THESIS

ESTIMATING FARMERS' WILLINGNESS TO PAY FOR IMPROVED IRRIGATION: AN ECONOMIC STUDY OF THE BONTANGA IRRIGATION SCHEME IN NORTHERN GHANA

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ABSTRACT

ESTIMATING FARMERS' WILLINGNESS TO PAY FOR IMPROVED IRRIGATION: AN ECONOMIC STUDY OF THE BONTANGA IRRIGATION SCHEME IN NORTHERN GHANA

This thesis estimates the willingness of farmers under the Bontanga Irrigation Scheme (BIS) in Northern Ghana to pay for improved irrigation services. The Contingent Valuation Method (CVM) was used in this study and farmers were randomly selected for interviewing based on the location of their farms (upstream, middle, and downstream) within the scheme. The payment card elicitation format was used and the data were analyzed using Maximum Likelihood Estimation (MLE) procedure that is capable of accommodating the intervals in payment card data. The mean willingness to pay was found to be GHC 16.32 (US$ 8.50) per ha per year and the median was GHC 14.00 (US$ 7.29) per ha per year.

Tobit regression model was also used to estimate the mean number of labor days farmers under the scheme would be willing to contribute to improve the project. The mean labor days was found to be 5.26 days per year and the median was 5.28 days per year.

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DEDICATION

To my lovely mother, Mma Ayi, for her unwavering support and inspiration over the years.

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CHAPTER ONE: INTRODUCTION

The main objective of this thesis is to estimate willingness of the beneficiary farmers of the Bontanga Irrigation Scheme (BIS) in Northern Ghana to pay for improved irrigation using contingent valuation method (CVM). The steps involve surveying the representative sample of the total number of farmers based on the locations of their farms (upstream, middle, and downstream) in the scheme. The payment card (PC) method is used to elicit the farmers' willingness to pay (WTP) and the results are analyzed to determine the relationship between WTP and other variables that affect demand including the characteristics of the respondents using the Maximum Likelihood interval techniques.

1.1 Overview of Impacts of Rain-fed Agriculture on the Economy of Ghana

Agriculture is the main source of employment in Ghana. It accounts for the largest share of the Gross Domestic Product (GDP) of Ghana. However, its share of the GDP declined from over 44 percent in 1990 to about 37 percent in 2005 (MOFA, 2007), to about 31 percent in 2009, and further down to about 30.2 percent in 2010 (MOFA, 2011; World Bank, 2012). One would have thought that the decline in agriculture's share of the GDP is due to increases in output from other sectors (industries and services), but that is not the case. Agriculture's GDP growth rate in 2007 decreased by 1.7% and that of crops sector contribution to agriculture's share of the GDP decreased by 1.3%. And from 2009 to 2010, agriculture's GDP growth rate decreased by about 26% and the crops sector contribution decreased by about 50% (GSS, 2011). Several factors contribute to the gradual decline of the agricultural productivity in Ghana and the over-dependence of the country on rain-fed agriculture may be one of them.

The average annual rainfall in Ghana ranges from 800mm to 2400mm and said to vary on inter-annual and inter-decadal timescales. The Northern part of the country registers the lowest annual rainfall while the southern part of the country registers the highest annual rainfall. The entire country has two major seasons, rainy and dry. The Northern part has two seasons, the rainy season which starts somewhere in April and ends somewhere in mid September, followed by a prolonged dry season. The southern part has two rainy seasons: from April to June, and from early September to ending of October. Due to variations in the annual rainfall of Ghana, reliance on rain-fed agriculture can contribute to the economic decline of the country. Among the expected consequences of climate change, crop yield from rain-fed agriculture in most African countries is expected to decrease by 50% by the year 2020 (IPCC, 2007). To mitigate this expected consequence of global change, not just irrigation but improved irrigation is necessary to supplement the commonly rain-fed crop production in Africa including Ghana. And also, for Ghana to achieve solid economic growth, reduce poverty, and ensure food security, the agricultural production in Ghana should not be solely rain-fed.

1.2 Overview of Irrigation Schemes in Ghana

Establishments of public irrigation projects in Ghana date back to the 1960s (Kyei-Baffour and Ofori, 2006). The irrigation schemes were initially established and managed by the Ministry of Food and Agriculture (MOFA). In 1977, the Ghana Irrigation Development Authority (GIDA) was set up by the government for the responsibility of establishing, managing, and maintaining public irrigation schemes. As of 2011, GIDA constructed 22 public irrigation projects in the whole country, covering a developed total land area of more than 6,500 hectares (MOFA, 2011). Another 22 irrigation schemes have been constructed under the Small Scale

Irrigation Development Project (SSIDP), and 6 schemes under the Small Farms Irrigation Project (SFIP). Almost all of the rest of the 28 irrigation projects are small and none covers a total land area of more than 1000 hectares (MOFA, 2011).

The irrigation potential of Ghana is estimated to be between 0.36 and 2.9 million hectares (Namara et al., 2010) which is known to be highly underutilized. Table 1.1 summarizes the developed and irrigated land areas of public irrigation schemes in Ghana. It shows that, even with an estimated developed land area of about 9000 hectares for the public irrigation projects, the level of utilization was about 60% as at 2003 and has even gone worst in recent years. Also, majority of these public irrigation projects are either not functioning properly, or their beneficiaries who are indigenous small-scale farmers always complain of low outputs. The public irrigation projects in Ghana can best be characterized by lack of maintenance and abandonment.

The irrigation systems in Ghana also lack improvements in terms of irrigation technology and availability of irrigation facilities, rendering farmers' unwillingness to invest in irrigated farming. Irrigation charges for the public irrigation schemes are low (25 GHC per ha per season in the case of Bontanga) which are often not even collected because most farmers do not pay them. Underinvestment in the maintenance of the public irrigation schemes leads to eroded dams/reservoir walls, blocked canals and laterals, and siltation, which is a common problem in the gravity type irrigation systems. The lack of improvements or underinvestment in the irrigation systems in Ghana affects the efficiency and sustainability of the irrigation schemes. The poor nature of public irrigation schemes in Ghana including poor irrigation technology, lack

Table 1.1 **Public Irrigation Schemes in Ghana (as of June 30, 2003)**

No.	Scheme	Area of developed land (ha)	Area of irrigated land (ha)	% of utilization	Irrigation type	Target crop	Remarks
1	Ashaiman	155	56	36.13	Gravity	Rice and vegetables	
2	Dawhenya	200	150	75.00	Gravity & pump	Rice	
3	Kpong	2,786	616	22.11	Gravity	Rice and vegetables	
4	Weija	220	0	0.00	Pump	Vegetables	Abandoned 2003-Rehabilitated
5	Afife	880	880	100.00	Gravity	Rice	
6	Aveyme	60	0	0.00	Gravity	Rice	Abandoned 1998-Rehabilitated
7	Kpando Torkor	40	6	15.00	Pump	Vegetables	
8	Mankessim	17	17	100.00	Pump	Vegetables	
9	Okyereko	81	42	51.85	Gravity	Rice	
10	Subinja	60	6	10.00	Pump	Vegetables	
11	Tanoso	64	15	23.44	Pump	Vegetables	
12	Sata	34	24	70.59	Gravity	Vegetables	
13	Akumadan	65	0	0.00	Pump	Vegetables	Abandoned - Rehabilitated
14	Anum Valley	89	0	0.00	Gravity & pump	Rice	Abandoned - Rehabilitated
15	Amate	101	0	0.00	Pump	Rice	Abandoned
16	Dedeso	20	8	40.00	Pump	Vegetables	
17	Kikam	27	0	0.00	Gracity & pump	Rice	Abandoned
18	Bontanga	450	390	86.67	Gravity	Rice and vegetables	
19	Golinga	40	16	40.00	Gravity	Rice and vegetables	
20	Libga	16	16	100.00	Gravity	Rice and vegetables	
21	Tono	2,490	2,450	98.39	Gravity	Rice and vegetables	
22	Vea	850	500	58.82	Gravity	Rice and vegetables	
	Total	8745	5192	59.37			

Source: Miyoshi and Nagayo 2006, cited in Namara et al., (2010). Modified by author of proper management, lack of maintenance, lack of irrigation facilities, as well as the lower irrigation charges render them unproductive.

1.3 Management of Irrigation Schemes in Ghana

Until 1990, all public irrigation projects were managed solely by GIDA. But due to low staff capacity and higher operation and maintenance costs, GIDA was not always able to manage the irrigation projects successfully. The government then introduced Participatory Irrigation Management (PIM) followed by the Joint Irrigation System Management (JISM) in the 1990s. PIM and JISM were both introduced as measures to reduce government costs in operation and maintenance of the irrigation schemes and also to help improve them. PIM and JISM are technically the same in that each management framework requires the beneficiary farmers or the Farmer Based Organizations (FBOs) to be stakeholders in the management of the irrigation projects. Through PIM/JISM, irrigation service charges paid by the beneficiary farmers are used directly for the operation and maintenance of the irrigation projects.

Currently, the Bontanga Irrigation Scheme practices JISM as the management system but is in a position to change the management system into Public Private Partnership system (PPP), after the system is satisfactorily improved. As the name implies, the irrigation system will be managed by both public (the FBOs), GIDA, and at least a large private farmer who will help with the provision of irrigation facilities, marketing of produce from the scheme, operation and maintenance of the project, and several other benefits will be provided in order to help the scheme achieve its goals of poverty reduction.

The main sources of funding to public irrigation schemes in Ghana are from the government and from the collection of irrigation service charges (ISC) from farmers. The ISCs in Ghana are usually very low depending on the type of irrigation. Gravity type irrigation charges are much lower than pump type irrigation charges. The Bontanga Irrigation Scheme (BIS) is a gravity type and its current irrigation service charge is GHC 50 (US$ 26.04)[1] per ha per year.

1.4. Importance of Irrigation in Northern Ghana

The northern part of Ghana is the driest part of the country. It records lower annual rainfall and has fewer river basins as compared to the south. It accounts for the highest rural population in the country, characterized by poverty, higher level of illiteracy, and unemployment (World Bank, 1995). The northern part of Ghana comprises the Upper East, Upper West, and the Northern regions. The Northern region is one of the largest regions in Ghana and has vast arable land which is suitable for irrigation. In addition to the Upper East and the Upper West regions, the land area available for irrigation is capable of producing larger quantities of rice and vegetables which do very well in these regions. As part of government goals to create rural employment, reduce poverty, and ensure food security, it is prudent for the government to establish more irrigation projects and also improve the existing ones in the 3 northern regions. The regions can boast of very few public irrigation schemes of which BIS is the largest.

BIS was established by GIDA in the early 1980s. It is simply an earthen dam with water supplied by gravity to the farmlands. The reservoir of the scheme is said to be capable of storing 25 million cubic meters (about 20,268 acre feet) of water, and supposed to irrigate about 495 hectares at a time (MOFA, 2011) which it does not really do due to lack of improvement. The irrigation system has just been rehabilitated (without any major improvements in the irrigation technology) by the Millennium Development Authority (MiDA) in 2011, for the first time in 30 years of its existence. The system is not capable of sustaining the water needs of the farmers

[1] 1 US Dollar traded for about GHC 1.92 as of August 25, 2012.

because of the kind of irrigation method and lack of regular maintenance, making water supply to the farmlands inefficient due to distribution, application and delivery losses. To increase efficiency, it would be better to improve the irrigation system: Support the gravity flow with pump, fix and replace the current gates with well designed gates for proper control of turnouts at laterals, install standard weirs at every turnout for proper measuring of flows, provide more irrigation facilities including machinery (tractors, combine harvesters, dredging machines and so on), and implement regular maintenance of the irrigation project. Improvement of the scheme is possible if farmers will be willing to assist in recovering the costs that will result from the improvement. Thus the improvement is not necessarily about increasing the quantity of water as much as reliability and complementary capital to raise the marginal productivity of the farmer.

BIS current irrigation service charge per hectare per year is very low and management of BIS is suggesting an increase in irrigation charges from 50GHC (US$ 26.04) per ha per year to about 246GHC (US$ 125.13) per ha per year to recover the cost of improving the systems and also for operation and maintenance (MiDA, 2011).. This proposal requires about 392 percent increase in the irrigation charges which is supposed to be done in a form of smaller increments annually. The management wishes to improve the irrigation system as well as acquire irrigation facilities which will help the farmers in their crop production. So this thesis will try to elicit the maximum amount each farmer will be willing to pay per hectare per year assuming the irrigation system is improved and the PPP management system is in place.

The outcome of this thesis will be used by the management of the BIS to determine the ISCs that will be collected annually for both the improvement and the operation and regular maintenance of the project. The results will also be used by other similar public schemes within and beyond the region to determine their ISCs assuming their schemes are improved.

The chapters of this thesis are arranged as follows: chapter one is introduction, chapter two is literature review, chapter three is methodology, chapter four presents the results and discussion of the results, and chapter five is for summary and conclusion.

CHAPTER TWO: LITERATURE REVIEW

2.1 Alternative Approaches to Valuing Irrigation Water

Most of the studies to value irrigation projects are centered on valuing the irrigation water. This may be from the fact that water is one of the main inputs in irrigation. And because water is generally a nonmarket good, nonmarket valuation approaches are widely used to value irrigation water. In situations where market prices of goods and services are nonexistent, economic values of these goods and services can be obtained through the use of non-market valuation techniques (Bateman and Turner, 1992; Young, 2005). Valuation of irrigation water as a nonmarket good can be grouped into two broad techniques which are deductive and inductive, and each technique is identified based on the mathematical procedures and the types of data used in the analysis (Young, 2005).

The deductive technique employs the use of mathematical programming which incorporates crop production functions and forecasts of input and output prices in order to model the behavior of the profit-maximizing farmer (Young, 2005; Medellin-Azuara et al., 2010, Qureshi et al. 2010). According to Young (2005), the deductive technique is a very flexible way of valuing irrigation water because it can fit into different policy options, economic and technological scenarios. However, its accuracy depends on the validity of the data and the suitability of the chosen model. An example of the most commonly used deductive technique is the residual imputation method (Young, 2005; Qureshi et al. 2010). The residual imputation approach requires that, the costs of all inputs except that of water are deducted from the total crop revenue resulting in the estimated value of water. The estimated value of the water is accurate only if the prices and the quantities of the other inputs are estimated correctly at their marginal values. Specification of production functions is a problem and may also affect the results from the residual imputation method. The deductive approach is not suitable for this paper because of data problems and difficulty in the choice of production functions.

Inductive techniques use econometric models to analyze data obtained from observations of water market transactions (prices of water rights or land and water rights transactions), survey responses, or from observed secondary data (Young, 2005; Qureshi et al. 2010). Inductive techniques are good because they reflect empirical data and its results are more reliable (Young, 2005; Medellin-Azuara et al. 2010). Dependence on large, quality datasets makes it a more data-intensive approach (Medellin-Azuara et al. 2010). Young (2005) also explains that, the accuracy of the inductive approach depends on the validity and the representativeness of the data used in the analysis, the variables selected, and the suitability of the functional form. Inductive techniques are observation-based approaches under which we can categorize the revealed and the stated preference methods of valuing irrigation water.

Revealed preference approaches are those that utilize data from actual choices including water market transactions, while the stated preference approaches are not observed but from surveys that ask respondents about their choices of the intended resources (Young, 2005; Qureshi et al. 2010; Boyle, 2003). Examples of the revealed preference approaches include travel cost method (TCM), hedonic property valuation (HPM), defensive behavior and damage costs (Boyle, 2003). Boyle (2003) describes the TCM as being used for recreational activities, while the defensive behavior and damage costs method is used to account for what respondents pay to "offset effects of exposure". Therefore, both the TCM and the defensive behavior and benefit costs methods are not suitable for irrigation water valuation. HPM reveals the implicit price of water in irrigation. It is used to determine how water rights for irrigation affect the price of a particular land, by considering the attributes of the land as well as land market transactions data in order to econometrically estimate parameters for the determinants of land price (Medellin-Azuara et al. 2010). Faux and Perry (1999) estimated irrigation water value in Malheur County, Oregon, using the HPM. They used all sales of agricultural property in the Treasure Valley during the years 1991 through 1995. The variables chosen by Faux and Perry (1999) were sale price, acreage, soil classification for each acre, location of property, date of sale, number of acres and source of irrigation supply, number of residential lots permitted, and estimated value of buildings. The median size of the properties was 78 acres with a median price of $1,394. The value of irrigation water on a least productive land was estimated at $9 per acre-foot and that on the most productive land was estimated at $44 per acre-foot. The hedonic price does not account for the soil quality which makes it less accurate (Faux and Perry, 1999). HPM is not suitable for the BIS study area because land market transactions data are not available. An example of the stated preference approach used in valuing irrigation water which is suitable for the BIS study area is the contingent valuation method (CVM). In the CVM, the individual's WTP is only stated as a response to the survey question and not observed.

2.2 The Contingent Valuation Method (CVM)

The CVM is a method used to determine individual's demand for a nonmarket good. It requires individuals to state their preferences for the non-market resource through their responses to WTP questions concerning the existing resource or one that is yet to be provided (Cameron and Huppert, 1989; Bateman and Turner, 1992; Portney, 1994; Boyle, 2003). The CVM was first introduced in 1947 in Ciriacy-Wantrup (1947) but fully implemented in Davis (1963) to estimate the value of a recreational area to hunters and wilderness lovers (Portney, 1994; Boyle, 2003), and later recommended by the NOAA Panel (1993).

The CVM is a recognized and widely used non-market valuation technique (Cameron and Huppert, 1989; Ready et al., 1996). In developing countries, CV surveys were originally applied in water supply and other environmental benefits estimation, and are much easier and very straight forward to conduct because the respondents take it more serious than in the industrialized countries (Whittington, 1998).The CVM is better as compared to the HPM method because it is suitable in eliciting both use and non-use values (Kramer and Eisen-Hecht, 2002; World Bank, 2002), and when there is no observable data that are available for the policy option to be analyzed (World Bank, 2002). CVM is also good because it allows accounts of the socioeconomic characteristics of the respondents (Portney, 1994). The CVM is used for this study because there is no observed data that are already available to help in the valuation of BIS. And also, the project is not yet improved so CVM will serve as the best method to value it since CVM can be used to value resources that are yet to be provided.

As proposed by Bateman and Turner (1992), and Boyle (2003), a good CVM survey questionnaire should include an introductory part that will help the respondent to understand what the survey is about, the non-market good should be well described and how it will be provided, the payment vehicle should be well defined (and should be what the respondent is familiar with), there should be a decision rule, the provider of the non-market good should be stated, and any other information including the method/format that will assist in the elicitation of the WTP. NOAA Panel (1993) also recommend following guidelines for survey design and implementation in order to come out with reliable CVM results. The survey can be face-to-face interviews, mail in, or telephone interviews. The survey described in this paper will use face-to-face interviews because both the telephone and the mailing systems are not effective in the area.

There are different elicitation formats that can be used in a CVM survey: open ended questions, closed ended questions, dichotomous choice (single, double, or multiple bounded), bidding game, and the payment card (Boyle et al. 1996; Boyle, 2003; Carson and Hanemann, 2005). All the elicitation formats have their advantages and disadvantages but Loomis (1990) and Boyle et al. (1996) have both concluded that, there is no significant difference between the open-ended and the dichotomous choice elicitation formats, and that both formats produce reliable results. The open ended question asks the respondent how much he/she will be willing to pay for the good while the closed ended gives options from which the respondent chooses how much he/she is willing to pay. The dichotomous choice format requires the respondent to answer "yes" or "no" to a specific payment (Alberini et. al, 1999). It is used widely in developing countries (FAO, 2000) but Whittington (1998) revealed that the variation of bids across individuals pose problems in tightly-knit communities such as those in developing countries. The dichotomous choice, according to Ready et al. (1996), has problems including starting point bias, uncertainty, inconsistence and strong assumptions.

The payment card elicitation format is used for this paper. It was first introduced by Mitchell and Carson (1981). The payment card consists of an ordered list of maximum WTP values on a card (Mitchell and Carson, 1981; Cameron and Huppert, 1987; Cameron and Huppert, 1989; Rowe et al. 1996). The respondent is asked to select only one choice on the card as his/her maximum willingness to pay value. Respondents who select zero are asked a protest bid question. The reason for the protest bid question is to find out if the respondent has other reasons for not willing to pay for the resource.

In the payment card, it is assumed that the bid selected by an individual is the lower bound of his or her willingness to pay, and the individual's true WTP bid lies between the selected bid and the next higher bid (Cameron and Huppert, 1989). These sounds similar to what one would expect farmers under BIS to behave if faced with different ISCs from which they should choose from and will therefore work well in our situation.

There are also problems with the payment card including range and centering biases (Mitchell and Carson, 1986) but Rowe et al. (1996) proposed that those problems can be minimized or totally eliminated provided an exponential payment scale is used with no truncation problem. The payment card approach is identified to conserve effort and also avoid higher non-response rate as compared to open-ended approach (Cameron and Huppert, 1989). The difficulty with the use of payment card in the survey area is that, some of the respondents have no formal education to be able to scan through and circle their bids and will need to be prompted by the interviewer. The PC approach is still suitable for the study area because, in the PC approach, all respondents receive the same bids which will curb the problem of distrust in the survey that might arise from variations in bid amounts across individuals.

2.3 Previous CVM Studies on Valuation of Irrigation

Most of the CVM studies conducted in developing countries including Whittington et al. (1991), Bohm et al. (1993), and Hsu et al. (1990) are on WTP for drinking water under improved water supply conditions, and very few of them are on valuation of irrigation. Considering CVM surveys conducted in developing countries which are most comparable to this paper, Weldesilassie et al. (2009), Chandrasekaran et al. (2009), Akter (2007), Basarir et al.

(2009), and Storm et al. (2010) have each estimated the economic value of irrigation water or improved irrigation under different CVM scenarios.

Weldesilassie et al. (2009) estimated the economic value of improved wastewater irrigation in Addis Ababa, Ethiopia. They used the CVM to assess the value farmers attach to the safe use of wastewater in irrigation. Their survey was conducted on farm households that used freshwater and also on those that used wastewater for irrigation within and around Addis Ababa. The double–bounded dichotomous choice format with an open-ended follow-up question was used to elicit the respondents' WTP for the improved or safe use of wastewater for crop production. The payment vehicle in Weldesilassie et al. (2009) was implemented in a form of annual water charge per hectare per year paid by the respondent immediately after harvest, which makes their study very similar to this paper. A total of 415 sample farm households were targeted for use in their study, comprising 175 farm households that used freshwater for irrigation and the other 240 were farm households that used wastewater for irrigation. But 372 households were used in the analysis due to non-responses during the face to face interviews. Of the 372 farmers, wastewater farmers were 223 and freshwater farmers were 149. Their survey results revealed that about 98% of the freshwater irrigators were willing to contribute to improve the existing irrigation practice while 90% of the wastewater farmers were willing to contribute. They used a standard probit, bivariate probit, and interval-data models to estimate WTP for the improved wastewater irrigation. The standard probit was used for only responses to the initial bids (single-bounded dichotomous choice) and the other two models were used for the full responses to the double-bounded dichotomous choices questions. Weldesilassie et al. (2009) estimated the mean WTP from the single-bounded model as ETB 39.57 (US$ 3.44) per hectare per year, ETB 39.10 (US$ 3.40) per hectare per year from the bivariate-probit model, ETB 39.72

(US$ 3.45) from the interval-data model, and ETB 35.35 (US$ 3.07) from the open follow up question. They found very little protesting behavior during their survey. Their results showed that location of farm, education, number of years with irrigation experience, and total annual yield value significantly influenced WTP. Based on the quality of their results, they suggested using the interval data model as the best to achieve more efficient estimates of WTP for improvement of programs.

Chandrasekaran et al. (2009) estimated farmers' WTP for irrigation water in the Tamil Nadu State in India. They used CVM to study farmers' WTP for tank irrigation water under improved water supply conditions during wet and dry seasons of paddy cultivation. They randomly selected 31 tanks from the Tamil Nadu State. And 62 respondents were drawn from the dependents of those 31 tanks. The survey was face to face interviews made up of both closed and open-ended questions. Farmers were asked whether or not they would be willing to pay a specific amount for tank irrigated water (close-ended) or how much they would be willing to pay for tank irrigated water (open-ended) under improved levels of water supply during dry and wet seasons. The payment vehicle was in the form of irrigation charges per hectare per year which also makes Chandrasekaran et al. (2009) similar to this thesis. They used the standard logit model to analyze the results. Their study revealed the mean value of farmers' WTP for water supplied by tank irrigation as 218.50 Indian Rupees (US$ 4.46) per ha per year. They found land area and where requirement of the crops to be significant. Their results also revealed that farmers were willing to pay for the irrigation water but the WTP values were considerably low

In Bangladesh, Akter (2007) determined the value of irrigation water in a government managed small scale irrigation project in the Homna sub-district. He used CVM to elicit farmers' WTP for the irrigation water under the government managed small scale irrigation project. The

CVM scenario in his study was "government managed" since most irrigation schemes in the study area were managed by private sectors. The payment vehicle was irrigation charges per decimal land area per cropping season. Single bounded closed ended WTP with follow up protest bid questions were used in his face to face interviews on 300 farmers in the study area. And the data from 257 valid respondents were analyzed using standard logit model. The mean WTP was estimated to be 1670 Taka (US$ 27.83) per kani (30 decimal) land area per season (four months). His results revealed that age, education, family size, number of income sources, ownership of farm land have significant impacts on WTP. And that farmers' WTP were high for areas of higher water scarcity.

Basarir et al. (2009) analyzed vegetable producers' WTP for high quality irrigation water in the Turhal and Suluova regions in Turkey. They used CVM by randomly selecting 130 producers from both regions on whom they conducted face to face interviews. They used open ended questions and a large amount of the respondents reported zero bids. Torbit and Heckman sample selection models were used in their study and the mean WTP was estimated as1 TL (US$ 0.63) per decare per day. Their results revealed gender and water quality to be significant.

Storm et al. (2010) also estimated farmers' demand for irrigation water in the Middle Draa Valley in Morocco using CVM. They gathered information from 63 farmers out of 95 farmers interviewed. They adjusted the CVM to estimate the demand for irrigation water along farmer's willingness to pay for one more unit of surface water or groundwater. Tobit regression was used and the results were that WTP for groundwater was 0.88DH/m^3 (US$ 0.11/m^3) and 1.18DH/m^3 (US$ 0.14/m^3) during winter and summer, respectively. They found knowledge of farmers demand for irrigation water to be important and recommend CVM as a reasonable method for areas with limited data availability.

Other CVM studies in developing countries which are to some extent related to this paper in terms of methodology are on valuation of drinking water supply services. But their results cannot be directly compared to that of CVM studies on valuation of irrigation water. We will have a brief look at Whittington et al. (1990) and Casey et al. (2005). Whittington et al. (1990) estimated willingness to pay for water services in Laurent, a rural community in Haiti. Face-to-face interview was used to elicit WTP from 170 households out of 225 households in the community. The bidding game format was used and the mean WTP was estimated to be 5.7 gourdes (US$ 1.14) per month. Whittington et al. (1990) recommended the use of photographs or visual aids in contingent valuation surveys, and added that developing countries are likely to produce high-quality CVM surveys than in industrialized countries. Casey et al. (2005) estimated WTP for improved water services in Manaus, Amazonas, Brazil. In their study, WTP was elicited from 1625 households within 6 low-income communities in the area using both open-ended (with and without introductory paragraph) and bidding game approach (ascending and descending), totaling 4 different elicitation formats. The mean WTP from their study was R$11 (US$ 5.61) per month. Casey et al. (2005) found that respondents were willing to pay more for drinking water than the current charges.

2.4 Analysis of Payment Card (PC) Data

2.4.1 The Theoretical Model

Through a CV survey, we try to assign value to the nonmarket good that is provided. Flores (2003) explains that cost is incurred in the provision of the nonmarket good and to recover the cost of providing the good, we need to consider the amount of income an individual will give up after the project is implemented to keep his/her utility constant - the compensating variation. In the case of BIS, the compensating variation can be explained using the equation below:

(1) $v(P^o, Q^o, y) = v(P^1, Q^1, y - C)$

where v(.) is the indirect utility function, P^o is the current ISC, P^1 is the ISC after the project is improved, Q^o is the current situation of the project, Q^1 is the improved project, y is the income of the farmer, and C is the compensating variation which is the WTP bid of the farmer.

2.4.2 The Empirical Models

In the PC data analysis, the respondent's true WTP, which is denoted Y_i, in (2), is assumed to be in the interval between the selected WTP, C as in (1), and the next highest WTP value on the PC (Cameron and Huppert, 1989; Hackl and Pruckner, 1999; Boyle, 2003). So in using the PC data to estimate average values or to estimate relationships between WTP and the variables that affect the WTP, the interval midpoints are used (Cameron and Huppert, 1989). Cameron and Huppert (1989) also add that, valuation is non-negative and that the lognormal conditional distribution for valuations can serve as useful first approximations.

Following Cameron and Huppert (1989), Y_i lies within lower and upper thresholds B_{li} and B_{ui}, then ($\log Y_i$) lies between($\log B_{li}$) and ($\log B_{ui}$). The $E(\log Y_i|x_i)$ is a function of $g(x_i, \beta)$. Where x_i is the vector of the independent variables of an individual and β is the vector of the coefficients to be estimated. To estimate β, we use the function:

(2) $(\log Y_i) = x_i'\beta + u_i$

where x_i' and β are the same as above, and u_i is the random error term assumed to be distributed normally with mean 0 and the standard deviation, σ.

Ordinary Least Squares (OLS) procedure can first be used to estimate (2) above using the logarithm of the midpoints of the WTP bids as the dependent variables. But the OLS in payment card data analysis yields biased parameter estimates, the effects of the variables on the resource value can be wrongly inferred, and it can also create biases in the overall resource value (Cameron and Huppert, 1989). To get a more appropriate estimation procedure, we proceed with the fact that Y_i is only stated by the respondent and not observed. Its probability falls within the interval and can be expressed in the form:

$$(3) \qquad \Pr(Y_i \subseteq (B_{li}, B_{ui}) = \Pr((\log B_{li} - x_i'\beta)/\sigma < z_i < (\log Bui - x_i'\beta)/\sigma)$$

where z_i is the standard normal random variable. The probability in (3) can be expressed as a difference between two standard normal cumulative density functions, z_{li} for the lower bound and z_{ui} for the upper bound in (3). Then (3) can be rewritten in the form $\varphi(z_{ui}) - \varphi(z_{li})$. Where φ is the cumulative standard normal density function. Interpreting the joint probability density function for **n** independent observations as a likelihood function defined over β and σ, the log-likelihood function is written as:

$$(4) \qquad \log L = \sum_{i=1}^{n} \log [\, \varphi(Z_{ui}) - \varphi(Z_{li})]$$

Equation (4) is then estimated using the maximum likelihood estimation (MLE) procedure, as the most efficient and priori superior method that can accommodate the intervals of

PC data (Cameron and Huppert, 1989). Equation (4) is therefore the model employed by this paper and the MLE is used to estimate the parameters of the PC interval data.

To compute the mean and the median WTP values, the fitted values of $\log Y_i$ are first constructed after the regressions. So the conditional mean of $\log Y_i$ is expressed in the form $x_i'\beta$, and $\exp(x_i'\beta)$ is used to retransform $\log Y_i$ into Y, which represents the median WTP value (Cameron and Huppert, 1989). Cameron and Huppert (1989) also suggest that, the mean of Y, is computed by scaling the median by $\exp(\sigma^2/2)$, where σ is the standard error for each regression.

CHAPTER THREE: STUDY METHODOLOGY

This chapter briefly describes the BIS and the survey area, outlines the steps in planning the study, designing and implementation of the survey.

3.1 The BIS and the Survey Area

In figure 3.1 is a map of Northern Ghana districts and BIS is located in the Tolon/Kumbungu district. The BIS is a public irrigation scheme which was constructed in 1983 by the Government of the Republic of Ghana. It is a gravity fed irrigation system consisting of an earthen dam/reservoir with two take-offs and a spillway. The reservoir's capacity is 25.00 Mm^3 (about 20,268 acre feet) (MOFA, 2011). The currently developed land area for irrigation is 570 ha out of the irrigation capacity of 800 ha. The scheme has a total number of 525 farmers from 13 different communities with an average land holding of about 0.6 ha per farmer. The farmers are organized into a cooperative made of 10 farmer based organizations (FBOs). The main objectives of the irrigation scheme are to provide employment for the youth in the catchment areas, and to enable farmers in the catchment areas to have access to all year round crop production. The main crops grown under the scheme are rice and vegetables.

BIS and most of its beneficiary farmers are located in the Tolon/Kumbugu District. The district is about 34km Northwest of the Northern regional capital, Tamale. Northern region lies between latitude 9^o 15 and 9^o 32 N and longitudes 0^o 45E and 0^o 93W, and located in the Guinea Savanna vegetation. The region has a relatively dry climate with only one rainy season, from May to September which is followed by a prolonged dry season. The amount of annual rainfall recorded for the region is between 750 mm and 1050 mm.

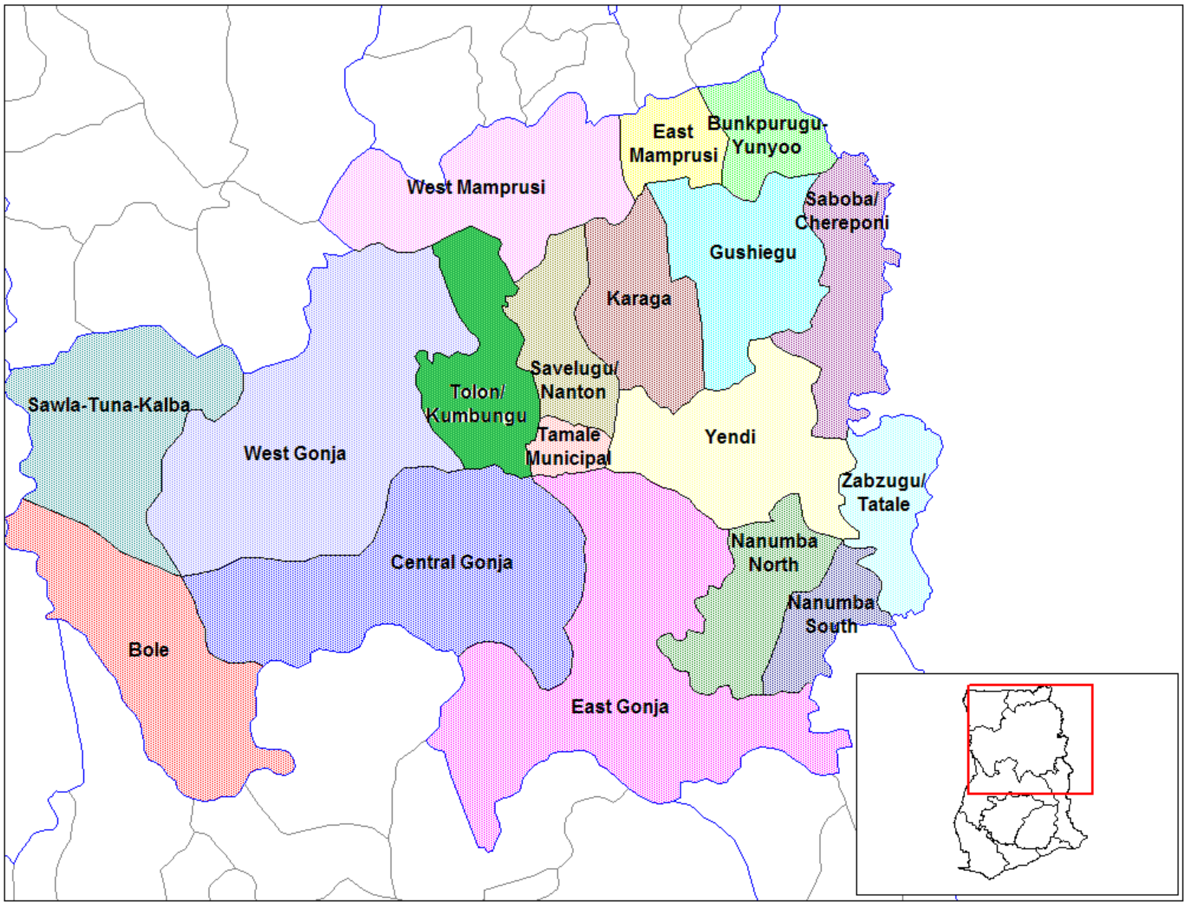

Figure 3.1 Map of the Northern Ghana Districts.
Source: http://en.wikipedia.org/wiki/File:Northern_Ghana_districts.png

3.2 Initial Planning of the Study

The initial planning of this study started in Fall 2011 in order to estimate the willingness of the farmers under the BIS to pay for improved irrigation. In 2011, BIS was rehabilitated by the Millennium Development Authority (MiDA) at the cost of about GHC 5 million (US$ 3 million). MiDA resurfaced the main and the lateral roads on the existing 570 hectares of developed land, dredged the drainage system, renovated 6 farm buildings, provided 33 new threshing floors, and 9 maintenance sheds. The next plan is to expand the developed land area to cover the irrigation potential of the scheme, and also to improve the irrigation system which is already discussed in chapter one. For the improvement of the scheme to take place, GIDA will have to increase the ISCs of the farmers to cover the operation and the maintenance cost of the project. This study will therefore conduct a CV survey to come out with a realistic ISC value for the scheme.

The outcome of this survey will be used by the management of the BIS to determine the revenue that will be available to the scheme annually. The outcome will also be used by other similar public schemes within and beyond the region to determine their ISCs assuming their schemes are improved.

3.3 Data Needs: Sampling Methodology and Sampling Location

After identifying the need to conduct this study, the communities within which the farmers reside were first identified but ended up being more scattered within the catchment area. The study was designed to be conducted based on the locations of the farmlands within the scheme. It did not matter if more than one individual farmer of the same household were selected during the interview process because farmers were selected based on the location of their farms not based on households. What mattered was the farmer has a land in the scheme and he/she is randomly selected to take part based on his/her plot of land. The main point was to ensure that the data collected would be representative of the farmer population. The representative sample in this case must include farmers with different farmlands at different locations (upstream, middle, and downstream) within the scheme, which could only be obtained through stratified random sampling. Farmland locations were initially identified by lateral numbers (1 to 14) and later converted into distances in kilometers (km). The laterals are spaced at regular intervals which were estimated to be 0.5km each. The distance from the reservoir to the first lateral was estimated to be 0.9km. In all, the laterals span over 6.5km from lateral 1 to lateral 14, but 7.4km from the reservoir to lateral 14.

The nature of BIS can be seen in figure 3.2 which represents the map of BIS. The decision to consider farmland locations was taken because we believe that farmers at different farmland locations within the scheme would value the irrigation scheme differently but not based on the communities in which they live nor the FBOs they belong to. It would also be difficult to judge a farmer's value based on the crop produced because almost all the farmers in the scheme produce the same crops at different seasons. And also to avoid something similar to the avidity bias (see Thomson, 1991), interviewing farmers at random on site would only capture farmers who visit their farms regularly or had more work to do on their farms during the survey period.

The survey was designed and pretested to ensure the questions were meaningful to the respondents. The survey was conducted face-to-face, either on the farm site or at the residence of the farmer. Even though, the face-to-face interview might influence the WTP due to interviewer bias (Boyd and Westfall, 1970), it is the best possible way to conduct survey in the area because telephone and mailing systems work poorly in the area. To avoid the interviewer bias, the interviewers were given several hours of training and even practiced among themselves. This was done to equip them with the ability to answer any questions that might arise during the interview. Respondents were also asked to give the possible ways by which they could be contacted after the survey in order to make follow ups if necessary. There were five interviewers and each was supposed to interview only 20 farmers in order to avoid spending large amount of time in conducting the entire survey.

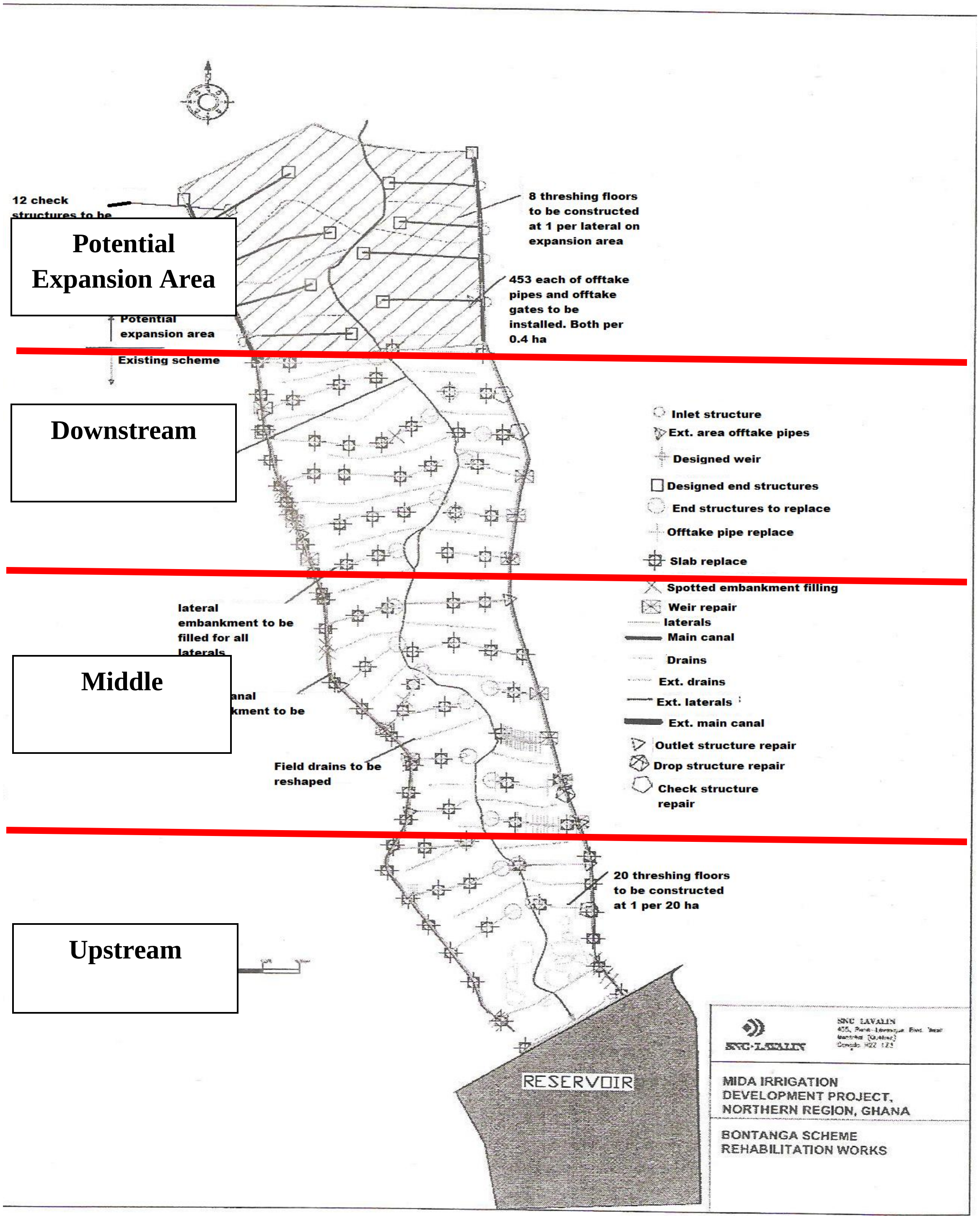

Figure 3.2 BIS Map. Source: MiDA Organization and Management Report, 2011

3.4 Survey Creation and Pretest

The survey questionnaire for this study was designed to follow the CVM survey questionnaire design proposed by Bateman and Turner (1992), Boyle (2003), and the World Bank's guidance on survey questionnaires design to assess demand and WTP of consumers (see Cointreau-Levine and Coad, 2000).

Both Bateman and Turner (1992) and Boyle (2003) propose that a good CVM survey questionnaire should include an introductory part that will help the respondent to understand what the survey is about. The non-market good should be well described and how it will be provided. The payment vehicle should be well defined (and should be what the respondent is familiar with). There should be a decision rule, the provider of the non-market good should be stated. Auxiliary questions should be included in the questionnaire, and any other information including the method/format that will assist in the elicitation of the WTP. Cointreau-Levine and Coad, (2000) divide the sections of WTP and demand assessment questionnaire into various sections including identification, major concerns, existing situation regarding the program under study, the WTP, demand assessment, and the demographic information section. These divisions may just be to simply demarcate one section from the other. The survey questionnaire for this study adopted the first three and the last sections suggested by Cointreau-Levine and Coad, (2000).

In the introductory part of the questionnaire, the background information of the BIS including the proposed program clearly states what the survey is about. The survey questionnaire is available in Appendix I.

The identification section is designed to give an identification number to the respondent and also to identify the location of his/her farmland in a form of a lateral number. The third question in the identification section is to find out about the position of the respondent, either head of the household or spouse of the head of the household.

The major concerns section is to find out about respondents' perception about over-dependence on rain-fed agriculture, we present a list of possible problems that might be faced by households at random basis to each respondent. Respondents are asked to select all their major concerns from lack of water for irrigation; lower crop yield from rain-fed agriculture; poverty, hunger and starvation; to severe drought. Respondents are also asked to rank their major concerns from most serious to second most serious.

The third section elicits existing situation regarding the BIS. Under this section, farmers are asked questions regarding the use of the irrigation facilities including water. Farmers are first asked questions about their land holdings within and outside the scheme just to find out where they are likely to produce more crops from. For farmers who have more plots of land at different locations within the scheme, they are asked to state their sizes and locations. Farmers are also asked to find out how they obtained those plots, and how much they paid for them the previous year if the plots are leased to them. And also to be able to estimate revenues of individual farmers as well as the average revenue to farmers in the entire scheme, farmers are required to answer questions about their previous year's crop yield and estimated cost of production. This information will also help in cost-benefit analysis of the scheme. As part of the auxiliary questions suggested by Boyle (2003), questions like the number of seasons they cultivate crops within the scheme, and whether there are other limitations to farming apart from lack of facilities and lack of water are also part of this section.

The WTP section clearly explains the payment vehicle as ISC per ha per year and also states the decision rule clearly that the program will not be implemented if the money collected is not enough. The WTP elicitation format is the PC approach. The PC was redesigned after the pretest, to cover the likely range of responses. The maximum WTP bids on the PC were determined using the exponential design suggested by Rowe et al (1996), by increasing the listed values and the intervals between the listed values at an increasing rate. This was done to avoid the range and centering biases in PC approach. The range of values used is to cover the proposed ISC that is proposed by MiDA. Labor days contributions of the farmers are also asked in this section to find out how many days farmers are willing to contribute to improve the project in addition to the ISCs. The final section is the other information which elicits the socioeconomic information of the respondents.

After the survey questionnaire was satisfactorily designed, it was sent out for a pretest during the final week of June, 2012. The purpose of the pretest was to ensure that all the questions were understood by the farmers and to find out if questions were supposed to be added or deleted from the questionnaire. 15 farmers were interviewed during the pretest after which, the questionnaire was edited after realizing that some of the farmers have no formal education, and also, could only measure their farm yields in bags, baskets, and buckets instead of in kilograms. The response option “no formal education” was added to the questions that elicits educational level. The farmers were also allowed to state their farm yields in whatever units they were familiar with so that the units could be converted into standard units after the survey.

3.5 Data Collection

The actual survey was conducted on July 05, 2012 through July 09, 2012. The scheme manager was first contacted to help identify the respondents based on the location of their farmlands within the scheme. There were 14 laterals to be used in identifying the farm locations.

The 14 laterals were divided into 3 groups: the first 5 laterals were considered as upstream, laterals 6 to 10 were considered as middle, and above ten were considered as downstream. After identifying all the lists of farmers in the upstream, middle, and downstream, 40 farmers were randomly selected from each group making up 120 farmers with the intention to interview only 100 farmers. 120 farmers were selected to make room for non-responses. The next step was how to locate the farmers because there is no proper address system in the area. Farmers' homes can be identified by asking the community members. The survey period fell within the rainy season in the area and very few farmers were visiting their farms within the scheme. Most of the BIS farmers who have larger amount of lands outside the scheme stop farming in the scheme during the rainy season and rather depend on the rain-fed crop production to only get back to the scheme during the dry season.

It was very difficult to locate respondents who were working on their farms outside the scheme. Farmers who were not met during the first visit were revisited at different times of the day in order to get them interviewed. Varying the visiting times in a day proved successful and 100 farmers were interviewed. Even though some of the farmers who have more plots within the scheme were not willing to reveal that for the fear of redistribution which they said occurred some time ago, the response rate was still 100% because the farmers took the survey very serious and some of them even mentioned that the introduction was very attractive.

After the interviews, questionnaires were checked to ensure that all questions were answered properly and the skip instructions were also obeyed. Follow ups were made to the homes of four respondents to fully complete their questionnaires. The data were coded and entered into a spreadsheet.

3.6 Treatment of Outliers

There were few outliers. By standard practice, observations with more than 3 standard deviations from the mean are likely to be outliers. The occurrence of few outliers could be because the survey was conducted face-to-face in addition to the interviewers being well trained to elicit the information. One respondent gave the cost of leasing less than a hectare of land as GHC 500 which was believed to be exaggerated. And a follow up revealed that the respondent stated the lease amount in the old Ghana currency (¢500 = GHC50). That lease amount was then adjusted to GHC 50. Labor days of three respondents were 100, 90, and 50. The rest of the labor days from other respondents were relatively low, from 1 to 25. The labor days values (100, 90, and 50) were dropped because they were considered as being too high and therefore outliers.

Also, some respondents gave their family sizes as being above 40 but these larger family size values were not dropped or adjusted because a previous survey (Al-hassan, 2008) in the catchment area gave family size values even beyond 50. During the interview process the interviewers made sure that respondents understood the questions that were asked before providing answers. If a respondent answered a question in a way that showed that the question was not understood, he/she was asked the question repeatedly with explanations until the respondent understood and provided an answer that simply matched the question.

CHAPTER FOUR: RESULTS AND DISCUSSION

Under this chapter, the detailed results of the survey including the OLS and the MLE results, and the mean and the median WTP values for the improved Bontanga Irrigation Scheme (BIS) are presented.

4.1 Socioeconomic Characteristics of the Respondents

Characteristics of the respondents are presented in table 4.1. Out of the total of 100 respondents, 6% were females and the rest were males. Fifty nine percent (59%) of the respondents were heads of households and the rest were in other positions including spouses of heads of households. The mean age of the respondents was 43.7 years. 54% of the respondents were between 35 and 54 years. 22% were between 25 and 34 years, and 4% were below 24 years with the lowest age being 19.5 years. 15% of the respondents were between 55 and 64 years, and 5% were above 65 years with highest age of the respondents being 69.5 years. The gender and age distributions of the respondents show that the BIS farmers are predominantly males of the active working age group (19-55 years).

The average of the highest level of education of the respondents is primary school; 73% of the respondents were without any formal education while 3% hold second or master’s degrees and above. The average household size was 16, with 2 as the lowest household size and 65 as the highest.

Mean gross income of the respondents in 2010/2011 farm year was GHC 1760, about 67% of the respondents had their gross incomes below the mean gross income with GHC 500 as the lowest while the rest earned above the mean gross income with the highest gross income

Table 4.1 Socioeconomic Characteristics of Respondents (n=100)

Characteristic	%
Gender:	
Female	6
Male	94
Position:	
Head	59
Other	41
Age:	
Under 24	4
25-34	22
35-44	27
45-54	27
55-64	15
Over 65	5
Education:	
No formal Education	73
Primary School	3
Middle/JHS	9
High School	9
Bachelor/Tertiary	3
Masters and above	3
Ownership:	
Lease	6
Other	94
Gross Income (GHC/year):	
< GHC 1000	27
GHC 1000 and 2000	40
GHC 2000 and 3000	22
GHC 3000 and 4000	6
>GHC 5000	3

being GHC 5500. The mean scheme income of the respondents in 2010/2011 farm year was GHC 780, about 67% of the respondents earned below the mean scheme income with the lowest being GHC 150 while the rest earned above the mean scheme income with the highest as GHC 2650. The mean off scheme income was GHC 980, about 65% of the respondents had off scheme incomes below the mean while the rest of the respondents had off scheme incomes above the mean.

The mean farmland size of the respondents in the scheme was 0.8 ha, the least being 0.2ha and the maximum being 2.8ha. 6% of the respondents were said to be leasing their lands from landowners while the rest acquired their lands through families or through redistribution which they term as balloting. This balloting occurred few years ago after most farmlands in the scheme were abandoned because most farmers resorted to farming outside the scheme. The reason for the abandonment could be due to the fact that the scheme never witnessed any major maintenance for the past 30 years until 2011. The average lease price per hectare of the farmlands based on the lease prices provided by the 6% of the respondents was GHC 24.17.

4.2 Major Concerns

The major concerns are presented in table 4.2. Finding out about expectations of the respondents concerning over-dependence on rain-fed agriculture showed that 92% of the respondents expressed concern about lack of water for irrigation in the near future. 89% of the respondents expect lower crop yield from rain-fed agriculture; 64% expect poverty, hunger, and starvation; and 52% of the respondents expect severe drought in the near future.

Table 4.2 Major Concerns (n=100)

Major Concern	%	Most Serious (%)	2nd Most Serious (%)
Lack of water for irrigation	92	27	53
Lower crop yield from rain-fed agriculture	89	46	29
Poverty, hunger, and Starvation	64	20	13
Severe Drought	52	7	5

In ranking their major concerns from most serious to second most serious, 27% of the respondents expressed lack of water for irrigation as being most serious while 53% expressed it as being second most serious. 46% of the respondents said lower crop yield from rain-fed agriculture is their most serious concern while 29% expressed it as their second most serious concern. 20% of the respondents identified poverty, hunger, and starvation as their most serious concern while 13% expressed it as their second most serious concern. And 7% expressed severe drought as their first most serious concern while 5% expressed it as their second most serious concern. From the analysis of the major concerns of the respondents, it is clear to judge lower crop yield from rain-fed agriculture as being the major concern of the farmers, followed by lack of water for irrigation in the near future. This information gathered from the farmers corresponds with the IPCC (2007) report.

4.3 Existing Situation Regarding BIS

As discussed in section 4.1, the average farmland area of the farmers within BIS was 0.8 ha. Most of the farmers with small landholdings revealed the fact that they do not depend on irrigated agriculture and rather have larger farmlands outside the scheme. The mean farmland size outside the scheme was reported as 2.4 ha, and about 36% of the farmers had farmland areas beyond the mean with the maximum being 8 ha.

The mean value of total farmland area, both inside and outside the scheme, owned by the respondents was 3.2 ha. Fifty seven percent (57%) of the respondents had total farmlands areas below the mean, and 36% had their total farmland areas above the mean with the maximum total farmland area reported as 10.8 ha. This shows that the farmers are mostly peasant farmers with very few commercial farmers. Almost all the farmers (93%) said it would have been a problem depending solely on the farmlands outside the scheme. Most of the farmers said they have farmlands at different locations within the scheme but much information was not captured on that aspect because the farmers expressed fears about redistribution of the lands in the scheme which occurred some few years ago and were only willing to give adequate information about the lands for which they were selected to take part in the survey.

Farming in the scheme is mostly done in two seasons, wet and dry. Ideally, the scheme should have been able to support farmers to grow crops all year round (in three seasons). The crops grown were reported as maize, rice, and vegetables. The maize and rice are grown in the wet season while vegetables are grown in the dry season. The average rice yield in the 2010/2011 farm year was about 21 bags[2]. Seventy six percent (76%) of the respondents said they were satisfied with the current allocation of water to their farms and the rest said they were not satisfied.

Forty eight percent (48%) of the respondents expressed concerns about lack of regular maintenance of the scheme while the rest said there was no problem with lack of regular maintenance. Ninety seven percent (97%) of the farmers expressed concern about lack of facilities to support farming within the scheme. This implies BIS needs more facilities to help

[2] One bag of “rough rice” was estimated to be 1kg

attract famers to the scheme. When farmers were asked about other facilities to help improve BIS, among the facilities mentioned were tractors, combine harvesters, fertilizers, storage facilities, sprayers, and planters. Farmers expressed small plot sizes, lack of credit, pests and diseases, and lack of markets for their produce as other limitations to production in BIS.

The average years of farming under the scheme was reported as 17 years. This means that majority of the farmers are experienced farmers and are mostly indigenes of the catchment area who are not willing to move to other areas for farming.

4.4 Willingness to Pay

In table 4.3(a) is the summary of the WTP bids, their corresponding intervals, and the weighted average of the WTP midpoints. The listed values on the payment card were GHC0, GHC10, GHC20, GHC50, GHC100, GHC150, GHC200, GHC250, GHC300, GHC350, GHC400, and GHC450. The response of an individual revealed the interval within which his/her WTP could be located. If a respondent circled GHC10 for instance, his/her WTP is assumed to be between GHC10 and GHC20. Some respondents circled zero as their WTP bids.

There are two potential issues with responses coded in the GHC 0 and GHC 10 interval. First, the zero responses may be protest bids. A protest bid occurs when a respondent states zero value for the nonmarket resource but may have a value greater than zero for the resource. This behavior may be due to ethical or other reasons including rejection of some aspects of the CVM such as the scenario or the payment vehicle (Halstead, Luloff, and Stevens, 1992; Boyle, 2003). Some respondents may state zero based on the belief that the good should be provided for free. Protest bids result in understating mean WTP or capable of biasing the aggregate benefits downward.

Table 4.3(a) WTP bids, their Corresponding Intervals, and the Weighted Average of the midpoints (n=100)

WTP Bid (GHC)	Interval (GHC)	%	Weighted Average
0	0-10	31	1.55
10	10-20	44	6.60
20	20-50	19	6.65
50	50-100	3	2.25
100	100-150	2	2.50
150	150-200	1	1.75
200	200-250	0	0
250	250-300	0	0
300	300-350	0	0
350	350-400	0	0
400	400-450	0	0
450	450 +	0	0
Total		100	21.30

There are no established criteria for identifying protest bids in WTP surveys because they appear problematic to identify in some cases (Boyle, 2003). Boyle (2003) also proposes that certain measures including follow up questions to obtain reasons for zero bids may be helpful, and that it is better to note that responses of individuals may suggest protests and their reasons may not. Table 4.3(b) is the summary of the number of the zero bids with reasons. Some of the respondents stated that management would misappropriate the money. Others said the cost of production under the scheme was too high, land sizes were too small, crop yield was too low,

Table 4.3(b) Number of Zero WTP Bids with Reasons

Reason	Number
Management will misappropriate the money	19
Cost of production is too high	2
Land sizes are too small	1
Crop yield is too low	4
Water is not well distributed	2
Prevalence of crop diseases	3

and water was not well distributed. Others too cited prevalence of crop diseases. In this case, misappropriation of the funds sounds like protest because the respondents seem to have value for the project but not sure the funds will be used as expected.

Second, the rest of the reasons in table 4.3(b) may be from respondents who actually have zero value for the good. These “actual zeros”, when used in the analysis as the midpoint interval of GHC 0 and GHC 10 will lead to overstatement of the mean WTP or the aggregate benefits from the improvement.

The presence of both sources of error (protest and actual zeros) with countervailing impacts means that one cannot determine systematically whether estimate is an understatement or overstatement of the mean WTP. The fact is that, each error does offset the other to some extent. For this reason, the analysis was conducted with the original dataset intact.

In addition to the ISC, all the respondents agreed to the question whether they will be willing to contribute labor to improve the outcomes of the project. The average number of labor days the respondents were willing to contribute was 5.51 days per year. About 73% of the respondents were willing to contribute labor days ranging from 1 to almost the mean labor days, while 24% were willing to contribute labor days above the mean value up to maximum of 25 days per year. Some of the labor days could be overstated by the respondents simply because an open ended question format was used to elicit the labor days. The interesting thing in this case is that the labor days and the WTP bid each negatively correlates with the location of the farm. This suggests strongly that, farmers located downstream in the scheme are to some extent pessimistic about the success of the project.

4.5 OLS and MLE Estimation Procedures

The empirical models for the OLS and the MLE estimations are already presented in section 2.4.2. Thirteen (13) variables were initially selected in the main OLS and MLE estimations. All the variables are already defined in table 4.4 and the descriptive statistics are in table 4.5. The OLS and the MLE estimations were done using STATA 11. In the OLS, **lnmidptwtp** was selected as the dependent variable and the other variables including the socioeconomic characteristics of the respondents were the independent variables. The OLS was estimated using the model (2) in 2.4.2.

In the MLE, **lnwtpl** and **lnwtpu** were both selected to represent the dependent variable because the two variables are required to make use of the interval between the logarithms of the lower and the upper WTP values. The same independent variables were used in the MLE. The MLE was estimated using model (4) in 2.4.2.

The MLE interval estimation is the best procedure in payment card data analysis so emphasis will be laid on the MLE results. Some of the variables in the main model appeared to be highly correlated so in choosing the variables as well as the best model, both likelihood ratio and wald tests were used. The likelihood ratio test was the nested type and several restrictions

Table 4.4 Definition of the Selected Variables

Variable	Definition
midptwtp	Midpoint of the WTP interval
lnmidptwtp	Logarithm of the midpoint of WTP interval
lnwtpl	Logarithm of the lower bound of the WTP interval
lnwtpu	Logarithm of the upper bound of WTP interval
locationoffarm	Location of the farmland (distance in km from the dam)
landin	Land size within the scheme in hectares
waterallocation	Dummy variable = 1 if satisfied, 0 otherwise
ownership	Dummy variable = 1 if land is leased, 0 otherwise
leaseprice	Lease price of the farmland in Ghana Cedis
sex	Dummy variable = 1 for male, 0 for female
age	Age of respondent in years: 19.5 = < 24 years, 29.5 = 25 to 34, 39.5 = 35 to 44, 49.5 = 45 to 54 59.5 = 55 to 64, 69.5 = > 65
labordays	Number of days a respondent is willing to work to improve the scheme.
education1	Level of education of respondent: 1 = no formal educ., 2 = primary school, 3 = middle/junior high school, 4 = high school, 5 = first degree, 6 = second degree and above.
familysize	Family size (numbers)
lnschemeIncome	Logarithm of the farmer's income from the scheme
lnoffschemeIncome	Logarithm of the farmer's income from outside the scheme
lngrossincome	Logarithm of the farmer's gross income
perschemincome	Percentage of farmer's income from the scheme
yield	Rice yield in kg

Table 4.5 Descriptive Statistics (n = 100)

Variable	Mean	Std. Dev.	Min	Max
midptwtp	21.3	26.0789	5	175
lnmidptwtp	2.6437	0.8613	1.6094	5.1648
wtpl	13.2	21.2194	0	150
wtpu	29.4	31.2636	10	200
lnwtpl[3]	1.6467	1.2969	0	4.6052
lnwtpu	3.0666	0.7215	2.3026	5.
locationoffarm	4.04	2.2157	0.9	7.4
landin	0.7984	0.5205	0.2	2.8
ownership	0.06	0.2387	0	1
leaseprice	1.45	6.5926	0	50
sex	0.94	0.2387	0	1
age	43.7	12.4056	19.5	69.5
education1	1.75	1.3735	1	6
familysize	16.36	12.4061	2	65
labordays	5.51	5.3837	1	25
grossIncome	1760	1177.397	500	5500
schemeincome	780	588.6983	150	2650
lnschemeincome	6.331207	0.8856	5.0106	7.8823
offschemeincome	980	588.6983	350	2850
lnoffschemeincome	7.2433	0.7115	6.2146	8.6125
Yield	21.135	22.2897	0	125

[3] Wtpl = 0 is not transformed but used as lnwtpl = 0 in the MLE interval analysis.

were placed on the main model. The main model is in table 4.6(a). The model in table 4.6(b) appeared to be the best model. The wald test was used to determine the joint significance of the highly correlated variables. The wald test results showed that, the **leaseprice** and **ownership** variables jointly in the main model creates statistical significant improvement but **lnoffschemeincome** and **lnschemeincome** jointly in the main model does not. The wald test also helped in the selection of the model in table 4.6 (b) as the best model to explain the findings in this thesis. The other WTP regressions and the test results are found in appendix II and III, respectively. The model in table 4.6(b) which is used for further analysis in this thesis gave a likelihood ratio chi square value of 26.01 which is significant at 1% level. The model is statistically significant meaning the independent variables jointly have effects on the dependent variable. This suggests that the model is good. The OLS was only used for first approximations but was not considered for further analysis because it is not suitable for PC data analysis (Cameron and Huppert, 1989). Each of **perschemincome** and **lngrossincome** variable was also used in the main model to substitute for the scheme and off scheme income variables and the results can be found in appendix II.

It was also realized that all the respondents agreed they would be willing to provide labor in a form of labor days to improve the scheme. This means all the respondents gave labor days greater than zero.To explore any relationship between the **labordays** variable and the socioeconomic characteristics of the respondents, tobit regression model was used with the **labordays** as a dependent variable in the same ways the other dependent variables were used. Tobit model was used because the labor days were censored at 1 day. Only the results of the tobit regression in which gross income was used are presented in table 4.6(c). The rest of the labor days' regression results are also in appendix II.

Table 4.6(a) Main OLS Midpoint Estimates of WTP and MLE Interval Estimates

Variable	**OLS**	**MLE**
Constant	7.0231	9.5363**
	(1.35)	(2.25)
Locationoffarm	-0.1172***	-0.0752**
	(-2.95)	(-2.44)
Ownership	1.9753***	1.8237***
	(2.72)	(2.69)
Leaseprice	-0.0542**	-0.0663**
	(-2.07)	(-2.22)
Sex	-0.0860	-0.1558
	(-0.21)	(-0.49)
Age	0.0073	0.0026
	(0.94)	(0.41)
education1	0.0274	0.0515
	(0.42)	(1.04)
Familysize	-0.0044	-0.0022
	(-0.49)	(-0.30)
Landin	0.2032	0.2342
	(1.00)	(1.51)
Waterallocation	0.1800	0.1177
	(0.89)	(0.75)
Lnoffschemeincome	-1.9915	-3.2458*
	(-0.87)	(-1.76)
Lnschemeincome	1.5586	2.5995*
	(0.86)	(1.79)
Yield	0.0047	0.0037
	(0.91)	(0.93)
σ	0.7950	0.5407
		(9.8413)
Log likelihood		-98.4487
LR chi2(12)		29.08***
Average median WTP	GHC 15.68	GHC 14.08
Average mean WTP.	GHC 21. 51	GHC 16.30

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

Table 4.6(b) OLS Midpoint Estimates of WTP and MLE Interval Estimates (Restriction: lnoffschemeincome = 0)

Variable	OLS	MLE
Constant	2.5647***	2.2207***
	(2.77)	(3.02)
Locationoffarm	-0.1178***	-0.0781***
	(-2.97)	(-2.48)
Ownership	1.9654***	1.8389***
	(2.71)	(2.75)
Leaseprice	-0.0569**	-0.0715***
	(-2.19)	(-2.56)
Sex	-0.0271	-0.0582
	(-0.07)	(-0.18)
Age	0.0071	0.0024
	(0.91)	(0.38)
education1	0.0206	0.0415
	(0.32)	(0.83)
Familysize	-0.0074	-0.0074
	(-0.91)	(-1.09)
Landin	0.1903	0.2167
	(0.94)	(1.38)
Waterallocation	0.2068	0.1619
	(1.04)	(1.02)
Lnschemeincome	-0.0114	0.0487
	(-0.11)	(0.54)
Yield	0.0040	0.0025
	(0.79)	(0.62)
σ	0.7939	0.5540
		(9.7784)
Log likelihood		-99.9817
LR chi2(12)		26.01***
Average median WTP	GHC 15.58	GHC 14.00
Average mean WTP.	GHC 21. 35	GHC 16.32

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

Table 4.6(c) OLS and Tobit Estimates of Labor Days when Gross Income is used

Variable	OLS	Tobit
Constant	18.9166**	17.4781**
	(2.38)	(2.21)
Locationoffarm	-0. 3026	-0.3217
	(-1.12)	(-1.21)
Ownership	5.3705	9.8425
	(0.94)	(1.26)
Leaseprice	-0. 2420	-0.4947
	(-1.27)	(-1.49)
Sex	0.4378	0.9044
	(0.16)	(0.33)
Age	-0.0160	-0.1672
	(-0.30)	(-0.32)
education1	0.4211	0.3812
	(0.89)	(0.81)
Familysize	0.0901	0.1029*
	(1.63)	(1.86)
Landin	-0.0919	-0.1454
	(-0.07)	(-0.11)
Waterallocation	1.6797	1.2859
	(1.26)	(0.97)
Lngrossincome	-2.1931**	-2.0347**
	(-2.35)	(-2.21)
Yield	0.0325	0.0336
	(0.95)	(1.00)
Log likelihood		-284.6423
LR chi2(11)		14.92
Average median labordays	5.59	5.28
Average mean labordays	5.51	5.26

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

4.6 Calculation of the Median and the Mean WTP

Following Cameron and Huppert (1989), the fitted values were constructed for the logarithm of the dependent variables (**lnmidptwtp** in OLS, and both **lnwtpl** and **lnwtpu** in MLE) after the regressions. For simplicity, say the fitted values of logY. For *x* vector variables, the conditional mean of logY can be expressed in the form $x_i'\beta$, and to retransform logY into Y (**lnmidptwtp** into **midptwtp**; **lnwtpl** and **lnwtpu** into **wtpl** and **wtpu** in our case), $\exp(x_i'\beta)$ is used which is the median WTP value. To compute the mean of Y, the median is scaled by $\exp(\sigma^2/2)$. Where σ is the standard error of the OLS or MLE regressions.

4.7 Discussion of the MLE WTP Results

The best MLE interval estimates are in table 4.6(b). The **locationoffarm** variable was selected to enable a test for how the locations of the farmlands along the stream affect WTP of farmers. This variable is significant at 1% level and proved to be negatively related to WTP.

The sign on the coefficient of the **locationoffarm** makes sense because irrigation farmers who own lands downstream at BIS abandon their lands due to many problems including siltation. One would have expected the downstream farmers to be willing to pay more for the improvement of the project, but the assumption is that they have lost hope in the project due to the long standing maintenance issues coupled with smaller land holdings which most of the farmers complained about.

The **ownership** variable was selected to find out if landowners and those on lease would have different WTP. **Ownership** is significant at 1% level and has a positive coefficient which suggests that the willingness of landowners to pay for the improvement of the scheme is low as compared to those on lease. This makes sense because section 3.4.2 of the MiDA Organization and Management Report which is about land committee under the scheme states that, there are land issues under the scheme and land owners who do not pay their ISCs will lose their lands in various ways, including the reallocation of the land to a family or community member (MiDA, 2011). This MiDA report reveals lack of well defined property rights with regard to land under the scheme. This might be the cause of land owners' unwillingness to invest in the project. The willingness of lessees to pay for the improvement may be because the lessees may not be indigenous of the catchment area and are likely at BIS for commercial farming. In this case, the lessees may be leasing the lands from GIDA and may be willing to pay more to improve the scheme so that they can increase their returns from the fixed land inputs.

Leaseprice variable is significant at 1% level and has a negative sign on its coefficient. This conforms to economic theory because willingness to pay for the improvement of the irrigation scheme is expected to decrease as the lease price of the farmland increases. Increase in land lease price has the tendency to affect the farmer's revenue from the scheme which will then negatively impact the farmers' WTP.

The rest of the selected variables: **lnschemeincome, sex, age, education1, Familysize, Landin, Waterallocation, and Yield** are, however, not statistically significant but have the expected signs on their coefficients. The sign on the coefficient of **lnschemeincome** is positive which makes sense because WTP is expected to increase as the farmer's income from the scheme increases. This conforms to economic theory. The sign of the coefficient of the **sex** variable is negative which makes sense because women in Ghana do not mostly participate in irrigated agriculture, but where they do, they mostly grow vegetables in order to sell and also to supplement the family needs. This is what happens at BIS and the women who are housewives are willing to pay more to sustain the scheme so that they can produce more vegetables from which they can earn income as well as serve their housewife duties.

The **age** variable has a positive sign on its coefficient which also makes sense because most of the farmers are within the active working age (19-55) and the proportion of farmers within the scheme increases as the age increases up to about 55 years before the proportion turns to decrease. The decrease in proportion of aged farmers does not suggest their unwillingness to participate in the irrigation project but due to the fact that aged farmers hand over their lands to their family members who are within the active working age group. In this case age can be judged as a proxy for experience and the experienced farmers can be willing to pay more to improve the project if they perceive it to be helpful to them.

One would have expected the **education1** variable to have a negative sign on its coefficient because farmers with higher education in the area probably have higher off farm incomes. But this is not the case under BIS and one would attribute the willingness of the more educated farmers to pay more to improve the scheme to the fact that, the educated farmers may very well understand the need to sustain the project and also, they may be the kind of farmers from outside the catchment area who travel to the area to do commercial farming. Such commercial farmers certainly want to pay more to improve the project so that they can maximize their profits. The **Familysize** variable has negative sign on its coefficient which suggests that, larger families are not will to pay more to improve the project. This may be due to the fact that larger families depend mostly on outside the scheme lands to feed their families. The **Landin** variable also has a positive sign on it coefficient which also makes sense. Farmers with more land within the scheme depend on the scheme for most of their earnings and are willing to pay more to improve the project.

Also, both the **waterallocation** and **Yield** variables have positive signs on their coefficients which are meaningful. The upstream farmers within the scheme are mostly those without water allocation issues. These farmers are optimistic about how much they can gain from improving the scheme and are therefore willing to pay more to improve the scheme. Also, once the farmer's crop yield within the scheme increases, the assumption is that his/her income will increase and the farmer would be willing to pay more to improve the scheme.

The MLE estimates when each of the **perschemeincome** and **lngrossincome** variables were used are in appendix II. The signs on the coefficients of the variables remained the same and the **perschemeincome** and **lngrossincome** variables still have the expected signs which are positive but still not statistically significant. The positive sign on the coefficient of the **perschemeincome** indicates that, as the percentage of the famer's income that is from the scheme increases, the farmer would be willing to pay more for the improvement of the project. This makes sense and conforms to demand theory.That of the positive sign on the coefficient of the **lngrossincome** also makes sense because the scheme income forms part of the gross income even though the off scheme income is higher for each farmer than the scheme income, both incomes are positively correlated which means they grow together. Likelihood ratio chi square test for each regression was significant at 1% which suggests the models are good.

4.8 Discussion of the Labor Days' Tobit Results

All the variables in the **labordays** regression when the gross income was used maintained the signs of their coefficients as in the main WTP MLE results except the **sex, age, familysize, and landin** variables. The sign on the **sex** variable switched to positive which might be due to the common perception in the catchment areas that men are supposed to provide farm labor. So in this case men are willing to work more days to improve the project as compared to women. The negative sign on the **age** variable tells us that the farmers in their younger ages are willing to work more days than the elderly farmers. The **landin** variable has a negative sign on its coefficient and this can be ascribed to the thinking that larger land holders are probably commercial farmers who prefer to pay in a form of money than in labor days.

The two most important variables in the labor days' regression are **familysize** and **lngrossincome.** The **familysize** variable is significant at 10% level while the **lngrossincome** variable is significant at 5% level. The sign on the coefficient of the **familysize** variable is positive which suggests that larger families are willing to pay in a form of labor than in a form of money. This makes sense because they may feel that they have more labor force to contribute than money in order to improve the project. And for the **lngrossincome** variable, the sign is negative which simply means that, farmers are willing to donate less labor to improve the project as their incomes increases. This could be due to the higher opportunity cost of their time. The results could also be from the fact that the marginal utility of income for the low income households is higher as compared to that of the higher income households. Therefore, lower income households will be more willing to pay in a form of labor days than in money.

CHAPTER FIVE: SUMMARY AND CONCLUSIONS

The main aim of this thesis was to determine how much farmers under the Bontanga Irrigation Scheme would be willing to pay for the improvement of the project. From the results, the median WTP was calculated as GHC14.00 (US$7.29) per ha per year and the mean WTP was calculated as GHC 16.32 (US$8.50) per ha per year. The median WTP value represents the amount 50% of the farmers will be willing to pay and at the same time it represents the amount 50% of the farmers will **not** be willing to pay. The mean represents the average amount an individual farmer will be willing to pay for the improvement of the project. The significant and most influencing factors that were identified to affect WTP of farmers are location of the farm, ownership, and land lease prices. Farmers upstream had higher willingness to pay for the improvement as compared to farmers downstream and in the middle. WTP decreases as the distance from the reservoir increases. Land owners have lower willingness to pay for the improvement as compared to lessees. This appears contrary to what one would expect but there appear to be land ownership issues under the scheme which are clearly stated under section 3.4.2 in the MiDA Organization and Management Report, 2011. The MiDA report states that, land owners who do not pay their ISCs may lose their lands to either family or community members.

Most of the CVM studies in developing countries are centered on WTP for irrigation water or drinking water under improved water supply conditions. So their results are not directly comparable to this study. There are also no similar studies on irrigation schemes in Ghana that are published for one to compare the results of this study to. Results from this study may only be comparable to those which are discussed in chapter two in terms of WTP values, simply because each study is carried out under different set up and CVM scenario. It sounds like WTP for irrigation services in developing countries are low, comparing our results to those of Weldasilassie et al (2009), Chandrasekaran et al (2009), Akter (2007), and Basarir et al (2009) which are discussed in chapter 2.

This study is only to provide a useful insight to the limited research in WTP for irrigation improvement in Ghana. So based on the results from this study, BIS could consider benefit cost analysis of the project to see if the total benefits from the improvement of the project would outweigh the total costs before charging farmers the new ISC. If the new ISC is implemented, it would serve as the first step to achieving the proposed GHC 246.42 (US$128.34) per ha per year as the ISC required under the PPP management framework.

The aggregate benefits per year for the improvement of BIS assuming each farmer is expected to pay the mean WTP amount can be calculated as GHC 9,302.40 (US$ 4,845.00) which is obtained by multiplying the mean WTP (GHC 16.32 (US$ 8.50)) by the current irrigated land area (570 ha). This aggregate benefits value does not reflect the additional benefits to the scheme when the irrigated land is expanded.

Another way BIS could improve the project is to utilize the supply of labor which is agreed upon by all the farmers. The average labor days of the respondents based on the tobit regression was calculated as 5.26 days/year and the median is 5.28 days/year. Comparing the average labor days to the mean WTP, GHC 3.10 (US$1.62) can be considered as the monetary value of a labor day under the scheme.

Limitations to the Study

Even though the response rate was 100% and respondents were willing to participate in the interviews, it was still difficult to obtain accurate measures of the respondents' farm outputs.

Based on that, farm outputs which were expressed in bags had to be converted into kilograms (rice especially) but those which were expressed in baskets (vegetables in particular) could not be converted into standard units. This conversion could be imprecise because a bag of “rough rice” under the scheme was estimated as 1kg. Also, because majority of the farmers in the scheme lack formal education, they rarely keep individual farm records which made it difficult for us to retrieve their farm data. So farmers under the scheme should be advised to start keeping records of their farming activities including their farm outputs in standard units which will make it easier for researchers to study the scheme.

Also, most of the farmers practice mixed cropping at all seasons and this makes itdifficult to estimate their crop water requirements which could have been used in our analysis. One next study could sort the farmers according to the crops they grow in order to include the crop water requirements which may also be an important factor in determining farmers’ WTP.

Another factor that might affect WTP of farmers in the catchment area is their political inclinations. It would not be surprising for farmers in developing countries to underestimate or overestimate their WTP bids based on their political party affiliations. One next study on the scheme should try to implicitly or explicitly elicit information about the political party affiliations of the farmers to find out the differences in WTP bids that might result from their political values.

Lastly, land ownership under the scheme seems not to be well defined because some farmers were not willing to disclose their total land sizes because of the fear of redistribution, which they said occurred some years ago. In this case, it is hard to get accurate farm data which are related to land sizes of the farmers.

Opportunities for Further Studies

1. The next step recommended is to conduct cost benefit analysis of the scheme to see if increasing the irrigation service charges based on this study would be beneficial.
2. Since location appears to be very important (significant) in all the WTP regressions, the next study under the scheme could try to control for location by estimating WTP for different locations (upstream, middle, and downstream) to see if WTP values for the locations will differ considerably.

3. If location really matters, regrouping the FBOs based on the location of their farms sounds like a good idea as compared to the current FBO formation which is based on communities. If the regrouping is done, the scheme may decide to charge the entire individual ISCs to the FBO and since WTP based on this research is location specific, the scheme may try to study the variations that are likely to occur in the payment of the ISCs and then decide what further actions to take.

4. If funding is available, researchers might consider estimating WTP for the two different seasons (wet and dry). This is because the level of utilization of the project depends on the season and this might create variations in WTP across seasons.

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APPENDICES

APPENDIX I: SURVEY QUESTIONNAIRE

Estimating Farmers' Willingness to pay for Improved Irrigation: An Economic Study of the Bontanga Irrigation Scheme in Northern Ghana.

Date of interview: ………………………………………………….

Name of interviewer ………………………………………………..

Background Information

I would like to ask you some questions that would assist you, other farmers and the government in determining how to improve the Bontanga Irrigation System. These questions usually take about 30 minutes. We are interviewing a sample of about 100 farmers of the Bontanga Irrigation Scheme, so your input is considered very valuable to this survey. The information you give will be treated as confidential.

As you are already aware, the Bontanga Irrigation System was rehabilitated by the Millennium Development Authority (MiDA) in 2011 at the cost of about GHC 5 million (US$ 3 million).

MiDA resurfaced the main and the lateral roads on the existing 570 hectares of developed land, dredged the drainage system, renovated 6 farm buildings, provided 33 new threshing floors, and 9 maintenance sheds. And still to increase the developed land area from the current 570 hectares to 800 hectares.

To ensure all year round farming in the irrigation district:

1. The Ghana Irrigation Development Authority (GIDA) is considering the improvement of the irrigation technology: supporting the gravity irrigation with pumps, fixing and replacing

the current gates with well designed gates for proper control of turnouts at laterals, and adding standard weirs at every turn for proper measuring of flows, and

2. Provision of more irrigation facilities including machinery (tractors, combine harvesters, dredging machines and so on).

PROPOSED PROGRAM: For these to happen, the management of the Bontanga Irrigation Scheme which you already know is made up of you, other farmers and the government, will have to share the operating and maintenance costs of the irrigation project. The current Joint Irrigation System Management (JISM) will be replaced by Public Private Partnership (PPP) system. Under PPP, the Farmer Based Organizations and the government will still manage the scheme but you will need a large private anchor farmer to use the newly developed land. This anchor farmer will help provide farm machinery and equipment for operation and maintenance of the scheme, buying and marketing produce from the scheme and providing links to existing markets and other valuable services, such as input supply.

Let me first ask you a few identification questions.

<u>Section A. Identification:</u>

1. Identification #: ………………………………………………..

2. At which lateral is your farm located? *(terminate if different from farm location for which the respondent is selected)* …………………………………

3. Position of Respondent:

a. Head of household **b.** Spouse of head of household **c.** Other, please specify ……………

<u>Section B. Major Concerns:</u>

(For this question, present the list in a different order on a random basis to each respondent)

"I would like to show you a list of possible problems that might be faced by your farm household in future"

(Select all that are major concerns to your farm household)

a. Lack of water for irrigation **b.** Lower crop yield from rain-fed agriculture **c.** Poverty, hunger, and starvation **d.** Severe drought **e.** none of the above *(skip to section c)*

1. Of these possible problems, which do you consider the most serious problem for your farm household? *(choose one)*

Most serious problem …………. (*Write letter – a to d*)

Don't know

2. And which do you consider the second most serious problem?

Second most serious problem …………………..(*Write letter – a to d*)

Don't know

Section C. Existing Situation Regarding the Bontanga Irrigation Project:

"Now, I would like to ask you some questions regarding the use of the irrigation facilities including water by your farm household."

1.Please give us the estimates of your farm land areas within and outside the irrigation scheme.

Land inside the scheme (acres)	Land outside the scheme (acres)	Total (acres)

2. How serious would it be if you were to depend solely on the farm lands outside the scheme?

a. Very serious **b.** Somewhat serious **c.** Not serious **d.** I don't know

3. Do you have farm lands at different locations within the scheme?

a. Yes **b.** No

4.. Please give us information about your farm lands within the scheme.

Land size (acres)	Location (Lateral number)	Ownership (Leased, purchased, family, other (please specify))	If **LEASED**, how much did you pay last year?

5. How many seasons do you grow your crops under the Bontanga Irrigation Scheme?

a. One season **b.** Two Seasons **c.** Other, please specify………………………….

Can we get the information based on your last year's (2010/2011) farm records?

Wet Season:

6. Type of crop	7. Area Cultivated (acres)	8.Yield (Kg)	9. Cost (GHC)

Dry Season:

10. Type of crop	11. Area Cultivated (acres)	12.Yield (Kg)	13. Cost (GHC)

14. Are you satisfied with the current allocation of water to your farm household?

a. Yes **b.** No **c.** I don't know

15. In your opinion, is there a problem of lack of regular maintenance of the irrigation project?

a. Yes **b.** No *(skip 16)* ***c.*** Don't know *(skip 16)*

16. If you answered yes in 15 above, how do you judge the lack of regular maintenance of the irrigation project?

a. Very serious **b.** Somewhat serious **c.** Not serious **d.** Don't know

17. In your opinion, is there a problem of lack of facilities to support farming under the irrigation project? *(Show to respondent the list of facilities)*

a. Yes **b.** No *(skip18 and 19)* **c.** I don't know *(skip18 and 19)*

18.If you answered yes in 17 above, how do you judge the lack of facilities to support farming under the irrigation project?

a. Very serious **b.** Somewhat serious **c.** Not serious **d.** Don't know

19. Are there any other facilities you think would help improve the project? (*List them below*)

……………………………………………………………………………………………………

20. Now I want to ask you about an irrigation system that gives you water in different amounts to produce crops in only one season in a year and another irrigation system with all facilities that gives you constant amount of water to produce crops all year round *(circle only one).*

a. I want to produce in one season **b.** I want to produce all year round **c.** I don't know

21. Are there other limitations to production besides water? List them below (Examples include Lack of credit, lack of storage facilities, Prevalence of pest and so on)

………………………………………………………………………………………………………

………………………………………………………………………………………………………

22. Are you a member of a Farmer Based Organization?

a. Yes **b.** No **c.** I don't know

23. How many years have you been farming under the Bontanga Irrigation Scheme?

………………….years

IMPROVED BONTANGA IRRIGATION PROJECT

"As mentioned, the Bontanga Irrigation Project has just been rehabilitated and the management including you (I mean including the Farmer Based Organizations of which you are likely to be a member) still require more money to improve the system, in order to:

1. Support gravity flow with pump,
2. Fix and replace the current gates with well designed gates for proper control of turnouts at laterals,
3. Install standard weirs at every turn for proper measuring of flows,
4. Provide more irrigation facilities including machinery (tractors, combine harvesters, dredging machines and so on), and
5. Implement regular maintenance of the irrigation project.

If the system is improved, you will have the opportunity to farm all year round (at least 3 seasons) and be able to pay a flat Irrigation Service Charge (ISC) per hectare per year."

<u>Section D. Willingness to Pay</u>

"Now, I would like to ask you questions to help us understand how much you value the irrigation facilities including the water you use currently and in the future. You are not required to pay anything as we go through the questions but we want you to answer the questions as if you would have to pay. It will be helpful for us to know what you think about the irrigation project now and in the future.

We already mentioned that the PPP system will be made up of you, all other farmers, the government, and the large anchor private farmer. The anchor private farmer will provide the scheme with machinery and equipment for operation and maintenance of the scheme, buying and marketing produce from the scheme and providing links to existing markets. If the money collected is not enough, the new program will NOT be implemented":

1. What is the highest Irrigation Service Charge per hectare per year your household would pay for the improved irrigation program? *(Answer just for the farm land for which you are selected to take part in this survey)*

Please circle ONLY ONE as the highest amount per hectare per year you would pay for the improved program

0 GHC	10 GHC	20 GHC
50 GHC	100 GHC	150 GHC
200 GHC	250 GHC	300 GHC
350 GHC	400 GHC	450 GHC

(For response greater than zero, skip question 2)

2.If you selected zero in 1 above, please state your reason(s) for not willing to contribute to the program;

…………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………

3.In your opinion, what do you think about increasing the irrigation charges above the current GHC 50 per ha per year (25 per ha per season) to improve the irrigation project?

a. reasonable **b.** Unreasonable **c.** I don't know

4. In addition to paying your ISCs would you be willing to contribute labor to improve the outcomes of the project?

a. Yes **b.** No *(skip to section E)*

5. If you answered yes to 4 above, how many days per year would you be willing to work to improve the project? ……………….days

Section E. Other Information

"We will soon be ending this interview. Before we do end it, I would like to ask some questions about you and your family."

1.Are you

a. Male **b.** female

2. What is your age?

a. Under 24 **b.** 25 to 34 **c.** 35 to 44 **d.** 45 to 54 **e.** 55 to 64 **f.** Over 65

3. What is your highest level of education?

a. No formal education **b**. Primary school **c.** Middle school/ Junior high school **d.** High school

e. First degree/Tertiary/Post-secondary **f.** Second degree and above

4. What is the highest level of education of the most educated member of your household?

a. No formal education **b**. Primary school **c.** Middle school/ Junior high school **d.** High school

e. First degree/Tertiary/Post-secondary **f.** Second degree and above

5. How many people (children and adults) live in your household? ……………….

6. How many people in your household contribute to the household income? …………………………

7.How much was your last year's total household income from all sources?

a. less than GHC 1000 **b.** between GHC 1000 and 2000 **c.** between GHC 2000 and 3000 **d.** between GHC 3000 and 4000 **e.** Between GHC 4000 and 5000 **f.** More than GHC 5000

8. How much of your last year's total household income do you think came from farming under the scheme?

GHC …………………………………………

"Thank you for your contribution to this survey. We hope to use these results to determine how best to provide affordable and desirable irrigation services to the farmers under the Bontanga Irrigation Scheme. We promise to contact you if we need additional information"

APPENDIX II: WTP AND LABOR DAYS' REGRESSIONS

Table II.1 OLS Midpoint Estimates of WTP and MLE Interval Estimates when the Percentage of Scheme Income is used.

Variable	OLS	MLE
Constant	2.3835	1.1276
	(1.16)	(0.67)
Locationoffarm	-0.1172***	-0.0764**
	(-2.96)	(-2.43)
Ownership	1.9756***	1.8496***
	(2.73)	(2.78)
Leaseprice	-0.0570**	-0.0712**
	(-2.20)	(-0.57)
Sex	-0.0254	-0.0648
	(-0.06)	(-0.20)
Age	0.0071	0.0023
	(0.91)	(0.35)
education1	0.0219	0.0442
	(0.34)	(0.88)
Familysize	-0.0078	-0.0075
	(-0.98)	(-1.12)
Landin	0.1854	0.2121
	(0.92)	(1.36)
Waterallocation	0.2085	0.1601
	(1.05)	(1.01)
Perschemeincome	0.1288	1.6185
	(0.06)	(0.86)
Yield	0.0039	0.0024
	(0.78)	(0.60)
σ	0.7939	0.5518
		(9.7664)
Log likelihood		-99.7575
LR chi2(11)		26.46***
Average median WTP	GHC 15.58	GHC 14.00
Average mean WTP	GHC 21. 35	GHC 16.30

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

Table II.2 OLS Midpoint Estimates of WTP and MLE Interval Estimates when the Gross Income is used.

Variable	OLS	MLE
Constant	2.6465**	2.1673**
	(2.28)	(2.31)
Locationoffarm	-0.1180***	-0.0786**
	(-2.98)	(-2.50)
Ownership	1.9623***	1.8349***
	(2.71)	(2.74)
Leaseprice	-0.0568**	-0.0715**
	(-2.19)	(-0.57)
Sex	-0.0285	-0.0576
	(-0.07)	(-0.18)
Age	0.0071	0.0025
	(0.91)	(0.39)
education1	0.0202	0.0407
	(0.31)	(0.81)
Familysize	-0.0073	-0.0073
	(-0.89)	(-1.06)
Landin	0.1921	0.2186
	(0.95)	(1.39)
Waterallocation	0.2058	0.1617
	(1.03)	(1.02)
lngrossincome	-0.0214	0.0495
	(-0.16)	(0.43)
Yield	0.0041	0.0025
	(0.80)	(0.63)
σ	0.7938	0.5545
		(9.7795)
Log likelihood		-100.0338
LR chi2(11)		25.91***
Average median WTP	GHC 15.58	GHC 14.00
Average mean WTP	GHC 21. 35	GHC 16.33

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

Table II.3 OLS Midpoint Estimates of WTP and MLE Interval Estimates (Restriction: leaseprice = 0)

Variable	**OLS**	**MLE**
Constant	8.4833	10.9872***
	(1.61)	(2.54)
Locationoffarm	-0.1289***	-0.0853***
	(-3.22)	(-2.69)
Ownership	0.6705*	0.4129
	(1.82)	(1.31)
Sex	-0.2747	-0.3484
	(-0.67)	(-1.10)
Age	0.0078	0.0031
	(0.99)	(0.48)
education1	0.0246	0.0494
	(0.37)	(0.97)
Familysize	-0.0038	-0.0024
	(-0.42)	(-0.32)
Landin	0.2555	0.2872
	(1.25)	(1.82)
Waterallocation	0.1702	0.1181
	(0.83)	(0.73)
lnofschemeincome	-0.5413	-3.7989**
	(-1.10)	(-2.01)
lnschemeincome	1.9859	3.0310
	(1.08)	(2.03)**
Yield	0.0036	0.0028
	(0.70)	(0.69)
σ	0.8097	0.5606
		(9.7117)
Log likelihood		-101.1490
LR chi2(11)		23.68**
Average median WTP	GHC 15.27	GHC 13.87
Average mean WTP	GHC 21. 19	GHC 16.23

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

Table II.4 OLS Midpoint Estimates of WTP and MLE Interval Estimates (Restriction: ownership = 0)

Variable	OLS	MLE
Constant	7.3430	10.1211**
	(1.36)	(2.28)
Locationoffarm	-0.1313***	-0.0849***
	(-3.22)	(-2.63)
Leaseprice	0.0075	-0.0004
	(0.56)	(-0.03)
Sex	-0.3594	-0.4190
	(-0.87)	(-1..31)
Age	0.0061	0.0022
	(0.76)	(0.34)
education1	0.0227	0.0526
	(0.34)	(1.02)
Familysize	-0.0037	-0.0031
	(-0.40)	(-0.41)
Landin	0.2588	0.2972*
	(1.24)	(1.85)
Waterallocation	0.1895	0.1425
	(0.91)	(0.87)
lnoffschemeincome	-1.8938	-3.3340*
	(-0.80)	(-1.72)
lnschemeincome	1.4564	2.6546
	(0.78)	(1.74)*
Yield	0.0027	0.0021
	(0.51)	(0.51)
σ	0.8234	0.5704
		(9.7590)
Log likelihood		-101.9812
LR chi2(11)		22.01**
Average median WTP	GHC 15.05	GHC 13.71
Average mean WTP	GHC 21. 12	GHC 16.13

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

Table II.5 OLS Midpoint Estimates of WTP and MLE Interval Estimates (Restriction: lnschemeincome = 0)

Variable	OLS	MLE
Constant	2.6465**	2.1673**
	(2.28)	(2.31)
Locationoffarm	-0.1180***	-0.0786**
	(-2.98)	(-2.50)
Ownership	1.9623***	1.8349***
	(2.71)	(2.75)
Leaseprice	-0.0568**	-0.0718**
	(-2.19)	(-2.56)
Sex	-0.085	-0.0577
	(-0.07)	(-0.18)
Age	0.0071	0.0025
	(0.91)	(0.39)
education1	0.0202	0.0407
	(0.31)	(0.81)
Familysize	-0.0073	-0.0073
	(-0.89)	(-1.06)
Landin	0.1921	0.2186
	(0.95)	(1.39)
Waterallocation	0.2058	0.1617
	(1.03)	(1.02)
lnoffschemeincome	-0.0214	0.0495
	(-0.16)	(0.43)
Yield	0.0041	0.0025
	(0.80)	(0.63)
σ	0.7938	0.5544
		(9.7784)
Log likelihood		-100.0338
LR chi2(11)		25.91***
Average median WTP	GHC 15.58	GHC 14.00
Average mean WTP	GHC 21. 35	GHC 16.33

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

Table II.6 OLS Midpoint Estimates of WTP and MLE Interval Estimates (Restriction: leaseprice = 0; lnoffschemeincome = 0)

Variable	OLS	MLE
Constant	2.8082***	2.4538***
	(2.99)	(3.23)
Locationoffarm	-0.1305***	-0.0897***
	(-3.26)	(-2.76)
Ownership	0.5760	0.2788
	(1.61)	(0.89)
Sex	-0.2103	-0.2607
	(-0.52)	(-0.81)
Age	0.0076	0.0032
	(0.96)	(0.348
education1	0.0155	0.0380
	(0.24)	(0.73)
Familysize	-0.0078	-0.0090
	(-0.94)	(-1.27)
Landin	0.2421	0.2749*
	(1.18)	(1.70)
Waterallocation	0.2043	0.1753
	(1.01)	(1.07)
lnschemeincome	-0.0180	0.0436
	(-0.16)	(0.47)
Yield	0.003	0.0013
	(0.53)	(0.31)
σ	0.8106	0.5792
		(9.7839)
Log likelihood		-103.1362
LR chi2(11)		19.70**
Average median WTP	GHC 15.18	GHC 13.76
Average mean WTP	GHC 21. 08	GHC 16.27

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

Table II.7 OLS Midpoint Estimates of WTP and MLE Interval Estimates (Restriction: leaseprice = 0; lnschemeincome = 0)

Variable	**OLS**	**MLE**
Constant	2.9226** (2.48)	2.4302** (2.50)
Locationoffarm	-0.1307*** (-3.26)	-0.0904*** (-2.78)
Ownership	0.5742 (1.61)	0.2746 (0.88)
Sex	-0.2120 (-0.52)	-0.2603 (-0.81)
Age	0.0076 (0.96)	0.0032 (0.48)
education1	0.0151 (0.23)	0.0371 (0.71)
Familysize	-0.0076 (-0.90)	-0.0088 (-1.23)
Landin	0.2423 (1.19)	0.2772* (1.71)
Waterallocation	0.2031 (1.00)	0.1745 (1.06)
lnoffschemeincome	-0.0318 (-0.23)	0.0408 (0.34)
Yield	0.0028 (0.54)	0.0013 (0.32)
σ	0.8105	0.5797 (9.7932)
Log likelihood		-103.1857
LR chi2(11)		19.60**
Average median WTP	GHC 15.18	GHC 13.77
Average mean WTP	GHC 21. 08	GHC 16.29

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

Table II.8 OLS Midpoint Estimates of WTP and MLE Interval Estimates (Restriction: ownership = 0; lnoffschemeincome = 0)

Variable	**OLS**	**MLE**
Constant	3.1006***	2.6064***
	(3.31)	(3.44)
Locationoffarm	-0.1319***	-0.0878***
	(-3.24)	(-2.67)
Leaseprice	0.0048	-0.0049
	(0.37)	(-0.40)
Sex	-0.3021	-0.3230
	(-0.74)	(-1.01)
Age	0.0060	0.0021
	(0.74)	(0.31)
education1	0.0162	0.0426
	(0.24)	(0.81)
Familysize	-0.0066	-0.0086
	(-0.78)	(-1.21)
Landin	0.2463	0.2809*
	(1.18)	(1.72)
Waterallocation	0.2149	0.1899
	(1.04)	(1.14)
lnschemeincome	-0.0365	0.0346
	(-0.33)	(0.37)
Yield	0.0021	0.0008
	(0.40)	(0.20)
σ	0.8217	0.5847
		(9.8160)
Log likelihood		-103.4437
LR chi2(11)		19.09**
Average median WTP	GHC 15.01	GHC 13.65
Average mean WTP	GHC 21. 04	GHC 16.19

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

Table II.9 OLS Midpoint Estimates of WTP and MLE Interval Estimates (Restriction: ownership = 0; lnschemeincome = 0)

Variable	OLS	MLE
Constant	3.2495***	2.5938***
	(2.75)	(2.67)
Locationoffarm	-0.1320***	-0.0883***
	(-3.25)	(-2.68)
Leaseprice	0.0048	-0.0050
	(0.37)	(-0.41)
Sex	-0.3040	-0.3224
	(-0.75)	(-1.01)
Age	0.0060	0.0021
	(0.74)	(0.32)
education1	0.0160	0.0419
	(0.24)	(0.80)
Familysize	-0.0064	-0.0085
	(-0.76)	(-1.18)
Landin	0.2481	0.2828*
	(1.19)	(1.73)
Waterallocation	0.2136	0.1893
	(1.04)	(1.14)
lnoffschemeincome	-0.0527	0.0314
	(-0.38)	(0.26)
Yield	0.0022	0.0009
	(0.41)	(0.21)
σ	0.8216	0.5850
		(9.8303)
Log likelihood		-103.4763
LR chi2(11)		19.02**
Average median WTP	GHC 15.01	GHC 13.66
Average mean WTP	GHC 21. 04	GHC 16.21

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

LABOR DAYS' REGRESSIONS

Table II.10 Main OLS and Tobit Estimates of Labor Days

Variable	**OLS**	**Tobit**
Constant	60.8038*	57.2873*
	(1.73)	(1.65)
Locationoffarm	-0. 2910	-0.3121
	(-1.08)	(-1.19)
Ownership	5.3660	8.9778
	(0.94)	(1.25)
Leaseprice	-0. 2135	-0.4236
	(-1.11)	(-1.42)
Sex	-0.1296**	0.2758
	(-0.05)	(0.10)
Age	-0.0145	-0.0145
	(-0.28)	(-0.28)
education1	0.4657	0.4261
	(0.98)	(0.91)
Familysize	0.1181	0.1277**
	(1.98)	(2.18)
Landin	0.0185***	-0.0168
	(0.01)	(-0.01)
Waterallocation	1.4120	1.0581
	(1.04)	(0.80)
Lnoffschemeincome	-21.0207	-19.8900
	(-1.37)	(-1.31)
Lnschemeincome	14.8953	14.1200
	(1.23)	(1.18)
Yield	0.0384	0.0391
	(01.11)	(1.16)
Log likelihood		-283.9565
LR chi2(11)		16.29
Average median labordays	5.79	5.60
Average mean labordays	5.51	5.28

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

Table II.11 OLS and Tobit Estimates of Labor Days when Percentage Scheme Income is used

Variable	OLS	Tobit
Constant	29.7339**	27.3874**
	(2.09)	(1.96)
Locationoffarm	-0. 2992	-0.3164
	(-1.10)	(-1.18)
Ownership	5.4198	10.5858
	(0.94)	(1.26)
Leaseprice	-0. 2524	-0.5404
	(-1.31)	(-1.48)
Sex	0.6975	1.2175
	(0.25)	(0.44)
Age	-0.0157	-0.0170
	(-0.30)	(-0.32)
education1	0.4312	0.3866
	(0.90)	(0.59)
Familysize	0.0709	0.0865*
	(1.31)	(1.59)
Landin	-0.2255	-0.2890
	(-0.17)	(-0.21)
Waterallocation	1.8297	1.3999
	(1.36)	(1.05)
Perschemeincome	-30.309**	-28.2255**
	(-1.96)	(-1.83)
Yield	0.0279	0.0338
	(0.81)	(0.87)
Log likelihood		-285.3563
LR chi2(11)		13.49
Average median labordays	5.50	5.34
Average mean labordays	5.51	5.26

Note: *** = significance at 1% level; ** = significance at 5% level; * = significance at 10% level. Values in parentheses are t-values.

APPENDIX III: SIMPLE CORRELATIONS, LIKELIHOOD RATIO AND WALD TESTS RESULTS

TABLE III.1 SIMPLE CORRELATIONS

	lnmidp~p	locati~m	owners~p	leasep~e	sex	age	educat~1	family~e	landin	watera~n	lnoffs~e	lnsche~e	yield
lnmidptwtp	1.0000												
locationof~m	-0.3543	1.0000											
ownership	0.1359	0.0031	1.0000										
leaseprice	-0.0104	0.0631	0.8750	1.0000									
sex	-0.0441	-0.1845	-0.1135	-0.0212	1.0000								
age	0.0364	0.0831	-0.1883	-0.1888	-0.0846	1.0000							
education1	-0.0283	0.0564	0.1078	0.1174	-0.0462	-0.3824	1.0000						
familysize	-0.0295	0.1220	0.0098	-0.0109	-0.3534	0.4079	-0.1248	1.0000					
landin	0.1710	-0.0023	-0.0805	-0.1206	-0.2447	0.1963	-0.0887	0.3032	1.0000				
wateralloc~n	0.2117	-0.3307	0.0434	0.0171	0.0552	-0.0175	-0.1199	-0.0236	-0.0017	1.0000			
lnoffschem~e	0.0255	-0.0066	-0.1288	-0.1247	-0.2403	0.2484	-0.1726	0.4535	0.3896	-0.0443	1.0000		
lnschemein~e	0.0306	-0.0181	-0.1441	-0.1399	-0.2177	0.2416	-0.1807	0.4261	0.3770	-0.0343	0.9980	1.0000	
yield	0.1106	0.0965	-0.0775	-0.0768	-0.4541	0.1683	-0.0568	0.3464	0.6178	-0.0420	0.3974	0.3785	1.0000

LIKELIHOOD RATIO TEST RESULTS

y1: Unrestricted (main) model

y2: Restricted model (leaseprice =0)

y3: Restricted model (ownership =0)

y4: Restricted model (lnoffschemeincome = 0)

y5: Restricted model (lnschemeincome = 0)

y6: Restricted model (leaseprice = 0; lnoffschemeincome = 0)

y7: Restricted model (leaseprice = 0; lnschemeincome = 0)

y8: Restricted model (ownership = 0; lnoffschemeincome = 0)

y9: Restricted model (ownership = 0; lnschemeincome = 0)

Table III.2(a) LR Test Results with One Variable Restriction

LR Test	LR chi2(1)	Prob>chi2	Comment
y2 nested in y1	5.40	0.0201	Reject Ho
y3 nested in y1	7.06	0.0079	Reject Ho
y4 nested in y1	3.07	0.080	Reject Ho
y5 nested in y1	3.17	0.0750	Reject Ho

Table III.2(b) LR Test Results with Two Variables Restriction

LR Test	LR chi2(2)	Prob>chi2	Comment
y6 nested in y1	9.38	0.0092	Reject Ho
y7 nested in y1	9.47	0.0088	Reject Ho
y8 nested in y1	9.99	0.0068	Reject Ho
y9 nested in y1	10.06	0.0066	Reject Ho

<u>WALD TEST RESULTS</u>

Table III.3 Wald Test Results

Wald Test	LR chi2	Prob>chi2	Comment
Ownership and leaseprice	7.29	0.0261	Reject Ho
Lnoffschemeincome & lnschemeincome	3.41	0.1822	**Fail to reject Ho**
Lnoffschemeincome	3.08	0.0791	Reject Ho
Lnschemeincome	3.19	0.0739	Reject Ho
Ownership	7.23	0.0072	Reject Ho
Leaseprice	4.92	0.0265	Reject Ho