Paper 4

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

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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.

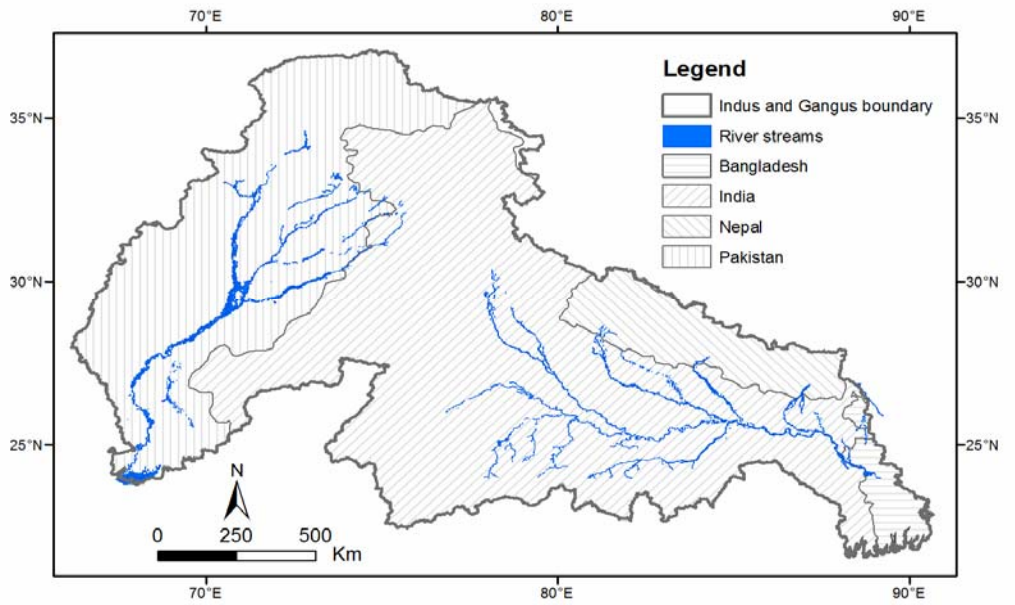

Figure 1. The Indo-Gangetic basin area

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).

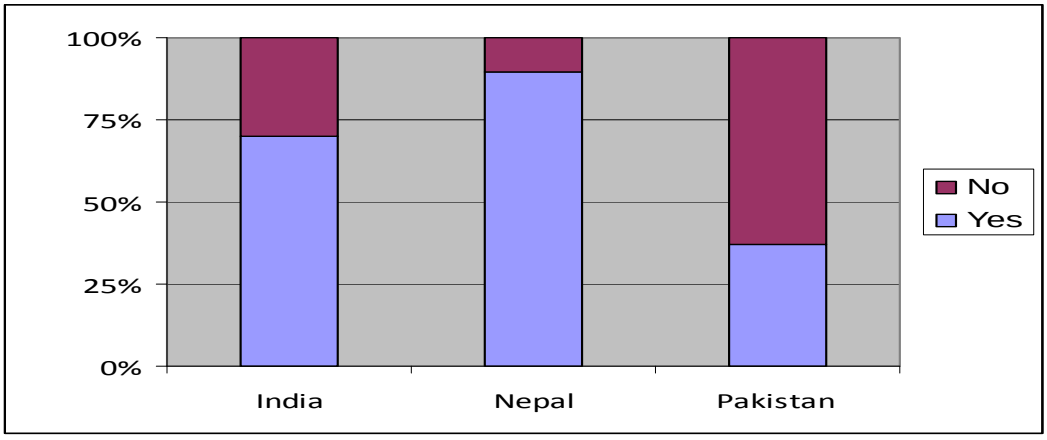

Figure 2. Farmers' stance on their participation to WTP query

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.

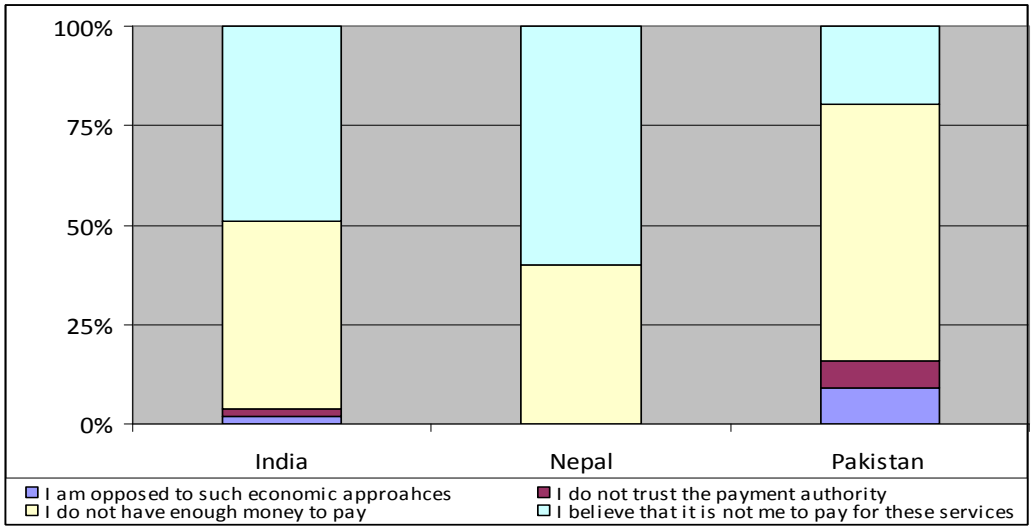

Figure 3. Reasoning of the negation in WTP inference

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 Fitting Criteria			**Likelihood Ratio Tests**		
Model	**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	.	5.401E8	-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]	0[b]	.	0	.	.	0[b]	.	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]	0[b]	.	0	.	.	0[b]	.	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]	0[b]	.	0	.	.	0[b]	.	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.

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