NAIP-IFAD:
Water and
Rural
Livelihoods

Research Analysis on

"THE EFFECTS OF AGRICULTURAL WATER AND LANDHOLDINGS TO RURAL LIVELIHOODS IN INDO-GANGETIC BASIN"

(with emphasis on BIHAR State)

Stefanos Xenarios,
Bharat R Sharma,
Upali Amarasinghe,
Atul Singh

IWMI International Water Management Institute

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Technical Details of Survey Analysis

1. Design and development of the survey analysis in Bihar state.

A brief description of the initiation of the NAIP/ICAP project will enhance the rationale of the current analysis. The NAIP/ICAP project was formally inaugurated through a workshop held in 26-27 November 2008 with the participation of decision makers, researchers and stakeholders at the offices of ICER/ RCER in Patna, Bihar. In the workshop sessions, the goals of the project were demonstrated while the mutual beneficial output from the cooperation between the International Water Management Institute (IWMI) and ICER/RCER was underlined.

Emphasis was given to the need for participatory development mechanisms for the pursuing of livelihood improvement while the strengthening of livelihood security for the socially weakest communities was mentioned. For the achievement of the aforementioned targets, the capacity building mechanisms between the researchers and the farmers should be initiated through the direct elicitation of the farmers' views and preferences. In line with above objectives, an integrated Baseline Survey was elaborated. The survey was initially consisted of two distinctive household and village profiles which were formulated through two separate questionnaire forms accordingly.

In the following day of the workshop, a visit to Vaishali was conducted as a selected district for the pre-testing of all the questionnaires. The pretest phase proved to be rather instructive and crucial for the redesigning of the survey according to the respondents' preferences.

A following workshop was held in Patna at 19-20 January 2009 under the supervision of ICER/ RCER. In this workshop, a thorough and detailed presentation of the redesigned questionnaire forms was performed. All the forms were displayed in a stepwise manner so as to enable the participants suggesting or correcting the final versions. The majority of the local researchers to distribute the questionnaire were present, while researchers from ICER/RCER provided a very fruitful input in the final refining of the survey.

After the highly productive interacting session, another pre-testing of the questionnaire forms was accomplished inside the ICER/RCER premises through the sampling of two farmers from the nearby villages, with high and low income respectively. The input of the pretest together with a larger scaling pretest survey on the field in the following day, enhanced the coherence, accuracy and adaptability of the forms to the respondents.

The very remarkable results raised up by the two pretests, revealed the need to simplify the questionnaire of household profile particularly in the sections related the holding size and crop productivity. For this reason, an extra 1-page questionnaire was developed instead which should be applied only to farmers with highly fragmented cultivated land.

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__NAIP-IFAD Project__

Research Analysis on

The Effects of Agricultural Water and Landholdings to Rural Livelihoods in Indo-Gangetic Basin

With emphasis on BIHAR State

Stefanos Xenarios
Bharat Sharma
Upali Amarasinghe
Atul Singh

International Water Management Institute (IWMI)
New Delhi office, India
ICAR Research Complex for Eastern Region, Patna (Bihar), India

Executive Summary

The current research analysis is focused on the identification of the agricultural water use and land scaling effects to rural livelihoods in Indo-Gangetic basin (IGB) with emphasis to Bihar state. In particular, water use and landholding factors are widely acknowledged as major determinants of agricultural development and hence rural wealth in IGB basin and Bihar. High attention is mainly given to irrigation policy while land is often apprehended through soil productivity aspects.

However, little importance is given to land scaling and water consumption effects in respect to agricultural development and rural livelihoods. Further, the valuation of agricultural water is another burden issue which has not been sufficiently elaborated. Another major aspect which is still poorly investigated pertains to farmers' perceptions towards the significance of institutional and environmental related parameters of agricultural water. Last but not least, little attention has been given to crucial socio-demographic indicators which could act as potential drivers to farmers' perceptions towards environmental related parameters of agricultural water.

The aforementioned subjects are investigated in a research conducted by International Water Management Institute (IWMI) in cooperation with ICAR Research Complex for Eastern Region in selected regions of IGB area by focusing on Bihar state. The outcome is presented in four separate research papers which have been already submitted for publication in scientific journals.

The first paper examines the economic effects of water use and landholding scale to farming in agricultural development. The results signify that the economic viability of marginal and small landholders and water users is threatened when the study focuses on the land scaling effects to farming. Practical recommendations towards the rescheduling of irrigation and land use policies are introduced. The second paper is further focused only on less developed clusters of Bihar state by assessing the value of irrigated water and of environmental services which are highly affecting water quality and quantity status. The effects on different landholding groups are analyzed by giving particular emphasis to marginal landholders. The third paper, presents an economic assessment through a stated preference approach on crucial institutional and environmental related parameters of agricultural water that could enhance productivity potential. Deeper analysis on the economic value rendered to environmental services related with agricultural water is presented in the fourth paper. Also, vital socio-demographic elements are examined as influential factors.

The overall analysis signifies that the enhancement of rural livelihoods demands the possession of a minimum landholding scale, the introduction of institutional settings for the empowerment of groundwater irrigation and the incorporation of environmental water related services in irrigation policy. More detailed policy recommendations are described in each paper accordingly.

Acknowledgments

The research was undertaken through the project "Sustainable Livelihood Improvement through Need Based Integrated Farming System Models in Disadvantaged Districts of Bihar" by the government and the "Basin focal project of the Indo-Gangetic basin funded by the ChallenProgram for Water and Food.

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Contents

Paper 1

Economic effects of water use and landholding scale to farming in South Asia: evidences from Indo-Gangetic basin

Stefanos Xenarios [a], Bharat Sharma[b], Upali Amarasinghe [b]

[a] International Water Management Institute, East Africa& Nile Basin Office Addis Ababa, Ethiopia
[b] International Water Management Institute, New Delhi office, India

Abstract

Water use and landholding factors are widely acknowledged as major determinants of agricultural development in agrarian regions of the Indo-Gangetic basin (IGB). High attention is mainly given to irrigation policy while land is often apprehended through soil productivity aspects. However, the nexus between land scale and water consumption in respect to the economic implications of agricultural development is poorly elaborated. To this aim, this paper examines the economic effects of water use and landholding scale to farming in agricultural communities of IGB area. The research is based on an extensive survey conducted in representative areas of Pakistan, India and Nepal situated along the IGB basin. The results signify that the economic viability of marginal and small landholders and water users is threatened when the study focuses on the land scaling effects to farming. Practical recommendations towards the rescheduling of irrigation and land use policies are introduced.

Keywords : Water consumption, land scale, total costs and revenues, crop allocation, Indo-Gangetic basin

1. Introduction

The Indo-Gangetic basin (IGB) represents the drainage system of southern Himalayas and provides the economic base for about a billion people residing in the plains (Sharma et al, 2010). Rich alluvial soils and abundant surface and groundwater sources indicate the high agricultural potential in the riparian countries of Pakistan, India and Nepal.

Public interventions and private undertakings often attempt to enhance irrigation potential and land productivity through economic measures and technical progress in all the three countries. The public interventions are largely concentrated on investments to canal irrigation for the increase of agricultural productivity but also for poverty alleviation purposes (Bhutto and Bazmi, 2007; Shah, 2009). To this end, water charges for canal irrigation services are often undervalued through subsidization policies for the minimum water provision in staple crops and the sustenance of subsistence farmers (Shah, 2008).

The need to enhance irrigation potential through the construction of large scale canal networks has motivated land consolidation in the IGB area. Extensive irrigated schemes were developed in Pakistan in an attempt to curb the high cost of supplying surface water to fragmented land holdings (Hussain and Hanjra, 2004). National land reallocation programs in India made an effort to mitigate uneven distribution by endowing marginal farmers with better irrigated and more productive lands (Palmer- Jones and Sen, 2006). Food processing companies have acquired large irrigated plots with high soil fertility in India and Pakistan for the production of starchy crops (Anderson (ed.), 2009). Extensive land use changes against forested areas occur in the lowlands of Nepal towards the expansion of cultivated and irrigated areas (Tiwari, 2000).

The economic contribution of agricultural water and land use to farming and to rural livelihoods in the IGB area are also traced in the relevant literature. The studies of economics and irrigation are mainly concentrated on poverty alleviation and efficient water supply (Ataman and Beghin, 2005; Amarasinghe et al, 2007). The development of efficient irrigation schemes is frequently portrayed through the adjustment of water pricing mechanisms under competitive market conditions (Rosegrant et al, 2000; Limon and Riesgo, 2004; Shah, 2009a). The estimated water input is determined through the maximization of crop productivity until profits are undermined (Tsur, 2005). Indicative cases in India define efficient water levels of agricultural use through productivity maximization of staple commodities (Ranganathan and Palanisami, 2004; Kakumanu and Bauer, 2008). The efficient contribution of water resources in IGB area is also pointed out through the introduction of selected economic instruments in irrigation policy (Hellegers and Perry, 2006). Broadly, the water efficiency reflected in price signaling is thoroughly investigated in the aforementioned studies. However, the effects of different levels of water consumption to farming profitability are not sufficiently explored.

The linking of agricultural water with land has in part been studied mainly through the impacts of inappropriate water supply to soil productivity. Land degradation and poor soil fertility due to erratic rainfall patterns and to inappropriate irrigation are found in Nepal and India (Singh and Singh, 1995; Acharya et al, 2008). Also, technical and social constraints occurring in canal irrigation network have been identified as major barriers for improving soil productivity (Narain, 2008a,b). Few studies deal with the size of landholdings in isolation as a factor affecting economics conditions of agriculture (Niroula and Thapa, 2005). Land scaling and the relationship to returns have been studied in Pakistan cases, but the findings are currently considered outdated (Renkow, 1993; Khan, 1997). Land consolidation and reform are the major aspects investigated in more recent land related studies in India (Gajendra et al, 2005; Robinson, 2008; Awasthi, 2009). Studies related to land allocation in Nepal mainly focus on forest management under both government and community control (Coward, 2000; Edmonds, 2002). However, insufficient attention has been paid to the issue of size of landholdings as an influential factor for the enhancement of farming in the agrarian regions of IBG area.

Against this background, this paper first delineates the water volume and land scaling features of representative agricultural clusters[1] in India, Pakistan and Nepal situated in the IGB area. The research findings are extracted from an extensive survey through household questionnaires while focus groups analysis with key stakeholders is also conducted. In Section 2, a stepwise explanation of the methodology is exhibited while the case study areas are presented. Section 3 describes the application to the study areas by focusing on the results of the analyses. In Section 4, the methodological and applications' assumptions are overviewed while rigorous policy recommendations are placed.

2. Methodology and applications

The individual potential economic effects of water and land factors to farming in IGB selected clusters is explored through separate bivariate regression analyses. Total costs and revenues are introduced as dependent variables in order to capture the marginal effects of water consumption and land scaling factors with respect to the sampling. We employ quadratic equations as functions which could better render the economic effects of water volume and land scale in real case situations. The findings of the quadratic functions represent the amount of total costs and revenues change when a marginal differentiation of land and water factor occurs as below:

$$Y_{tc,tr} = a + b_1 X_w + b_2 X^2{}_w \qquad ....(1)$$

$$Y_{tc,tr} = a + b_1 X_l + b_2 X^2{}_l \qquad ....(2)$$

Where

$Y_{tc,tr}$ = Marginal effects to total costs and total revenues (dependent) variables

[1] Cluster is considered to be a compound of small settlements which may be formed as villages or sparse inhabitants' areas.

a = Constant
b = Regression coefficient
X_w = Water consumption independent variable
X_l = Land size independent variable

For the identification of the total costs for agricultural inputs, a disaggregation into the main cost components is conducted as below:

$$TCP = \sum_{crops} Q_s p_s + h_{ml} p_{ml} + h_{fl} p_{fl} + h_t p_t + p_p + p_h + Q_f p_f + C_p + C_m + C \text{ ....(3)}$$

Where
TCP = Total Costs of production
p_s = price/kg of seed
p_{ml}, p_{fl}, p_t = male and female labour cost and tractor cost per hour
p_p, p_h = pesticide and harvesting cost per ha
p_f = price per kg of fertilizer
Q_s, Q_f = quantity (in kg) of seeds and fertilizer used
h_{ml}, h_{fl}, h_t = total number of hours of male and female labour and tractor hours for crop production
C_p = water charges from public/canal water on a seasonal basis
C_m = water charges and the capital and O&M cost of pumping units and the depreciated value of fixed assets (pumps, well construction etc.)
C_t = costs of purchasing water through trading from pumping devices

The analysis did not include the capital costs of land possession due to the highly complicated property status along IGB area. There are plenty of cases where land is leased for long periods from public authorities for a nominal amount (Bac, 1998). In other cases, farmers apply shareholding practices where land is provided in exchange of a portion of the harvest (Dusen et al, 2006). Although the absence of capital land costs might cause some deviation from the accuracy of the results, its inclusion would highly distort the cost related findings.

The revenues from the agricultural production were estimated from the primary data of the survey. They are disaggregated into crop and pricing indices while the byproducts and the shadow pricing from self-consumption are also considered as below:

$$TR = \sum_{c \in crops} (p_{mc} \times Q_{mc}^{sold} + p_{bpc} \times Q_{bpc}^{sold} + p_{sc} \times Q_c^{cons}) \qquad \text{.......(4)}$$

Where
TR = Total revenue

Q_{mc}, Q_{bpc}, Q_{sc} = Quantity sold of the main crop, by product and self-consumption

p_{mc} = Price of crop in the local market

p_{bpc} = Price of the crop byproduct in local market

p_{sc} = Shadow price of the self-consumption

It should be noted that the costs and revenues investigated encompass only the agricultural economic activities. Since the intention was to focus on the effects to agricultural activities by excluding other potential costs or revenues sources which might distort the expected outcome, total expenditure and income were not determined.

The determination of water and land variables is thereafter estimated. Initially, for the case of water use, the outflow should be accounted through the consumed volumetric withdrawals. Water supply in the areas examined was provided in three main ways. Canal irrigation through the public network, private groundwater pumping and purchased water from unofficial market schemes again derived by pumping devices. The survey respondents stated the hourly water consumption of each crop for different seasons in respect to the use of different source types. The volumetric equivalence for canal irrigation could be then easily measured through the acquisition of information about the canal dimensions in each network (IWMI, 2010). However, in the cases of pumping and traded water, the high heterogeneity of pump types and the lack of information for the hourly volume of traded water were insufficiently captured through primary or secondary data. For this reason, the water assessment was preferred to be indicated on hourly basis through the information provided by the farmers from the questionnaires. In effect, the analysis is based on the comparative water consumption rate among different users' groups. The potential volumetric variations implied in the hourly consumption within the groups are equally applied for all.

The landholding size for each crop and season was captured through the questionnaire. The accumulating amount indicates the overall land possession, owned and/or leased by farmers. For a better clarification of the water and land effects to costs and revenues variables, a classification of four groups comprising marginal, small, medium and large water users and landholders was designated.The benchmark values for each group were slightly adjusted from the ones adopted by the national statistical services of India (Ministry of Statistics and Programme Implementation, 2010), Nepal (Central Bureau of Statistics, 2010) and Pakistan (Federal Bureau of Statistics, 2010) as presented in Table 1:

Table 1. Group classification of landholders and water users

Groups	Water (hrs/yr)	Land Size (acres)
Marginal	<= 50	<= 1.00
Small	50- 99	1.0 – 2.99
Medium	100 - 150	3 – 5.99
Large	150+	6+

Note: hrs/yr = Hours of water use on a yearly basis

Along the data screening, a highly positive skewing mainly of costs and revenues estimations was observed. For a better distribution of the data elements, a conversion to natural logarithmic values was conducted for all variables. It is acknowledged that logarithmic conversion may sometimes result in ambiguities in results (Osborne and Overbay, 2004). To avoid this, other attempts to treat the sample – for example, through the introduction of weight estimation, conversion to inverse numbering and square rooting - were tested. The natural logarithm proved to be the most successful and befit to our needs due to even distribution of the data and avoidance of misspecifications. However, the very small size of land plots would result in negative numbers along the logarithmic conversion. For that reason, a constant was added for the conversion in positive values (Osborne, 2002).

In turn, we use a multivariate general linear model (MGLM) to provide insight into land and water interactions among the groups in regard to total costs and revenues. As Garson (2010) notes, the use of MGLM technique is often recommended for the reasons below:

a. the use of dependent variables as a criteria for reducing a set of independent variables to a smaller, more easily modelled number of variables.

b. the comparison of groups formed by categorical independent variables on group differences in a set of interval dependent variables.

c. the identification of the independent variables which differentiate a set of dependent variables the most.

The reason why a MGLM model was selected in our research was twofold. Initially, we wanted to explore the significance and the effects of each water and land group individually and in pairs with total agricultural costs and revenues in a single model. Second, the interaction of water and land with total costs and revenues could be better described in a non-linear relationship. In that sense, the MGLM could better explain relationships between predictors and dependent variables which may not be linear in nature (Dobson, 2001). Our model employs total costs and revenues as dependent variables predicted by the coefficients of water use and land scale. The entire analysis was run with the PASW 18 statistical software.

The data of the analysis was obtained through an extensive survey based on a household questionnaire form and selected focus groups responding to key stakeholders in the examined clusters. The survey was conducted in representative agriculturally dependent regions of the IGB in the countries of Pakistan, India, Nepal and Bangladesh. However, for the case of Bangladesh, the survey concentrated only on the effects of water use to aquaculture by inhibiting a comparative analysis with the findings of the other riparian clusters. Hence, the research considered the survey results from the examined clusters in Pakistan, India and Nepal. Still though, the vast area of the IGB meant it was impossible to investigate all the potential land and water source types found in the three countries. For the identification of the most representative cases, the IGB was categorized in three main parts. The Upper Catchments (UC), where the Himalayan region is situated, the Western Indo Gangetic Plains (WIGP) which encompasses Pakistan territory and the Eastern

Gangetic Plains (EIGP) which encloses areas of Nepal, India and Bangladesh (Figure 1).

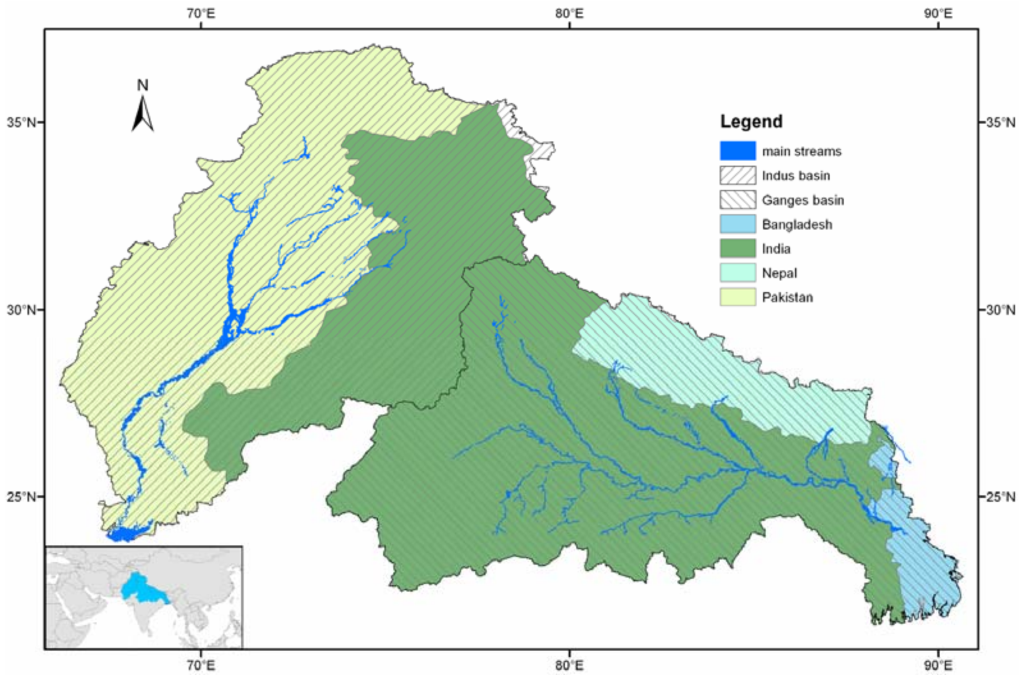

Figure 1. The Indo-Gangetic basin area

The selection of the sampling areas was deliberately focused on the most agricultural dependent regions in IGB with highly diversified environmental, water supply and landholding features. For the Upper Catchments, the political and geophysical situation of the area prevented a survey being conducted and also limited the availability of secondary data. For the case of Western Indo Gangetic Plains (WIGP), its hydrological and geographical identification with Pakistan directed the selection of four (4) highly agriculturally dependent districts in Punjab province. Two (2) sample villages were adopted on the basis of a best geographical dispersion in each district. For the case of India, the highly fertile but also rather poor state of Bihar, situated in the eastern regions of Ganges basin, partly represented the southeast EIGP area. For the needs of survey, 7 disadvantaged villages from 4 districts were chosen as Indian cases.

The northern EIGP territory was investigated through Biratnagar region positioned in Koshi Zone on the southern lowland belt of Nepal, near the south-eastern border with India. Four (4) disadvantage villages in two (2) districts were taken as case studies. Overall, 978 farmers from 10 Districts and 23 clusters were surveyed. A random sample of about 30% of the total households was collected from each cluster while all interviews were conducted on-site though qualified local researchers.

3. Results

3.1Allocation of water and landholding groups

The findings initially figure out crucial inferences about the allocation of water and landholding groups. Indicatively, more than half of the farmers are marginal water (<=50 hours/ annum) consumers as presented in Table 2. Also, about 1/3 of farmers has access to less than 1 acre of land by classifying them in the marginal landholding group.

The correspondence of marginal and small landholding groups with all water users is further assessed. In the case of marginal landholders, the absolute majority (89.7%) are identified as marginal water users. For small landholder (1-3 acres), still half of the farmers belong to marginal water users while another 1/3 correspond to small water consumers (50-100 hrs/yr). This indicates the low dependence of marginal and small landholders to irrigation by actually portraying rainfed farming practices and probably the cultivation of water resistant crops.

Table 2. Grouped frequencies for water and land factors

Groups	Water (hrs/Yr)	Valid Percent	Land <=1 acre	Land 1-2.99 acre	Land Size (acres)	Valid Percent	Water <=50 (hrs/yr)	Water 50-99(hrs/yr)
Marginal	**<= 50**	52.8	89.7	57.6	**<= 1.00**	29.2	49.7	12.5
Small	**50- 99**	19.2	8.2	26.7	**1.0 – 2.99**	32.5	33.5	45.3
Medium	**100 - 149**	9.4	2.1	9.2	**3 – 5.99**	19.5	10.5	28.1
Large	**150+**	18.5	.0	6.5	**6+**	18.7	4.3	14.1
Total (%)		**100**	**100**	**100**	**Total**	**100**	**100**	**100**

When however examining marginal and small water groups versus landholdings, a considerable number of marginal water users are equally divided between those with small and medium landholdings. The situation is surprisingly altered in the case of small (50-99 hrs/yr) water users. An insignificant amount is represented by marginal landholders while the bulk of consumption is met in small and secondarily medium (3-6 acres) holdings. This situation could arise from a number of causes which cannot be thoroughly explained in the current research. However, it becomes apparent that limited water consumption is met in almost all the landholding groups by actually emphasizing the relative rarity of irrigated water. By taking into consideration that rainfall in IGB is concentrated only in few months within a year, the constraints derived by the limited irrigated water use become more acute.

3.2 Water consumption and welfare implications

The regressions of water and land use with agricultural costs and revenues reveal some substantial differences between the groups. The findings of the bivariate linear regression between water use and total revenues present a satisfactory fit of the model (R^2 = .429) at a statistically significant level (F (2, 664) = 251.351, p <.05). The revenues increase almost linearly with a slight reduction at greater water consumption. The same roughly situation occurs with costs. The R^2 is moderately lower (R^2 = .390) though still acceptable (F (2, 664) = 214.257, p <.05). The two quadratic functions analyzed in relation to the water users' groups are exhibited in Figure 2.

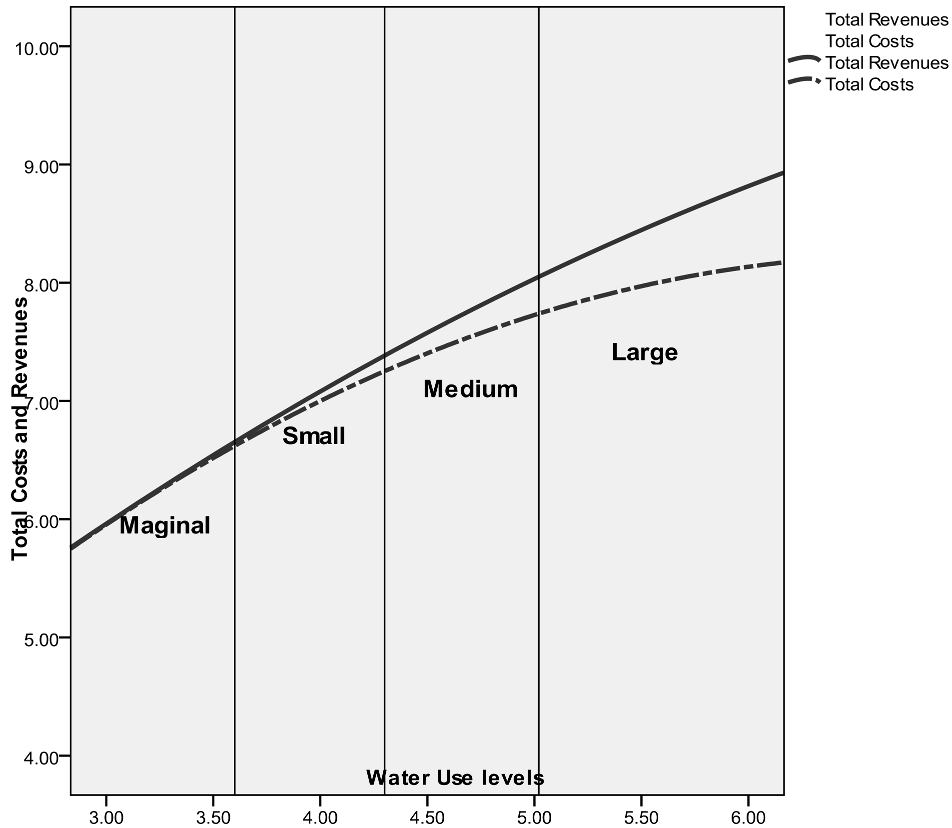

Figure 2. Water use groups with total costs and revenues (in logarithmic metric units)

Water use appears to be an indifferent benefit potential for marginal consumers. Small users slightly benefit from higher consumption while a more transparent surpassing of revenues over costs appears in the medium consumers. Water use for large consumers clearly comprises a high motivation for revenues increase.

An investigation of the average water use per year and the different water supply sources as presented in Table 3, could possibly further explain the regressions' findings. Marginal water users consume on average 23 hrs/year while they are heavily reliant on surface water sources. The situation actually portrays rainfed cultivation where irrigation seems to be crucial at key times without however consisting of the prevalent water source. For small consumers, total revenues begin to surpass total costs and water use per capita is getting three times as much as marginal farmers while half of the water is pumped from ground sources.

In the case of medium users, a distinctive exceeding of total revenues over total costs as presented in Figure 2, is signaled by a twofold water use increase per capita. Also, the surface and groundwater ratio remains almost similar to small users. The exacerbation of water use and revenues in large consumers is accompanied by greatly increased consumption, on average 345 hrs/yr per capita. Surprising is the observation that groundwater sources supply only 15% of large consumers needs.

Table 3. Water use and allocation of ground and surface sources

Statistics	**>50 Hrs/Yr (Marginal)**			**Statistics**	**50-99 Hrs/Yr (Small)**		
	Total Use	**Surface water**	**Ground water**		**Total Use**	**Surface water**	**Ground water**
Mean	22.82	19	3.89	**Mean**	68.57	46.00	22.57
% of Total Sum	11.9	12.0	11.5	**% of Total Sum**	13.0	10.6	24.2
% of Total N	52.8			**% of Total N**	19.2		
Statistics	**100-149 Hrs/Yr (Medium)**			**Statistics**	**150+ Hrs/Yr (Large)**		
	Total Use	**Surface water**	**Ground water**		**Total Use**	**Surface water**	**Ground water**
Mean	123.54	89.05	34.49	**Mean**	345.74	301.34	44.40
% of Total Sum	11.5	10.1	18.2	**% of Total Sum**	63.5	67.3	46.1
% of Total N	9.4			**% of Total N**	18.6		

In total, marginal water users consist half of the entire sample but they share only about 12% of the entire water consumption. Also, all the marginal and small farmers comprise 73% of the population while they just share 25% of the entire water used in agriculture. The bulk of water use is actually directed to the small portion of large farmers (19%) who however make use of about 64% of the total water resources. Future water resource development programs and policies need to alleviate such a large inequity.

3.3 Land scaling and welfare implications

The bivariate regression of land with total revenues provides a very good fit (R^2 = .634) at statistically significant level (F (2, 664)= 578.108, p <.05) (Figure 3). An upwards curvilinear condition denotes the incentive offered by land scale for revenues rising at a progressively decreasing rate. However, the land and total cost regression shatters the revenue raising portrait displayed by land factor. Although land and cost regression is moderately explained (R^2 = .258) in a still significant level (F (2, 664)= 116.525, p <.05), the situation gets burdensome for marginal holders. Land possession appears to be economically unsustainable for marginal farmers (<1 acre) and for most of the small landholders (1-3 acres). The situation is altered for medium land sized farmers (3-6 acres) while land comprises a very good prospect for large farmers (6+ acres).

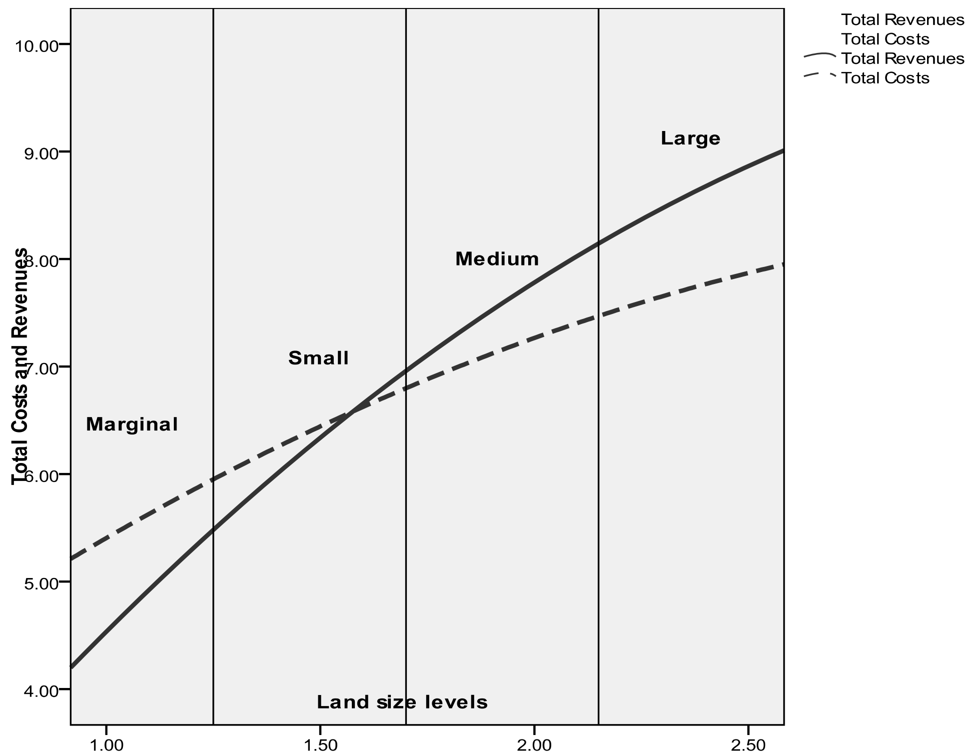

Figure 3. Landholding groups with total costs and revenues (in logarithmic metric units)

A differentiation among the cropping patterns in respect to the landholding groups could possibly provide some explanation for the findings of the regression analysis. To this aim, we examine the most prevalent crops cultivated in the surveyed clusters which dominate approximately 95% of the entire harvesting. The observations are concentrated on two main aspects as presented in Figure 4. Initially, the proportion of each crop is assessed within the four land groups. Wheat and rice crops appear to dominate the entire harvest, mainly complemented by maize in all group cases.

For marginal farmers, the predominant crops are rice and wheat (44% and 45%). A small differentiation occurs in the case of small farmers where the rice is decreased and seems to be substituted by wheat. The rice share is further decreased for medium farmers and instead cotton, maize and sugarcane are cultivated. For farmers with large landholdings, rice and wheat cultivation remain comparatively the same with medium farmers, but the maize is largely replaced by vegetables.

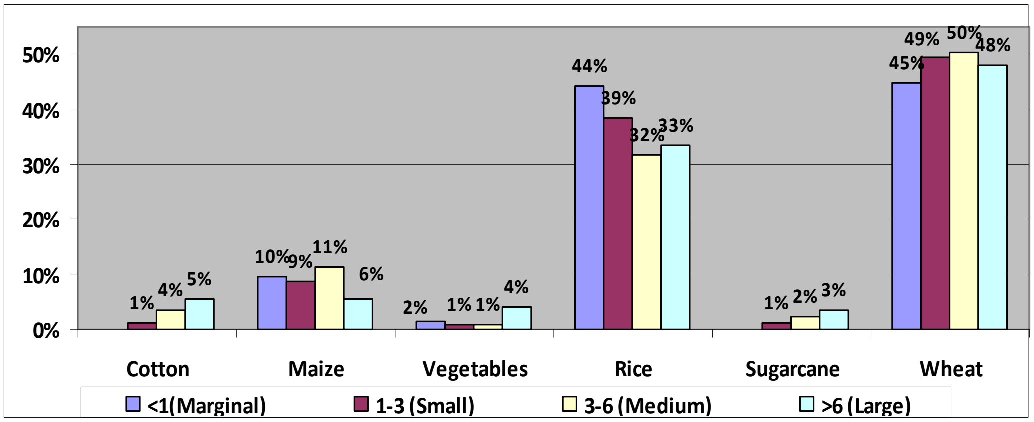

Figure 4. Crop allocation between different landholding groups

These findings could be the cause of the economic loss presented by marginal farmers who are dominantly rainfed rice producers. Often than not, marginal farmers plant rice mainly for self-consumption without having the chance to substitute it with other more beneficial staple or cash crops (Erenstein, 2009). The substitution of rice with another staple crop (wheat) appears to be profitable for small farmers with relatively larger plots. The revenues further diverge from costs when rice and maize are substituted by cash crops in the case of large farmers.

A more detailed analysis of differences between farmers, land distribution and crops reveals other important findings as presented in Figure 5. Particularly, we examine how much land size (SUM) is allocated for each crop for every landholding group. The amount of land size to be allocated for each crop is defined in a percentage format as part of the total cultivations.

Then, we define the frequency (N) of each cultivated crop to be allocated in each landholding group. The frequency actually represents the amount of farmers to cultivate the same crop in each group accordingly. Again, the amount of observations for each crop is defined in a percentage format. The comparative analysis between the crop observations (N) and the land size (SUM) infers the amount of farmers to share the cultivated land in each crop case. The comparison of the two components which are both measured in a percentage format is conducted in a ratio order. For instance, an almost equal amount of frequencies (23% of total) and land size (25% of total) of a crop for the case of marginal landholders would be interpreted in an approximately 1:1 ratio.

The comparative analysis of the cultivated crops in all groups, presents that marginal farmers are comparatively four times more than the land size in cases of wheat, rice and vegetables crops (ratio 4:1) and almost thrice the land size in maize crop (ratio 3:1). The land distribution for rice, maize and wheat is highly improved to a 2:1 ratio in the case of small farmers. Cotton and sugarcane allocation are approximately about at 3:1 ratio.

The situation is altered for medium farmers where an almost 1:1 ratio is portrayed in all staple (wheat, rice and maize) crops. The three other cash crops (cotton, vegetables and sugarcane) still sustain a 2:1 ratio. The relations between frequencies and land sizes are capsized for all the cultivations in the case of large farmers with an average ratio 1:3 for rice and wheat and almost 1:1.5-2 for the other crops.

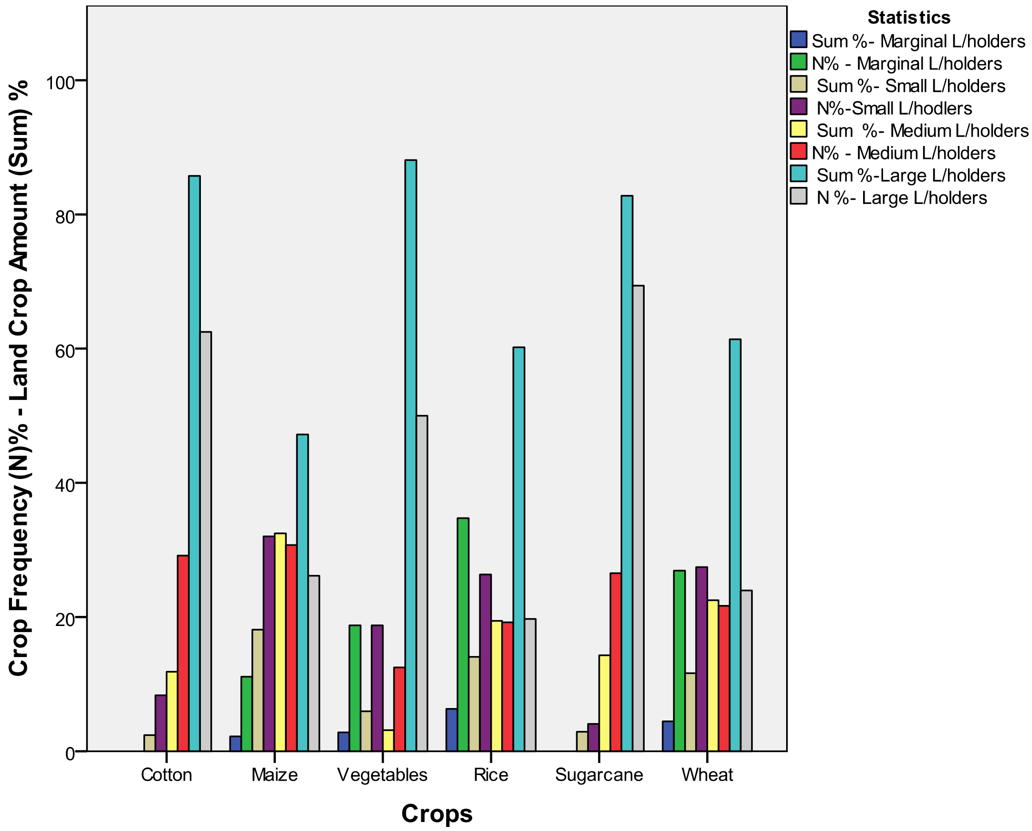

Figure 5. Land and Farmers' distribution in a crop wise manner

These findings highlight that land availability for staple crops (rice, wheat, maize) plays a key role to agricultural benefit up to the medium land group level. In effect, land size acts as a constraint for staple crops in case of marginal farmers due to very small plot size. Small and medium landholders can grow these crops in bigger plots by increasing their benefit potential. In the case of cash crops (cotton, vegetables, sugarcane), the ratio between land and farmers remains almost unchanged in all three groups (marginal, small and medium). Hence, the land scaling does not appear to attribute that much significance for cash crops. The situation is altered for the group of large farmers where the land and farmers' ratio for both staple and cash crops could substantially justify the increased revenues.

3.4 Multivariate General Linear Model (MGLM)

The findings of MGLM reveal some key elements of the land and water interaction in relation to costs and revenues as presented in Table 4. The model is successfully interpreted for revenues ($F = 68.348$ $p < .05$, $R^2 = .586$) and less satisfactorily but reasonably in regard to costs ($F = 33.548$, $p < .05$, $R^2 = .406$). The results confirm a significant relation of each factor except for the interaction between water and land where the relation is rather weak.

Table 4. Assessing model significance within each predictor and dependent variable

Source	Dependent Variable	Type I Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Sq.
Corrected Model	Revenues	1141.728[a]	14	81.552	68.348	.000	.595
	Costs	624.057[b]	14	44.576	33.548	.000	.419
Intercept	Revenues	10905.607	1	10905.607	9139.882	.000	.933
	Costs	10857.069	1	10857.069	8171.253	.000	.926
WaterGroup	Revenues	16.188	3	5.396	4.522	.004	.020
	Costs	161.380	3	53.793	40.486	.000	.157
LandGroup	Revenues	225.397	3	75.132	62.968	.000	.225
	Costs	8.236	3	2.745	2.066	.103	.009
WaterGroup * LandGroup	Revenues	10.489	8	1.311	1.099	.362	.013
	Costs	51.018	8	6.377	4.800	.000	.056
Error	Revenues	777.959	652	1.193			
	Costs	866.306	652	1.329			
Total	Revenues	34285.204	667				
	Costs	32285.360	667				
Corrected Total	Revenues	1919.687	666				
	Costs	1490.364	666				

In turn, the significance of each land and water group is assessed through factorial analysis for both costs and revenues. As presented in Table 5, small water users seem unrelated with the total revenues while the significance of marginal and medium users is also weak. The situation is however different for total cost dependent where only the medium water farmers appear to act insignificantly while a similar situation occurs for marginal landholders.

The interaction between land and water seems to be unrelated with total revenues although in the separate regression analysis (Figure 2 above) the models present a satisfactory fitting. The situation is altered for the cost dependent where all the combinatory land and water groups present a good statistical significance despite the low model fitting in the presented regression analysis (Figure 3 above).

Table 5. Significance estimation for water and land groups separately and interactively

Parameter Estimates						
Dp. Vr.	Parameter	B	St. Err.	t	Sig.	Pr.Et.Sq.
Total Revenues	Intercept	9.062	.121	74.666	.000	.895
	[WaterGroup=1]	-.554	.273	-2.032	.043	.006
	[WaterGroup=2]	-.161	.258	-.626	.532	.001
	[WaterGroup=3]	-.493	.250	-1.974	.049	.006
	[WaterGroup=4]	0[a]	.	.	.	.
	[LandGroup=1]	-2.503	.588	-4.255	.000	.027
	[LandGroup=2]	-2.012	.559	-3.596	.000	.019
	[LandGroup=3]	-.813	.217	-3.751	.000	.021
	[LandGroup=4]	0[a]	.	.	.	.
	[WaterGroup=1] * [LandGroup=1]	-.654	.642	-1.018	.309	.002
	[WaterGroup=2] * [LandGroup=2]	-.297	.625	-.475	.635	.000
	[WaterGroup=3] * [LandGroup=3]	-.530	.406	-1.304	.193	.003
	[WaterGroup=4] * [LandGroup=4]	0[a]	.	.	.	.
Total Costs	Intercept	8.272	.128	64.588	.000	.865
	[WaterGroup=1]	-1.563	.288	-5.430	.000	.043
	[WaterGroup=2]	-1.127	.272	-4.137	.000	.026
	[WaterGroup=3]	-.325	.264	-1.232	.218	.002
	[WaterGroup=4]	0[a]	.	.	.	.
	[LandGroup=1]	.771	.621	1.241	.215	.002
	[LandGroup=2]	-2.175	.590	-3.683	.000	.020
	[LandGroup=3]	-.853	.229	-3.730	.000	.021
	[LandGroup=4]	0[a]	.	.	.	.
	[WaterGroup=1] * [LandGroup=1]	-1.834	.678	-2.705	.007	.011
	[WaterGroup=2] * [LandGroup=2]	2.073	.660	3.142	.002	.015
	[WaterGroup=3] * [LandGroup=3]	3.005	.687	4.375	.000	.029
	[WaterGroup=4] * [LandGroup=4]	.998	.429	2.329	.020	.008

A delineation of the predicted means of total costs and revenues with each land and water group is displayed in two separate profile plots (Figures 6&7). A diagrammatic representation offers a good insight about the prospective interacting trends of water and land groups towards potential farming development. Each point in the profile plots indicates the estimated marginal mean of total costs and revenues at one level of each water and land group.

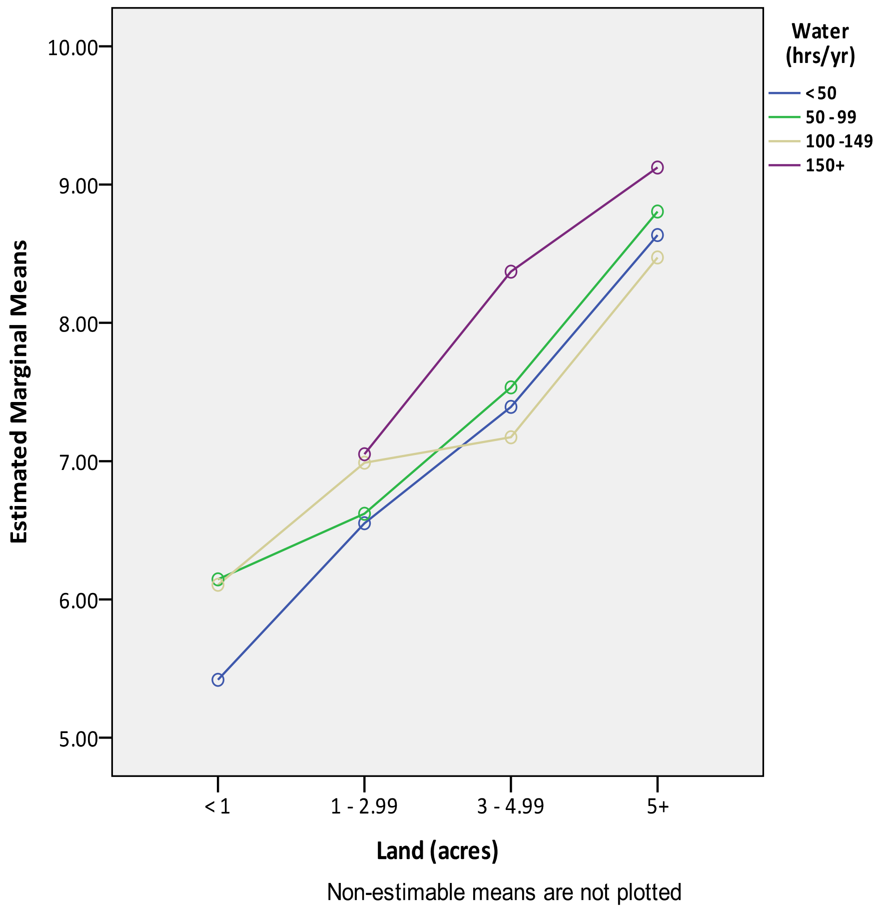

Figure 6. Estimated Marginal Means for Total Revenues

As presented in Figure 6, there is a revenue raising incentive for marginal water users which is exponentially raised with incremental land size. Almost the same situation occurs for small and medium water users while in the case of large water users the land increase seem to be a less but still sufficient revenue incentive.

In the case of total costs (Figure 7), an initially steep but progressively slow increase is observed for marginal water users as land size increases. A steady situation is noted for the case of small water and land users in almost all the land size levels. Interesting is the case of medium water users where the total costs are initially increased up to the small land level and then are progressively decreased. Contradictorily, large water consumers exhibit an upward trend as land size is augmented.

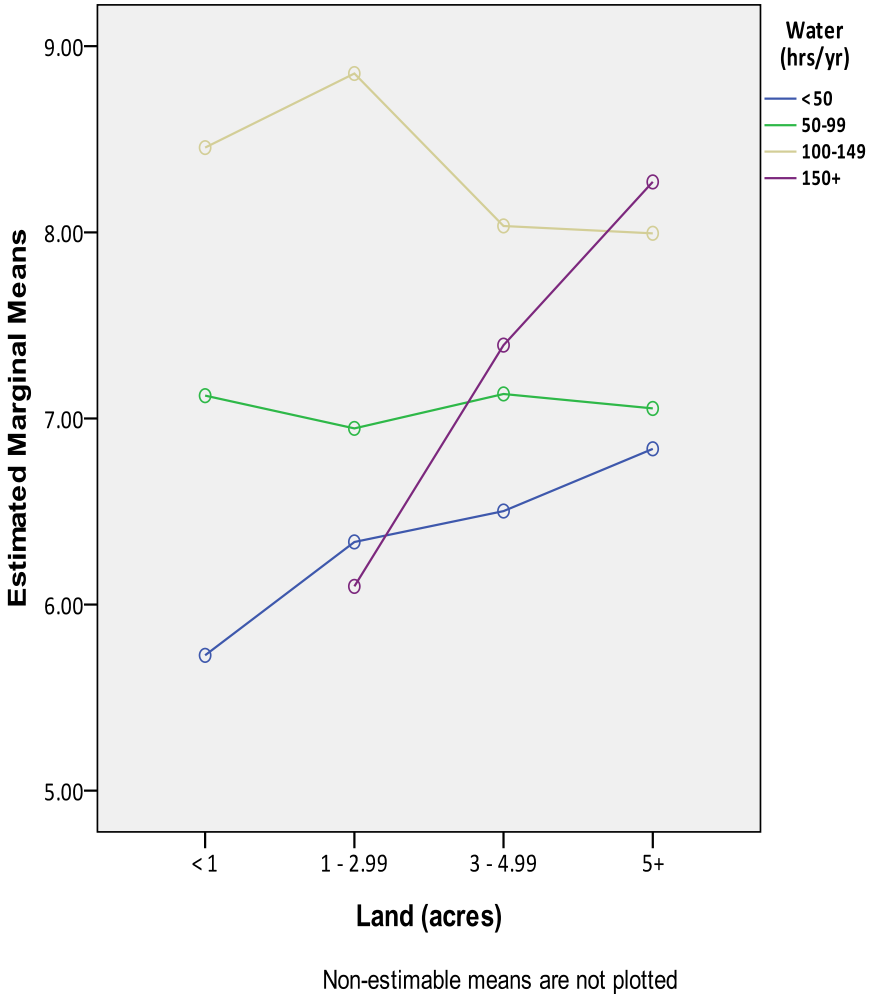

Figure 7. Estimated Marginal Means for Total Costs

4. Discussion and concluding remarks

The assessment of land scaling and water volume effects to the economic aspects of farming in the IGB area through a group wise analysis was based on some methodological assumptions. First, the economic analysis did not seek efficient water and land levels to be attained for the profit maximization of farmers. The identification of profit maximization in our analysis through a break-even point analysis would be of inferior importance for the following reasons. Initially, the profit maximization would be identified in far higher land size and water use levels than the current ones. As presented in figures 2&3 there is a huge potential to exhaust water and land factors until total revenues will be curbed to the point total costs will be met. This projection would be interesting from a theoretical perspective but with no actual use under the current situation. Moreover, the seeking of the most efficient water and land use levels for profit maximization would have overridden the effects to each water and landholding groups. A separate analysis could run instead for each group individually for the identification of the most efficient water and land size levels. This has been indirectly presented in the regression charts and explained according to water source and cropping pattern allocations. However, the shapes of individual diagrams for each group would possibly question the accuracy of results due to the fragmentation in very small samples.

In the second assumption, the research concentrated on the effects of water consumption and land scale to farming as the most profound factors for development in the agrarian economies of IGB (FAO, 2006). It is acknowledged that the individual assessment of land and water in regression analyses might have exacerbated the effects of each determinant due to the absence of other influential factors. However, the analyses attempted to investigate the effects of land and water though representative sampling and high statistical levels for the minimization of conceptual and numerical errors.

Looking through the limitations occurring in the application stage, it is comprehended that a very extensive territory demarcated by the IGB river basin, was covered. It is inevitable that a plethora of different land sizes and cropping patterns could misrepresent the cultivating conditions on national level. For instance, cotton cultivation is far more dominant in Pakistan than in Nepal where biophysical conditions do not permit it. Rice cultivation is prevalent in the Indian and Nepalese sample, but is rare in Pakistan. High heterogeneity is also pointed out in water use practices. Indicatively, pumping from deep wells and boreholes is very rare in southeast Nepal where the sample was taken. However, in northern parts of India and in the southeast of Pakistan large numbers of pumps are used for groundwater extraction. Unofficial water trading mainly of groundwater is also a prevalent custom in east and northeast India but it is almost unknown in the Nepalese and Pakistani sampling area.

Consequently, heterogeneous natural and human made features existing in the vast IGB area constrain the applicability of ours results. However, the splitting of the sample on a national scale would possibly increase prediction error due to the unrepresentativeness of the respondents towards the population. Besides, our prime objective was the assessment of water and land determinants in the IGB area where different climatic, water and soil fertility conditions are met.

Looking through a policy perspective, it appears that a significant benefit potential stands for large water consumers and landholders. To this purpose, appropriate technological and economic incentives should be provided for a more efficient water and land use. One the other hand however, the high distributional inequity between the large and marginal water users and the relative water rarity encountered by all landholding groups underline the need for rearrangement of irrigation policy. A reallocation of water supply in favor of marginal water users together with the enhancement of supply services to all landholding groups could offer substantial economic improvements in the agrarian IBG areas.

Further, the marginal and small landholders who are identified with marginal and small water users seem to strive for their economic survivability. The tiny and scattered land holdings appear to be economically unviable for the dependent large rural populations by verifying previous research findings

(Niroula and Thapa, 2005). To this effect, investments towards land consolidation and irrigation expansion projects for these landholding groups should be prioritized in the agrarian clusters of IGB area. An additional supporting policy also targeted to marginal and small landholding groups should be the substitution of rice cultivations with more beneficial cash crops as manifested in the research findings.

Lastly, the combinatory analysis of water and land groups on revenues and cost dependent variables addresses the high potential of all groups except the large ones to drastically improve their economic situation when land and water factors are interchanged. To this end, policy makers should strongly consider the simultaneous rescheduling of land and water use policy for the gaining of the synergetic effects to arise in all the three groups. .

It is generally acknowledged that the current research did not exhaust all the possible influential factors and the relevant conditions that may affect agricultural development in IGB area. However, by taking into consideration that water use and land scaling constitute the major affecting factors in the agrarian economies of IGB where farming is almost the only source of income, the study findings offered clear insights about the vulnerable agriculturists to be supported. Also, indicative policy recommendations are suggested for the improvement of the very fertile but still low income IGB area.

Acknowledgements
The research was undertaken through the project ''Sustainable Livelihood Improvement through Need Based Integrated Farming System Models in Disadvantaged Districts of Bihar'' by the Indian government and the "Basin focal project of the Indo-Gangetic basin funded by the Challenge Program for Water and Food.

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Paper 2

Valuating agricultural water use and ecological services in agrarian economies: evidences from eastern India

Stefanos Xenarios [a], Upali Amarasinghe [b], Bharat Sharma [b]

[a] International Water Management Institute, East Africa& Nile Basin Office Ethiopia, Addis Ababa
[b] International Water Management Institute, New Delhi office, India

Abstract

Agricultural water use in agrarian economies is often state subsidized for the enhancement of agricultural productivity while poverty alleviation is also targeted. The Indian agricultural dependent states offer representative examples of undervalued irrigation services mainly sourced by canal networks. However, the current inefficient operation of canal irrigation systems diverts water demand to private initiatives by significantly increasing economic value of agricultural water. The additional recent acknowledgement of economic value encompassed in supportive ecological services enhances the request for reevaluation of agricultural water. The paper attempts to assess the value of irrigation and related ecological services in representative backward clusters of Bihar state in Eastern India. The effects on different landholding groups are analyzed by giving particular emphasis to marginal landholders.

Keywords: Agricultural water use, irrigation services, ecological services, valuation, marginal farmers, Eastern India

Introduction

Agricultural water use value is customarily defined through the water demand for crop production (Hanemann, 2006). A practical approach is the division of net crop value output with the estimated water input. Under competitive market conditions, an efficient valuation of agricultural water use should be attained through the maximization of crop productivity until profits will be diminished (Tsur, 2009). The revenues from agricultural produce should allow farmers to effectively undertake the costs of irrigation services through an efficient pricing mechanism. Namely, the labor, capital, operational and maintenance costs of the irrigation system should be sufficiently covered while funding for reinvesting in new projects should be ensured. However, the objectives of irrigation policy in agrarian economies are not always aligned with the theoretical background of agricultural water use value.

The economic value of water use is de-linked from crop profit maximization by mostly pursuing an equitable minimum water volume for staple crops (Ataman and Beghin (Ed.), 2005). Sound examples are spotted in agricultural dependent states of eastern India where water sufficiency in rice and wheat crops is highly prioritized for the sustenance of subsistence farmers. To this end, low water tariffs usually conveyed through a flat payment rate are introduced in most of the agricultural Indian states for the affordability of water charges (FAO, 2006).

However, low water tariffs often result in poor operational and maintenance funding by in turn leading to inefficient supply services (Meinzen-Dick et al, 2002). The dysfunctional canal irrigation networks are giving priority to privately owned groundwater pumping (Davis et al, 2008). Rapid construction of private tube wells and installation of diesel pumping devices are nowadays profoundly apparent in North and Eastern India (Shah et al, 2009). However, the private groundwater initiatives steeply increase the actual irrigation costs which becomes hardly affordable for subsistence farmers.

The expansion also of groundwater pumping in high permeable alluvium derived soils met especially in Eastern India has induced water pollution from agrochemical residuals. Further, over pumping practices have diminished groundwater reserves by provoking erosion and salinization effects (Sharma et al, 2009). The close linkage of ground with surface water sources has resulted in an overall degradation of water status. A quantitative and qualitative deterioration has mostly affected the ecological services associated with water cycle. Indicatively, the services related with natural water filtration, replenishment of groundwater sources and preservation of low vegetation have been distinctively disturbed by in turn rendering profound problems in agriculture. Water scarcity in dry season, high soil salinity and erosion are the most crucial problems emanating from the disturbance of the supported ecological services met in eastern Indian states (Shah, 2008). Although until recently the assessment of these services in agricultural water value was unusual, nowadays, they are acknowledged as indirect use values. They are however considered of equal significance with water use values (e.g. irrigation services) which are mostly identified as direct ones.

The paper attempts to identify the actual water value from irrigation and water related ecological services in representative backward clusters[1] of Bihar state in India. The direct water use values from irrigation services are disaggregated on surface and groundwater sources. Namely, the charges from canal irrigation, the capital, operational and maintenance expenditures from pumping and the shadow pricing from water trading are investigated. The indirect use value of ecological services is assessed through the environmental related problems on water quantity and quality status met in the examined districts.

For the assessment process, an extensive survey analysis in combination with secondary data is adopted. The survey is materialized through a household questionnaire form while the secondary data is originated from national authorities and sources from international organizations.

It should be mentioned that the research highly contemplates previous studies based on equilibrium analysis through demand and supply approaches (Krysiak and Krysiak, 2003; Xepapadeas, 2005; Kossioris et al, 2008; Phaneuf et al, 2008). Sound supply oriented econometric studies for water pricing through staple commodities in India have been also reviewed (Ranganathan and Palanisami, 2004; Kakumanu and Bauer, 2008). The introduction of user's preference approach for the demand assessment of irrigation in Indian cases is also apprehended (Kumar, 2001; Somanathan and Ravindranath, 2006; Kumar and Singh, 2005; Carson (Ed), 2007). The capturing of the total economic water value through relevant frameworks is another valuation approach that we share common research issues (Norberg, 1999; Faber et al, 2002; US EPA, 2002; Turner et al, 2004).

It should be noted however that the suggested approach does not follow a supply or demand oriented analysis neither does it offer an additional generic methodology for agricultural water valuation. It is instead accepted that the current canal charges linked with an administered price from governmental authorities, do encompass a direct water use value. Additional also direct use

[1] Cluster is considered to be a compound of small settlements which may be formed as villages or sparse inhabitants' areas.

values stemming from groundwater pumping costs and water purchasing costs are also identified. The indirect use value associated with related ecological services appears also to be a major determinant in agricultural water assessment (Bennet and Birol,2010). In this light, the analysis attempts to identify the actual water value corresponding to farmers in Eastern India from irrigation and related ecological services.

For a better correspondence of water value with farmers' economic status, a classification based on landholding size is conducted. By adopting the assumption that landholding size strongly pertains to farmers' wealth (CPWF, 2010), a classification between marginal, small, medium and large landholders is established. Emphasis is given to the water value attributed to marginal farmers.

Methodological context

The valuation of agricultural water preconditions a water economy scheme to be initially outlined. The prevalence of a resource base (aquatic ecosystem) together with the users and suppliers supervised by a regulatory mechanism are the essential components (Tsur, 2005). However, water valuation is not always perceived as a desirable action. Numerous ethical dilemmas are raised on the foothold that human beings are incapable of valuing s environmental related assets of which they are a part of (Limburg et al, 2002).

Nevertheless, water valuation concept is not based on the assessment of the entity per se. The entity's valuation is perceived through the intrinsic/inherent values acknowledged in an ecosystem and often remains a black box in valuation analysis (Brouwer et al, 1997). It is the instrumental value to be attributed in water related services (Spash, 2000). To this aim, the division between direct, indirect and non use values has been widely developed through a range of valuation guidelines and frameworks (Bateman and Willis 1999; Louviere et al 2000; Haab and McConnell, 2002; Champ et al, 2003; World Bank, 2004; Hensher et al, 2005). A representative example of economic valuation frameworks is depicted in Pearce (1993) as below:

Total economic value (TEV) = Use Values (Direct Use Value + Indirect Use Value) + Non Use Values (Option Values+ Existence Value)

Direct use values represent the services that are apparently linked with market commodities. The irrigation services or the sand extraction in a riverine ecosystem for instance, are directly distinct use values with a price tag. Direct use values with less distinctive association to markets as for instance flood or erosion avoidance are identified through shadow pricing from proxy or surrogate market commodities (US EPA, 2000). The indirect use values detect ecological services which somehow contribute to human welfare but are hardly quantifiable and matched with market products. Indicatively, natural water filtration in riverine ecosystem is an ecological process which could be theoretically assessed in economic terms through the mechanical filtration systems. However, such equivalence would undervalue the multiple benefits that simultaneously occur with the natural process such as fauna and flora improvement, microclimate stabilization and others.

The Non Use value category is of equal importance with Use values, but it exhibits intangible services provided by an environmental entity to human welfare. The prime category of Option values corresponds to a kind of deposit of ecological services for future use which could be perceived as an insurance premium for supply reserves (Atfield, 1998). Indicatively, the option value attributed to fishery stocks in a riverine ecosystem, could be rather high due to the assumption that a minimum viable population should be sustained for future fishing activities. The Existence value is interpreted as the instinctive desire of the individuals to preserve an ecological entity for aesthetical or intergenerational purposes.

The direct use vales emanating from irrigation services and the indirect values associated with ecological services are on the focus of this study. The economic values of irrigation are extracted from primary data through survey analysis for each water source type. Namely, the charges from canal water on a seasonal basis, the capital, operational & maintenance costs of pumping units and the costs of purchasing water through trading are assessed.

The ecological services are accordingly assessed through Willingness to Pay inference by open ended questions (Bateman and Willis, 1998). The biases of open ending approaches are taken into consideration as a threat to the distortion of the assessing outcome (NOOA, 1995). To this aim, an extensive introduction about the concept of economic assessment was offered by trained local researchers. The median value of the WTP was adopted due its relative steadiness in case of outliers (Garrod and Willis, 1999). The WTP related questions set in the assessment process are presented in Appendix 1.

For the estimation of the water value per unit of consumption or otherwise the marginal water use value, the capturing of the volumetric withdrawals should be accomplished. The respondents have noted the hourly water consumption of each crop type for different seasons. Based on this information, the equivalence of hourly consumption from canal water could be measured through secondary outflow data in a district level. However, for the case of pumping from groundwater the high heterogeneity of pump types could not be captured through secondary or primary data. Also, the rapidly expanded water trading derived by groundwater pumping is another major water source practice which could be hardly measured through actual data. In effect, a common practice mostly for marginal farmers with limited access to water sources is the purchasing of water on an hourly basis from farmers with private wells and pumps. Again, the high variation of pumping devices obstructed the gathering of information from the questionnaire or secondary sources.

To this aim, the water withdrawal was accounted according to the estimations of the net evapotranspiration for each cultivated crop in the examined districts. For a better clarification of the followed approach, the net evapotranspiration term is outlined. The evapotranspiration (ET^p) is a measurement of the amount of water required for plant growth. ET^p measures the quantity of water transpired from plant tissues and evaporated from the surface of surrounding soil, expressed as a depth. ET^p can be based on a number of factors including the local temperature, precipitation, cloud cover, solar radiation, and the type of plants cultivated in the examined area. The net ET^p estimates the evapotranspiration after the deduction of the effective rainfall.

In our case, the data source for the monthly reference evapotranspiration (ET^p) and rainfall were provided by the Water and Climate Atlas data base created by International Water Management Institute (IWMI, 2010). In turn, the extracted monthly data was used to estimate the net evapotranspiration or the portion of consumptive water use (CWU) met from irrigation for the area of each cropping pattern as given from the survey.
The CWU required from irrigation for an i^{th} crop in j^{th} season is the difference between potential evaporation in four growth periods (initial, development, mid- and late stage) minus the effective rainfall. This is presented in equation (1) below:

$$CWU_{ij}^{IR} = A_{ij}^{IR} \times \left(\sum_{k \in growth\ periods} \left(Kc_{ijk} \times \sum_{l \in months} Et_{jkl}^{P} - \sum_{l \in months} ERF_{jkl} \right) \right) \tag{1}$$

Where

A_{ij}^{IR} = the irrigated area of the i th crop (either rice, wheat, maize, other cereals, pulses, oilcrops, roots and tubers, vegetables, fruits, sugarcane, cotton or other crops) in the j^{th} season (Kharif season (May to October) or Rabi season (November to April))

Kc_{ijk} = the crop coefficients of i^{th} crop in k^{th} growth periods on the j^{th} season

Et_{jkl}^{P} = the monthly potential evapotranspiration amount of the l^{th} month in the k^{th} growth period in the jth season

ERF_{jkl} = the effective rainfall of the l^{th} month in the k^{th} growth period in the jth season

Thereafter, the marginal water use value for each source type is defined through the weighted average water charges stated by each farmer divided by the estimated corresponding CWU as below:

$$MWUV_{c,p,t}^{LMSM} = MV\{\ (E[X_p]V_p / CWU_p), (E[X_m]V_m / CWU_m), (E[X_t]V_t / CWU_t)\ \} \quad (2)$$

Where

$MWUV_{c,p,t}^{LMSM}$ = Marginal Water Use Value on Canal (c), Pumping (p) and traded water (t) for Large, Medium, Small and Marginal farmers (^{LMSM})
MV = Marginal Value
$E[X]$ = Weighted Average
V_p = the charges from public/canal water on seasonal basis
V_m = the capital, operational & maintenance costs of pumping units
V_t = the costs of purchasing water through trading
CWU = Consumptive Water Use

For a more comprehensive assessment about the effects in farming community, the landholding size is introduced as a representative wealth related indicator. The sampling is classified in four landholding groups of large (>5ha), medium (2-5ha), small (1-2ha) and marginal farmers (<1ha).

Next, we explore the water dependence of farming groups to each water source type in an attempt to better address the valuation effects for each landholding group separately. In turn, we identify the median WTP for ecological services for each individual landholding group. However, the median WTP represents the yearly bid offered by respondents for the preservation of the ecological services. For the estimation of the marginal WTP per cubic meter on a yearly basis, the weighted average of WTP is examined in respect to the CWU on a landholding group wise order as below:

$$MWV_{es}^{LMSM} = E[X_{es}](WTP_{es} / CWU\ ) \quad (3)$$

MWV_{es}^{LMSM} =Water value for ecological services
WTP_{es} = Willingness to Pay for ecological services like preservation of moisture, microclimate, avoidance of salinity, soil stabilization

The aggregation of equations 2 and 3 define the actual marginal water value reflected in irrigation and ecological related services for specific landholding groups in the cases examined.

Case Analysis

Bihar state situated in the eastern region of Ganges river in India was selected as a representative pilot case due to the abundant water recourses and diversified supplying types. On the other hand, low agricultural productivity, extreme poverty and regional disparities within the state constitute a highly contradictory profile. This is up to an extent justified by the highly fragmented landholdings and the extraordinary percentage of landless and marginal farmers (85% of population, Thorpe, 2007).

Also, the poor water control often results in the appearance of extreme events such as drought and floods but also in regular problems of not getting water to crops at appropriate times. Hence, the mismanagement of water supply is also to be heavily blamed for the deterioration of the rural livelihoods. The uneven land allocations and the poor water control mechanisms combined with high population density (880 persons/ sq. km), determine 43% of the population below the poverty line (BPL) (World Bank, 2005). Out of the 150 most disadvantaged districts in India, 15 districts are located in Bihar state.

The analysis attempted to shed light on the water value attributed to irrigation and ecological related services in selected backward districts of Bihar. For the accomplishment of the survey, 7 villages from the backward districts of Vaishali, Darbhanga, Munger and Patna were chosen as presented in the map below :

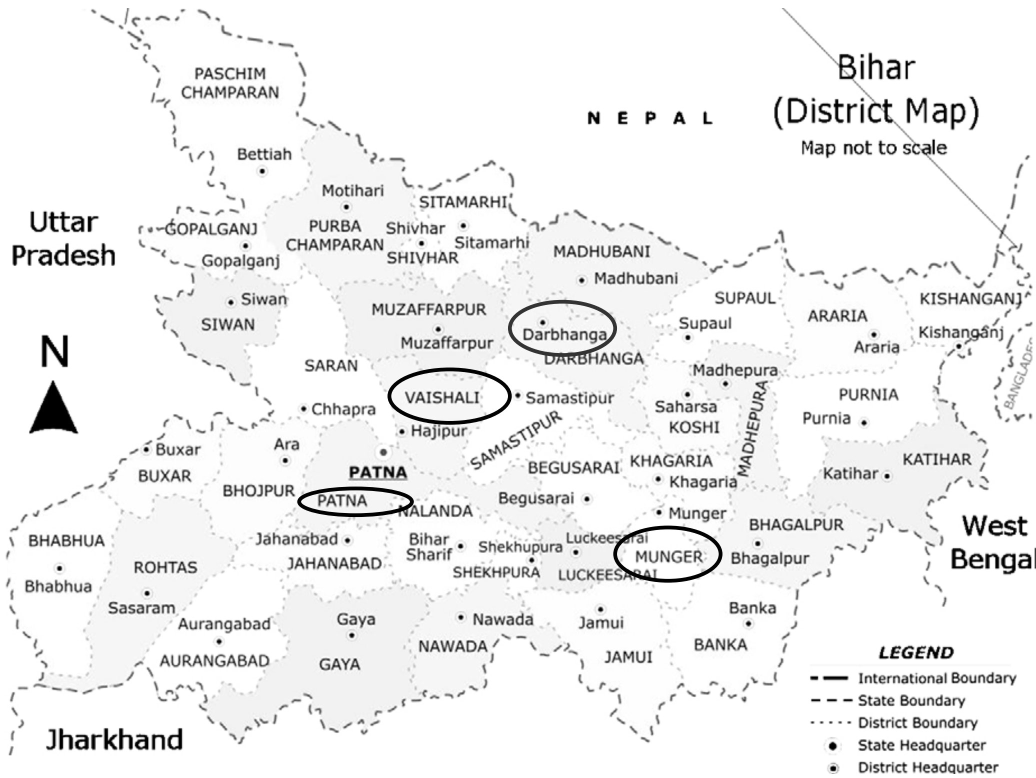

Figure 1. Selected districts in Bihar state of Eastern India

The selection of the clusters was based on a set of environmental, socioeconomic and technical criteria so as to attain the maximum possible diversification in the sampling size (Appendix 2). A random sample of about 30% of the total households was collected from each cluster resulting in a total of 489 responses as below:

Table 1. Land and Farmers distribution in the survey

Districts	Clusters	Nos of Questionnaire
Vaishali	Chakramdas	89
	Pirapur	115
Darbhanga	Saramohanpur	85
Munger	Matadih	50
	Tikarampur	50
Patna	Rambad	50
	Hulsi-Tola	50
Total	**489**	

The entire undertaking was held in cooperation with the Indian Council of Agricultural Research for Eastern Region (ICER/RCER) located at the capital of Bihar in Patna. The ICER/RCER drastically helped in the adjustment of the survey to the local peculiarities and to the appointment of local researchers. The survey was displayed and modified in a stepwise manner together with ICER/RCER partners through two workshops held in Patna at November 2008 and January 2009 where also the local researchers participated. A two rounds pre-testing was conducted in a village level as well to large, middle and marginal farmers respectively. The very remarkable results emerged by the two pretests, revealed the need to simplify the questionnaire particularly in the sections related the holding size and crop productivity. The entire undertaking lasted 9 months (November 2008 - August 20009) while the distribution and collection of the questionnaire was completed in 3 months. The local researchers where originated from nearby areas so as to ensure a familiarity with the customs and culture of the selected villages. The interviews were held on a face to face basis either in common reference buildings (e.g school, cooperatives etc.) or the in the houses of the interviewees. The on site interviews by local trained researchers eliminated the no response cases by almost attaining the target of 500 fully completed questionnaires.

The classification of the sample in the established landholding groups offered an insight about the land distribution and farmers' allocation in the surveyed areas. As noticed, more than half of respondents belong to marginal and small farmers who however possess only about 1/6 of the land examined in the sample area. . (Table 2).

Table 2. Land and Farmers distribution in the survey

Landholding size (ha)	Land distribution (ha)	Farmers (%)	Land Area (%)
0-1 (marginal)	56.5	29.8	5.3
1-2 (small)	124.1	24.5	11.7
2-5 (medium)	297.7	28.6	28.2
5-50 (large)	574.3	17.1	54.8
Total	1052.6	100	100

A reverse situation is figured in the case of large farmers with land possession of more than half of the total area but representation of about 1/6 of the sample. The highly unequal land distribution confirms the theoretical speculation of land accumulation from large owners in agricultural dependent regions of developing countries (Khandker and Haughton, 2010).

For the assessment of the marginal water value, the estimates of net evapotranspiration (the difference between the potential evapotranspiration minus effective rainfall) for the examined districts are identified. In the case of paddy cultivation, a 200 millimeters (mm) for percolation requirements is added (Table 3).

Table 3. Net evapotranspiration in selected districts of Eastern India (in mm).

Districts	Vaishali			Munger			Darbhanga			Patna		
Crop/Season	**K**	**R**	**A**	**K**	**R**	**A**	**K**	**R**	**A**	**K**	**R**	**A**
Paddy	159	615		108	597		129	540		167	633	
Wheat		278			291			260			285	
Maize		249			260			232			255	
Oth.Cereals		213			225			200			219	
Pulses		179			189			170			184	
Oil Crops		197			210			186			203	
Vegetables	71	343		25	354		47	318		77	352	
Fruit			369			332			317			385
Sugar			755			704			669			777
Cotton			156			142			142			165
Fodder	74	282		26	296		48	267		80	289	

Note : K = Kharif season (May to October), R= Rabi season (November to April), A= Annual

Source: *Authors estimates based on the climate data from IWMI Water and Climate Atlas, 2010*

In turn, the marginal water use value for each source type is explored. The findings reveal a high value difference in pumping water between large farmers and other landholders (Table 4). This is mainly to be justified by the capital costs for drilling works, pump purchasing and high operational and maintenance costs in case of diesel pumps (Amarasinghe et al, 2007a). However, at the same time marginal farmers are also called to pay an even higher value for the traded water. By considering that the study accounts only the purchased traded water without assessing the benefit from water selling practices, it appears that the condition of communicating vessels between large and marginal farmers occurs. Large farmers bear the high costs of pumping water by however transferring the burden to the marginal landholders through the unofficial traded schemes. The earnings from water selling by large farmers are internalized in their income and hence they are not assessed again in the analysis due to double counting effects.

Table 4. Weighted average water charges for each source type (in US$)

Landholders	Pumping [$/m3]	Canal [$/m3]	Traded [$/m3]
Marginal	0.010	0.012	0.023
Small	0.011	-----	0.012
Medium	0.013	-----	0.013
Large	0.021	0.011	0.013

To this end, marginal farmers are requested to afford about twice the price for purchased water while for the rest three groups the cost is almost equal. More, marginal farmers appear to expend the higher amount for canal water than large landholders while there is no data for medium and smaller ones.

The burden of the traded water value for marginal farmers could be better conceived through a water source dependence overview. As presented in Table 5, more than 2/3 of the marginal farmers rely on water purchasing while the amount fall into 1/3 for the case of large landholders. On the contrary, almost half of large farmers own pumping devices mostly for groundwater extraction while the amount of marginal farmers with pumping devices is negligible.

Table 5. Water source dependence

Water Sources	All landholding groups (%)	Marginal Farmers (%)	Large Farmers(%)
Canal Water(public)	11.85	13.64	8.33
Pumping (private)	23.22	6.82	45
Water Buying	54.93	77.27	31.67
Pumping (priv.)& buying	9	2.27	15
Total (%)	100	100	100

The low coverage and unreliability of canal irrigation together with the high capital and operational costs of pumping systems seems to force low incomes into water purchasing. For the case of canal water, the dependence of both large and marginal landholders is almost equally low which is also reflected in the case of all landholding groups.

The large dependence of marginal farmers on highly charged traded water results in the boosting of the overall marginal water use value for the three water source types (canal, pumping, trading). Marginal farmers appear to get charged almost twice the value of the small and medium ones while a distinctive difference among large farmers is portrayed (Table 6).

When assessing the median WTP for ecological services it is clearly depicted the strong willingness of large farmers to finance the resolution of water related environmental problems. Noteworthy is the almost equal contribution of marginal farmers with the small and medium groups despite the considerable income differentiation. In an attempt to portray WTP on marginal basis, we account the WTP for each landholding group in respect to the estimated CWU for all irrigated areas of each farmer. It is then exhibited that because marginal farmers consume nominal water, the WTP per cubic meter becomes the highest amongst all other groups. Contradictorily, in the case of large landholders the manifold water consumption in comparison to marginal group distinctively lowers the marginal WTP into half .

Table 6. Marginal Water Value for irrigation and ecological related services

Landholders	M. Wat.V. [$/m3]	WTP ($/year)	Est.CWU (m3/yr)	M. WTP [$/m3/CWU]	M.Wat.V.(irr.+ ec.) [$/m3]	Diff.(%)
Marginal	0.021	3.13	665	0.0026	0.0238	118
Small	0.011	3	2,950	0.0012	0.0129	18
Medium	0.010	4	5,654	0.0008	0.0109	-------
Large	0.017	18.45	16,988	0.0013	0.0189	73

Note*: M. Water Value: Marginal Water Value for irrigation, Est. CWU: Estimated Consumptive Water Use, M. WTP: Marginal Willingness to Pay, M.Wat.V.(irr+ec.)=: Marginal Water Value of Irrigation and Ecological related services, Diff (%): Difference among the value attributed to medium and the other landholding groups*

This observation is not theoretically validated by relevant guidelines where standard deviation indicator usually signposts the dispersion of the WTP bids (Bann, 1997; Brouwer et al, 1997). However, it could comprise a consistent indicator of the highly notable willingness of marginal farmers to factually participate in the conservation of ecological services.

The sum up of the values from irrigation and ecological services, reveals the highest marginal water use value to distinctively correspond to marginal farmers. An about twofold difference is observed amongst the marginal and medium together with small farmers where in the case of large farmers the difference is decreased in half.

Discussion

The valuation of the direct and indirect water use of irrigation and ecological related services followed some presumptions. Initially, the estimation of the net evapotranspiration might have deviated from the actual water use conditions met in each single case of the sampled area. The plethora of water supply systems might attribute different actual water consumptive use than the estimated ones. In that case, the dependence of cropping patters on the actual water sources and land size might varies from our estimations in the four examined districts. However, the measurement of the actual data was hindered by the high heterogeneity of pumping devices and broadly the extraction devices met in groundwater sources. Hence, the valuation of irrigation services through an approximate volumetric outflow of groundwater sources would possibly entail in much higher divergence from our estimations. Thus, the estimated net evapotranspiration approach was selected instead.

Second, the research assessed the marginal value of specific water uses, namely the direct use value from irrigation and the indirect from ecological related services. The marginal value from irrigation services stems from the actual costs for water supply per cubic meter of water. The research assumes that the actual water supply costs should be reflected in an efficient pricing mechanism set by irrigation authorities which accordingly should reveal the marginal value for irrigation services.

Third, the water value attributed to ecological related services is known to be alternatively captured through cost replacement methods and supply side approaches. In that case, the costs required for the remediation of the disturbed ecological services mainly through mechanical interventions should reflect the value of these services (Carson, 2007). However, these methods often underestimate the contribution of ecological services to agriculture and they totally ignore users' (farmers') potential economic contribution for the restoration of these services. To this aim, a demand side approach was selected based on the WTP inference to reveal the actual farmer's condescension in the preservation of ecological services.

The study findings present an exclusive almost dependence of marginal farmers to water purchasing which mostly derives from groundwater pumping. Still however, the bulk of irrigation investments in Bihar state are spent on canal irrigation for sufficient production but also for ensuring livelihood security to subsistence farmers. According to Central Water Commission of India (2008), 118m US$ were invested on average per annum for the years 1995-2003 in irrigation projects to Bihar state. The vast majority of the investments are driven towards large and medium canal irrigation projects.

Currently, the extremely low investing returns (0.19%) of the irrigation expenditures in Bihar do not justify the invested amounts. All the more, the recovery indicator accounts only for working expenses since the capital outlay is acknowledged to prevalently promote infrastructural purposes.

In case a redesigned pricing policy would be planned towards more efficient canal irrigation, then the weakest farming group to potentially benefit from a change should be considered. A potential scenario with the data findings of the four disadvantaged districts could be elaborated. In case large farmers would be requested to pay higher charges for revenues improvement and transfer payment to marginal farmers, low effects are anticipated to occur. The negligible proportion of large landholders (8.33%) that is currently supplied from canal irrigation would possibly decrease in the hearing of higher canal charges. Additionally, the benefits to marginal farmers from heavier subsidization by transfer payments would be also rather low. Bearing in mind that currently only 13.64% of marginal farmers use canal irrigation through a nominal pricing policy it is questionable whether an even free of charge supply scheme would be more attractive.

In the case of ecological services, the median WTP findings reaffirm the theoretical background about the proportional increase of WTP in respect to welfare status (Bennet and Birol, 2010). However, when estimating marginal WTP per cubic meter, it seems that results are partly in discrepancy with theory. Marginal farmers appear to offer twofold WTP bids from small and medium farmers by also taking the lead from large landholders.It is still questionable though whether the agreeable stance stems from their awareness on environmental issues or the conceiving of the proposed assumptions as mere hypothetical scenarios.

Conclusions

The highly unequal land distribution depicts a de facto difficulty of marginal farmers to implement large-scale irrigation systems and reduce water costs. The comprehensive description taken in our study on the allocation of water charges in regard to source types, reaffirms the heavy burden undertaken by marginal farmers. The water pumping charges which initially seem to designate large farmers as the evident water value undertakers are completely offset by the higher water trading charges attributed to marginal farmers. This cost shifting portrays marginal farmers to get aggravated with the highest charges for irrigation services. The situation seems unlikely to reverse since marginal landholders can hardly receive financial aid for groundwater facilities under the current irrigation policy.

The highest water value signaled to marginal farmers is further confirmed through their leading contribution inferred by the apportionment of WTP with the estimated water consumptive trends (CWU). However, this experimental distribution should be validated through similar research findings. Overall, the affirmative stance of all the landholding groups indicates that a potential inclusion of environmental charges would not meet stiff resistance from users.

The structural deficiencies of the current irrigation policy seem to be blamed for the actual manifold water value corresponding to each landholding group and the disproportionate effects to marginal farmers. Specifically, the poor maintenance of canal networks highly discourage most of the farmers to make use of canal irrigation. The reorientation from canal to groundwater irrigation projects with subsidization of marginal farmers could reverse the current trends and lead to efficient pathways (Shah et al, 2009). However, the subsidization of groundwater project would not avail alone, unless some also complementary measures would be adopted. A promising initiative could be the replacement of hydrophilic staple crops with more water resistance cropping patterns. Recent introduction of diversified cropping patterns in the examined districts gives an insight of alternative successful cultivation with high economic potential (Amarasinghe et al, 2007b). The level of reformulation and the synergies emerged from a simultaneous change are subject to an in depth research and out of the scope of the paper. However, the supervision of underground irrigation systems through institutional settings and regulatory mechanisms are anticipated to be essential organizational components (Shah, 2008).

The appropriateness of the analysis to real case situations was tested and appraised in representative backward clusters of Bihar state in Eastern India. The generalization of the research findings to other Indian or South Asian resembling cases could probably lead to misleading assumptions. However, the cautious transfer of the suggested valuation approach in similar cases met in South Asia could aid towards a more efficient and equitable irrigation policy.

Acknowledgements

The research was undertaken through the project *''Sustainable Livelihood Improvement through Need Based Integrated Farming System Models in Disadvantaged Districts of Bihar''* funded by the Indian government and the *"Basin focal project of the Indo-Gangetic basin"* funded by the Challenge Program for Water and Food.

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Appendix 1. WTP Questions for Environmental Services

<table>
<tr><td colspan="4">1 Nowadays, there is no cost for the water as a good but only for pumping and distribution services. If the government would ask for a charge in order to preserve <u>the environmental services provided by freshwater, like preservation of moisture, microclimate, avoidance of salinity</u> etc. would you be willing to financially contribute for its preservation?</td></tr>
<tr><td>Yes (<u>Go to Q.1.1)</u></td><td>Depends on the amount asked(<u>Go to Q.1.1)</u></td><td>No <u>(see below)</u></td><td></td></tr>
<tr><td colspan="4">IF ''NO'' Why : I am opposed to such economic approaches =1, I do not trust the payment authority =2, I do not have enough money to pay =3, I believe that it is not me to pay for these services =4</td></tr>
<tr><td colspan="2">IF ''YES'' 1.1 What is the maximum amount you could <u>contribute per year?</u> (Mention to the farmer that the amount is per year only)</td><td colspan="2">Maximum amount Rs/ Year
________________</td></tr>
</table>

Appendix 2. Criteria for the selection of a representative clusters Bihar state

<table>
<tr><th>Agro-ecological sub-region (iternation al indexes)</th><th>Soil type (international indexes)</th><th>Agricultural water patterns</th><th>Cultivation seasons</th><th>Environmental characteristics</th></tr>
<tr><td rowspan="4"></td><td rowspan="4"></td><td>Tube well</td><td rowspan="2">Kharif (rainy)</td><td>Near to river</td></tr>
<tr><td>Bore well</td><td>Near to spring</td></tr>
<tr><td>Canal</td><td rowspan="2">Rabi (winter)</td><td>Near to forest</td></tr>
<tr><td>Pond/tank</td><td>Water congested area</td></tr>
</table>

<u>*Notes:*</u> *Kharif season: May to October; Rabi season: November to April*

<u>Paper 3</u>

Assessing institutional and environmental parameters of agricultural water use in South Asia: Evidences from the Indo-Gangetic Basin

Stefanos Xenarios [a], Bharat Sharma [b]

[a] International Water Management Institute, East Africa& Nile Basin Office
Addis Ababa, Ethiopia
[b] International Water Management Institute, New Delhi office, India

Abstract

The Indo-Gangetic Basin encompasses most of the fertile landholdings in South Asia. However, low agricultural productivity is observed in the four riparian countries - India, Pakistan, Nepal and Bangladesh - by nailing down rural welfare. Accusations are directed at the inability of water supply sector to ensure high productivity rates and security of subsistence farmers. However, little is known about the demand side and farmers' perceptions towards the effects of water use on agricultural productivity. To this aim, we conduct an economic assessment through a stated preference approach on crucial institutional and environmental related parameters of agricultural water that could enhance productivity potential. Also, vital socio-demographic elements are examined as influential factors. The analysis is based on an extensive research survey accomplished in selected clusters along the Indo-Gangetic Basin.

Keywords: South Asia, Indo-Gangetic Basin, agricultural water, stated preference, economic assessment

1. Introduction

The Indo-Gangetic Basin (IGB) drains the southern Himalayan and Hindu Kush "water tower" of Asia and provides the economic base for agriculture, forestry, fisheries, livestock, and urban and industrial water requirements for about a billion people (Sharma et al, 2010). Rich alluvial soils and abundant surface and groundwater sources suggest a high agricultural potential in the four riparian countries of Pakistan, India, Nepal and Bangladesh. However, productivity in large parts of the IGB is relatively low while the rural poverty is distinctively high (Amarasinghe et al, 2007a).

Inefficient water management has been highlighted as a major cause of low yields and revenues in the IGB (Diao et al, 2003; Hellegers et al, 2006; Cai and Sharma, 2010). Supply-side technical and economic solutions such as the revitalization of existing projects, introduction of new large-scale irrigation dams and low recovery cost schemes try to reverse conditions of inefficient water use (Jain et al, 2007; Mukherji et al., 2009). However, a recent shift from supply-side solutions to demand-side management is underway. The rapid expansion of private groundwater pumping and informal water trading mainly in Indian regions portrays a new era to agricultural water in IGB area. Farmers justify the rapid growth of private initiatives on the inability of the state supply projects to efficiently cover the augmented water needs (Asian Development Bank, 2007).

The expansion of groundwater pumping in high permeable alluvium derived soils which are usually met in IGB area has induced water pollution from agrochemical residues and geogenic contamination with arsenic. Also, over-pumping practices have diminished groundwater reserves by provoking erosion effects (Rodell et al; 2009; CPWF, 2010). The close linkage between groundwater and surface water sources progressively induces an overall degradation of the water status in IGB. A quantitative and qualitative deterioration has mostly affected the ecological services associated with the water cycle. Water scarcity in the dry season, high soil salinity, and erosion in several downstream areas are the most indicative problems related with the disturbance of ecological services (Chakraborti et al.; 2004; Sharma and Cai, 2009). The significance of ecological services is acknowledged amongst scientific community but was unknown to the farming community in the IGB until recently. However, water deterioration has given profound insights to farmers about the vital role of ecological services by triggering the need for preservation initiatives (Ambastha et al, 2007).

The absence of an appropriate institutional setting for private water initiatives and the still unclear- for farmers- linkage of water with ecological services set forth new dimensions stemming from the demand side. Noteworthy attempts have been mainly focused on the assessment of water demand in the IGB through water pricing and agricultural growth proxies (Ranganathan and Palanisami, 2004; Kumar, 2005; Shah et al 2006, 2009; Singh, 2007; Kakumanu and Bauer, 2008). The effects of economic instruments on water demand and the impact on agricultural productivity in the IGB is another approach that has been also explored (Hellegers et al, 2006; Narain, 2008). It is generally observed that high attention is given to the identification of the optimal water pricing which could best enhance agricultural growth. However, there are still poor evidences about users' preferences on institutional and environmental key attributes that significantly affect water status and agricultural growth in IGB area.

This paper attempts to elicit through a stated preference approach vital institutional and environmental related attributes of agricultural water. The research data is extracted from the survey analysis of selected clusters[1] of the four riparian countries of Pakistan, India, Nepal and Bangladesh. In Section 2, the methodological context of the study is explained while in Section 3, a brief description of the sampling areas is presented. In Section 4, the economic assessment of institutional and environmental related parameters is conducted while the relationship with key socio-demographic elements is exhibited. Section 5 discusses the research findings while the conclusions of the study are presented.

2. Methodological Context

The research initially attempts to infer economic implications in major institutional and environmental water related parameters through a demand side analysis. The environmental and institutional parameters to be assessed are identified by the relevant literature review and experts' opinion who participated in the research projects under which this study was conducted (Fan et al, 2000; Sabau and Haghiri, 2008; Sharma et al, 2010).

The major institutional services are discerned in the establishment of groundwater market, the revitalization/introduction of common tube well systems and the discontinuation of water provision from private tube wells. Accordingly, the environmental services are directly and indirectly identified. Directly, crucial supportive services such as microclimate stabilization, infiltration of groundwater reserves and erosion protection are underlined. Discontinuation of water-intensive crops/ varieties and the control of agricultural residuals are investigated as indirect environmental attributes.

The assessment of all the institutional and environmental parameters is realised through a stated preference approach. The stated together with the revealed preference approach constitute the core methodological tools for the elicitation of individuals' perceptions (Pearce, 1993; Hanley and Louviere, 2009). An initial

[1] Cluster is considered to be a compound of small settlements which may be formed as villages or sparse inhabitants' areas.

distinction between stated and revealed preferences would enlighten the differentiation between the two and the reasoning behind our selection.

The assessment of predefined perceptions - expressed by the revealed preference approach - is conducted through surrogate or proxy markets (Pearce and Ozdemiroglu, 2002). For instance, we may assume the development of a large reservoir for irrigation purposes which is about to create a new artificial lake in IGB area. The funding organisation may desire to estimate the economic benefits from future fishing activities through a feasibility assessment. The revenues from fishing activities can be captured from already existent prices of similar goods in the nearby markets. Then, the relevant benefits could be accounted through some necessary adjustments for the enclosure of local peculiarities. However, such an assumption presupposes that the inhabitants will be willing to fish in the lake by setting aside their current professional activities. In other words, it is required that their preferences towards fishing instead of farming which mainly occurs in rural areas of IGB, are taken for granted. This means, that farmers' preferences are conceived as *predetermined* which should be revealed from the developers for the estimation of the relevant benefits.

In another case however, the developers may desire to know the preferences of local farmers before estimating the potential benefits from fishing. In other words, they desire to create a hypothetical case for a fishing market where the benefits will depend on farmer's preferences. This approach is known as *stated preference approach* where the assessment is conducted through a hypothetical or constructed market mainly based on survey analysis (Alpizar et al, 2001, DTLR, 2002). In our case, the difficulty to define surrogate markets for institutional and environmental related services in IGB obstructed the implementation of the revealed preference technique. Further, the biases emanating from stereotype presumptions about the inferiority of institutional water-related interventions and environmental services strengthened our inclination to stated preferences.

The implementation of stated preference for the economic assessment of water and environmental related parameters is conducted through the Willingness to Pay (WTP) and Willingness to Accept (WTA) techniques. Both techniques are based on hypothetical payment scenarios, which try capturing people's desirability to pay (WTP) or get compensated (WTA) for specific aspects or the entirety of goods and services (Carson et al, 1995). The application of WTP and WTA in our study is conducted through questionnaire forms and open-ended questions in representative clusters of Pakistan, India, Nepal and Bangladesh. The open-ended question is preferred towards a multiple choices setting due to the potential biases emerging from the adoption of predetermined bids. It is acknowledged that similar biases may occur in open-ending questions when unrealistically high or low bids appear (Cameron and Quiggin, 1994; NOOA, 1995). To this aim, an extensive introduction on the concept of economic assessment was offered to respondents by trained local researchers. Further, the outliers were excluded from the sample as a potential distortion of the final outcome (Garrod and Willis, 1999).

The consultation of the relevant literature review, experts' opinion and the conducting of field visits in the examined areas contributed to the designing of the following WTP and WTA questions (Table 1):

Table 1. WTP and WTA assessment framework

Examined Parameters	Area	Approach	Inference
Establishment of groundwater market	India-Pakistan-Nepal	Stated Preference-Questionnaire Form	WTP
Preservation of environmental services			
Revitalization/introduction of common tube well systems	India-Nepal		
Discontinuation of private tube well use for the preservation of common sources			WTA
Replacing high water-consuming crops	Nepal-Pakistan		
Managing agricultural residues			
Pausing fishing activities for protective purposes	Bangladesh		
Discontinue water consumptive rice			

The respondents who refused to participate in the economic assessment were also explored for the identification of potential methodological inconsistencies. It is almost evident that the potential negation of respondents is followed with zero or extremely high bids (Bateman et al, 2002). However, it is unclear whether the negation pertains to the economic situation of the arguer or low confidence of the methodology *per se*. In case the method is encountered as inappropriate, the negations are perceived as protest bids. If the economic situation is the causal factor for arguers' response, then a negation is apprehended as zero bid with no actual impacts on the theoretical grounds of the method. To this end, the presence of protest bids is investigated in our study through a set of negation options (Table 2) as below:

Table 2. Protest and zero WTP/WTA bid options

Options	Technique	Inference
Opposed to such economic approaches	WTP/WTA	Protest bid
No trust in the payment authority	WTP/WTA	
It is not me who should pay for these services	WTP	Zero bid
Not enough money to pay	WTP	
No revitalisation of the common tube well effectively	WTP	
I do not believe they will compensate me effectively	WTA	
Do not know how much to ask for	WTA	
Prefer to use my own tube well	WTA	

In case of positive stance towards the economic assessment, the relevance of the responses with agricultural revenues[2] and basic socio-demographic elements are explored. We employ Univariate General Liner Model (UGLM) as a tool which can implement both regression and analysis of variance (ANOVA) approach. With UGLM the analyst may use simultaneously fixed factors, random factors and covariates as predictors. The dependents should be numeric while the independents may be categorical factors (including both numeric and string types) or quantitative covariates. The variance analysis uncovers the main and interaction effects of categorical independent variables (factors) on an interval dependent variable. Further, the inclusion of covariate as predictor allows the model to test main and interaction effects of the factors by controlling for the effects of selected other continuous variables which covary with the dependent. The data should be originated from a random sample for purposes of significance testing (Garson, 2010). In our case, the MGLM fitted to our objectives because we were allowed to explore the effects of socio-demographics as categorical fixed factors and the revenues as interval co-variable in the same model.

For the operational aspects of UGLM we consider y_1, y_2, . . . y_n to denote n independent observations on a response. We treat y_i, as a realization of a random variable Y_i. In the general linear model, we assume that Y_i has a normal distribution with mean μ_i and variance σ^2 as shown below:

$$Y_i \sim N(\mu_i, \sigma^2)\text{.......(1)}$$

We further assume that the expected value μ_i is a linear function of p predictors that take values $x'_i = (x_{i1}, x_{i2} \ldots, x_{ip})$ for the i-th case, so that $\mu_i = x'_i\beta$, where β is a vector of unknown parameters (Burridge and Sebastiani, 1992).

[2] It should be mentioned that the revenues derived from agricultural activities are to be identified with the agricultural income since the sampling were exclusively farming communities

Due to the high right skewing in most of the WTP and WTA bids a normalisation of the values has occurred into natural logarithms. However, the very small bids would result in negative numbers along the logarithmic conversion. For that reason, a constant was added for the conversion in positive values as below (Osborne, 2002):

$$X : X' = Ln(X + C) \ldots\ldots.(2)$$

The right skewing of agricultural revenues which is used as a predictor in our model was also treated through the transformation in logarithmic values. The conversion in logarithmic scale (base 10) instead of natural logarithm is justified by the theoretical assumptions of the stated preferences assessment (Bateman et al, 2002). In effect, the income which is identified with agricultural revenues in our case, acts as a predictor for the estimation of WTA/WTP bids to be offered for the examined services. The WTA and WTP bids in turn should reflect the utility derived by the assessment of these examined services. The utility can be directly identified through a bids function model or alternatively through the insertion of proxies and normalisation processes (Hanemann, 1994; Fisher, 1996). In our case, the bids function model was chosen due to the relative straightforward assumptions. However, the higher the income, the less the utility to be derived from bids due to the marginal declining utility levels (Bateman et al, 2002). For that reason, a logarithmic transformation of income should better reflect the assessment process as presented below:

$$B_{WTP,\,WTA} = a + bLogY_{ij} \ldots\ldots.(3)$$

where:

$B_{WTP,\,WTA}$ = Bid for WTA and WTP in the related questions

Y_{ij} = Income (revenues) for i-th cases and j-th respondents

a = constant

b = marginal impact on income (revenues)

The socio-demographics to be inserted in UGLM analysis should be converted into ordinal and nominal factors as dictated by the model. Namely, the household, the age and education socio-demographic components were transformed to dummy categorical variable (Table 3) as below:

Table 3. Socio-demographic characteristics of the respondents

Classification	Age (year)	Household Size (no.)	Education level
1	>25	>4	Postgraduate
2	25-34	4-6	Graduate
3	35-44	7-10	Secondary School
4	45-54	11-14	Primary School
5	55+	15+	Madrasah (only for Pakistan)
6	--------	---------	Not Schooled

The significance of the socio-demographic factors and the revenues covariate towards the economic assessment are then examined on a national scale. However, a comparative cross-national analysis between the offered (WTP) and accepted (WTA) bids is also conducted for the identification of well established models. Further, a more detailed analysis on the significance of each category of the factors is undertaken for the understanding of its contribution to the model.

The study does not consider the occurrence of unpredicted external conditions (i.e., natural disasters, price squeezing because of rapid trade liberalisation, etc.) as being influential to the findings. Although external factors are indirectly considered through the error term in the analysis, however, there is not an explicit reference to the erratic and unpredicted effects of such conditions.

3. Case Study Analysis

The IGB area is featured with a set of contradictory natural and socio-economic elements. The high soil fertility provoked by the abundance of surface water and groundwater delineates the highest crop productivity potential for the countries sharing the basin (Cai and Sharma, 2010). However, the IGB is currently discerned as a hotbed of rural poverty in South Asia (Amarasinghe et al, 2007b). Poverty estimations point out that almost over 40% of the IGB belongs to the Below Poverty Line (BPL) group with people living on less than US$2 per day (Khandker and Haughton, 2010; World Bank Indicators, 2010). The following figure depicts the IBG basin while the main streams and political boundaries of the riparian are mentioned:

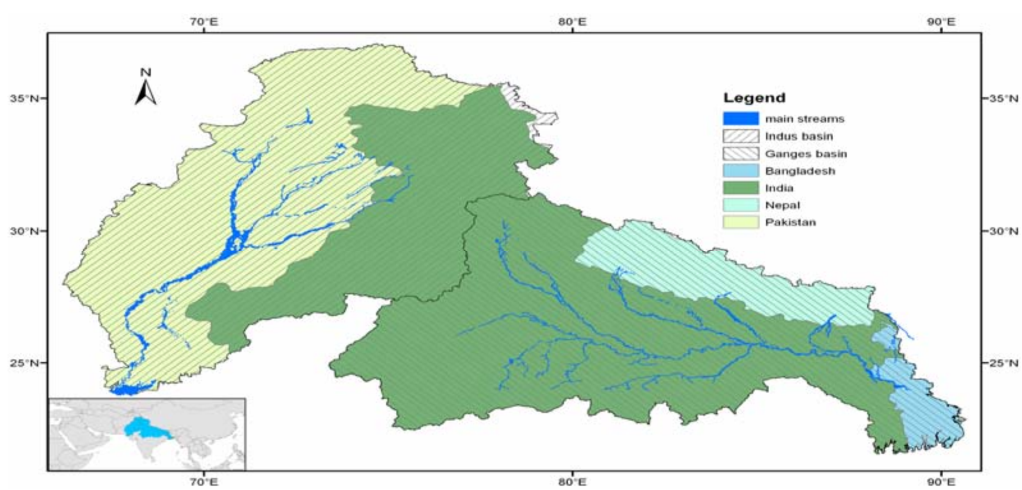

Figure 1. The Indo-Gangetic basin area

The clusters selected from India were situated in the state of Bihar, along the eastern regions of the Ganges Basin. Bihar is enriched with fertile alluvial plains and abundant water resources. However, the region is confronted with low agricultural productivity, extreme poverty and regional disparities (World Bank, 2005; Sharma et al, 2010). With 43% of the population below the poverty line, Bihar presents some of the lowest income rates in South Asia. For the needs of the survey, seven disadvantaged villages from four districts were chosen.

In the case of Pakistan, the examined area is divided through Upper Rechna, Middle Rechna and Lower Rechna catchment area in the Indus Basin. The four districts enclosed in the Rechna subbasin, namely Hafizabad, Sheikhupura, Faisalabad and Toba Tek Singh, were chosen. Two sample villages were adopted on the basis of best geographical dispersion in each district. The farmers were grouped according to their landholding size in eight classes. The number of farmers selected in each class was determined proportionately.

In Nepal, the area of Biratnagar was chosen due to its location in the wider basin of the Ganges River. Biratnagar is positioned in the Koshi subbasin on the southern lowland belt of Nepal, near the south-eastern border with India. Four disadvantaged villages in the two districts of Morang and Munsari were adopted as case studies. Emphasis was given to the difficulties faced in drought conditions by also contemplating the rarity of canal irrigation and pumping devices.

In Bangladesh, the study area was positioned in the Eastern Ganges Basin (EGB) as a sub-sector of the broader IGB where a maximization of water allocations is appraised. The area chosen was based on a rough division between the upper, middle and lower stream of the sub-basin. A sample of three districts and 27 representative clusters was adopted for the collection of water productivity values and drivers on different capture and culture fishery systems. Overall, 1,950 farmers were surveyed from 13 districts and 50 clusters in the entire IGB area.

A random sample of about 30% of the total households was collected from each cluster while all interviews were conducted on-site through qualified local researchers. To achieve high heterogeneity of the sample, a set of environmental, technical and socioeconomic criteria were introduced for the selection. The heterogeneity aspired to attribute a representative geophysical and socioeconomic overview of the surrounding clusters in the IGB area. Emphasis was given to the least developed regions where dependence on agriculture and water supply is more evident. Due to the particular characteristics of each area, the environmental and institutional issues considered in the selection process vary accordingly. The differentiation is distinctive in the case of Bangladesh due to the large dependence on aquaculture and capture fisheries activities. However, the findings inferred from the entire sampling in the four countries attribute a concrete insight into the major water-related issues affecting farming activities.

The selected clusters should overall cover a set of diversified criteria as shown in Table 4.

Table 4. Criteria for the selection of a representative cluster in the IGB area

Criteria for the cases of India, Nepal and Pakistan

Agro-ecological subregion (according to international indices)	Soil type (according to international indices)	Agricultural water patterns	Cultivation seasons	Environmental characteristics
		Tube well	Kharif (rainy)	Near to river
		Bore well	Rabi (winter)	Near to spring
		Rain-fed	Summer	Near to forest
		Canal		Water congested area
		Pond/tank		

Criteria for the case of Bangladesh

Capture fisheries	Culture fisheries	Other fishery systems	Environmental characteristics
River and *Beel*	Cultured	Rice-fish culture	High fish diversity
Beel and Khal	Culturable	Golda culture	Moderate fish diversity
Beel	Derelict	Bagda culture	Low fish diversity
Baor			High vegetation diversity
River			Moderate vegetation diversity
Khal			Low vegetation diversity
Floodplains and/or river/*khal*			

*__Notes:__ **Kharif season**: May to October; **Rabi season**: November to April**; Beel**: Low-lying depression in the floodplain (small lakes); **Khal:** Connecting canals that feed the beels with water in some instances; **Cultured Pond**: Pond where culture of fish is practiced under definite production plan; **Culturable Pond**: Pond usually not under planned aquaculture practice; **Derelict Pond**: Pond or ditches where aquaculture is difficult without possible major renovations; **Bagda culture**: Marine shrimp (Penaeus monodon); **Golda culture**: Freshwater shrimp (Macrobrachium rorenbergii);*

4. Results

4.1. Economic assessments trough WTP and WTA

The stance of respondents towards their agreeability or reluctance to participate in the assessment process is initially delineated. As presented in Figure 2, the highest negation is perceived from Pakistanis to all the relevant cases, with large divergence from the other respondents. On an average, about two-thirds of the Pakistani farmers are reluctant to offer (WTP) or accept (WTA) any payment. The negation is drastically decreased for Indian respondents related to WTP bids whereas it gets minimized when Indians are asked to get reimbursed (WTA) for the discontinuation of private tube wells.

The Nepalese stance seems to be highly differentiated between WTP questions, where the negation is rather low, and WTA ones, where the refusal to participate becomes threefold higher. The Bangladesh respondents generally show the lowest negation levels for the WTA cases in which they are assessed.

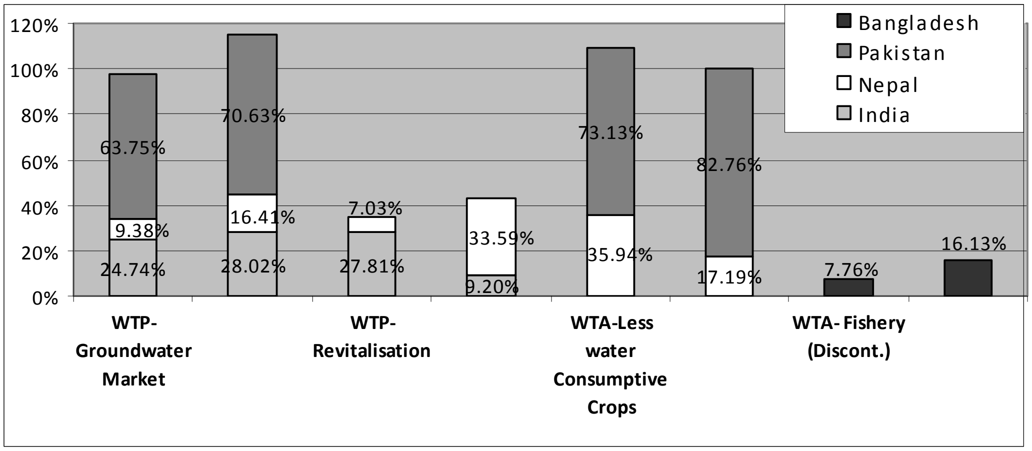

Figure 2. Negative responses in WTP/WTA inferences

In turn, we unravel the negation reasoning through a set of predefined replies for the identification of protest and zero bids (Figure 3). The payment affordability ("Not enough money to pay") comprises the major reason for WTP bids. Accordingly, for WTA bids an equally high amount of respondents is uncertain about the amount to request for compensation (''Do not know how much to ask for''). The stance of all respondents clarifies their unfamiliarity to economic assessments. However, these responses are not classified as protest bids and do not set in doubt the elicitation approach.

The highest voting for protest bids are distinctively lower than zero ones as indicatively occurs with the suspicion towards the reliability on the compensating authorities or the sufficient compensating amount. Generally, the opposition towards the elicitation approach stands among the lowest ranked options which enhance the credibility of the entire undertaking.

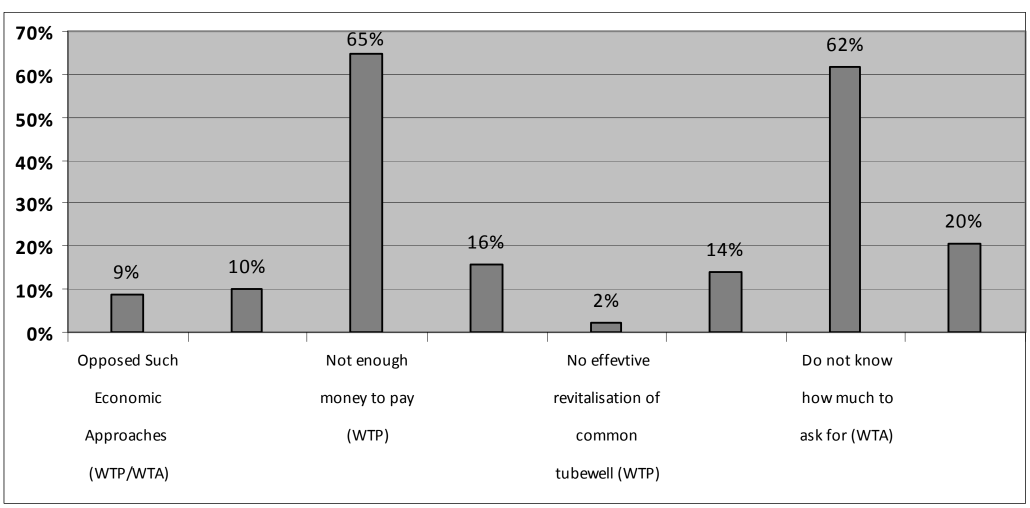

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Figure 3. Reasoning of the negation in WTP/WTA inferences

The assessment of WTP bids for the establishment of a groundwater market and the preservation of environmental services ascribes the highest amount to Pakistani respondents (Table 5). Interesting though is the fact that the majority of Pakistani participants had already expressed the highest opposition towards these two water related parameters. Nevertheless, the remaining respondents are willing to offer a threefold to fourfold higher amount as compared to Indian farmers and distinctively higher from the Nepalese ones.

For the case of WTP in the revitalisation of common tube wells, Nepalese appear distinctively more positive than the Indians by comparatively offering a six-fold amount. This eagerness could be in part justified due to the fact that the sample area in Nepal is largely dependent on shallow common wells except for a few canal irrigated lands. Observations on the central tendency indicators (mean and median) display an almost normal distributed sample. The only exception appears to be on the Nepalese stance towards a groundwater market where some higher bids provoke a right skewing of the distribution.

Table 5. WTP for institutional and environmental related services in the IGB area ($/yr)

Parameter	Groundwater Market			Environmental Services			Revitalization of common well	
	India	Nepal	Pakistan	India	Nepal	Pakistan	India	Nepal
Valid	328	58	50	312	50	48	320	60
Missing	161	69	270	177	77	270	169	67
Mean	7.25	22.21	27.26	6.32	15.97	28.69	6.082	29.05
Median	5.18	16.38	27.33	5.18	16.38	30.22	5.18	29.77
Std. Dev.	1.90	1.58	2.66	1.83	1.46	2.27	1.97	1.6

In case of WTA queries as presented in Table 6, the highest WTA amounts is requested by Bangladesh farmers for the discontinuation of fishing activities and the replacement of water consumptive rice. This is extensively justified due to their absolute dependence on fishing and secondarily rice for self-consumption and market purposes. A discontinuation of these farming practices would result in deprivation of their basic nutritional intake and almost complete loss of their income. An also distinctively high amount is requested by Indian farmers for discontinuing pumping from private tube wells. This is again justified by the large dependency of Indian respondents to groundwater sources and pumping practices in the examined districts.

Much lower WTA amounts are requested by Pakistani clusters. However, in the case of Pakistan, the WTA bids do not question the pausing of the current cultivation and hence their future employment status per se, as is the case in India and Bangladesh. Instead, they are related to the adoption of more environmentally friendly options in cultivation patterns.

Table 6. WTA for Institutional and Environmental related services in IGB area ($/yr)

Parameter	Stop private use		Change high water consumptive crops		Manage agricultural residuals		Reduced/ no fishing	Change rice cultivation
	India	Nepal	Pakistan	Nepal	Pakistan	Nepal	Bangladesh	Bangladesh
Valid	31	27	48	24	35	48	236	154
Missing	458	100	272	103	285	79	1050	1132
Mean	69.37	18.49	22.97	18.83	37.46	17.74	178.97	165.04
Median	112	16.39	27.33	16.39	9.08	16.39	158.98	148.13
Std. Dev.	1.75	1.34	1.98	1.4	6.5	1.28	1.93	2.36

The central indicators reveal a concrete stance of Indian respondents to get reimbursed for the discontinuation of private water sources. The inverse situation occurs in Pakistani clusters for the management of agricultural residues where some high bids steeply raise the mean indicator. Few high bids appear to also give a slight advance to the mean indicator in Bangladesh while the Nepalese sample is almost identically distributed.

4.2. UGLM analysis with explanatory factors

Initially, the case of WTP for the establishment of groundwater market is exhibited. As presented in Table 7 the Indian sample offers a moderate explanation (R^2= 0.205) of the model with household size and revenues to justify this condition. Contradictorily, the bids are poorly explained in the case of Nepalese farmers (R^2= 0.159). In Pakistan, although the model is explained satisfactorily (R^2= 0.345), it is only the educational factor to weakly ascribe this relation.

Table 7. WTP for establishment of groundwater market (India-Nepal- Pakistan)

Source	India				Nepal				Pakistan			
	T. III	df	F	Sig.	T. III.	df	F	Sig.	T. III	df	F	Sig.
Cor.M.	25.92[a]	14	4.960	.000	1.45[a]	10	.641	.769	13.581[a]	11	1.531	.169
Inter.	4.018	1	10.763	.001	7.194	1	31.79	.000	6.328	1	7.847	.009
Educ.	.437	5	.234	.947	.311	3	.457	.714	7.507	3	3.103	.040
Age	3.032	4	2.031	.090	.285	3	.420	.740	3.990	3	1.649	.198
Hsd	12.603	4	8.440	.000	.830	3	1.223	.316	2.521	4	.781	.546
Reven.	6.599	1	17.677	.000	.011	1	.051	.823	1.372	1	.000	.997

Note: Cor. M. = Corrected Model, Inter. = Intercept, Educ= Education, Hsd= Household size, Reven=Revenues, T. III= Type III Sum of Squares (The abbreviations also apply for the tables, 8, 9, 10, 11, 12, 13)

Table 7. About here

The cross-national analysis for the WTP in environmental services is quite alike with groundwater market potential in terms of significance conditions (Table 8). The household and revenues components seem to adequately explain the comparatively lower significance of Indian model (R^2= 0.103) towards to Nepalese (R^2=0.298) and Pakistani (R^2= 0.446) ones. However, again the Nepalese sample acts insignificantly for all variables while the marginal significance attributed by Pakistanis is slightly explained by household factor.

Table 8. WTP for Environmental Services (India-Nepal- Pakistan)

Source	India				Nepal				Pakistan			
	T. III	df	F	Sig.	T. III.	df	F	Sig.	T. III	df	F	Sig.
Cor.M.	10.91[a]	14	2.109	.012	1.609[a]	10	1.103	.396	11.10[a]	11	2.196	.043
Inter.	6.049	1	16.366	.000	6.179	1	42.335	.000	2.250	1	4.893	.035
Educ.	2.028	5	1.098	.362	.345	3	.788	.511	3.272	3	2.371	.090
Age	1.348	4	.912	.457	.551	3	1.259	.309	1.713	3	1.242	.312
Hsd	4.650	4	3.146	.015	.745	3	1.702	.191	4.945	4	2.688	.050
Reven.	2.018	1	5.460	.020	.158	1	1.083	.308	.448	1	.975	.331

In the case of WTP for the revitalization of common wells the responses of both Indian (R^2= 0.076) and Nepalese (R^2= 0.16) farmers seems to be unrelated with the revenues and the socio-demographic elements (Table 9).

Table 9. WTP for the revitalization of common wells

Source	India				Nepal			
	T. III	df	F	Sig.	T. III.	df	F	Sig.
Cor.M.	10.62[a]	14	1.57	.086	1.47[a]	10	.66	.746
Inter.	6.92	1	14.37	.000	9.74	1	44.28	.000
Educ.	3.76	5	1.56	.170	.37	3	.57	.636
Age	2.91	4	1.51	.198	.3	3	.54	.657
Hsd	2.53	4	1.31	.264	.71	3	1.07	.372
Reven.	1.50	1	3.12	.078	.00	1	.01	.918

However, the situation radically changes for the WTA towards the discontinuation of private tube wells where the Indian model appears rather satisfactory (R^2= 0.686). This change seems to be mainly attributed to the educational factor. On the other hand, the model for the Nepalese farmers is exhibited as rather insignificant (R^2= 0.173) and with high irrelevance towards any of the factors (Table 9).

Table 10. WTA for the discontinuation of private tube wells (India-Nepal)

Source	India				Nepal			
	T. III	df	F	Sig.	T. III.	df	F	Sig.
Cor.M.	63.42[a]	11	3.76	.006	.24[a]	9	.302	.961
Inter.	8.04	1	5.25	.033	4.13	1	45.92	.000
Educ.	14.83	3	3.23	.046	.06	3	.228	.875
Age	2.13	3	.46	.710	.10	3	.402	.754
Hsd	9.05	4	1.47	.248	.07	2	.419	.666
Reven.	.02	1	.01	.896	.00	1	.004	.951

The findings of the other examined WTA paired questions are exhibited in Table 11. As presented for the WTA about the replacement of water consumptive crops, there is a moderate relation for the Pakistani sample (R^2=0.353) while the relation becomes highly satisfactory for the Nepalese (R^2=0.908) case. However, when looking through the variables it is well perceived that only the revenues covariate influences the relationship of the model. In the case of WTA for the management of agricultural residuals, a moderate relationship is observed for both the Nepalese (R^2= 0.234) and Pakistani (R^2= 0.451) which is however very poorly explained by all variables. Finally, the WTA bids of Bangladeshi for stopping fishing activities seems irrelevant towards all variables with a very weak relationship status (R^2= 0.039). The situation is moderately altered in the case of rice replacement (R^2= 0.152) where the revenues comprise the only highly influential factor.

Table 11. WTA related paired questions

WTA for the replacement of water consumptive crops (India-Nepal)								
Source	**Nepal**				**Pakistan**			
	T. III	df	F	Sig.	T. III.	df	F	Sig.
Cor.M.	.660[a]	10	4.955	.046	6.368[a]	11	1.539	.168
Inter.	3.928	1	294.75	.000	1.149	1	3.054	.090
Educ.	.063	3	1.588	.303	2.235	3	1.981	.137
Age	.172	3	4.309	.075	.995	3	.882	.461
Hsd	.077	3	1.930	.243	1.966	4	1.307	.289
Reven.	.403	1	30.239	.003	1.701	1	4.522	.042
WTA for the management of agricultural residuals (Nepal- Pakistan)								
Source	**Nepal**				**Pakistan**			
	T. III	df	F	Sig.	T. III.	df	F	Sig.
Cor.M.	.540[a]	9	.950	.500	45.896[a]	12	1.096	.423
Inter.	6.660	1	105.35	.000	4.349	1	1.246	.281
Educ.	.250	3	1.316	.289	9.509	4	.681	.615
Age	.321	3	1.690	.192	13.588	3	1.298	.309
Hsd	.062	2	.494	.615	14.079	4	1.009	.432

Reven.	.015	1	.239	.629	1.276	1	.366	.554
WTA for pausing fishing and replacing water consumptive rice (Bangladesh)								
Source	**Bangladesh-Fish**				**Bangladesh-Rice**			
	Typ.III S.Sq.	df	F	Sig.	Typ.III S. Sq.	df	F	Sig.
Cor.M.	3.960[a]	12	.750	.701	17.207[a]	12	2.110	.020
Inter.	65.325	1	148.47	.000	5.032	1	7.404	.007
Educ.	.369	3	.280	.840	5.137	3	2.519	.061
Age	2.467	4	1.402	.234	.887	4	.326	.860
Hsd	1.184	4	.673	.611	3.144	4	1.156	.333
Reven.	.587	1	1.334	.249	7.221	1	10.624	.001

Overall, the model for Indian respondents seems to act distinctively better than the others by explaining the three out of four WTP and WTA bids. Also, the revenues, the household size and the educational factor constitute the major influential parameters. The Bangladeshi sample then follows with an explanation in one out of two cases while the revenues constitute the only influential factor in the relations. It should be mentioned however, that the few cases assessed in Bangladesh cannot offer a clear insight about the significance of the selected variables in other potential cases. The Nepalese are getting behind with an explanation of two out of six models while alike to Bangladeshi, revenues is the only explanatory factor. The last ranking is rendered to Pakistani sample with one out of four satisfactory relations and the educational factor to consist of a moderate factor.

Also, there are not noticeable differentiations in the significance relations of the models among WTA and WTP responses. It is equally five insignificant against three significant relations for both WTP and WTA bids. This condition indicates the indifferent almost role of socio-demographic components and revenues between WTA and WTP bids for the institutional and environmental related parameters.

Further, a more detailed analysis on the categories of each socio-demographic factor is conducted according to the classification presented in Table 3. A concise description of the results is delineated here, while the detailed findings are displayed in Appendixes 1 and 2. A significance of prevalently very small (<4) and secondarily small (4-6) and medium (7-10) households is revealed while also the mature age groups (45-54) are influential for the Indian cases. Accordingly, the young (25-34) and medium aged (35-44) farmers affect in some cases the Nepalese sample. For the case of Pakistani and Bangladeshi samples there is hardly any category to act significantly in the examined models.

4. Discussion and Concluding Remarks

The economic assessment of institutional and environmental related parameters which affect the water demand side and agricultural productivity in the IGB area followed the main assumptions of the stated preference approach. It is acknowledged, however, that for the analysis of WTA and WTP bids, logarithmic related models and logistic regressions are usually applied. Indicatively, linear, logit and probit models predict the expected WTP and WTA frequencies, address the relative importance of economic coefficients and test the validity through a goodness of fit test (the likelihood ratio) (Garson, 2010). The case of logistic regression follows a similar conceptual pattern although the impact is usually explained in terms of odds ratios. These techniques could better explain dichotomous and payment-ladder queries which are often introduced for the elicitation of bids (Bateman et al, 2002; Bennet and Birol, 2010).

In our study however, an open-ending query was applied instead which cannot be explained through probabilistic analysis as is the case in the aforementioned techniques (Fisher 1996, Bateman et al, 2002). The study attempted to figure out the behavioral stance of farmers in the IGB towards a wide range of environmental and institutional parameters coupled with revenues and socio-demographic elements.

If looking through the application area, the study covered a very extensive territory demarcated by the IGB. It is inevitable that a plethora of other water source types, cropping and fishing patterns could be identified elsewhere in each country and between them. To this end, the introduction of diversified criteria as presented in Table 4, aimed at the selection of representative samples from agriculturally dependent regions with low economic welfare. It is acknowledged though that the capturing of all the water use and agricultural types in the IGB area could not be attained within this study.

The findings denote the positive stance of respondents in the assessment of crucial water-related services that could possibly enhance agricultural productivity. The negative responses seem to be related to high poverty levels and the unawareness of the respondents towards economic assessments. However, the approval of the stated preference approach with WTP and WTA inferences is indicated through the low attendance given to protest bids.

The explanatory analysis of the proposed bids through the UGLM technique revealed some substantial hints in country-wise and parameter-oriented contexts. It also appears that the differentiation between WTA and WTP query types does not remarkably affect the models' fit. Instead, it seems to be the country origin that better determines models' significance and cohesion between the predictors and dependent variables.

The outcome of our research indicates the high willingness of farmers to factually enhance agricultural productivity through the set up of water-related institutional and environmental services. To this end, an enclosure of the examined parameters and socio-demographic features in a reoriented irrigation policy could possibly improve water use and agricultural produce of agrarian regions in IGB area.

Acknowledgements

The research was undertaken through the project *''Sustainable Livelihood Improvement through Need Based Integrated Farming System Models in Disadvantaged Districts of Bihar''* funded by the Indian Government, and the *"Basin Focal Project of the Indo-Gangetic Basin"* funded by the CGIAR Challenge Program on Water and Food (CPWF).

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Appendix 1. Detailed analysis of components in socio-demographic factors for WTP related questions

Cases	WTP Groundwater Market						WTP Environmental Services						WTP Revitalize common wells			
Countries	**India**		**Nepal**		**Pakistan**		**India**		**Nepal**		**Pakistan**		**India**		**Nepal**	
Parametr.	t	Sig.	t	Sig.	t	Sig.	t	Sig.	t	Sig.	t	Sig.	t	Sig.	t	Sig.
Intercept	4.717	.000	4.080	.000	2.171	.037	4.717	.000	4.080	.000	2.171	.037	4.701	.000	4.675	.000
[Educ=.0]	-.345	.731		.996			-.345	.731		.996			-.389	.698		
[Educ=1.0]	.512	.609		.279			.512	.609		.279			1.520	.130		
[Educ=2.0]	-.583	.560	-.004	.418			-.583	.560	-.004	.418			-.333	.740	.069	.945
[Educ=3.0]	.415	.678	-1.10	.	-2.01	.052	.415	.678	-1.10	.	-2.01	.052	-.215	.830	-1.15	.258
[Educ=4.0]	.299	.766	-.820		-1.31	.197	.299	.766	-.820		-1.31	.197	1.863	.064	-.145	.886
[Educ=5.0]	.	.	.		-.449	.656	.	.	.		-.449	.656	.	.	.	.
[Educ=6.0]						.						.	-.489	.625		
[Age=1]	-.327	.744					-.327	.744					1.470	.143		
[Age=2]	1.422	.156	.866	.392	1.962	.058	1.422	.156	.866	.392	1.962	.058	-.011	.992	.494	.625
[Age=3]	.043	.966	.219	.828	.995	.327	.043	.966	.219	.828	.995	.327	1.980	.049	.690	.495
[Age=4]	2.498	.013	-.043	.966	.152	.880	2.498	.013	-.043	.966	.152	.880	.	.	-.283	.779
[Age=5]	.	.	.	.	.	.	.	.	.	.	.	.	-1.576	.116	.	.
[Hsd=1]	-3.605	.000	-.170	.866	1.151	.258	-3.605	.000	-.170	.866	1.151	.258	-2.176	.030	.267	.791

[Hsd=2]	-4.943	.000	1.429	.162	1.650	.109	-4.943	.000	1.429	.162	1.650	.109	-1.799	.073	1.588	.121
[Hsd=3]	-3.887	.000	1.112	.274	.974	.337	-3.887	.000	1.112	.274	.974	.337	-1.381	.168	1.313	.198
[Hsd=4]	-.913	.362	.	.	.844	.405	-.913	.362	.	.	.844	.405	.	.		.
[Hsd5]	.	.			.	.	.	.			.	.	1.768	.078		

Appendix 2. Detailed analysis of components in socio-demographic factors for WTA related questions

Cases	**WTA No private Wells**				**WTA Consumptive Crops**				**WTA Agricultural Residuals**				**WTA Fishing**		**WTA Rice**	
Countries	**India**		**Nepal**		Nepal		Pakistan		Nepal		Pakistan		Bangladesh		Bangladesh	
Parametr.	t	Sig.	t	Sig.	t	Sig.	t	Sig.	t	Sig.	t	Sig.	t	Sig.	t	Sig.
Intercept	2.645	.016	6.441	.000	13.202	.000	1.145	.261	10.345	.000	.656	.521	10.999	.000	2.837	.005
[Educ=.0]	1.046	.309														
[Educ=1.0]																
[Educ=2.0]			-.341	.739	-1.463	.203			.080	.937	.288	.777	.340	.734	-.037	.970
[Educ=3.0]	1.162	.260	.294	.774	-1.560	.180	-1.375	.179	-1.857	.074	-1.31	.207	.886	.376	1.027	.306
[Educ=4.0]	-1.28	.224	-.505	.622	-1.843	.125	-1.223	.231	-.595	.557	-.646	.528	.540	.590	2.724	.007
[Educ=5.0]	.	.	.	.	.	.	-.101	.920	.	.	-.674	.510	.	.	.	.
[Educ=6.0]							.	.			.	.				

[Age=1]													1.785	.076	-.671	.697
[Age=2]	-.771	.450	-.160	.876	2.828	.037	1.301	.203	.685	.499	1.028	.319	1.727	.086	-.305	.611
[Age=3]	-.071	.944	.087	.932	3.200	.024	.705	.486	-.194	.848	1.795	.091	.904	.367	-.326	.469
[Age=4]	.356	.726	-.707	.492	.629	.557	-.249	.805	-1.383	.178	1.486	.157	.311	.756	-.483	.339
[Age=5]	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
[Hsd=1]	-1.617	.122	.120	.906	-2.115	.088	1.616	.116	-.866	.394	.327	.748	-.919	.359	-1.562	.146
[Hsd=2]	-1.71	.102	.853	.409	-1.858	.122	1.978	.057	.211	.834	.710	.488	-1.176	.241	-1.094	.247
[Hsd=3]	-.043	.966	.	.	-1.096	.323	1.218	.233	.	.	1.039	.314	-.428	.669	-1.216	.059
[Hsd=4]	-1.13	.271			.	.	.740	.465			-.678	.507	.066	.947	-1.053	.351
[Hsd5]	.	.					.	.			.	.	.	.	.	.

Paper 4

Environmental services and agricultural water in South Asia: Evidence from Indo-Gangetic basin

Stefanos Xenarios[a], Bharat Sharma[b] and Atul Singh[c]

[a]International Water Management Institute, East Africa& Nile Basin Office
Addis Ababa, Ethiopia,
[b]International Water Management Institute, New Delhi office, India
[a] ICAR Research Complex for Eastern Region, Patna (Bihar), India

Abstract

The environmental services related with agricultural water are increasingly acknowledged as a critical factor for farming development in South Asia. However, little attention is given to the demand side linked with the preservation of these services. To this aim, we conduct a stated preference approach for the elicitation of farmers' preferences towards the economic value rendered to environmental services related with agricultural water. The research is based on an extensive survey in selected clusters of India, Pakistan and Nepal. The case studies are situated along Indo-Gangetic basin due to more evidential linkages between environmental services and irrigation. The findings depict a highly agreeable stance of Indian and Nepalese farmers for the contribution to environmental services while the majority of Pakistani are opposed to such a contribution. However, they almost all agree on the type of the assessment approach while the agreeable Pakistanis offer the highest contributions. The association of the economic assessment with key wealth indicators and socio-demographic elements depicts the high significance of household size.

Keywords : Environmental services, agricultural water, stated preference, South Asia, Indo-Gangetic basin

Introduction

Agricultural water use in Indo-Gangetic Basin (IGB) area is a major determinant of farm productivity and rural welfare for the inhabiting agrarian communities (Erenstein and Thorpe, 2010). The recent rapid expansion of groundwater exploitation in IGB has resulted in a considerable agricultural growth (Amarasinghe et al, 2007). However, pumping in permeable alluvium derived soils which are usually met in IGB area has induced water pollution from agrochemical residuals. Also, over pumping practices have diminished groundwater reserves especially in intensive irrigated areas situated at northwest of IGB (CPWF, 2010). The close linkage of groundwater with surface water sources has resulted in an overall degradation of water status (Jain et al, 2007).

A quantitative and qualitative deterioration has mostly affected the ecological services associated with water cycle. Water scarcity in dry season, high soil salinity and soil erosion are the most indicative problems emanating from the disturbance of supported ecological services (Sharma and Xueliang, 2009). The significance of supported ecological services is widely acknowledged in scientific community but was until recently unknown to farming community in IGB areas. However, the deterioration of water quality and quantity has given profound insights to farmers about the vital role of ecological services by triggering the need for preservation initiatives (Ambastha et al, 2007).

To this aim, the paper attempts to elicit through a stated preference approach, the economic value of vital environmental services related with agricultural water. In Section 2, the general concept of economic valuation is presented while an overview of the selected case study is exhibited. In Section 3, the methodology of the study is delineated by initiating with the implementation of the Willingness to Pay (WTP) inference. The opposition or approval of respondents to participate in the economic assessment is also captured on a country wise-basis. We further deploy the differentiations of WTP bids between countries while main central tendency indicators are discussed. Finally, we employ wealth indicators and socio-demographic elements for the comprehension of farmers' stance towards the economic assessment. In Section 4, the results of the case study are displayed while in Section 5 the discussion and the concluding remarks are placed.

2. Material and Methods

The necessity of valuating services related to an environmental entity like water is not always perceived as a desirable action. Numerous ethical dilemmas are raised on the premise that human beings are not capable of valuing ecological assets of which they are part of (Heal, 2002). However, the water valuation concept is not based on the assessment of the ecological entity *per se*. The entity's valuation is perceived through the intrinsic/inherent values acknowledged in an ecosystem and remains a black box in valuation analysis (Brouwer et al, 1997). It is the instrumental value that is attributed to the environmental goods and services (Pearce and Ozdemiroglu, 2002). To this aim, the division between direct, indirect and non-use values has been developed through a wide range of valuation frameworks (Haab and McConnell, 2002; World Bank, 2005; EVRI, 2010). A representative example of economic valuation framework is depicted in Pearce (1993) as below:

Total economic value (TEV) = Use Values (Direct Use Value + Indirect Use Value) + Non Use Values (Option Values+ Existence Value)

The Direct use values represent the environmental services that are apparently linked with market commodities(Markantonis and Bithas, 2010). Indirect use values go a step beyond this linkage with market by detecting the environmental services which somehow contribute to the human welfare but are hardly quantifiable and matched with market commodities. The non-use value category exhibits intangible services provided by an environmental entity to the human welfare which are however of equal importance with the use values (Israel et al, 2007). The analysis will be explicitly focused on indirect use values represented by environmental services to agricultural water. The outcome will attribute a mere subtotal of freshwater value. However, we purposively focus on the indirect use values linked with the environmental services in IGB area due to the assumptive ignorance of farmers on these services and its proven linkage with agricultural development.

The implementation area consists of representative clusters[1] along the IGB from India, Pakistan and Nepal. It is acknowledged that Bangladesh also shares a large part of IGB (Figure 1). However, the almost exclusive aquaculture farming in Bangladeshi riparian areas obstructed the extension of our survey to these clusters due to the high heterogeneity with the other riparian areas of India, Pakistan and Nepal.

[1] Cluster is considered a compound of small settlements which may be formed as villages or sparse inhabitants' areas.

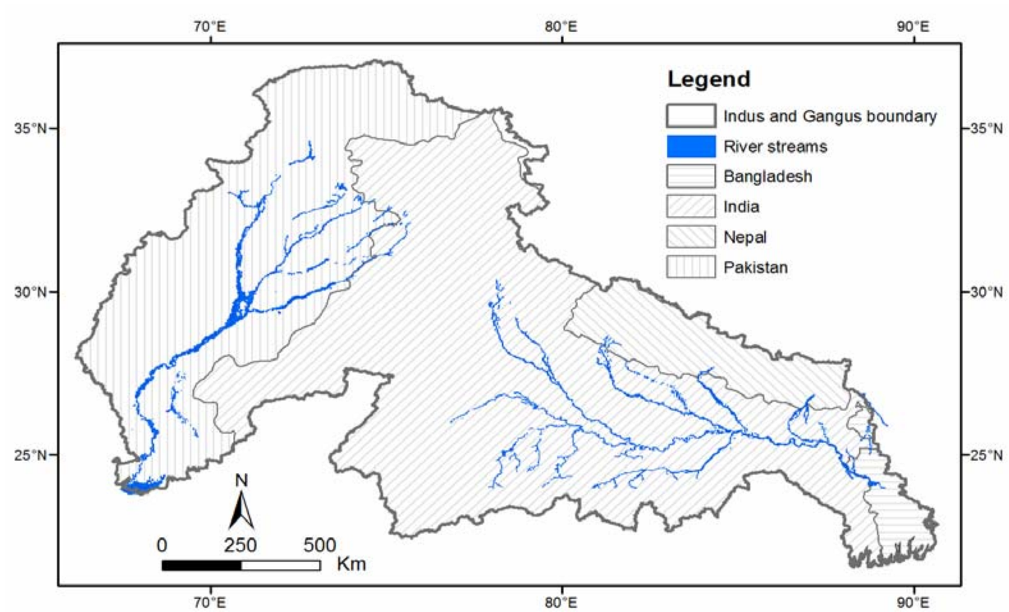

Figure 1. The Indo-Gangetic basin area

The clusters selected from India, were situated in the state of Bihar, along the eastern regions of Ganges basin. Bihar is enriched with fertile alluvial plains and abundant water resources. However, the region is confronted with low agricultural productivity, extreme poverty and regional disparities. With 43% of the population below the poverty line Bihar presents some of the lowest income rates in South Asia (World Bank, 2005). For the needs of the assessment, 7 disadvantaged villages from 4 districts were chosen.

In the case of Pakistan, the examined area is divided through Upper Rechna, Middle Rechna and lower Rechna catchment area which are situated in Indus basin. The four districts in Rechna sub basin, named as Hafizabad, Sheikhupura, Faisalabad and Toba Tek Singh were chosen. Two sample villages were adopted on the basis of a best geographical dispersion in each district.

In the case of Nepal, the area of Biratnagar was chosen due to its location in the wider basin of Ganges river. Biratnagar is positioned in Koshi sub-basin on the southern lowland belt of Nepal, near the south-eastern border with India (Ganges basin). Four disadvantaged villages in two districts of Morang and Munsari were taken as case studies. Emphasis was given on the difficulties faced in drought conditions and the entire almost absence of groundwater pumping and canal irrigation systems.

Overall, 937 farmers were surveyed from 10 Districts and 23 clusters as below:

Table 1. Allocation of research instruments in the three countries

Country	Questionnaires	Districts	Clusters
India	490	4	7
Pakistan	360	4	12
Nepal	128	2	4

The sampling within the villages was selected randomly where an about 30% of the entire population in each village was queried. All the interviews were conducted on-site through qualified local researchers.

3. Empirical Model and model Variables

The stated preference approach is introduced as an appropriate methodological tool for the assessment of farmers' preferences. In stated preferences, the assessment is conducted through a hypothetical or constructed market based on survey analysis (Alpizar et al, 2001; DTLR, 2002). Respondents are asked to reply in a set of choices by directly assessing non-economic goods and services. The introduction of stated preferences in water related environmental problems is widely used in literature (Bateman and Willis 1999; Louviere et al 2000; EVRI Database, 2010). In our case, the assessment was focused on crucial supportive services related to agricultural water use such as microclimate stabilization, infiltration to groundwater reserves and erosion protection (Funes-Monzote et al, 2009).

For the implementation of stated preferences approach, a quantitative economic assessment based on Willingness to Pay (WTP) is introduced. The environmental related services are elicited through direct open-ending questions. An extensive introduction about the concept of economic assessment was offered to respondents by trained local researchers for the minimization of biases emanating by opening-ending format. Also, to this aim the outliers were cautiously omitted whereas the reasoning of extreme bids was asked (NOOA, 1995).

Initially, the positive or negative stance of respondents in regard to the participation on the assessment is investigated on a country basis. We further describe the offered bids with two central tendency indicators while the presence of protest bids is examined. Protest bids represent the responses which generally do not reflect the true preferences. They are identified through the refusal of respondent to participate in the elicitation process or the stating of zero or an unrealistically high value (Bateman et al, 2002). The high presence of protest bids in an assessment process should question the success of the undertaking. To this aim, the actual zero value attributed by respondents in case of economic or conceptual reasons should be differentiated from the zero values linked with protest bids.

The identification of protest bids in our analysis is conducted through a follow-up question where the negation options below are offered:

Table 2. Protest and Zero WTP/WTA bid options

Options	**Technique**	**Inference**
Opposed to such economic approaches	WTP	Protest bid
No trust to the payment authority		
Not me to pay for these services		Zero bid
Not enough money to pay		

Finally, we try to comprehend farmers' responses in juxtaposition with significant wealth related indicators and socio-demographic features. To this aim, we employ a Multinomial Logistic Regression (MLR) model for the analysis of WTP stance as a dependent variable while the wealth and socio-demographic indicators act like predictors. Namely, the revenues, the agricultural water consumption (in hours per year) and the land possession (acres) consist of the wealth related indicators which are introduced as continuous variables. Similarly, the education, the age and the household-size comprise the socio-demographic factors which are included as dummy categorical variables.

The concept of logistic regression is based on the application of maximum likelihood estimation after transforming the dependent into a logit variable (the natural log of the odds of the dependent occurring or not). In this way, logistic regression estimates the odds of a certain event occurring (Garson, 2010). The selection of MRL modelling for our analysis was reasoned due to following factors. Initially, the non linearity of revenues in regard to respondents' stance is highly acknowledged in the literature (Bateman et al, 2002). The MLR helps to that aim, since it does not assume a linear relationship between the dependent (WTP stance) and the independent (revenues) variables. Second, other independent variable as the water amount and land size are not normally distributed due to high variance among many extremely poor and few rather wealthy farmers. The MLR model overcomes this constraint by allowing the dependent variable (WTP) to get shaped within the range of the exponential family of distributions, such as normal, Poisson, binomial, and gamma. In general, MRL model performs less stringent requirements than other regression analyses by still offering reliability in results.

4. Results

Initially, the condescendence of farmers to contribute in the preservation of environmental services is explored. Indian and moreover Nepalese farmers seem rather willing to concede towards the financial contribution of environmental services. However, in the case of Pakistan farmers, almost 2/3 of the sample is reluctant to offer any payment (Figure 2).

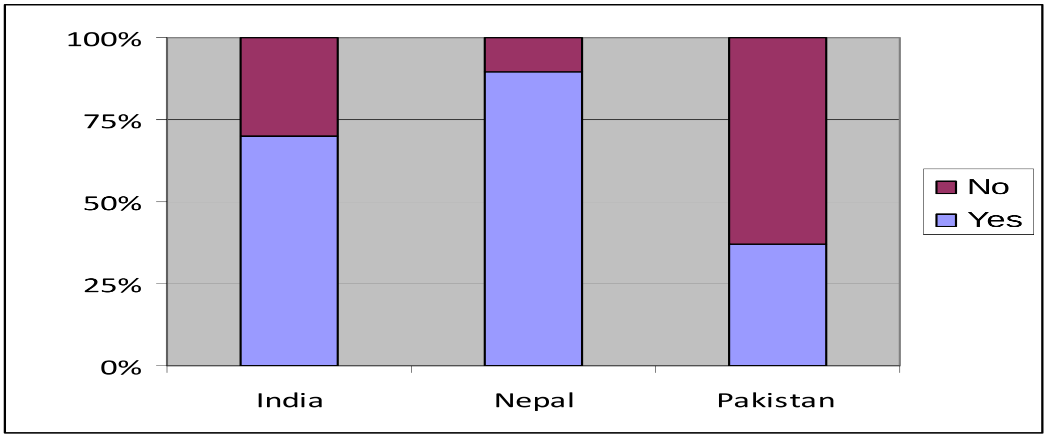

Figure 2. Farmers' stance on their participation to WTP query

Interesting though is the fact that the remaining Pakistani respondents seem willing to offer a threefold to fourfold higher amount in regard to Indian farmers. Nepalese farmers appear to be balanced amongst the Indian and Pakistani respondents. The close results between mean and median indicators and the absence of high deviance denotes an almost normally distributed sample.

Table 3. WTP for Environmental related services in IGB area

Parameters	WTP for Environmental Services		
Countries	**India**	**Nepal**	**Pakistan**
Valid	312	50	48
Missing	177	77	270
Mean	6.32	15.97	28.69
Median	5.18	16.38	30.22
Std. Deviation	1.83	1.46	2.27

In turn, we unravel the negation reasoning through a set of predefined replies for the identification of protest and genuinely zero bids as presented in Figure 3. The inappropriateness of the respondents to pay for these services is ranked as a first reason for both Nepalese and Indian respondents. In the case of Pakistan, the payment affordability comprises the major reason of a negative stance while the inappropriateness option is quite low. However, the minimum importance given to protest bids clarifies farmers' approval towards the applied assessment approach.

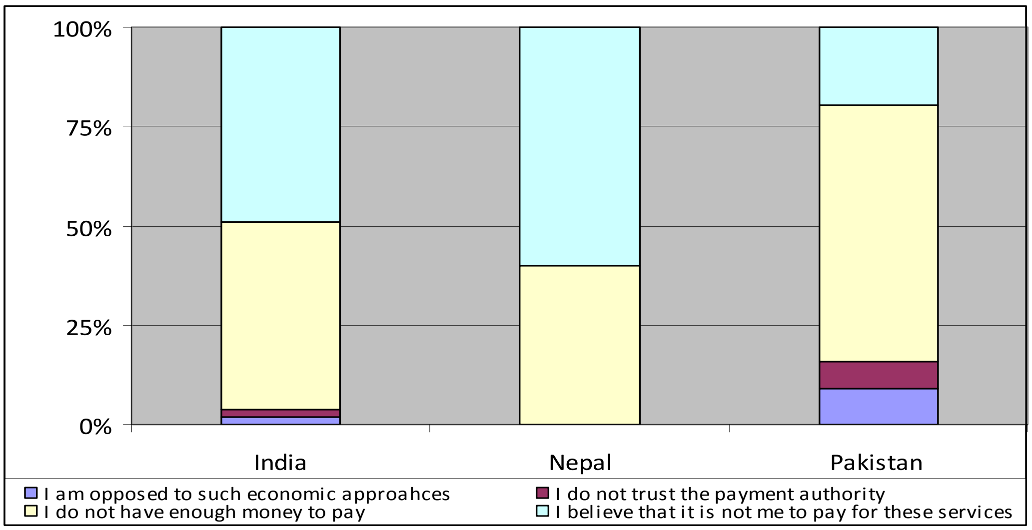

Figure 3. Reasoning of the negation in WTP inference

For the accomplishment of the Multinomial Logistic Regression (MLR) certain socio-demographic indicators are interpreted as dummy variables through the following classification format:

Table 4. Socio-demographic dummy variables

Classification	Age (year)	Household Size (no.)	Education
1	>25	>4	Post Graduate
2	25-34	4-6	Graduate
3	35-44	7-10	Secondary School
4	45-54	11-14	Primary School
5	55+	15+	Madrasah (only for Pakistan)
6	--------	---------	Not Schooled

The MLR model initially presents a statistically significant level. We further employ the Akaike Information Criterion (AIC) as a common information theory statistic used when comparing alternative models. The lower value is considered to present a better fit as exhibited in the final stage of the model. In a similar manner, the Bayesian Information Criterion (BIC) is a common information theory statistic used when comparing alternative models (Garson, 2010). Again, the lower value implies a better fit of the model as affirmed again in the final stage. For further clarification about the fitness of the model, the Goodness of Fit indication is presented through Pearson's and deviance indicators. The non significance of the tests denotes the close relation between the observed and the predicted values which appear to hold in our case. Further, the strength of our model association is measured through a set of pseudo-R^2 measures. A satisfactorily association is presented in all three indicators.

Table 5. Model fitting information

Model	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC	**BIC**	**-2 Log Likelihood**	**Chi-Square**	**df**	**Sig.**
Intercept only	798.135	802.491	796.135			
Final	594.870	677.636	556.870	239.265	18	.000

Pearson			Deviance		
Chi-Square	**df**	**Sig.**	**Chi-Square**	**df**	**Sig.**
455.981	552	.999	555.248	552	.453

Pseudo R-Square					
Cox and Snell	.340	Nagelkerke	.453	McFadden	.300

The analysis of MLR model with the wealth and socio-demographic indicators, initially presents revenues as a statistically significant variable but with an indifferent reaction to both the positive and negative WTP responses. Inversely, water use appears to act insignificantly with the WTP query. However, when the distinction between surface and groundwater use is introduced, it appears that it is only the use of groundwater that acts insignificantly instead. Contrary to this, surface water use is a positive predictor for the willingness of farmers to contribute in the preservation of environmental services.

Landholding size constitutes a highly insignificant factor for both negative and positive stances. Looking through the education variables it appears that none of the categories comprise a significant factor except for the secondary school graduates. They seem to support the rejection of the economic assessment although the statistical level is not quite strong. The age factor is highly insignificant in all categories for both the supporters and opponents of the assessment. The surprising results derive from the household size element. The families composed by up to 10 people react positively in a highly significant level for both negative and positive responses. However, in the case of positive response, the significance is absolute while the family size of up to 4 people acts a multiplier factor for the affirmative stance.

Table 6. Multinomial Logistic Regression (MLR) analysis

Variables	WTP (Reference category is ''No'')					WTP (Reference category is ''Yes'')				
	B	St.Er	df	Sig.	Exp(B)	B	St.Er	df	Sig.	Exp(B)
Intercept	3.218	1.141	1	.005		-3.218	1.141	1	.005	
Revenues	.000	.000	1	.018	1.000	.000	.000	1	.018	1.000
WaterHrs	-.008	.004	1	.069	.992	.008	.004	1	.069	1.008
WaterSrf	-.010	.005	1	.021	.990	.010	.005	1	.021	1.011
WaterGrnd	0[b]	.	0	.	.	0[b]	.	0	.	.
TotalLand	.000	.028	1	.981	.999	.001	.028	1	.981	1.001
[Educ=.0]	20.107	.000	1	.	5.401E 8	-20.107	.000	1	.	1.852E-9
[Educ=1.0]	.829	1.663	1	.618	2.291	-.829	1.663	1	.618	.437
[Educ=2.0]	1.933	1.021	1	.058	6.908	-1.933	1.021	1	.058	.145
[Educ=3.0]	1.952	.912	1	.032	7.046	-1.952	.912	1	.032	.142
[Educ=4.0]	1.632	.915	1	.074	5.116	-1.632	.915	1	.074	.195
[Educ=5.0]	1.669	.916	1	.069	5.304	-1.669	.916	1	.069	.189

[Educ=6.0]	0b	.	0	.	.	0b	.	0	.	.
[Age=1]	.091	.982	1	.926	1.096	-.091	.982	1	.926	.913
[Age=2]	.247	.387	1	.524	1.280	-.247	.387	1	.524	.781
[Age=3]	-.153	.292	1	.600	.858	.153	.292	1	.600	1.166
[Age=4]	-.011	.261	1	.967	.989	.011	.261	1	.967	1.011
[Age=5]	0b	.	0	.	.	0b	.	0	.	.
[Hsd=1]	-4.390	.880	1	.000	.012	4.390	.880	1	.000	80.609
[Hsd=2]	-3.777	.754	1	.000	.023	3.777	.754	1	.000	43.698
[Hsd=3]	-3.672	.740	1	.000	.025	3.672	.740	1	.000	39.330
[Hsd=4]	-.801	.889	1	.368	.449	.801	.889	1	.368	2.227
[Hsd=5]	0b	.	0	.	.	0b	.	0	.	.
b. This parameter is set to zero because it is redundant.										

5.Discussion and concluding remarks

The current research attempted to capture farmers' preference towards the preservation of environmental services related to water use in IGB area while explanatory variables were also introduced. From a methodological perspective, it is acknowledged that the reliability tests undertaken in our study for the validity of the assessment could be further explored. There is an abundance of validity tests based on statistical and econometric assumptions which could further justify the protest and zero bid options offered in our research (Carson et al, 1996; Brouwer et al, 1997; Bateman and Willis, 1999, Sarkhel and Banerjee). However, the further exploration of the negation reasoning would demand a much more extensive analysis which was beyond the scope of this paper.

The introduction also of the Multinomial Logistic Regression (MLR) for the potential significance attributed to income and socio-demographic indicator could be better employed through sample splitting on a country basis. The sample splitting though could possibly endanger the reliability of the results due to the fragmentation in insufficient sampling sizes.

Looking through the case study limitations, it should be noted that the absence of similar studies in IGB area inhibited a comparative analysis of our assessment. Related researches are often country specific with particular focus on water and poverty issues (Sampath and Akhler, 1988; Sanjay, 2002; Shah, 2006; Singh, 2007; Kakumanu and Bauer, 2008, Mythili and Mukherjee). However, this also consists of a comparative advantage for our study which covers a significant gap towards the valuation of environmental services related to agricultural water use in IGB area.

Broadly, the valuation of environmental services becomes an increasingly indispensable factor for efficient agricultural water use. The assessment of these services gets more essential in agrarian economies where the water use dependence is highly apparent and promotes development patterns. To this aim, our study managed to elicit farmers' preferences from representative clusters in IGB area by contemplating the validity of the assessment approach. Also, a set of explanatory variables helped to the better understanding of farmers' stance.

The study results revealed a moderate opposition of farmers to economically contribute in the preservation of environmental services which however derived from their unfamiliarity with such approaches and their low income status. The remaining farmers presented a highly agreeable stance which could be perceived as a highly encouraging message for the inclusion of environmental services in irrigation policy. Also, it is perceived that vital wealth and socio-economic indicators may significantly affect farmers' attitude towards their economic contribution to environmental services. To this effect, it is suggested that a reorientation of irrigation policy in IGB towards the preservation of environmental services should highly contemplate the socioeconomic features of the agrarian regions.

Acknowledgements

The research was undertaken through the research projects *''Sustainable Livelihood Improvement through Need Based Integrated Farming System Models in Disadvantaged Districts of Bihar''* and *"Basin focal project of the Indo-Gangetic basin"* funded by the Indian government and the Challenge Program for Water and Food respectively.

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Site Interviewing

The circulation of the questionnaire was initiated in 3 least progressive districts of Bihar while a more developed district was decided for comparative analysis. Particularly, the districts of Vaishali, Darbhanga and Munger were selected whereas for a developed case the district of Patna was adopted. However, the villages selected in Patna were also inhabited by low income farmers with highly fragmented land. In effect, the specific villages in Patna were spotted due to the high accumulation of arsenic deposited in the surrounding areas. The data to be collected towards the environmental status of the linked water resources was agreed to be investigated through the local soil researchers of ICAR-RCER.

For a representative and diversified sampling, the distribution to 1-2 villages for each district was decided. The village selection was conducted through a set of criteria concerning the cultivation type, the irrigation practices and the environmental status in the surroundings of each village so at avoid a large homogeneity of the villages' profile as presented below:

<table>
<tr><th rowspan="6">Agro-ecological sub-region (according to international index)</th><th rowspan="6">Soil type (according to international index)</th><th>Agricultural water patterns</th><th>Cultivation types</th><th>Environmental characteristics</th></tr>
<tr><td>Tubewell</td><td>Kharif</td><td>Near to River</td></tr>
<tr><td>Borewell</td><td>Rabi</td><td>Near to Spring</td></tr>
<tr><td>Rainfed</td><td>Summer</td><td>Near to Forested area</td></tr>
<tr><td>Canal</td><td></td><td>Water congested area</td></tr>
<tr><td>Pond/Tank</td><td></td><td></td></tr>
</table>

Table 1. Criteria for selection of the clusters

Specifically, from 25th of April two persons launched the survey at Chakramdas and Monhanpur villages in Vaishal and Darbhanga districts respectively. A field trip to all the selected districts was conducted in 10th-12th May by the postdoc fellow of IWMI, Dr. Stefanos Xenarios and the Senior Researcher of ICER, Dr. Atul Kumar to Vaishali district and the clusters of Chakramdas and Pirapur. The ongoing distributing and collecting process was monitored through the interaction with the local researchers Mrs Veean and Mr.Arunin Chakramdas and Mr.Sanjeev in Paripur accordingly. Their remarks substantially helped in the better explication of some still unclear points to the farmers. In total, the amount of 489 questionnaires was collected from the 7 villages in the 4 predefined districts are presented below:

Districts	Clusters	Nos. of Questionnaire
Vaishali	Chakramdas	89
	Pirapur	115
Darbhanga	Saramohanpur	85
Munger	Matadih	50
	Tikarampur	50
Patna	Rambad	50
	Hulsi-Tola	50
Total	**489**	

Table 2. Questionnaires collected from the selected villages.

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IWMI New Delhi Office :
CG Block B, 2nd Floor,
NASC Complex, Dev Praksh Shastri Marg, Pusa,
New Delhi 110 012 India
Telephone: +91-11-2584 0811, 2584 0812
Telefax: +91-11-2584 2075
Web : www.iwmi.org, E-mail: iwmi-delhi@cgiar.org