Nature Environment and Pollution Technology
An International Quarterly Scientific Journal
p-ISSN: 0972-6268 (Print copies up to 2016)
e-ISSN: 2395-3454
Vol. 22 No. 1 pp. 189-197 2023
Original Research Paper
https://doi.org/10.46488/NEPT.2023.v22i01.017
Open Access Journal

Economic Valuation and Benefit Transfer of Restoring the Teesta Riverine Ecosystem

Pravesh Tamang
Department of Economics, Presidency University, 86/1, College Street, Kolkata 700073, West Bengal, India
†Corresponding author: Pravesh Tamang; pravesh.econ@presiuniv.ac.in

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 25-05-2022
Revised: 27-06-2022
Accepted: 30-06-2022

Key Words:
Economic valuation
Teesta river
Contingent valuation
Benefit transfer

ABSTRACT

This study seeks to understand the socio-economic and ecological impacts of the hydroelectric power projectsalong the upper basin of the river Teesta in Sikkim. This study estimates the non-market benefits of restoring the Teesta riverine ecosystem and evaluates the transferability of welfare estimates. This study is a first of its kind undertaken in the Teesta basin which uses a unique dataset of 830 households obtained from the affected regions of the river basin. During the study, nine villages adjacent to the river Teesta, dams, and powerhouses were identified and surveyed. Double bounded dichotomous choice questions were used to elicit willingness to pay (WTP). Both the logistic and normal distribution models were fitted and the results were mostly similar. The median WTP was INR 373.00 and the variables that described the rating on dams, ownership of property, monthly expenditure of the household, informal employment status, and satisfaction about the state of the river Teesta were among the significant variables in the model. The benefit function value transfer estimated was INR 232.00 with the percentage transfer error (PTE) of 61.9%.

INTRODUCTION

The rivers of the Earth not only play an important role in shaping the physical landscape of the planet but also have an impact on the well-being of billions of people living around the world. Rivers provide ecosystem goods like fish, drinking water, wildlife, etc., and services such as boating and swimming. Free-flowing rivers add to the aesthetic values and recreation, leading to an increase in property values for those living near them (Lewis et al. 2008). In addition, free-flowing rivers also help dilute wastewater discharges helping maintain water quality. Rivers also provide habitat for endangered and threatened species (Richardson & Loomis 2009, Mathieus et al. 2010).

However, the ability of the rivers to provide such ecosystem goods and services is reduced when anthropogenic activities are performed beyond a sustainable threshold level. For instance, river-damming creates a threat to many native species of fish due to the reduction in the fish passage. Extensive anthropogenic interventions have resulted in the loss of biodiversity in recent decades in India. In particular, development works such as the construction of roads, dams, and urban spaces have been carried out in the Himalayan region of India, which has created a negative impact on the Himalayan biodiversity (Gaur 1999, Kanwal & Joshi 2010).

The river Teesta is a major river in the Himalayan region that originates from the glaciers of Sikkim in the north at an elevation of 8,250 m. The entire state of Sikkim covers the upper basin of the river Teesta. The Teesta River joins the river Rangeet at Teesta Bazar (in West Bengal) and then flows through the Darjeeling district in West Bengal before joining the river Brahmaputra in Bangladesh. The Sikkim Himalaya, with its rugged topography, ongoing seismic activity, and heavy rainfall, is subjected to intense landslide activities.

India has an estimated total hydroelectric power potential of 84 GW. Of this, Sikkim's potential share is 2.9% or about 4.29 GW. The Central Electricity Authority of India prepared a preliminary feasibility report in 2004 on the establishment of 162 new hydroelectric schemes with a total potential of over 50,000 MW. In this scheme, Sikkim has ten projects with an installed capacity of 1,469 MW (CEA 2015). The total hydroelectricity potential in Sikkim stands at 5,325 MW spread across different stages of implementation (EDPS 2020). Currently, 15 projects are under different stages of construction, and according to the Draft National Electricity Plan 2018, all the projects shall be completed by 2022.

However, in recent times, there has been a disappearance of springs/streams leading to a decrease in water shortages in different parts of Sikkim. Also, dams have blocked the natural river water and reduced downstream river levels.

The use of dynamites in road construction and underground tunneling by hydropower projects have caused cracks in aquifers resulting in water loss. Traffic congestion, accidents, and deaths are other issues faced by the local people living near the project sites. While cultural intrusion also forms a major issue levied by the local people upon migration, there also seems to be a change in the agricultural productivity in the project sites. Thus, there is an intense need to evaluate the restoration benefits of the Teesta Riverine Ecosystem for long-term sustainability and a wide range of flora and fauna protection. Such benefits could be accrued not only to wildlife but also could be utilized for achieving long-term inclusive growth.

Understanding public support for ecosystem restoration is critical to its successful implementation because the sustainability of sound resource management is rooted in stakeholders' support (Alam 2013). The contingent valuation method (CVM) is one of the important tools widely used in the restoration literature. Alam (2013) used CVM to estimate the WTP for restoring the Buriganga river in Bangladesh. It was found that there existed a significant relationship between participants' willingness to participate in the ecosystem restoration and their socio-demographic characteristics and their perceptual characteristics. A variety of factors, including demographic and socioeconomic variables such as gender, age, race, number of people living in the household, level of education, size of the household, respondent's status within the household, individual and household income, and bid values, are likely to influence public preferences (Pate & Loomis 1997, Bandara & Tisdell 2004, Haile & Slangen 2009, Mohammed 2009, Nallathiga & Paravasthu 2010).

Other variables include residence proximity to the resources in question and frequency of uses/visits to the resources (del Saz Salazar & García Menéndez 2007, Weber & Stewart 2009), residence location (Zhongmin et al. 2003), awareness of the current state of the services (Weber & Stewart 2009), and membership in environmental organizations or NGOs (Haile & Slangen 2009). The attractiveness of the resource, degree of trust, environmental priorities, prior awareness of pollution/degradation, prospective danger, and existing level of protection are all proven to be influential determinants of WTP (Haile & Slangen 2009).

The Contingent Valuation method (CVM) is a major source of economic values for benefit transfer-based policy analysis (Johnston & Wainger 2015). According to Carson (2011), the CVM has been mostly used since 2007 and is hence the most cited method in the valuation literature. However, considering the amount of time and resources required in CVM surveys, the benefits transfer approach was developed so that the findings from one site (the study site) can be applied to another site (the policy site). Benefit transfer has been used in different policy contexts since the 1950s. Two influential CVM-benefit transfer studies done by (Luken et al. 1992) and (Desvousges et al. 1992) motivated the development of benefit transfer as a distinct field of research. Both the studies employed unit value transfer which is applying the WTP estimate obtained in the study site directly to the policy site. However, Loomis (1992) introduced the benefit function transfer in which an empirical model developed in a study site can be used to estimate the benefits at the policy site. Generally, the results from a benefit function transfer are better than the ones from a unit value transfer (Johnston & Rosenberger 2010). Boyle & Bergstrom (1992) were the first to propose the convergent validity test i.e. the percentage transfer error, which is very commonly used in contemporary research.

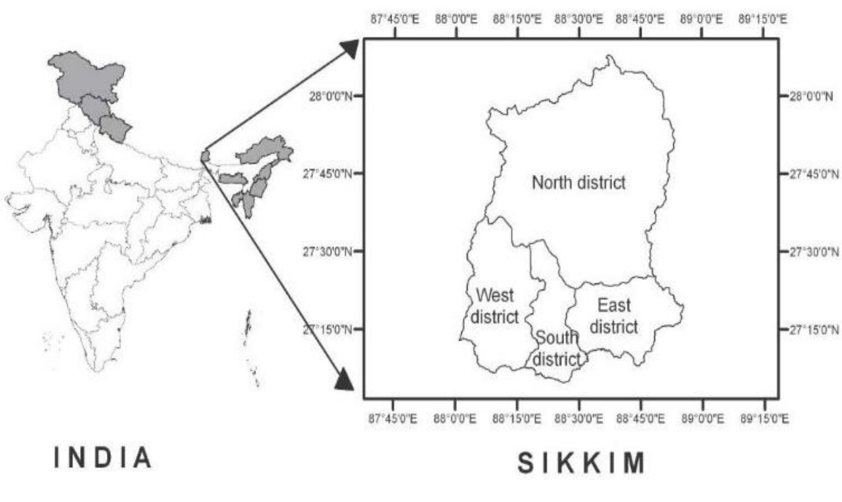

Fig. 1: Map of Sikkim.

Downing & Ozuna (1996) use the CVM-benefit transfer method to estimate the benefits of marine recreational fishing in Texas bay and find a few equal coefficients. Also, another study by Kirchhoff et al. (1997), find that the transfer of the benefit estimates obtained from Arizona and New Mexico studies resulted in the rejection of the convergent validity test in 55 to 90% of the benefit function transfer. Kaul et al. (2013) remark that benefits function transfer outperforms the unit value transfer and the CVM performs equally to other methods.

Over the last three decades, the use and challenges of benefit transfer have grown along with the concerns of validity and accuracy (Johnston & Wainger 2015). Newer developments in the fields of understanding, application, and limitations have come up while the objective of the benefit transfer has remained the same. The benefit transfer is used not only for WTP estimates but also for other welfare estimates, and newer methods and understanding of the factors that influence transfer accuracy have evolved.

This study is the first of its kind that looks into the restoration of ecosystem services and benefits transfer in the upper basin of the Teesta River. This study also uses a unique dataset of 830 households obtained from a primary survey in the affected areas of the river basin. This paper tries to (a) analyze the effects of hydropower projects in the upper basin of the Teesta River on various issues such as natural ecosystems, culture, livelihoods, and river water quality, (b) estimate the willingness to pay (WTP) for restoration of the riverine ecosystem and evaluate the transferability of welfare estimates.

MATERIALS AND METHODS

The Study Area

The survey was implemented in the different villages and small towns near the river Teesta, the Teesta Stage V dam, and the Teesta Stage V powerhouse. More specifically, the Teesta Stage V in Sirwani and the Dikchu dam in Dikchu were prominent destinations. More precisely the places of survey and the sample size are outlined in Table 1. The villages were chosen considering their proximity to the river Teesta as well as the dams so that the impact becomes prominent (Fig. 2).

Questionnaire and Sampling

Purposive sampling was used to select the villages based on the geographic location and proximity to the river Teesta, the Teesta Stage V dam, and the Teesta Stage V powerhouse. After the villages were selected, sample households in each village were selected randomly. A pre-testing of the questionnaire was done in all the villages outlined in Table 1. In each village, 5 households were surveyed amounting to a total of 45 households for pre-testing the questionnaire. In the pre-test questionnaire an open-ended Willingness-to-Pay (WTP) question regarding the hypothetical river

Table 1: Survey villages with sample size.

Village	Bardang	Dikchu	Majitar	Makha	Mamring	Manglay	Rangpo	Singtam	Sirwani
Sample	82	198	92	48	72	122	42	132	42

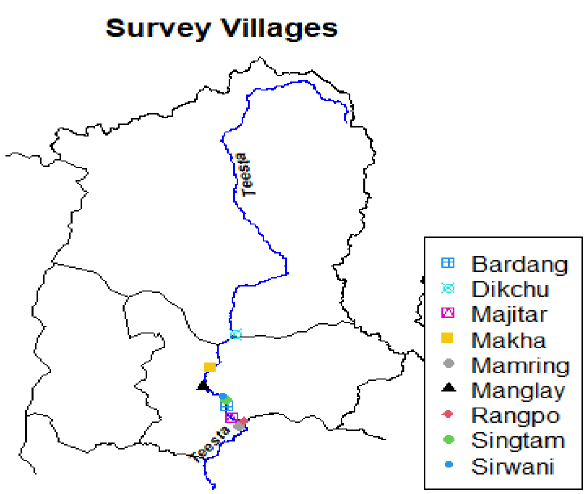

Fig. 2: Map showing the survey sites.

Table 2: Bid values for the main survey.

Bids	Initial.bid	High.bid	Low.bid
Bid 1	100	200	50
Bid 2	250	500	125
Bid 3	500	1,000	250

restoration project was asked. A follow-up question was also asked to understand the specific reason for the contribution.

Similarly, for those who answered *No* to the open-ended WTP question, a similar follow-up question to understand the specific reason for not contributing was asked.

For the main survey, double-bounded dichotomous choice (DBDC) willingness-to-pay (WTP) questions were asked. The rationale behind using the DBDC format was the improvement in statistical efficiency that it provides in contingent valuation studies (Jeanty et al. 2007). In the DBDC format, the respondents were asked if they were willing to pay the initial bids, and the 'yes/no' answers were followed by the corresponding 'high/low' bids as specified in Table 2. All three bids (Bid 1, Bid 2, and Bid 3) were randomly presented to the households.

The questionnaire was carefully designed after considering the different aspects of the river Teesta including its ecological, economic, and other socio-cultural values. The questionnaire was conceptually focused on assessing information on the socio-economic profile of the households, water availability and consumption behavior, impact of the hydroelectric projects on the agricultural lands (if they own) and the livelihood of the people, perception of impact on water and wild habitat, environment, culture, and the river itself, identifying the ecosystem services or functions that could be associated with the river, and finally asking the willingness-to-pay questions on restoring the river Teesta. The question on WTP was a double-bounded dichotomous choice (DBDC) type. The bid values used in the main survey, detailed in Table 2, were obtained from the estimates of the pre-testing survey.

Contingent Valuation

A survey-based methodology that can be used for eliciting the values that people place on different kinds of goods and services is the Contingent Valuation (CV) method (Boyle 2003). In the CV method, there are different formats like the bidding games and open-ended questions. These two formats were widely used in the early years of CV. In the bidding game, the willingness-to-pay WTP is elicited by an auction, and in the open-ended format a direct question like "How much are you willing to pay?" is asked. During the 1980s, two other formats emerged - the Single Bound Dichotomous Choice (SBDC) and the double-bound dichotomous choice (DBDC) (Boyle & Bishop 2012). The main drawback of the open-ended format is that the respondent may not be familiar with the price of the good or service in question. So in the SBDC format a question like *"Will you be willing to pay Rs. X ?"* makes it easier for the respondent to answer the WTP question. The SBDC format is easier from the perspective of the respondent, but it is "statistically less efficient and requires the large sample to attain a given level of precision" (Hanemann et al. 1991). The double-bounded dichotomous choice (DBDC) format improves th e efficiency of the SBDC.

In the DBDC format, a question is asked after an SBDC format question like *"Will you be willing to pay Rs X?"*, and if the respondent answers Yes, then a follow-up question with double the bid value is asked like *"If yes, will you be willing-to-pay Rs 2X ?"*. Similarly, if the respondent answers No, then a follow-up question with half the bid value is asked as *"If No, will you be willing-to-pay Rs. 0.5X ?"*. This DBDC method is asymptotically more efficient than the SBDC method(Hanemann et al. 1991).

Following Hanemann et al. (1991) the parametric DBDC model can be summarised as follows. Let the first bid be t_n and the second bid be t_n^U if respondent n answers "yes" to the first question, and t_n^L otherwise. Further, let respondent n's maximum WTP be denoted by y_n^*.

The probability that the respondent n answers "yes" to the first and the second questions is given by $P^{yy}(t_n, t_n^U) = \Pr(t_n \leq y_n^*, t_n^U \leq y_n^*) = \Pr(t_n^U \leq y_n^*)$ $= 1 - F(t_n^U)$

Similarly, the probability that respondent n answers "no" to the first and the second questions is equal to $P^{nn}(t_n, t_n^L) = \Pr(y_n^* \leq t_n, y_n^* \leq t_n^L) = \Pr(y_n^* \leq t_n^L) =$ $1 - F(t_n^L)$

The probability that respondent n answers "yes" to the first question and "no" to the second question, or "no" to the first and "yes" to the second is given, respectively, by $P^{yn}(t_n, t_n^U) = \Pr(t_n \leq y_n^*, y_n^* < t_n^U) = \Pr(t_n^U \leq y_n^* < t_n^U)$ $= F(t_n^U) - F(t_n)$

and, $P^{ny}(t_n, t_n^L) = \Pr(y_n^* \leq t_n, y_n^* \geq t_n^L) = \Pr(t_n^L \leq y_n^* < t_n) = F(t_n) - F(t_n^L)$

Therefore, for a given sample of N independent observations, the log-likelihood function can be written as;

$$\ln L = \sum_{N-1}^{N} \begin{matrix}[d_n^{yy} \ln\{P^{yy}(t_n, t_n^U\} + d_n^{nn} \ln\{P^{nn}(t_n, t_n^L)\} + \\ d_n^{yn} \ln\{P^{yn}(t_n, t_n^U\} + d_n^{ny} \ln\{P^{ny}(t_n, t_n^L)\}]\end{matrix}$$

where d_n^{yy}, d_n^{nn}, d_n^{yn}, and d_n^{ny} are binary-valued indicator variables. For example, d_n^{yy} is equal to 1 if the respondent answers "yes" to the first bid t_n and second bid t_n^U, and 0 otherwise.

Benefit Transfer

Benefit transfer can be defined as using the research results from an existing primary study at one or more policy or study sites to predict welfare estimates (Rolfe et al. 2015). But certain criteria must be met to conduct a benefit transfer study estimate. According to Boyle & Bishop (2012), benefits transfer is valid only when source and target or policy sites, population, and welfare measures are identical. Bennett (2006) also points out that the biophysical conditions, the scale of environmental change, and the socio-economic characteristics of the population in the source site must be similar to those of the target or policy site.

The economic theory and methods of benefit transfer applied to most market and non-market goods are also the same as ecosystem services (Champ et al. 2017, Freeman et al. 2014). However, some sources of error can diminish the accuracy of the results in benefit transfer. Two types of errors can occur – the measurement error and the generalization error. Measurement errors are caused by the errors in primary or source studies which are used for transfer and get transferred to policy sites (Rosenberger & Stanley 2006). The second type of error which is the generalization error is caused by a lack of similarity between study and policy contexts.

Usually, two types of benefit transfers can be calculated – unit value transfers and benefits function value transfers. Unit value transfers include a single number or a set of numbers from pre-existing primary studies. The transferred quantities can include a single unadjusted value, a value adjusted according to the attributes of the policy context, a mean or a median value of the study site, or a range of estimates from prior studies (Johnston & Wainger 2015). Benefit function transfers are based on the benefit function derived from a primary study or a set of studies and used to calculate a welfare estimate, such as the WTP, calibrated to the characteristics of the policy site (Loomis 1992, Rosenberger & Stanley 2006). There are two requirements for a benefit function transfer. The first one is a parametric function and the second is a set of variables for the policy site.

Following Johnston & Wainger (2015), a single-site benefit function transfer can be illustrated as

$$\widehat{y_{Js}} = g(x_{js}, \widehat{\beta_{Js}})$$

where j is the survey site, s is the population at the survey site j, $\widehat{y_{Js}}$, is a predicted welfare estimate, x_{js} is a vector of variables, and $\widehat{\beta_{Js}}$ is a vector of estimated parameters. A simple linear benefit function would be

$$\widehat{y_{Js}} = \widehat{\beta_{Js0}} + \sum_{k=1}^{K} \widehat{\beta_{Jsk}}\, x_{jsk} + \widehat{\epsilon_{Js}}$$

where K is the number of non-intercept variables in the model and $\widehat{\epsilon_{Js}}$ is the residual.

For a single-study benefit function transfer all the information would be gathered from a single primary study Johnston & Wainger (2015). Normally all the information for x_{js} for policy sites are not available. For this we can split x_{js} into $x_{js} = [x_{js}^1, x_{js}^2]$, where x_{js}^1, where are the variables for which policy site data are available, x_{js}^2 and are the variables for which policy site data are not available. If we are considering a benefit function transfer to a similar site i with population r, then the parallel value for x_{js}^1 shall be x_{ir}^1 and the associated benefit transfer estimate shall be given by

$$\hat{y}_{ir}^{BT} = g([x_{ir}^1 x_{js}^2], \hat{\beta}_{js})$$

The parameterized function $g(.)$ is used to calculate the benefit transfer estimate by substituting the updated values of those variables for which policy site information is available x_{ir}^1. For variables with no updated policy site information, the original values from the study site are used x_{js}^2 (Johnston & Wainger 2015).

The reliability of empirical accuracy of a benefit transfer is measured by the magnitude of transfer error and is quantified with convergent validity tests. Convergent validity is a measure of benefit transfer accuracy in which transfer error is calculated based on the difference between a transferred value estimate and an alternative value estimate for the same site. For unit value (UV) transfers and benefits function value (BFV) transfers, the percentage transfer error (PTE) is

$$PTE_{UV} = ((WTP_s - WTP_p)/WTP_p) \times 100$$

where WTP_S is the transfer value estimate of the study site and WTP_P is the transfer value estimate of the policy site. The average value of percentage transfer error is 36% and the range lies between 20% to 125% (Barton 2002, Kaul et al. 2013). According to Kaul et al. (2013), the benefit function value transfer tends to outperform unit value transfer in the benefit transfer literature.

RESULTS AND DISCUSSION

Willingness to Pay

Table 3 describes the different variables used in the DBDC model. The variable *r1* describes the response to the initial bid of the DBDC question on WTP. If the respondent answers 'yes', the value 1 is registered and a higher bid option is placed before the respondent. If the respondent answers 'no' then the value 0 is registered and a lower bid option is placed. The follow-up bid with a higher value and a lower value is captured by the variable *r2*. Again, in this case, too, a 'yes' answer gets a 1 and a 'no' gets 0. The median and standard deviation for *r1* and *r2* are 1, 0, and 0.43, 0.45 respectively.

The other variable coded *age* describes the age of the respondent in years. The median age of the respondents was 41 with a standard deviation of 41.87. The variable *religious* describes whether the households practice any religious activities near the river. This question was asked because people who practice Hinduism and some tribal religions perform many rituals related to the river. This came up when we talked with some of the local people, as in focus-group interviews, during our pre-testing of the questionnaire.

The most common rituals associated with the river include – funerals along the river bank, Chat puja, Sansari puja, and Makar Sankranti. The median number of members in a household (members) is 4, and the median rating of the respondents on whether hydroelectric projects are important is 3 which is a pretty high rating. Most of the households do not own any agricultural land near the river ownership. The median value of this variable *ownership* is 2 which indicates 'do not own any agricultural land near the river Teesta'.

The median monthly expenditure of the household *exp* is INR 8,000.00. Also, a significant number of respondents or family members were working in informal businesses, shops, food sellers in the market, working in a private company, as casual workers, or were unemployed indicated by the variable employ. The variable *satisfied* captures the idea that whether the respondent is satisfied with the current state and condition of the river Teesta. A majority of respondents (median value of satisfied = 2 meaning 'not satisfied') in the sample are not satisfied with the condition of the river. Finally, the variables *bd1* and *bd2* are the initial and the follow-up bid values for the double-bounded dichotomous choice questions.

We can see from the logistic distribution regression output in Table 4 that the variable rating is significant and negatively related to WTP. The implication is that if the importance of hydroelectric projects (HEP) is rated high by the households then the WTP for restoration would decline. This would mean that the households who rate the HEPs high are attaching more value to employment and other economic benefits rather than the restoration benefits of the river Teesta.

The other significant variable is the *ownership*. The implication is that if a household owns any agricultural land near the river then the household shall be willing to pay for the restoration of the river. The reason for such a decision would be the *flood prevention benefit* that the household sees from river restoration. Even the households who have rented the land for irrigation, the variable *ownershipRented*, are willing to pay for river restoration because of the same *flood prevention benefit* that these households would get and thus not lose the land which is a major source of their income.

The variable *log.exp* which is the log of the expenditure is also significant and positive implying that households with higher monthly expenditures are willing to pay for the restoration of the river. The other variable that has turned out to be significant is the *employ.other* variable. This variable describes the category of employment among the household members who are in informal business, works in a shop, sells food in the market, works in a private compa-

Table 3: Description of variables used in the model (N = 830).

Variables	Description	Median	sd
r1	response to initial bid (1 = Yes, 0 = No)	1	0.43
r2	response to follow-up bid (1 = Yes, 0 = No)	0	0.45
age	age of the respondent (in years)	41	41.87
religious	whether the household practices any religious activities in the river Teesta	2	0.35
members	number of members in the household	4	2.03
rating	how important are the HEPs to the area and the river Teesta? (rating on the scale of 0 to 5. 0 = HEPs are not important at all, 5 = HEPs are a must.	3	1.32
ownership	whether the household owns any agricultural land near the river?	2	0.65
exp	monthly expenditure of the household (Rs/month)	8000	9,670.93
employ	employment status of the head (government employee, farmer, others	3	0.55
satisfied	Whether satisfied with the state and conditions of the river Teesta?	2	0.42
bd1	initial bid value	250	161.07
bd2	follow-up bid value	500	335.23

Table 4: DBDC Logistic distribution output.

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	0.769527	1.071887	0.7179	0.472808	
log.age.	0.032537	0.15272	0.213	0.83129	
religiousYes	-0.21059	0.186607	-1.1285	0.259109	
log.members.	0.013905	0.164878	0.0843	0.932788	
Rating	-0.15153	0.050635	-2.9925	0.002767	**
ownershipOwned	0.418503	0.207769	2.0143	0.043981	*
ownershipRented	0.485399	0.218181	2.2248	0.026098	*
log.exp.	0.147915	0.084772	1.7448	0.081012	.
employGovt..employee	-0.12047	0.368587	-0.3268	0.743795	
employOther	-0.57704	0.266647	-2.1641	0.030459	*
satisfiedNot.satisfied	0.300565	0.152049	1.9768	0.048068	*
BID	-0.00484	0.000181	-26.6946	< 2.2e-16	***

Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Distribution: logistic
Number of Obs.: 830
Log-likelihood: -1226.101465
LR statistic: 74.291 on 1e+01 DF, p-value: 0.000
AIC: 2476.202931 , BIC: 2532.522815

Table 5: 95% Confidence interval of the DBDC logistic model.

	Estimate	LB	UB
Mean	405.32	382.12	428.91
truncated Mean	395.45	373.75	417.13
adjusted truncated Mean	414.73	389.17	441.16
Median	373.67	346.57	399.46

ny, is a casual worker, or is unemployed. This category is negatively related to WTP for river restoration compared to the other categories (farmers and government employees). Since this category does not have any direct economic dependence on the river as opposed to the farmers (possibly those having landed near the river), it could be a reason for the negative and significant relation seen in the regression result.

Also, the variable *satisfied* describes whether the respondent was satisfied with the present state and condition of the river Teesta. The regression result shows that the variable is significant and positively related to the WTP. This means that the respondents who were not satisfied with the current state and condition of the river Teesta are willing to pay for the restoration of the river.

Next, we look at the median WTP estimates in Table 5 using the Krinsky-Robb (Krinsky & Robb 1986) procedure. The median WTP is INR 373.27. The 95% confidence interval for the median WTP estimate is INR 346.41 to INR 373.267. In Fig. 3, the median WTP estimate has

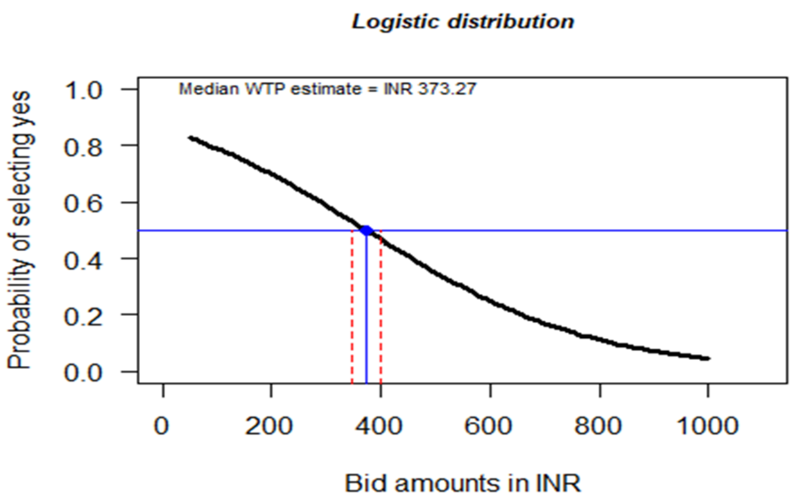

Fig. 3: DBDC logistic distribution.

Table 6: Benefit transfer estimate.

Variables	Coefficient	Mean	Product
Const	0.76952676	1.0000000	0.76952676
Age	0.03253655	44.8843373	1.46038149
religious	-0.21058544	0.8530120	-0.17963192
members	0.01390538	4.7365854	0.06586404
Rating	-0.15152592	2.4793187	-0.37568105
ownership	0.41850305	2.2092457	0.92457609
ownership	0.48539882	2.2092457	1.07236528
exp (INR/1000)	0.14791446	11.0648458	1.63665070
satisfied	0.30056500	0.2481928	0.07459806
D			5.44864945

been plotted along with the 95% confidence interval obtained using the Krinsky-Robb (Krinsky & Robb 1986) procedure.

The Benefit Transfer Estimate

Following Johnston & Wainger (2015) key variables were selected from the regression model, and their coefficients and their corresponding mean values have been calculated as in Table 6. The product of the coefficient values and their means are calculated.

The sum of these products is labeled as *D* whose value is 5.4486494 as shown in Table 6. This value represents the predicted natural log of WTP for the restoration of the river Teesta. In the final step, a standard formula is used to transform this predicted natural log to the desired WTP estimate (Johnston & Wainger 2015).

$$WTP = e^D$$

where *e* is the exponential operator and *D* is the sum of the products of the means and coefficients. Using this formula the value of *WTP* is INR 232.44 which represents per household willingness to pay for the restoration of the river Teesta. This estimate can be transferred to approximate ecosystem service value for the illustrated policy change, in the absence of the original study results.

The percentage transfer error (PTE) is calculated using the formula (Brouwer et al. 2016):

$$PTE = [(WTP_{source} - WTP_{policy})/WTP_{policy}] \times 100$$

The weighted mean transfer error of the CVM studies in Kaul et al. (2013) is 36% with a range of 20% (Barton 2002) to 125%. In this study, the percentage transfer error is 61.98%. This value is the benefit function value transfer which is regarded better in the benefit transfer literature (Barton 2002).

CONCLUSION

This study seeks to understand the socio-economic and ecological impacts of the hydroelectric power projects along the upper basin of the river Teesta in Sikkim. Double-bounded dichotomous choice questions were used to elicit willingness to pay (WTP) for the restoration of the Teesta riverine ecosystem. The median WTP was INR 373.00 and the variables that described the rating on dams, ownership of property, monthly expenditure of the household, informal employment status, and satisfaction about the state of the river Teesta were among the significant variables in the model. One important issue that can be understood is that people having property or fam lands near the river have been more affected by the dams and they are more interested in the river restoration project as compared to those who derive livelihood in the dam sites as informal or private employees (the variables *ownership* and *employ*). Those who have expressed their dissatisfaction over the state of the river seem to be more interested in the restoration project and are willing to pay.

The benefit function value transfer estimated is INR 232.44 which represents per household willingness to pay for the restoration of the river Teesta. This estimate can be transferred to approximate ecosystem service value for the illustrated policy change, in the absence of the original study results.

ACKNOWLEDGMENT

The study was funded by Impactful Policy Research in Social Science – Indian Council for Social Science Research (IMPRESS-ICSSR), Government of India.

REFERENCES

Alam, K. 2013. Factors affecting public participation in river ecosystem restoration: Using the contingent valuation method. J. Develop. Areas, 47(1): 71-89.

Bandara, R. and Tisdell, C. 2004. The net benefit of saving the Asian elephant: A policy and contingent valuation study. Ecol. Econ., 48(1): 56-63.

Barton, D.N. 2002. The transferability of benefit transfer: Contingent valuation of water quality improvements in Costa Rica. Ecol. Econ., 42(1-2): 111-121.

Bennett, J. 2006. Choice Modelling and the Transfer of Environmental Values. Edward Elgar, Cheltenham, UK, pp. 1-9.

Boyle, K.J. 2003. Contingent Valuation in Practice. In P. Champ, K. Boyle, and T. Brown (eds), A Primer on Nonmarket Valuation, Springer, Cham, pp. 111-169.

Boyle, K.J. and Bergstrom, J.C. 1992. Benefit transfer studies: Myths, pragmatism, and idealism. Water Resour. Res., 28(3): 61.

Boyle, K.J. and Bishop, R.C., 1988. Welfare measurements using contingent valuation: A comparison of techniques. American Journal of Agricultural Economics, 70(1): 20-28.

Carson, R. 2011. Contingent Valuation: A Comprehensive Bibliography and History. Edward Elgar, Northampton, M. A.

CEA. 2015. Status of 50,000 MW Hydro Electric Initiative. https://cea.nic.in/wp-content/uploads/hpi/2021/01/Status%20of%2050000.pdf

Champ, P.A., Boyle, K.J. and Brown, T.C. 2017. The Economics of Non-Market Goods and Resources: A Primer on Nonmarket Valuation. Second Edition. Springer, Cham.

del Saz Salazar, S. and García Menéndez, L. 2007. Estimating the non-market benefits of an urban park: Does proximity matter? Land Use Policy, 24(1): 631.

Desvousges, W.H., Naughton, M.C. and Parsons, G.R. 1992. Benefit transfer: Conceptual problems in estimating water quality benefits using existing studies. Water Resour. Res., 28(3): 675-683.

Downing, M. and Ozuna, T. 1996. Testing the reliability of the benefit function transfer approach. J. Environ. Econ. Manag., 30(3): 71-89

EDPS. 2020. Status of Ongoing and/or Completed Schemes. Energy and Power Department Sikkim. Available at: https://power.sikkim.gov.in/status-of-ongoing-andor-completed-schemes (Accessed December 26, 2020).

Freeman, A.M., Herriges, J.A. and Kling, C.L. 2014. The Measurement of Environmental and Resource Values. Third edition. RFF Press, Routledge, New York.

Gaur, R. 1999. Flora of the District Garhwal, Northwest Himalaya (with Ethnobotanical Notes). Transmedia, Srinagar, UP.

Haile, D.T. and Slangen, L. 2009. Estimating the willingness to pay for the benefit of AES using the contingent valuation method. J. Nat. Resour. Policy Res., 1(2): 545.

Hanemann, W.M., Loomis, J. and Kanninen, B.J. 1991. Statistical efficiency of double bounded dichotomous choice contingent valuation. Am. J. Agric. Econ., 73: 1255-1263.

Jeanty, P., Habb, T. and Hitzhusen, F. 2007. Willingness to Pay for biodiesel in Diesel Engines: A Stochastic Double Bounded Contingent Valuation Survey. Research in Agricultural and Applied Economics, Ohio, pp. 1-37

Johnston, R.J. and Rosenberger, R.S. 2010. Methods, trends, and controversies in contemporary benefit transfer. J. Econ. Surveys, 24(3): 69.

Johnston, R.J. and Wainger, L.A. 2015. Benefit transfer for ecosystem service valuation: An introduction to theory and methods. In: R. J. Johnston, J. Rolfe, R. S. Rosenberger and R. Brouwer (eds) Benefit Transfer of Environmental and Resource Values. pp. 273-237, Springer, Dordrecht.

Kanwal, K. and Joshi, H. 2010. Floral diversity assessment in four forest types of Garhwal Himalaya, Uttarakhand. Vegetos Int. J. Plant Res., 23(2): 76-85.

Kaul, S., Boyle, K.J., Kuminoff, N. V., Parmeter, C.F. and Pope, J.C. 2013. What can we learn from benefit transfer errors? Evidence from 20 years of research on convergent validity. J. Environ. Econ. Manag., 66(1): 41-50

Kirchhoff, S., Colby, B.G. and LaFrance, J.T. 1997. Evaluating the performance of benefit transfer: An empirical inquiry. J. Environ. Econ. Manag., 33(1): 141.

Krinsky, I. and Robb, A. 1986. On approximating the statistical properties of elasticities. The Rev. Econ. Stat., 68: 715-719.

Lewis, L.Y., Bohlen, C. and Wilson, S. 2008. Dams, dam removal, and river restoration: A hedonic property value analysis. Contemp. Econ. Policy, 26(2): 175-186.

Loomis, J.B. 1992. The evolution of a more rigorous approach to benefit transfer: Benefit function transfer. Water Resources Research, 28(3): 701-705.

Luken, R.A., Johnson, F.R. and Kibler, V. 1992. Benefits and costs of pulp and paper effluent controls under the clean water act. Water Resour. Res., 28(3): 89.

Mathieus, G., Suplee, M. and Blend, J. 2010. Final Report to the Environmental Quality Council on Progress Toward Numeric Nutrient Standards for Montana's Surface Water. https://leg.mt.gov/content/Committees/Interim/2009_2010/Environmental_Quality_Council/Meeting_Documents/July/deq-nutrient-report-2010.pdf

Mohammed, E.Y. 2009. Measuring the benefits of river quality improvement using the contingent valuation method: The case of the ping river, Chiang Mai, Thailand. J. Environ. Assess. Policy Manag., 11(3): 64-77.

Nallathiga, R. and Paravasthu, R. 2010. Economic value of conserving river water quality: Results from a contingent valuation survey in Yamuna river basin, India. Water Policy, 12(2): 54.

Pate, J. and Loomis, J. 1997. The effect of distance on willingness to pay values: A case study of wetlands and salmon in California. Ecol. Econ., 20(3): 14-28.

Richardson, L. and Loomis, J. 2009. The total economic value of threatened, endangered and rare species: An updated meta-analysis. Ecol. Econ., 68(5): 1535-1548.

Rolfe, J., Johnston, R.J., Rosenberger, R.S. and Brouwer, R. 2015. Introduction: Benefit Transfer of Environmental and Resource Values. Springer, Cham.

Rosenberger, R.S. and Stanley, T.D. 2006. Measurement, generalization, and publication: Sources of error in benefit transfers and their management. Ecol. Econ., 60(2): 541-552.

Weber, M.A. and Stewart, S. 2009. Public values for river restoration options on the Middle Rio Grande. Restor. Ecol., 17(6): 762-771.

Zhongmin, X., Guodong, C., Zhiqiang, Z., Zhiyong, S. and Loomis, J. 2003. Applying contingent valuation in China to measure the total economic value of restoring ecosystem services in Ejina region. Ecol. Econ., 44(2-3): 345-358.