if a farmer is confronted with these situations, he will choose situation (v^1) provided it is as large as v^0. The monetary value of this situation which keeps the farmer on the same utility level is the compensating variation (cv) which is defined implicitly as:

$$V(b^1, y - cv) = v(b^0, y) \quad (9)$$

The aggregate demand for change from situation 0 to 1is given by

$$d = D(a) = 1 - F_{wtp}(a) = prob(WTP \geq a) \quad (10)$$

Where D(a) is the aggregate demand function and F_{wtp} is the cumulative distribution function. Empirically, $\Pr ob(WTP \geq a) = 1 - F_{wtp}$ can be interpreted as the proportion of yes answers given by respondents if they are ready to pay a particular bid *a* for change from situation 0 to 1. This proportion may be estimated using data from contingent valuation method questionnaire

Given that $prob(wtp \geq a) = [v^1(b^1, y - a) - v^0(b^0, y) \geq 0] \cong [\Delta v \geq 0]$ (11)

Then $\Delta v = [\sum_i^m = 1(\partial v(b^0, y) \big/ (\partial bi(b_i^1 - b_i^0)] - (\partial v(b^0, y)\partial y)a \cong \alpha - \beta$ (12)

$$\Rightarrow \Delta v = \alpha - \beta a \quad (13)$$
$$\Leftrightarrow d = \alpha - \beta a \quad (14)$$

This also means that, the $prob(wtp \geq a)$ can be written as:
$prob(\alpha - \beta a \geq 0)$, where α and β are the coefficient to be estimated, introducing I in the equation yields

$$prob(wtp \geq a) = prob(\alpha - \beta a + \theta I \geq 0) \quad (15)$$

and I stands for the variables to be considered. Equation (15) is the model to be estimated for farmers' willingness to pay for improved water.

Specification of Econometric Model for Willingness to Pay

Considering that the probability of willingness to pay for improved water is ρ then that for not willing to pay is given by $1-\rho$. The ratio, $\rho/(1-\rho)$ known as odd ratio, is the odd in favour of those willing to pay. When the natural logarithm is taken, it gives the log of odd ratio, which is estimated by the logit method. The logit model implies that the log of the odd ratio is a linear function of the explanatory variables (Gujarati, 1990).

$$\ln(\frac{\rho}{1-\rho}) = \theta_0 + \theta_1 Hs + \theta_2 NC + \theta_3 Ar + \theta_4 Ed + \theta_5 Sx + \theta_6 Poc + \theta_7 cty + \theta_8 aty + \theta_9 sty + \varepsilon \quad (16)$$

θ: Row vector of coefficients to be estimated, Hs: Household size, NC: Number of other economic activities, Ar: Area of plot under cultivation, Ed: Number of years of education, Sx: Sex of respondents, Poc: Primary occupation, cty: Crop type dummy, aty: Season type dummy, sty: Soil type dummy[1] and ε : The error term.

Logistic regression Results

Logistic regression model was used to estimate effects of factors on farmers' willingness to pay for an improved form of water. The Econometric Views (E-Views) software was used to run the logistic model. The dependent variable, willingness to pay, was specified as a dummy variable, with a value of 1 assigned to respondents who were willing to pay for an improved irrigation system and 0 for those not willing to pay. The independent variables are dummy for crop type, dummy for season, and dummy for soil type dummy for sex dummy for primary occupation, number of years of education, number of other economic activities, household size and size of farm.
The equation to be estimated is:

$$\ln(\frac{\rho}{1-\rho}) = \theta_0 + \theta_1 Hs + \theta_2 NC + \theta_3 Ar + \theta_4 Ed + \theta_5 Sx + \theta_6 Poc + \theta_7 Ct + \theta_8 Dr + \theta_9 St + \varepsilon$$

Where the variables have their usual meaning.

RESULTS AND DISCUSSION

Sample Characteristics

In all, 282 household heads consisting of 90% males and 10% females. Majority of the respondents (99%) were permanent residents of their settlement. Ages of farm household heads range from 16 to 95 years, with mean age of 50 and modal age of 45 years. The survey revealed that 55% of the farmers had not had any form of education. Only 12% of the respondents were middle school leavers. The lack of education could be affecting productivity levels. Afari (2001) has argued that, low productivity in Ghana may be attributed partly to low skilled labour force, illiterate and semi-literate farmers who had persisted in the use of traditional farm implements and methods in farming. Ninety percent of the respondents were farmers. Also, 51% did not engage in any other economic activities, apart from farming, while 45% engage in only one additional economic activity. Household size in the communities ranges from 1 to 16, with mean number of 8. About 60% of the individuals in the communities use firewood as source of fuel. Sixty-five percent of these individuals collect the wood from the bush. Household members, mostly women, use six hours, on average, in search of fuel wood. Tables 1 and 2 present summaries of the means and frequency distributions of some socio-economic factors in the study area respectively.

Table 1 Socio-economic characteristics of household heads (means)

Variables	#	Min.	Max.	Mean	Std. deviation
Age	281	6	95	50	14.8
Years of school	276	0	17	4.5	5.4
Other economic Activity	249	0	7	0.6	0.7
Household size	281	1	16	8	3.0
Time to harvest fuel wood in hours	149	1	720	129	150

Source: Survey data (2005)

Table 2 Socio-economic characteristics of household heads (percentages)

Variables	Total Number	Percent
Female	28	10
Male	253	90
Other settlement (other than the study area)	2	1
This settlement (study area)	278	99
Single household head	28	10
Married household head	253	90
No schooling	151	55
Some schooling	129	45
Non farming activities	28	10
Farming activities	252	90

Table 2: continues

Buy fuel wood from market	38	25
Cut fuel wood from bush	111	75
Time spent (20-120 minutes) in cutting fuel wood	202	72
Time spent(150-720 minutes) in cutting fuel wood	79	28
Engage in dry season agriculture	115	41
Does not engage in dry season agriculture	135	59
Other economic activities (other than farming)	103	41
Only farming activity	149	59

Source: Survey data (2005)

The study conducted identified different types of irrigation systems that are practiced by the communities in the study area (Upper East Region) and also estimated farmers' willingness to pay for improved water system of irrigation using logit regression model.

It was revealed that gravity and bucket irrigation were the main systems that are practised by the respondents. The bucket irrigation was normally carried out by means of boreholes, wells and rivers. It was also found that while gravity was carried out both in the dry and rainy seasons; bucket irrigation was normally practised in the dry season. The study revealed that between 36,000 to17, 370,000 litres with mean of about 108,618 litres per hectare of land of water are used by farmers to irrigate their farm in the dry season.

It was also revealed that, mean value of Gh ¢ 20.50 was spent on irrigation in the wet season per acre (0.4 hectare) of land and mean value of Gh ¢ 11.85 spent per acre (0.4 hectares) in the dry season for agricultural purposes in the area. The total cost incurred was about Gh ¢120.00 per hectare of land in the dry season and about Gh ¢70.00 in the wet season.

The results also showed that 79.5% were willing to pay for an improvement in their system of irrigation, whilst 25.5% of them said they were not willing to pay for an improvement. The amount the respondent said they were willing to pay should their output level increase by

25% ranges from 1.00 to Gh ¢160.00 cedis per household whilst the range lied between 1.50 cedis and Gh ¢ 60.00 cedis per household if their output level increases by 50%.

Empirical results from logistic regression showed that crop type, soil type and agricultural activities were significant determinants of willingness to pay for improvement in the irrigation system. Crop type and agricultural activities met the *a priori*, expectation (positive). Soil type however did not meet the *a priori* expectation. It exhibited negative sign.

The results from Table 3 below showed that the constant term, crop type, soil type, and season dummies significantly affect willingness to pay. The effects of sex, primary occupation, household size, education, area under cultivation and other economic activities were not statistically significant. Crop type and season dummies met the *a priori* expectation whiles soil type did not meet the *a priori* expectation. This meant that farmers who were into dry season farming and also water-loving crops were more willing to pay for such an improvement. Like it was stated above, farmers will always use water for dry season agriculture and especially if they are water-loving crops like tomatoes, melon ,onions and garden eggs; farmers therefore were willing to pay for such improvement since there was no other option. The negative coefficient of soil type meant that individuals who cropped on humus soils were less willing to pay for improvement in water than those who farm on sandy and gravelly soils. This may be due to the relatively high water retention capacity of loamy or humus soils. This also meant that farmers attach more importance to sandy soil for irrigation but not necessary loamy, because, additives (both organic and inorganic) were available to give the plants the required nutrients. Surprisingly farmers with higher levels of education were not willing to pay for improved irrigation system. This finding was contrary to the work of Ampadu (2001) who found out that farmers willingness to pay for compost depends on their level of education.

Table 3 Estimated Logistic Model for Willingness to Pay

Variable	Coefficient	z-Statistic	Prob.
C	-2.185496	-2.764265	0.0057
SXDM	0.550735	1.055532	0.2912
HHN	0.063074	1.330838	0.1832
PMROCC	-0.376361	-0.769189	0.4418
S2DQ2A_1	0.048778	0.667357	0.5045
S1Q13_1	0.219460	0.975722	0.3292
S1Q11A_1	-0.031108	-1.055848	0.2910
CTYPED	1.021866	2.726166	0.0064
STYPD	-1.198546	-2.699174	0.0070
DRYSD	1.697551	4.395434	0.0000

Dependent Variable DWTP, McFadden R-squared =18%

Where SXDM- Sex dummy, HHN- Household size, PMROCC- Primary occupation dummy, S1Q13_1- Number of other economic activities, S2DQ2A_1- Area of plot, S1Q11A_1- Years of education, CTYPED -Crop type, STYPD- Soil type, DRYSD- Season type, WTP- Willingness to Pay Dummy. Source: Author's Computation.

CONCLUSION

In conclusion, data analysis show that the respondents are willing to pay for improvements in their irrigation system since thy rely mostly on manual method; they have no option than to use that method because of the long dry season in the area coupled with the water loving nature of their crops. These suggest that, for the production of some major crops all year round in the area and for that matter, the country as a whole, the system of irrigation in the study area must be improved upon, by doing so, other problem like migration for non-existing jobs by the respondents elsewhere may be minimized.

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