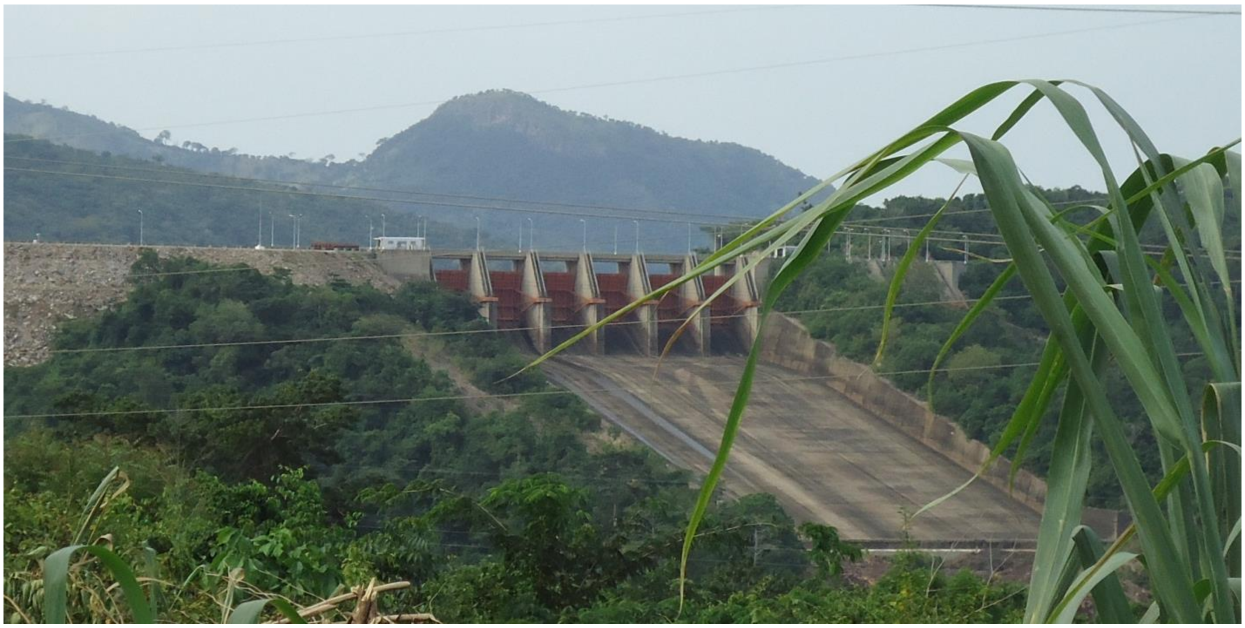
REOPTIMISATION AND REOPERATION STUDY OF AKOSOMBO AND KPONG DAMS



Project component

- Alternative means of restoring agriculture for livelihood improvement in the absence of flooding to enable recession agriculture.

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1. Introduction

In Ghana, agricultural systems are recognized as significant drivers of rural growth and poverty reduction (Lawson et al., 2012). In the downstream area of the Akosombo dam, more than 60% of the rural populations are reliant on farming activities for livelihood (Tsikata, 2006). The success of farming activities highly depends on the timely availability and the appropriate use of water resources. Before the construction of the Akosombo dam, local populations benefited from flood recession agriculture made possible by the seasonal floods of the lower Volta (Tsikata, 2006). The floods used to add to soil moisture and nutrient rich sediment beneficial for agricultural production (Preckel et al., 2008).

After the building of the Akosombo dam, the seasonal cycle is disrupted (McCartney et al., 2001). The livelihoods of downstream populations is threatened by unfavorable climatic conditions and increasing human pressure on land and the related resources. In fact, agriculture systems adjacent to the river have changed significantly following the modifications of annual floods; and the resulting sharp decline in soil fertility remains a major challenge in many areas (Gyau-Boakye, 2001). Currently, the area is dominated by small scale unorganized farmers who depend on rainfall and simple labour intensive production techniques. As a result, the agriculture is characterized by low productivity as well as high post-harvest losses (Titriku, 1999). It is imperative to help and accompany the population in the quest of alternative livelihoods strategies that will enable them to adapt effectively to the present conditions and build resilience in the prospect of future climate change.

Although some success has been achieved with high value crops such as rice, onions and tomatoes, using various irrigation systems such as individual pumps, these practices were not up-scaled or out-scaled and did not benefit the poorest in the communities (Namara et al., 2011). Moreover, while farm products, especially vegetables, have high values in markets in large cities like Accra, the farm gate prices continue to be surprisingly very low (Laube et al., 2008; Keraita et al., 2008; Faulkner et al., 2008). Consequently, opportunities for productivity improvement that would allow the most vulnerable groups to benefit from adequate technological options need to be explored. In addition, market access constraints need to be addressed for agricultural crops with potential high value in order to improve the access of the poor to higher income and additional nutritional benefits.

Different water management systems can be used to promote agricultural production and limit the risks involved in the farming activities. These systems have to be adapted to both the ecological setting of the area targeted, socio-economic factors and the preferences of the population (Adeoti, 2008). In different parts of Ghana, various irrigation technologies have been used (Namara et al. 2010). For example, emerging irrigation systems include various types of water lifting systems (such as treadle pumps and diesel pumps) used individually or in groups on a small scale or even sometimes on large scale (Namara et al. 2010). These systems sometimes include also small dams, reservoirs and tanks interconnected through a water distribution network. Investments of such irrigation systems involve costs and entail various types of risks both productive and financial. As a result, farmers' propensity to adopt them is likely to be influenced by their preferences for risks and their discount rate (time preference). To capture these aspects, the study puts a specific emphasis on farmers risk and time preferences.

The objective of the present study is to define alternative strategies for enhancing the socio-ecological resilience and adaptive capacity of farming communities in the downstream area of the Akosombo dam. The intent is too effectively reduce poverty in the long run by analysing various options including improved water use technologies, accessibility to diversified crops varieties, creating better business models and reliable value chains. This type of study mobilizes different but complementary socio-economic instruments as described in the methodology section.

The rest of the report is organized as follows. The following section presents the methodological approach used to identify alternative farming strategies and to anticipate possible challenges to their success. Section 3 presents the main results and discusses their implication in terms of targeted interventions to facilitate the sustainable uptake of solutions proposed. The final section concludes.

2. Methodology

Capturing farmers' behavior under risk and over time are fundamental to understanding their decision-making process (Andreoni and Sprenger, 2012). It helps to predict how they may choose to invest time, effort and capital in alternative farming options. These options could be a given irrigation technology, a specific land management practice or varieties of crops. An important part of the methodology aimed at eliciting risk and time preferences. A multifaceted methodological approach was used. Different tools including group discussion, key informant interview and questionnaires were used for data collection. The subsequent data analysis was manifold. First, an econometric model was developed in order to identify the variables that affect the willingness to accept given interest rates. The assumption is made that risk preferences and time preferences are different concepts following previous studies (Andreoni and Sprenger, 2012).

2.1. Data collection methods

Three representative downstream communities were selected for the study to cope with the time and funding constraints of the project. The preponderance of farming activities was one main selection criteria. In the three selected communities along the Lower Volta, detailed socio-economic studies were undertaken to understand the opportunities and constraints to the adoption of alternative means of promoting agricultural systems that can improve the livelihood of the downstream populations. The communities are Adidome Tokor (Central Tongu District, Volta Region), Tefle (South Tongu District, Volta Region), Atrobinya (Shai Osudoku District, Greater Accra Region).The field data collection included focus group discussions, key informant interviews and individual face to face interviews.

In each community, separate focus group discussions were organized with a group of elderly men, a group of elderly women and a group of young inhabitants. The discussion groups were separated in order to collect the unbiased views of different social categories.

Furthermore, key informant interviews were conducted with members of the unit committees in each of the communities or key people with higher experience in vegetable farming. This individual or small group interviews made it possible to clarify and complement information obtained during focus group interviews. The focus group discussions and key informant interviews enabled the understanding of the issues.

Using a questionnaire (see appendix), a baseline survey was conducted in order to establish the background conditions of the farmer population regarding basic socio-demographic characteristics, income sources and the use of different agricultural practices with an emphasis on water management. A randomly selected sample of 212 farming households were invited for face-to-face interviews to enable a high response rate to all relevant questions (nearly 77%). The potential opportunities and constraints for the implementation of various water productivity improvements options were assessed. Moreover, farmers' perceptions pertaining to soil fertility and moisture management were considered.

A special section of the questionnaire allowed for the assessment of the risk and time preferences of farmers. This information was subsequently associated with socio-economic data through econometric technics to understand determinants of risk and time preference in the area. Following Holt and Laury (2002), the degree of risk preferences was elicited using a menu of paired structured lottery choices with crossover point. Farmers were asked to make choices between a series of 2 options representing different risk situations represented by Option A and Option B, each one associated to hypothetical payoffs (Kahneman and Tversky, 1979). The hypothesis underpinning the analysis is that more risk averse farmers will tend to choose option involving less risk even if the average pay-off is lower. Constant relative risk aversion for money utility function was assumed to estimate risk aversion coefficient. This allows for simplicity and comparability with other studies made on risk aversion.

A similar methodology is used to elicit time discounting or time preferences. A series of questions were formulated to help determine maximum interest rate farmers were willing to accept from hypothetical micro-credit institutions to undertake irrigation activities (Tanaka et al., 2010). A regression analysis was then performed to indicate how risk and time discounting relates to other socio-economic variables including gender, secondary activity, education etc. The detail methods used for this are presented in subsequent sections.

Based on the field survey information and the results of the economic analysis, different realistic strategies for livelihood improvement through alternative water and land use possibilities were identified. Potentially suitable water use technologies were identified and presented. Also, constraints to the access to markets located in larger cities were qualitatively assessed. Finally, interventions aiming at overcoming them are discussed. The following sections presents the methodological details of the analysis of risk and time preference data.

2.2. Risk preferences

Risk preference is an economic concept used to describe the way economic agents perceive and make decisions in an environment with risk related outcomes. Risk aversion refers to a behavior whereby economic agents tend to prefer an outcome that has certainty to an outcome involving risk. Farming activities involve several types of production risk due to climatic factors and biotic factors. Particularly, the introduction of new technologies or practices may involve risk as to the type of outcome they lead to (Foudi and Erdlenbruch, 2011). For example, a given technology may prove to improve considerably agricultural yields in case of drought due to improved soil water conservation but lead to crop failure in case of abundant rainfall due to water logging problem. Because of this unpredictable variability involved, farmers may decide not to adopt such a technology or prefer other technologies to it. Therefore, a technology although bringing about a higher agricultural production on average may induce more variability hence risk and be discarded by the farmer. In economics, different methods have been developed to capture the magnitude of risk preferences of agents. For example, by proposing hypothetical pay-offs associated with well-chosen probabilities, it is possible to design a survey instrument allowing to have a good idea of where agents risk preferences lie.

Different conceptual frameworks are used to give a measurable value to risk preferences. In most of the frameworks, it is assumed that farmers (or any other economic agent) have a utility function for money or other goods they may receive, reflecting the level of satisfaction from getting such goods. The risk preference is determined by the shape of the utility function. Therefore, to conceptualize the behavior of the farmer towards risk, we need to presume a functional form for the utility function of farmers. Following Moschini and Hennessy (2001), we opt for a utility function with constant relative risk aversion (CRRA) because of its simplicity, computational convenience and ease of interpretation (Holt and Laury, 2002). Moreover, this functional form is commonly used in agricultural economics, which allows us to have the estimated parameters comparable with results from other studies. A utility function that can be associated to CRRA is presented as follows:

$$U(x) = \frac{x^{1-r}}{1-r}$$

Where,

U(x) is the utility function of money or other goods. The good considered here is agricultural crop product to adapt to the farming context in which the survey was conducted.

x is the good or product in question

r is the coefficient of risk aversion (Reynaud, 2008; Sidibe et al., 2010). It is also called the Arrow-Pratt coefficient.

Understanding the risk preference of farmers is being able to estimate the Arrow-Pratt coefficient. To do this, we used the setting inspired from the Holt and Laury (2002) experiment that elicited the risk behaviour of respondents by submitting to them a series of choices between 2 predefined options A and B. The procedure relies on proposing choices between the paired lotteries. In order to adapt the Holt and Laury (2002) setting, our lotteries have been contextualized to the situation of farmers. Options proposed were described as different agricultural technological packages promoted by 2 different companies or NGOs. The pay-offs were described in terms of the number of bags of 25kg of the main crop they cultivate that could potentially be obtained from each of the options depending on the climate variability they are facing (represented by probabilities of getting given quantities of agricultural production). To keep the survey simple and practically manageable, fewer questions were asked compared to Holt and Laury

(2002). Also, the figures used by these authors were changed. Pay-offs and associated probabilities are presented in table 1.

Table 1. The three Paired Lottery-Choice Decisions with Payoffs and Probabilities.

Options A	Option B	Expected Pay-off difference
1/10 of 20, 9/10 of 16	1/10 of 38, 9/10 of 1	11.7
5/10 of 20, 5/10 of 16	5/10 of 38, 5/10 of 1	-1.5
9/10 of 20, 1/10 of 16	9/10 of 38, 1/10 of 1	-14.7

According to the answers provided by respondents, the three questions allow to categorize farmers into 3 classes as presented in table 2. The rationale of the classification is as follows. If a farmer chooses A for the first question and B for the other questions then we can infer that the farmer is better off in terms of expected utility with option A if the first climate variability definition is true but with option B in the second state of climate variability. For that farmer, we can write the following inequality:

$$\frac{1}{10}U(20)+\frac{9}{10}U(16)\geq\frac{1}{10}U(20)+\frac{9}{10}U(16)$$
$$\frac{2}{10}U(20)+\frac{8}{10}U(16)\leq\frac{2}{10}U(20)+\frac{8}{10}U(16)$$

Solving the inequality allow concluding that the CRRA *r* of that particular farmer is between -1.76 and 0.13. Following similar approach for all farmers, we can categorize them according to table 2. Section 3 presents the results obtained from the survey.

Table 2: Risk classification of farmers according to the survey responses.

Number of safe choices	Range of Risk Aversion Coefficient	Risk Preference Classification
1	-1.76 ≤ r ≤ 0.13	Risk loving to risk neutral
2	0.13 < r ≤ 1.36	Slightly to very risk averse
3	1.36 ≤ r	Highly risk averse

As evidenced by previous studies, risk preference may be linked to other socio-economic household characteristics such as age, experience in farming, gender, household assets, education, type of crop grown, marital status, secondary household activity and number of dependents etc. (Kebede et al., 1990). Knowing how these factors affect risk preference may help to design adequately tailored policy interventions for different socio-economic groups or influence risk preferences indirectly through intervention that target socio-economic factors.

This link was established through a regression analysis. Ordinal logit model also known as the proportional odds model was used for several reasons. First, our dependent variable which is the risk preference is a multichotomous. Second the categorization of the risk preferences constitute ordinal variables. As the exact value of the risk preference $Y_i^*$is not known, it can be considered as a latent variable in the model with the following equations:

$$Y_i = 1\ if - 1.76 \leq\ Y_i^*\ \leq 0.13$$

$$Y_i = 2\ if\ 0.13 < Y_i^*\ \leq 1.36$$

$$Y_i = 3\ if\ 1.36 < Y_i^*$$

Then, we assume that the latent variable (which is the exact value of the risk aversion) is explained by a number of other variables denoted X_k.

$$Y_i^* = \sum_{k=1}^{K} \beta_k X_{ki} + \varepsilon_i$$

K is the total number of regression variables. X_{ki} represent the regression variables. β_k are the regression coefficients. ε_i is the random disturbance term in the equation. With the parallel curve hypothesis which assumes that the coefficients for the different categories are the same for each explanatory variable and allows an easy interpretation of the results, the regression equation for each category can be written:

$$log\big(Prob(Y > i)/Prob(Y \leq i)\big) = \beta_{1i} + \sum_{k=2}^{K} \beta_k X_k$$

The above model is then estimated using a XLSTAT statistical package.

2.3. Time preferences

Time preferences also referred to as time discounting is the relative valuation of a good at one date relatively to another one. The core idea is that the value of a good at a present time is different from its value at a later date. In fact, generally, the value of the good is, or is perceived higher if it is made available to the economic agent now than later (Tanaka et al., 2010). Different explanations have been provided to explain this reality such as the real rate of interest or a psychological factor reflecting the degree of impatience. However our objective, rather than seeking the deep reasons of time preference, is to be able to have a measurement of it. It is an important economic concept that describes the way individuals make trade-offs between present and future benefits and costs. It can also be used to infer individuals' investment behavior. Since investments in general involve costs that have to be paid in the present while the benefits can be reaped only at a future date, an individual with strong preferences for the present may be reluctant to undertake such investments even if the benefits seem to largely exceed the costs. In the irrigation context, for example, the initial investment in equipment such as pumps, water containers, pipes etc. may be high even though the future outcome in terms of increased agricultural production and income may be more substantial. Farmers with a higher discounting rate may opt against such investments.

The conceptual framework used for the estimation of the time preference relies on linear discounting function. This framework has been used both for its simplicity and relative ease of implementation. Similar approach was used by a number of authors in developing countries (Bauer and Chytilova, 2010; Klemick and Yesuf, 2008; Holden et al., 1998). However, our survey has put the elicitation process into context by inviting farmers to assume a hypothetical bank or other similar credit institution willing to give loans reimbursable in one year from a given interest rate. Then the farmers had to declare the maximum interest rate of which they would accept the loan. It was made clear to farmers that a collateral has to be presented as a guarantee to the bank or financial institution, the land, and that the institution will credibly get the value of the loan from the collateral in case of default. The interest rates proposed are nominal interest rates. The following table shows the way the questions were structured.

Table 3: Table showing different options proposed

				Choices						Accept or Reject
1	Receive	100	GHS	today	and	pay back	100	GHS	in a year	
2	Receive	100	GHS	today	and	pay back	105	GHS	in a year	
….	…	…	…	…	…	…	…	…	…	
20	Receive	100	GHS	today	and	pay back	170	GHS	in a year	
21	Receive	100	GHS	today	and	pay back	200	GHS	in a year	

The aim of the first question is to verify that the respondent would accept credit even with no interest rate. This is important because some individuals may reject the very principle of paying interest rate. After the first question, increasing interest rates are proposed to the farmers until they switch and reject the interest rate proposed.

Reponses were subsequently classified into 4 main categories according to the maximum interest rate accepted. Four classes of time preference groups or categories were defined: the first group include those who have a maximum willingness to accept an interest rate from 0% to 20% (low interest rate). Compared to interest rates practices in Ghana, this range of interest rates may in fact appear to be low. The second include those willing 21% to 40%. This category is referred to as "medium interest rate". The third include those willing to accept 41% to 60% (high interest rate) and the fourth group those from 61% to 100% (very high interest rate).

Table 4: Categories of farmers according to the maximum willingness to accept interest rates

Categories	Range of interest rate	Time Preference Classification
1	$0\% < r \leq 20\%$	Low interest rate
2	$20\% < r \leq 40\%$	Medium interest rate
3	$40\% < r \leq 60\%$	High interest rate
4	$60\% < r$	Very high interest rate

As for the risk preference, we analyzed how time preference may be explained by different socio-economic factors including age, experience in farming, gender, household assets, education, type of crop grown, marital status, secondary household activity and number of dependents. Also, similar econometric approach is used to model the data since the dependent variable here also is qualitative and ordinal in nature.

The next section presents the different results. First, it shows the main results of the focus group discussions and the key informant interviews. Second, it presents both in terms of descriptive and inferential statistics, the analysis of the data collected on time and risk preferences of farmers. Finally, it discusses their implication in terms of means to improve farming livelihoods.

3. Results and discussion

The study was conducted in three communities along the lower Volta. The area has an agro-ecological zone from Sudanian to Guinean type with a bimodal rainfall. Rainfall varies between 900 to 1100 mm/a and occur in two seasons: the major season runs from April to June while the minor season covers September and October. Soils types vary from clay to silty clay (Allotey, 2008).

Focus group discussions and key informant interviews revealed different opportunities and constraints in the 3 communities surveyed. Most of the households in the communities are involved in farming. However, several community members are also involved in secondary activities (47% from our sample) including teaching, masonry, trading etc.

While issues in Adidome Tokor and Tefle are similar, Atrobinya has several specificities because the community has an irrigation scheme mainly dedicated to growing rice. Therefore, results in Adidome and Tefle are discussed separately from those in Atrobinya. The main rainfed crops grown in Adidome and Tefle are maize and cassava. They are food crops that substantially contribute to the subsistence of the inhabitants. Vegetable crops, which are also cash crops are tomato, garden egg, different types of pepper and okra. While cassava provides a stable yield from year to year, the yield of maize is highly variable and greatly depends on rainfall fluctuations. Because of changing climate patterns, the rainfall variability in the area has been increasing making any anticipation difficult.

Vegetables crops are mostly grown under rainfed conditions and dry season irrigation is rarely practiced. Although, markets in Accra, Lome, Kumasi provide good opportunities for farmers to sell their vegetables at high prices, a number of factors prevent the access to these potentially lucrative markets. These factors include perceived high transport costs for agricultural products.

Anecdotal evidence suggests that few farmers who initiated irrigated dry land vegetable farming along the river using diesel pumps could not keep up the activity due to poor returns associated with high fuel costs and the difficulty of market access. Although groundwater may be thought as an alternative solution, several obstacles may prevent farmers from using it. First, groundwater abstraction may require more energy than direct abstraction from the river. Second, groundwater in some of the areas in the downstream of the Akosombo Dam may be salty and inappropriate for vegetable farming as evidenced by some previous studies (Allotey, 2008). Although, shallow groundwater irrigation systems are in use along Keta, the out scaling may face some challenges.

There is a staggering problem of labour availability and cost because of considerable migration to cities. This was also mentioned as one major constraint. Soil fertility is equally a major concern for farming systems in general in the communities surveyed. For example, in Tefle, fertile lands along the river mostly used for other activities (e.g. construction).

In Atrobinya where the population benefit from a public irrigated scheme with privately owned plots of land of one acre on average, rice is the main crop grown during the dry season. Cassava, maize, plantain and vegetables such as pepper are grown during the rainy season. The yield of irrigated rice in the community is high on average (more than 5 tons per ha), however farmers face other forms of challenges. Farmers generally sell the rice as paddy (not milled) which has low market price. Middlemen who buy the rice and sell it in cities such as Accra and Kumasi have a much higher bargaining power than individual rice farmers. However, women rice farmers who represent about half of the farmers have more control over the supply chain and are able to sell rice in major cities by bypassing the middlemen. There is no operational farmer organization among the rice farmers in Atrobinya.

Another major problem mentioned was the unavailability of tractors to plough land so as to enable farmers to start rice plantation earlier. Solving this problem may allow some farmers to increase their cropping intensity (from once a year to twice).

Table 5: Showing the proportion of farmers in the different communities

Communities	Number of households	Percentage of farming households	Number of vegetable farmers*
Atrobinya	194	161 (83%)	111 (69%)
AdidomeTokor	217	193 (89%)	68 (35%)
Tefle	912	575 (63%)	282 (49%)

*Vegetable farmers are part of the general farmer group. Source: Data from district assemblies 2013.

Descriptive statistics and comments

Respondents' answers fall into four categories: 1. Risk loving to risk neutral 2. Slightly to very risk averse 3. Highly risk averse. Up to 68% of the respondents are slightly to highly risk averse with more than 35% being highly risk averse.

In the first category, there are significantly more women than men in terms or percentage. In the 2nd category, the difference is much more reduced. However, men are overrepresented in the 3rd risk category with 40% while women are only 29%. Women are more risk takers than men. This descriptive statistics suggest that gender may be an explanatory factor of risk aversion as it is demonstrated later on by the regression analysis. This results contrasts with the literature where men are believed to be more risk takers than women.

Table 6: Farmers classified by risk preferences

Variable	**Categories**	**Male**	**Female**	**Frequencies**
Risk Preferences	1	25 (25%)	28 (43%)	53 (32%)
	2	35 (25%)	18 (28%)	53 (32%)
	3	39 (40%)	19 (29%)	58 (36%)

A total number of 212 households were interviewed. Out of this, 161 could provide all the useful information with regard to the relevant variables of the study representing more than 77%. This high percentage could be achieved thanks to the use of face-to-face interview and to experienced enumerators. Out of the 164 households interviewed, 60% of the household heads were men and 40% women.

Table 7: Farmers classified by time preferences

Variable	Categories	Male	Female	Frequencies
Maximum accepted Interest Rate	0	39 (39%)	29 (47%)	68 (42%)
	1	23 (23%)	22 (35%)	45 (28%)
	2	26 (26%)	5 (8%)	31 (19%)
	3	11 (12%)	6 (10%)	17 (11%)

A relative majority of respondents (42.24%) are willing to pay an interest rate between 0% to 20% but not more. Around 28% of them are not willing to pay interest rates above 40%. However rural banks and other microfinance institutions in Ghana often request annual interest rates of up to 60% (Kadri et al., 2013).This high interest rate may substantially limit the access to credit as only 10.6% of respondents were willing to accept such interest rates. The data also suggests that women are less willing to pay high interest rates than men. This is later confirmed in the regression analysis. Ordinal logit model were developed and presented in the following section.

Table 8: Summary of statistics of the main variables

Variable	Observations	Min	Max	Mean	Std. deviation
Risk Preferences	161	1	3	2.02	0.83
Age of household head (Years)	161	22	89	51.40	13.30
Sex of household head (Reference: Female)	161	0	1	0.61	0.49
Years of experience in farming	161	2	75	24.13	18.14
Secondary livelihood activities of the household head	161	0	1	0.47	0.50
Educational level of household head (years)	161	0	17	3.99	4.62
Grows rice in dry season	161	0	1	0.17	0.37
Rain-fed cultivated area (acres)	161	0	20	2.52	2.20
Irrigated cultivated area (acres)	161	0	7.5	0.46	1.21
Number of male HH members	161	0	13	3.19	2.04
Number of female HH members	161	0	11	3.30	1.94
HH members with 0-15 yrs	161	0	12	2.24	2.20
HH members with 15-64yrs	161	1	16	4.06	2.79
HH members with > 64 yrs	161	0	4	0.19	0.51
Married	161	0	1	0.67	0.47
Divorced	161	0	1	0.12	0.32
Widowed	161	0	1	0.17	0.38

Model with willingness to pay interest rates as dependent variable

Model 1: Regression with all variables

Because the age of the household head is strongly correlated with his/her years of experience in farming, that variable was taken out of the regression. The other regression variables are included in the model.

Table 9: Results of the Ordinal Logit regression model on 13 variables

Source	Value	Standard error	Wald Chi-Square	Pr> Chi²
Intercept0	-0.765	0.494	2.392	0.122
Intercept1	-2.155	0.523	16.982	< 0.0001
Intercept2	-3.581	0.572	39.128	< 0.0001
Sex of household head (Ref: Female)	1.615**	0.473	11.641	0.001
Years of experience in farming	0.014	0.010	1.964	0.161
Secondary livelihood activities of the household head	0.829*	0.328	6.413	0.011
Educational level of household head	-0.041	0.038	1.136	0.287
Grows rice in dry season	-0.240	0.612	0.153	0.695
Rain-fed cultivated area (acres)	0.003	0.084	0.001	0.975
Irrigated cultivated area (acres)	0.035	0.175	0.039	0.843
Number of male HH members	1.543	1.576	0.958	0.328
Number of female HH members	1.945	1.618	1.444	0.229
0-15 yrs	-1.764	1.606	1.206	0.272
15-64yrs	-1.660	1.590	1.089	0.297
> 64 yrs	-2.621	1.607	2.662	0.103
Married	-0.817*	0.449	3.311	0.069

The results show that few variables have significant effects on the willingness to accept higher interest rates. Gender is highly significant at 1% while Secondary livelihood activity and Married are significant at 10%. Years of experience in farming increases the likelihood of accepting a higher interest rate, however this variable is not significant. To make the analysis more focused, in the subsequent model, we dropped variables with low correlation with the dependent variables.

Model 2: Regression with selected variables

Table 10: Results of the Ordinal Logit regression model on selected variables

Source	Value	Standard error	Wald Chi-Square	Pr> Chi²
Intercept0	-0.228	0.378	0.364	0.546
Intercept1	-1.515**	0.396	14.628	0.000
Intercept2	-2.960**	0.453	42.723	< 0.0001
Sex of household head (Ref: Female)	1.491**	0.420	12.617	0.000

Secondary livelihood activities of the household head	0.637**	0.300	4.507	0.034
Number of male HH members	-0.189*	0.110	2.956	0.086
15-64yrs	0.180**	0.080	5.109	0.024
> 64 yrs	-0.466	0.350	1.781	0.182
Married	-0.949**	0.422	5.060	0.024

In this model that includes fewer explanatory variables, gender, secondary activity the number of household members whose age is between 15 and 64 years and married are highly significant at 1% to 5%. The number of male household members is also significant at 10%. The interpretation is that being a man (compared to a woman) increases the (log) odds of being in a higher category of willingness to accept interest rates. In other words, all other things being kept equal, men are likely to accept higher interest rates than women. A similar interpretation can be made for secondary activities. All other things being kept equal, those practicing a secondary activity (as compared to those not practicing it) are willing to accept higher interest rates. The secondary activities often involve trading (petty trading, fish commerce etc.). Generally people involved in those activities are more familiar with investment and because of their experience, may be able to put loans to a profitable use in agriculture as well even when granted with relatively high interest rates. Also having more family members with ages between 15 and 64 years increases the willingness to accept higher interest rates. The rationale probably is that with more people still able to work, it is possible to make a beneficial investment; pay back loans even with high interest rates and still make profits. Conversely, having more household members with age above 64 years decreases the willingness to take credit. People in the older age are no more productive and therefore, cannot contribute to the effort necessary to make investments profitable. Also the, number of male household members seem to lead to decrease the likelihood of accepting higher interest rates. However, the interpretation of the former two variables must be done with great caution as the result is not robust from one model to the other. In fact, the sign of those two variables changes from model 1 to model 2.

Model with risk aversion interest rates as dependent variable

Model 1: Regression with all variables

Table 11: Results of the Ordinal Logit regression model on 13 variables

Source	**Value**	**Standard error**	**Wald Chi-Square**	**Pr> Chi²**
Intercept1	0.003	0.485	0.000	0.996
Intercept2	-1.429**	0.499	8.195	0.004
Sex of household head (Ref: Female)	0.751*	0.430	3.051	0.081
Year of experience in farming (years)	0.001	0.010	0.006	0.938
Secondary livelihood activities of the household head	0.623*	0.322	3.752	0.053
Educational level of household head	-0.029	0.036	0.662	0.416
Grows rice in dry season	0.476	0.628	0.574	0.449

Rain-fed cultivated area (acres)	0.042	0.082	0.265	0.607
Irrigated cultivated area (acres)	0.194	0.180	1.161	0.281
Number of male HH members	-0.701	1.412	0.246	0.620
Number of female HH members	-0.731	1.424	0.264	0.608
0-15 yrs	0.807	1.426	0.320	0.571
15-64yrs	0.668	1.416	0.223	0.637
> 64 yrs	0.682	1.344	0.258	0.612
Married	-0.264	0.439	0.361	0.548

Gender and secondary livelihood activities are significant variables. The other variables are not significant at 1%, 5% or even 10%. Like for the time preferences, a second model where variables with very low correlation were removed was run.

Model 2:

Table 12: Results of the Ordinal Logit regression model on selected variables

Source	Value	Standard error	Wald Chi-Square	Pr> Chi²
Intercept1	0.367	0.340	1.171	0.279
Intercept2	-1.053**	0.349	9.101	0.003
Sex of household head (Ref: Female)	0.539*	0.306	3.112	0.078
Secondary livelihood activities of the household head	0.495*	0.297	2.789	0.095
Irrigated cultivated area (acres)	0.239*	0.130	3.410	0.065
15-64yrs	-0.065	0.052	1.531	0.216

The regression result indicates that three variables are significant namely, gender, secondary activities and the area of irrigated cultivated area. For all the three variables the (log) odds are positive showing that they tend to increase the likelihood of being in a higher category of risk aversion. For example, the variable sex of household head is positive. This means that men tend to be more risk averse than women. This may be seen as contrasting with part of the literature that claims that women are more risk averse than men (Borghans et al., 2009). However, some recent evidence point out that the result may be more mixed (Nelson, 2012). Our findings here add up to the literature by questioning the claimed higher risk aversion of women as compared to men.

Results suggest that farmers with a secondary activity tend to be more risk averse. Also, having more irrigated land increases the likelihood of being more risk averse. A simple explanation may support these two results: practicing a secondary activity leads to diversification of activities and therefore, allows farmers to hedge against risks. Consequently, risk averse farmers would tend to self-select and practice a secondary activity. Similar logic applies when it comes to irrigated cultivated land. Irrigation is a means to hedge against risks because irrigation protects against climate variability. Risk averse farmers would then tend to invest in more irrigated land in order to reduce their risks exposure.

The multi-level analysis undertaken shows that despite several constraints, opportunities for the expansion of alternative farming systems exist and can be potentially upscaled in a way to reach poor farming households in the downstream area. In this regard, dry season vegetable farming has been identified as one promising way to improve the livelihood of both women and men in the communities. The abundant availability of water resources coupled with a favorable climate with a high level of solar radiation offers vast potential for vegetable farming. Further to this, the existence of improved vegetable varieties with short cycle makes it possible to grow them 3 to 4 times a year without compromising the possibility to grow the usual food crops (cassava and maize). Also, because vegetables are in high demand in neighboring cities, the income generation potential is high. The results presented have several implications in terms of tailoring interventions that will allow promoting alternative means of restoring agriculture for livelihood improvement. Six major directions can be identified.

Innovative and suitable irrigation technologies

The use of shallow groundwater may not be appropriate in several areas because groundwater is often salty and water lifting from groundwater may not be economically justified when surface water is available. Specific river lift irrigation systems using individualized pumps may be more adapted.The use of low-cost motorized pumps has proved to be successful in several parts of Ghana when water availability is not a major constraint (Namara et al.,2011). This system allows high cropping intensity for vegetable crops for up to four times a year. The pumps are fed with petrol or diesel. The distribution system may use sprinkler, drip or furrow systems. Most sprinkler systems require high pressure therefore necessitate more powerful and expensive pumps. Also, drip systems may be costly for most small-scale farmers. To address these problems suitable innovative systems can be implemented. One of such systems is the low pressure irrigation method sometimes referred to as the California system. This irrigation system has proved to be remarkably efficient for vegetable farming in several West African countries including Mali and Senegal (WOCAT, 20015). The principle is at the same time simple and cost-effective.

It is about distributing water to crops through underground pipes made of rigid PVC pipes (ideal diameter range: 40-50 mm). The pipe network is buried deep to protect it from direct solar radiation and agricultural work. Intakes are connected to the main pipes at regular intervals. A movable and flexible part can be attached to the water intakes for watering individual plots. The installing the piping system can be made by local plumbers (Ministère de l'Agriculture, 2008). The water is provided by a pump (petrol or diesel engine) and brought to crops through the pipe system. The water goes from the collection point to the highest point of the plot and is not much affected by topography. Variations of the system can be considered to adapt it to local conditions. Also, the system requires a minimum labour force and can be operated by an individual farmer. Finally, an important advantage is that the system hardly requires maintenance. The maintenance of devices can easily be done by any farmer with no need of extensive training. The system can last for up to 10 years. Sandy-clay soils, as the ones found along the river banks of the Lower Volta are ideal for this system. Tomato and green pepper with short production cycle are recommended vegetable crops since farmers are familiar with them. Once farmers master the use of the irrigation system other more exotic vegetables and fruits like pineapple may be introduced.

However, to ensure the adoption and the sustainability of the irrigation systems mentioned, a set of accompanying measures would be necessary. These measures include good organization, improved access to credit, protection against associated risks, supporting the whole supply chain etc. they are discussed below.

Organization of farmers

The focus group discussion and the key informant interviews clearly showed that there is a deep deficiency in the organization of farmers in all the communities surveyed. The lack of good organization may be considered as one of the main issues to tackle because it underlies several other problems and constraints. For example, the access to major markets is made difficult because of poor organization of farmers, despite the existence of potentially lucrative markets in nearby major cities including Accra, Lomé and Kumasi. Because market access involves several types of transaction costs and bargaining power, individual farmers are less likely to succeed and have no other option but rely on low prices on local village markets. The transaction cost include for example transportation costs. An individual farmer is not likely to be able to profitably afford the high transportation costs to major cities since his/her production size is relatively small. On the other side, large production size may be possible if farmers were well organized and group their individual productions. It would be easier to convey it to larger markets at reduced per unit cost because of economies of scale thus achieved.

A better organization would also allow to cope with some of the coordination problems involved in vegetable farming. In fact, unlike grain crops where all the harvest can be done during one to three days, most vegetable crops produce fruits gradually so that the harvest is spread over a period of time that may run from few days to few weeks. Coordination among farmers would have the advantage of enabling them to decide harvesting at specific dates so transport to markets and sales can be better planned. Additionally, this would allow to substantially reduce post-harvest loss that is a major risk for highly perishable vegetable crops.

At another level, improved organization of farmers is necessary to establish a reliable market demand. A reliable market demand is crucial for perishable vegetables, especially tomato. Well organized farmers would be able to make contractual arrangements than isolated farmers with small production. Moreover, the bargaining power necessary to grant higher prices for agricultural products can only be used by organized groups. However, good organization cannot be achieved or if achieved will not be sustainable if not linked with other interventions indicated in this study.

Access to credit: The constitution of an initial capital that include equipment and operating funds is paramount to starting any irrigation farming. In fact, productive irrigated systems require water lifting and distribution systems, land preparation, adapted seeds etc. which all represent various costs that the average farmer cannot afford. However, with the possibility to access to loans, motivated farmers can have the possibility to make the initial investment that is necessary for vegetable farming activities.

In Ghana, the annual interest rates proposed by banks and other similar institutions to farmers may go up to 60% although interest rates for other activities fluctuate around 30%. Moreover, this high interest rate is sometimes accompanied with several other conditions that the average farmer cannot fulfill (Kadri et al., 2013). Although access to starting capital is crucial for irrigation farming, the survey results strongly suggest that the vast majority of farmers are not willing to accept the interest rates proposed by rural banks and other similar microfinance institutions. It is therefore necessary, to propose other mechanisms for financing vegetable farming.

Technologies reducing risks: Farming activities involve taking different types of risk, risks pertaining to market conditions (unpredictable changes in input and output prices) and risks pertaining to the production itself (biotic risks). Generally speaking, irrigation can reduce biotic risks by making water availability more reliable. A reliable water availability ensures a lesser variability in the yield and quality of the crops grown. However, different water management technologies address risks in different ways. For example, although sprinkler system allows reducing water stress in crops, it may create other forms of risks by making the leaves more vulnerable to different types of diseases (Damicone and Brandenberger, 2002). On the other hand, drip system may allow farmers to avoid such problems but may pose other risks because of the higher technicality of the system. Additionally, market risks cannot be completely addressed by irrigation technologies. Other mechanisms are necessary.

The adoption of new technology is dependent on both the risk aversion of farmers and the way they perceive the technology as a factor of risk (Feder, 1980). For example, previous studies in Ethiopia suggest that risk aversion has a negative impact on production technology adoption (Kebede et al., 1990). Risk averse farmers will tend to avoid adopting any new farming practice in which they perceive risk unless accompanying measures to hedge against the possible risks are also provided (Mara et al., 2003). Our findings revealed a high level of risk aversion among farmers. This risk attitude may hinder the uptake of irrigation systems and methods that may be proposed. To lessen this potential obstacle, direct insurance services may be proposed to the concerned farmers. The insurer may address fluctuation of yields and/or market prices. However, it is important to make the insurance as clear as possible because a poorly understood insurance system will neither be adopted. Insurers usually have conditionality specifying when insurance benefits apply. An insurance system that is at some degree involved in the farming activities, for example by facilitating the encounter between farmers and buyers would tend to be more efficient because by being involved itself in the business, information asymmetry is reduced.

Indirect insurance systems can also be promoted. For example, our finding suggested that secondary livelihood activities may be used to hedge against farming risks. Promoting such activities, especially those in the agricultural supply chain, would have a double advantage: they will provide insurance against risk and also they will open new opportunities for the supply of input and the sales of outputs. Demonstration and training in the specific technology may give more confidence and attenuate the perception of risk. The training aspect will be later discussed.

Capacity building in both irrigation technics and managerial skills: implementing advanced and productive irrigation methods requires considerable technical skills. The technical skills required pertain to the adequate operation and maintenance of the irrigation materials, the planning of the irrigation throughout the crop cycle, the land preparation etc. Above this technical skill, the success also depends strongly on good individual management skills in terms of getting laborers at the right time, insuring that they work as required, monitoring input and output market prices etc. The two set of skills are complementary and inseparable.

The study shows that farmers did not receive any training in this regard and that rudimentary knowledge in irrigation systems is lacking. Quasi-inexistent extension services in the area has prevented farmers to gain knowledge of new irrigation technologies that are now available. However, training to acquire irrigation and managerial skills can make a huge difference as demonstrated by a young farmer in the area who was not only able to set up modern tomato farms using greenhouses associated with drip system but could also make contractual arrangements with large supermarkets in Accra to facilitate the timely sale of his products. The technology described should be promoted and adapted according to the situation of different farmers.

Gender targeted policies: As suggested here, risk attitude and time preferences depend on gender. As an implication, intervention should be designed to target men and women in a differentiated way. For example, preferential interest rates for women may be considered. However, this should be undertaken with caution as not to disincentive other productive activities.

Supply chain activities: although farming activities should be the direct target of interventions, options to support the whole value chain should also be carefully considered. Irrigated farming systems can only be sustained if there is a strong value chain supporting it. Value chain consists of input and equipment suppliers, transporters and various other economic agents. Considering how to ensure the coordination between those activities and the vegetable production will not only reduce the transaction costs but will also substantially reduce the perceived risks associated with irrigated farming.

One way to do this is to inform and involve every value chain actors from the beginning of the intervention so that they can fill their respective roles. Such an approach has been used in a number of successful interventions around the world (Gold et al., 2010).

The interventions identified and discussed above should not be viewed as different separated options for promoting alternative farming system but as a coherent package in which every single component must be integrated harmoniously with the others in order to achieve the common goal.

4. Conclusion

The degradation of the livelihood of the downstream populations of Akosombo and Kpong dam is a major concern for local communities. Reoperation of the Akosombo may not be possible because of the technical difficulties it would involve and its strategic importance in electricity production in Ghana and beyond but also because the issue is highly politically charged. However, we have shown the possibility of another alternative option that is technically and economically feasible provided the constraints are reduced. We then recommended several directions to follow in order to reduce the constraints. Demonstration of political will through decisive action will be required to ensure that the recommendations will be implemented.

Possible limitations of the study

One of the possible limitations of the risk and time preference survey could be the reliance on declared and hypothetical statements provided by the respondents instead of revealed information that could be obtained by using incentives. This method was still used because of the trade-off between simplicity, available funds and time on the one hand, and obtaining of instructive information on the other hand (Charnessa et al., 2013). Moreover, this is the first study on risk aversion in the area.

A second limitation is the fact that only one incentive structure was used to elicit the risk attitudes. In fact, the study did not consider different levels of incentive and assumed that the utility function is of CRRA type, thus ignoring the possible effects of higher (or lower) incentives. However, as suggested by Harrison et al. (2005)and then by CRRA specification could be used as a local approximation to more general functional forms. Furthermore, Holt and Laury (2005) concluded their experiment indicating that scaling up hypothetical payments lead to no significant difference in risk aversion when possible order effects are eliminated. Since there are no order effects in our data, we don't expect the scale to have a significant impact on the results.

Finally, the study did not include income data in the regression. Since in the context of African agricultural systems, declared income data are often inaccurate and unreliable, we removed it in order not to bias the other results. However, this omission does not affect the main conclusions of the study.

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Appendices

Table A.1.: Correlation matrix model 1 time preferences.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	Time Preferences
1. Sex of household head (Ref : Female)	**1.00**	0.04	0.08	0.39	0.12	0.18	0.15	0.23	-0.06	0.11	0.05	-0.05	0.64	0.20
2. Year of experience in farming (years)	0.04	**1.00**	-0.11	-0.22	0.11	0.15	0.02	0.26	0.15	-0.11	0.32	0.30	-0.02	0.07
3. Secondary livelihood activities of the household head	0.08	-0.11	**1.00**	0.22	-0.19	0.04	-0.12	0.00	-0.05	-0.09	0.07	-0.16	0.02	0.21
4. Educational level of HH head	0.39	-0.22	0.22	**1.00**	0.09	0.02	0.15	0.00	-0.15	0.03	-0.10	-0.15	0.28	0.01
5. Grows rice in dry season	0.12	0.11	-0.19	0.09	**1.00**	-0.37	0.70	-0.05	-0.14	-0.03	-0.12	0.09	0.07	-0.08
6. Rain-fed cultivated area (acres)	0.18	0.15	0.04	0.02	-0.37	**1.00**	-0.29	0.29	0.18	0.10	0.24	0.07	0.22	0.06
7. Irrigated cultivated area (acres)	0.15	0.02	-0.12	0.15	0.70	-0.29	**1.00**	0.05	-0.13	-0.09	0.02	-0.04	0.08	-0.05
8. Number of male HH members	0.23	0.26	0.00	0.00	-0.05	0.29	0.05	**1.00**	0.29	0.30	0.68	0.10	0.25	-0.02
9. Number of female HH members	-0.06	0.15	-0.05	-0.15	-0.14	0.18	-0.13	0.29	**1.00**	0.51	0.48	0.16	0.07	0.11
10. 0-15 yrs	0.11	-0.11	-0.09	0.03	-0.03	0.10	-0.09	0.30	0.51	**1.00**	-0.22	0.01	0.14	-0.03
11. 15-64yrs	0.05	0.32	0.07	-0.10	-0.12	0.24	0.02	0.68	0.48	-0.22	**1.00**	0.00	0.13	0.12
12. > 64 yrs	-0.05	0.30	-0.16	-0.15	0.09	0.07	-0.04	0.10	0.16	0.01	0.00	**1.00**	-0.05	-0.15
13. Married	0.64	-0.02	0.02	0.28	0.07	0.22	0.08	0.25	0.07	0.14	0.13	-0.05	**1.00**	0.02
Time Preferences	0.20	0.07	0.21	0.01	-0.08	0.06	-0.05	-0.02	0.11	-0.03	0.12	-0.15	0.02	**1.00**

Table A.2.: Correlation matrix model 1 risk preferences.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	Risk Preferences
1. Sex of household head (Ref: Female)	**1.00**	0.04	0.08	0.39	0.12	0.18	0.15	0.23	-0.06	0.11	0.05	-0.05	0.64	0.19
2. Year of experience in farming (years)	0.04	**1.00**	-0.11	-0.22	0.11	0.15	0.02	0.26	0.15	-0.11	0.32	0.30	-0.02	0.01
3. Secondary livelihood activities of the household head	0.08	-0.11	**1.00**	0.22	-0.19	0.04	-0.12	0.00	-0.05	-0.09	0.07	-0.16	0.02	0.12
4. Educational level of household head	0.39	-0.22	0.22	**1.00**	0.09	0.02	0.15	0.00	-0.15	0.03	-0.10	-0.15	0.28	0.06
5. Grows rice in dry season	0.12	0.11	-0.19	0.09	**1.00**	-0.37	0.70	-0.05	-0.14	-0.03	-0.12	0.09	0.07	0.15
6. Rain-fed cultivated area (acres)	0.18	0.15	0.04	0.02	-0.37	**1.00**	-0.29	0.29	0.18	0.10	0.24	0.07	0.22	-0.01
7. Irrigated cultivated area (acres)	0.15	0.02	-0.12	0.15	0.70	-0.29	**1.00**	0.05	-0.13	-0.09	0.02	-0.04	0.08	0.16
8. Number of male HH members	0.23	0.26	0.00	0.00	-0.05	0.29	0.05	**1.00**	0.29	0.30	0.68	0.10	0.25	0.02
9. Number of female HH members	-0.06	0.15	-0.05	-0.15	-0.14	0.18	-0.13	0.29	**1.00**	0.51	0.48	0.16	0.07	-0.04
10. 0-15 yrs	0.11	-0.11	-0.09	0.03	-0.03	0.10	-0.09	0.30	0.51	**1.00**	-0.22	0.01	0.14	0.08
11. 15-64yrs	0.05	0.32	0.07	-0.10	-0.12	0.24	0.02	0.68	0.48	-0.22	**1.00**	0.00	0.13	-0.07
12. > 64 yrs	-0.05	0.30	-0.16	-0.15	0.09	0.07	-0.04	0.10	0.16	0.01	0.00	**1.00**	-0.05	-0.01
13. Married	0.64	-0.02	0.02	0.28	0.07	0.22	0.08	0.25	0.07	0.14	0.13	-0.05	**1.00**	0.08
Risk Preferences	0.19	0.01	0.12	0.06	0.15	-0.01	0.16	0.02	-0.04	0.08	-0.07	-0.01	0.08	**1.00**

Questionnaire

Alternative means of restoring agriculture for livelihood improvement in the absence of flooding to enable recession agriculture.

Introduction and Consent

Good morning/ Good afternoon!

My name is ________________________and I am from IWMI. We are conducting research on alternative strategies to improve farming systems in the downstream of the Akosombo dam. Currently we are conducting a research to find out adoption for improved water management technologies for vegetable growing in this community. You have been randomly selected to provide information for this research. The information you provide will help us to gain insights about adoption of water management technologies in the community. Filing this questionnaire may take a maximum of 1 hour. Any information you provide will be strictly confidential and will not be used for any purpose other than research.

Consent given ☐Yes ☐No

[If the answer is "No", do not tick. End the interview]

Questionnaire Identifiers

Date of Interview: Dd/Mm/Year ____/_____/______

Region: _____________________________

District: _____________________________

Community: _____________________________

Interview number ______________

Enumerator's Full Name: _________________________________

Household Head full Name: ___________________________________

Name(s) of Interviewed Household Member(s): ______

Phone number of Interviewed Household Member(s):

SECTION I - HOUSEHOLD CHARACTERISTICS

* A “household” includes all members of a residence that are sharing consumption of food and other items. Include workers or servants as members of the household only if resident at least six months in the household).

1.1. Age of household head	………Years			
1.2. Sex of household head	☐Male ☐Female			
1.3. Year of experience in farming	………Years			
1.4. Secondary livelihood activities of the household head				
1.5. Marital status of household head	☐Single ☐Married ☐Divorced ☐Widowed			
1.6. Educational level of household head	☐Illiterate ☐Read and write, Grade …………………….			
1.7. Number of male and female HH members	Male:…………….. Female:……………			
1.8. Number of household members per age and gender, activity.	Age groups	Number	School	Active
	0-15yrs			
	15-64yrs			
	> 64 yrs			

SECTION II - HOUSEHOLD ASSETSAND ACTIVITIES

Land use and tenure

Type of land use	**Area in (acres)**
Rain-fed cultivated area	
Irrigated cultivated area	
Area of land under fallow	
Area of land under fruit trees	

Tenure of land	
Area of land owned (indicate ownership type)	
Area of land rented	
Rental cost of land per year (GH₵)	
Area of land rented out	
Rental cost of land per year (GH₵)	
Other (specify)	

Income sources

Activity	**Time spent weekly/monthly or yearly (specify unit)**	**Average income weekly/monthly or yearly (specify unit)**
Crop production		
Livestock breeding		
Fishing		
Commerce/petty trading		
Others		

Which of the following agricultural equipment do you own?

Agricultural Equipment	**Quantity**
Cutlass/machete	
Hoe	
Axe	
Rake	
Harrow/Plough	
Hand fork/shovel/spade	
"Motor king"	
Wheelbarrow	
Knapsack sprayer	

Other to specify	

What crops do you grow during the major rainy season?...

Dry Season Vegetable Production

Do you grow dry season vegetables? ☐Yes ☐No

If no, why? (What reasons, constraints, difficulties or challenges)

………
………
………
………
………

If yes, what dry season crops do you grow?

………
………

If yes, which of the following irrigation equipment do you own?

Irrigation Equipment	**Quantity**
Treadle pump	
Diesel/petrol pump	
Electric pump	
Rope and washer pump	
Drip kits	
PVC pipes	
Watering can	
Buckets (20L)	
Other to specify	

Inputs, Cost, Yield &Practices (Rainfed crops)

Crop 1:	Area planted:		Production size:		
A					
Soil management practices					
B					
Cost Item	**Description**	**Unit**	**Quantity**	**Unit cost (GH₵)**	**Total Cost (GH₵)**
Land clearing	Labour for land clearing	Men.days			
	Cost land clearing (incl weeding)	Cedis			
Land preparation	Labour for ploughing, levelling, lining/pegging, bed-making, etc.	Men.days			
	Cost of ploughing, levelling, lining/pegging, bed-making, etc.	Cedis			
Fencing (if applicable)	Labour for fencing, etc.	Men.days			
	Cost of fencing materials, etc.	Cedis			
Planting	labour for planting , etc.	Men.days			
	Cost of seeds/seedling, etc.	Cedis			
Supplementary Irrigation(if applicable)	Labour for irrigation	Men.days			
	Cost of irrigation	Cedis			
Weed Control	Labour for weeding/spraying, etc.	Men.days			
	Cost of herbicides, etc.	Cedis			
Pest Control	Labour for spraying, etc.	Men.days			
	Cost of pesticides, etc.	Cedis			
	Labour for fertilizer application	Men.days			

Fertilizer application	Cost of fertilizers (NPK, urea, ammonia), etc. applied	Cedis			
Harvesting and Processing	Labour for harvesting, processing, packaging, drying, etc.,	Men.days			
	Cost of transporting produce to home, etc	Cedis			
Processing, packaging, drying,	Labour for processing	Men.days			
	Cost of processing	Cedis			
Marketing	Labour for transporting produce to market, etc.	Men.days			
	Cost of transporting produce from home to market, etc.	Cedis			
Other cash costs	Specify:	Cedis			
C					
Fraction consumed by family					
Fraction sold					
Where is it sold?					

Crop 2:		Area planted:		Production size:	
A					
Soil management practices					
B					
Cost Item	**Description**	**Unit**	**Quantity**	**Unit cost (GH₵)**	**Total Cost (GH₵)**
Land clearing	Labour for land clearing	Men.days			
	Cost land clearing (incl weeding)	Cedis			
Land preparation	Labour for ploughing, levelling, lining/pegging, bed-making, etc.	Men.days			

	Cost of ploughing, levelling, lining/pegging, bed-making, etc.	Cedis			
Fencing (if applicable)	Labour for fencing, etc.	Men.days			
	Cost of fencing materials, etc.	Cedis			
Planting	labour for planting , etc.	Men.days			
	Cost of seeds/seedling, etc.	Cedis			
Supplementary Irrigation(if applicable)	Labour for irrigation	Men.days			
	Cost of irrigation	Cedis			
Weed Control	Labour for weeding/spraying, etc.	Men.days			
	Cost of herbicides, etc.	Cedis			
Pest Control	Labour for spraying, etc.	Men.days			
	Cost of pesticides, etc.	Cedis			
Fertilizer application	Labour for fertilizer application	Men.days			
	Cost of fertilizers (NPK, urea, ammonia), etc. applied	Cedis			
Harvesting and Processing	Labour for harvesting, processing, packaging, drying, etc.,	Men.days			
	Cost of transporting produce to home, etc	Cedis			
Processing, packaging, drying,	Labour for processing	Men.days			
	Cost of processing	Cedis			
Marketing	Labour for transporting produce to market, etc.	Men.days			
	Cost of transporting produce from home to market, etc.	Cedis			
Other cash costs	Specify:	Cedis			
C					

Fraction consumed by family					
Fraction sold					
Where is it sold?					
Crop 3:	Area planted:	Production size:			
A					
Soil management practices					
B					
Cost Item	**Description**	**Unit**	**Quantity**	**Unit cost (GH₵)**	**Total Cost (GH₵)**
Land clearing	Labour for land clearing	Men.days			
	Cost land clearing (incl weeding)	Cedis			
Land preparation	Labour for ploughing, levelling, lining/pegging, bed-making, etc.	Men.days			
	Cost of ploughing, levelling, lining/pegging, bed-making, etc.	Cedis			
Fencing (if applicable)	Labour for fencing, etc.	Men.days			
	Cost of fencing materials, etc.	Cedis			
Planting	labour for planting , etc.	Men.days			
	Cost of seeds/seedling, etc.	Cedis			
Supplementary Irrigation(if applicable)	Labour for irrigation	Men.days			
	Cost of irrigation	Cedis			
Weed Control	Labour for weeding/spraying, etc.	Men.days			
	Cost of herbicides, etc.	Cedis			
Pest Control	Labour for spraying, etc.	Men.days			
	Cost of pesticides, etc.	Cedis			

Fertilizer application	Labour for fertilizer application	Men.days			
	Cost of fertilizers (NPK, urea, ammonia), etc. applied	Cedis			
Harvesting and Processing	Labour for harvesting, processing, packaging, drying, etc.,	Men.days			
	Cost of transporting produce to home, etc	Cedis			
Processing, packaging, drying,	Labour for processing	Men.days			
	Cost of processing	Cedis			
Marketing	Labour for transporting produce to market, etc.	Men.days			
	Cost of transporting produce from home to market, etc.	Cedis			
Other cash costs	Specify:	Cedis			
C					
Fraction consumed by family					
Fraction sold					
Where is it sold?					

Inputs, Cost, Yield & Practices (Dry season Vegetable Production)

Crop 1:	Area planted:		Production size:		
A					
Briefly describe Irrigation technology used					
Soil-water–irrigation management practices					
B					
Cost Item	**Description**	**Unit**	**Quantity**	**Unit cost (GH₵)**	**Total Cost (GH₵)**
Land clearing	Labour for land clearing	Men.days			
	Cost land clearing (incl weeding)	Cedis			
Land preparation	Labour for ploughing, levelling, lining/pegging, bed-making, etc.	Men.days			
	Cost of ploughing, levelling, lining/pegging, bed-making, etc.	Cedis			
Fencing (if applicable)	Labour for fencing, etc.	Men.days			
	Cost of fencing materials, etc.	Cedis			
Planting	labour for planting , etc.	Men.days			
	Cost of seeds/seedling, etc.	Cedis			
Irrigation	Labour for irrigation	Men.days			
	Cost of irrigation	Cedis			
Weed Control	Labour for weeding/spraying, et	Men.days			
	Cost of herbicides, etc.	Cedis			
Pest Control	Labour for spraying, etc.	Men.days			
	Cost of pesticides, etc.	Cedis			
Fertilizer application	Labour for fertilizer application	Men.days			
	Cost of fertilizers (NPK, urea, ammonia), etc. applied	Cedis			
	Labour for harvesting	Men.days			

Harvesting and Processing	Cost of transporting produce to home, etc	Cedis			
Processing, packaging, drying,	Labour for processing	Men.days			
	Cost of processing	Cedis			
Marketing	Labour for transporting produce to market, etc.	Men.days			
	Cost of transporting produce from home to market, etc.	Cedis			
Other cash costs	Specify:	Cedis			
C					
Fraction consumed by family					
Fraction sold					
Where is it sold?					
Min price					
Average price					
Max price					
Crop 2:	Area planted:		Production size:		
A					
Briefly describe Irrigation technology used					
Soil-water–irrigation management practices					
B					
Cost Item	**Description**	**Unit**	**Quantity**	**Unit cost (GH₵)**	**Total Cost (GH₵)**
Land clearing	Labour for land clearing	Men.days			
	Cost land clearing (incl weeding)	Cedis			
Land preparation	Labour for ploughing, levelling, lining/pegging, bed-making, etc.	Men.days			

	Cost of ploughing, levelling, lining/pegging, bed-making, etc.	Cedis			
Fencing (if applicable)	Labour for fencing, etc.	Men.days			
	Cost of fencing materials, etc.	Cedis			
Planting	labour for planting , etc.	Men.days			
	Cost of seeds/seedling, etc.	Cedis			
Irrigation	Labour for irrigation	Men.days			
	Cost of irrigation	Cedis			
Weed Control	Labour for weeding/spraying, et	Men.days			
	Cost of herbicides, etc.	Cedis			
Pest Control	Labour for spraying, etc.	Men.days			
	Cost of pesticides, etc.	Cedis			
Fertilizer application	Labour for fertilizer application	Men.days			
	Cost of fertilizers (NPK, urea, ammonia), etc. applied	Cedis			
Harvesting and Processing	Labour for harvesting	Men.days			
	Cost of transporting produce to home, etc	Cedis			
Processing, packaging, drying,	Labour for processing	Men.days			
	Cost of processing	Cedis			
Marketing	Labour for transporting produce to market, etc.	Men.days			
	Cost of transporting produce from home to market, etc.	Cedis			
Other cash costs	Specify:	Cedis			
C					
Fraction consumed by family					
Fraction sold					
Where is it sold?					
Min price					

Average price	
Max price	

SECTION III – Risk and Time preferences

Time preferences

Assume you have access to credit to invest in irrigation technologies because Credit Bank came to the community. The credit agency would give you a credit today and you will pay backwith some interest in a year. However, the credit agency would have your farmlandas guarantee so that in case you don't pay back it will take it from you. Further, you need to explain clearly how you plan to pay back the money (through investment for example). Please indicate how you will make sure you can pay back the bank's money. Also, please indicate for each amount if you would accept the credit offer or reject it.

	Choices									Accept or Reject
1	Receive	100	GHS	today	and	pay back	100	GHS	in a year	
2	Receive	100	GHS	today	and	pay back	105	GHS	in a year	
3	Receive	100	GHS	today	and	pay back	110	GHS	in a year	
4	Receive	100	GHS	today	and	pay back	115	GHS	in a year	
5	Receive	100	GHS	today	and	pay back	120	GHS	in a year	
6	Receive	100	GHS	today	and	pay back	125	GHS	in a year	
7	Receive	100	GHS	today	and	pay back	130	GHS	in a year	
8	Receive	100	GHS	today	and	pay back	135	GHS	in a year	
9	Receive	100	GHS	today	and	pay back	140	GHS	in a year	
10	Receive	100	GHS	today	and	pay back	145	GHS	in a year	
11	Receive	100	GHS	today	and	pay back	150	GHS	in a year	
12	Receive	100	GHS	today	and	pay back	155	GHS	in a year	

13	Receive	100	GHS	today	and	pay back	160	GHS	in a year	
14	Receive	100	GHS	today	and	pay back	165	GHS	in a year	
15	Receive	100	GHS	today	and	pay back	170	GHS	in a year	
16	Receive	100	GHS	today	and	pay back	175	GHS	in a year	
17	Receive	100	GHS	today	and	pay back	180	GHS	in a year	
18	Receive	100	GHS	today	and	pay back	185	GHS	in a year	
19	Receive	100	GHS	today	and	pay back	190	GHS	in a year	
20	Receive	100	GHS	today	and	pay back	195	GHS	in a year	
21	Receive	100	GHS	today	and	pay back	200	GHS	in a year	

Risk Preferences

Assume two irrigation management companies come to your community with 2 different irrigation systems. The companies are the Water-Master company and the Hydro-Tech company. Each irrigation system include a series of water and soil management methods. Unfortunately, each of the system include some risk and result in random agricultural outcomes (due to random factors related to the nature of the methods and climatic hazards). After several in-depth studies, the companies were able to establish how their respective irrigation systems perform over 10 years. The following table provides a series of outcomes that can be obtainedif Water-Master Company orHydro-Tech Company are irrigation systems were adopted over a period of ten years. Please **indicate your preference**, for the series of choices from 1 to 3 by indicatingWater-Master (if you would prefer Option “Water-Master”) or (if you would prefer Option “Hydro-Tech”).Example for line 2.

In a 10 year period will you prefer the company allowing you to harvest:

20 bags of maize/rice for 5 years and 16 bags for 5 years? I.e. Agricultural Water management Option “Water-Master”**OR**

38 bags of maize/rice for 5 years and 1 bag for 5 years? I.e. Agricultural Water management Option “Hydro-Tech”

	Option A: Water-Master	**or**	**Option B:** Hydro-Tech	**(A or B)**
1	1/10 of 20 Bags and 9/10 of 16 Bags		1/10 of 38 Bags and 9/10 of 1 Bag	
2	5/10 of 20 Bags and 5/10 of 16 Bags		5/10 of 38 Bags and 5/10 of 1 Bag	
3	9/10 of 20 Bags and 1/10 of 16 Bags		9/10 of 38 Bags and 1/10 of 1 Bag	

*Weight of a bag of maize/rice…………………………………………………