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Valuating intangible benefits from afforested areas: A case study in India

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ABSTRACT: Environmental compensation measures usually accompany energy projects. Willingness-To-Pay (WTP) for five intangible benefits derived from afforested areas of a compensatory afforestation programme of National Thermal Power Corporation Dadri are estimated. Conventional Contingent Valuation shows the average WTP € 2.1 per respondent per month with more than 43 % of total WTP for 'soil conservation and remediation' and 'improvement in underground water level'. Logit model method depicts the same order of magnitude but differs significantly at 5 % level for all the benefits. More informed decisions upon energy projects and afforestation programs shall help in conserving forests and their ecosystem services.

KEYWORDS: Contingent valuation, India, Intangible benefits, Logit model, WTP.

Valoración de los beneficios intangibles de áreas forestadas: un caso de estudio en India

RESUMEN: Las medidas de compensación ambiental suelen acompañar a los proyectos energéticos. Se estima la disposición a pagar (DAP) por cinco beneficios intangibles derivados de áreas forestadas del programa compensatorio de la Corporación Nacional de Energía Térmica Dadri. La valoración contingente muestra que la DAP es de 2,1 € por encuestado al mes, con más del 43 % para "conservación y regeneración del suelo" y "mejora del nivel del agua subterránea". El modelo Logit muestra el mismo orden de magnitud, pero difiere significativamente para todos los beneficios. Decisiones más informadas sobre los programas efectivos de forestación ayudarán a conservar los bosques.

PALABRAS CLAVE: Beneficios intangibles, India, Modelo Logit, valoración contingente, DAP.

JEL classification / Clasificación JEL: H43, Q51.

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1. Introduction

A large forest area is diverted for non-forest activities in India, which include agriculture, power projects, industries, roads, railway lines, construction of dams and canals etc., resulting in large scale deforestation and land degradation. The Government of India has notified the assessment of the ecological and environmental loss in such areas and its recovery by mandatory compensatory afforestation and other compensatory measures from the organization responsible for this loss. National Thermal Power Corporation (NTPC), the largest energy conglomerate of India, has set up a power project in Dadri (India) with the aim to increase the electric capacity of India. Under the compensatory afforestation, plantations constituting 1.48 million trees were raised by NTPC during 1995-2010. They comprise mainly the broad leave plantations of *Azadirachta indica, Pongamia pinnata, Dalbergia sissoo, Albizia lebbek, Cassia siamea, Leucaena leucocephala, Acacia auriculiformis, Terminalia arjuna, Eucalyptus* hybrid*, Populus deltoids,* etc. Similarly, large scale plantations of tree species to sequester maximum amount of carbon and also to increase forest cover are being raised under different afforestation programmes in India, so that the people dependent on forests can derive more tangible (e.g. timber, fodder, etc.) and intangible (e.g. pollution control, increase in soil fertility, etc.) benefits.

The resulting forest ecosystems provide several intangible benefits to local people and it is often seen that these are ignored by policy makers as they are not registered in conventional markets or are difficult to measure and quantify. Therefore, it becomes important to valuate the tree plantations raised as compensatory afforestation by the industrial units taking into consideration both their tangible and intangible benefits.

Many studies on the assessment and valuation of intangible benefits arising out of natural and manmade forests have been carried out in developed countries. For example, Morales (1980) evaluated the direct and indirect residential property values due to the presence of trees in the town of Manchester along with the extent of contribution made by trees in the areas observed. The results showed that trees do contribute to property value in the areas observed. The EU study by Mantau *et al.* (2001) finds the relationship between recreational and environmental markets for forest enterprises and shows that where property rights can be established, there is a substantial scope for market development of environmental and recreational goods and services. Saastamoinen (1997) has estimated the total value of forests in Finland in the late 1990s and provides the monetary estimates of the intangible components of total value. The highest monetary value was found for the carbon storage component. The full suite of economic values was explored, thus increasingly expressing the role of forests as a multifunctional resource with many facets of economic value.

Early case studies in developing countries concentrated on the value of Non-Timber Forest Products (NTFPs) (Bishop, 1999). Recently, Ninan and Inoue (2013) conducted a large scale survey to assess the economic value of seven ecosystem services of forests in Japan. The highest value was assessed for the component of water conservation and purification followed by the component of air pollutant absorption. Other important studies on the valuation of intangible benefits have been conducted, namely, to estimate water services in developing countries (Whittington *et al.,* 1990); to estimate the recreational use value of forest resources of Kayabasi forest of Turkey; to value health effects of air pollution in developing countries (Alberini *et al.,* 1997); to assess forest management strategies in urban forests of Georgia (Majumdar *et al.,* 2011), etc. Besides, Costanza *et al.* (1997) estimated the total annual value of the world's ecosystem services at an average of US$ 33 trillion, and of global forests at US$ 969 per ha.

In India, no such study has been taken up for assessing important intangible benefits that arise through the various afforestation schemes, including compensatory afforestation. This paper deals with the valuation of important intangible socio-economic benefits arising out of the recreational value of the plantations raised by NTPC. The well-known contingent valuation method (CVM) and the logit model are used for the valuation purpose. In this paper, we focus on five identified intangible benefits such as Pollution Control (PC), Improvement in Underground Water Level (IUGWL), Soil Conservation and Remediation (SCR), Increase in Wildlife (IWL) and Eco-tourism (ET). These benefits were identified during a preliminary survey-cum-discussion with local people who depend upon the manmade forests raised by NTPC.

In the next section we describe the sampling methodology used to select the respondents along with some characteristics of the study area. This section also deals with an empirical model (utility difference model), which is based upon the logistic distribution (logit model) to estimate the people's mean and median willingness-to-pay (WTP). This section is followed by the results, and finally discussion and conclusions are presented.

2. Methods

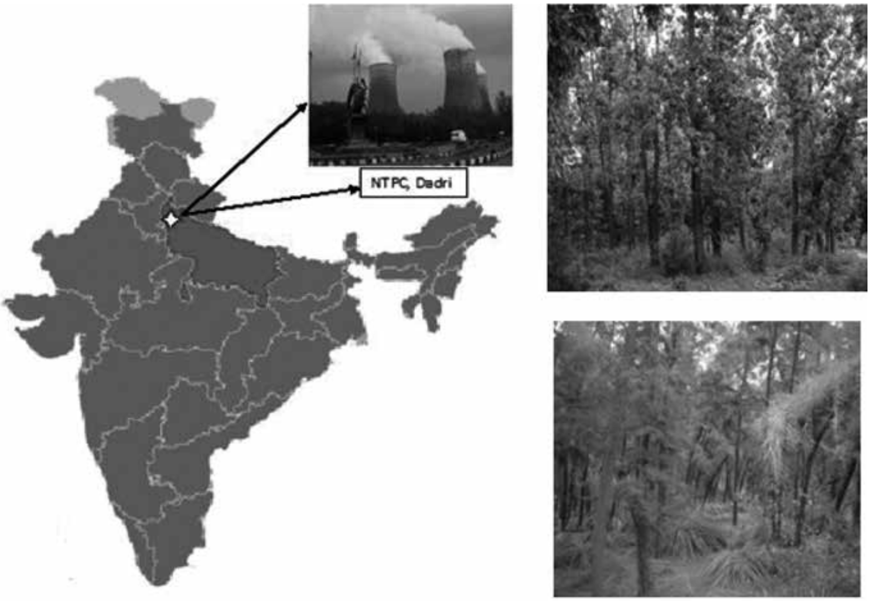
2.1. Study area

NTPC has set up a power project at Dadri (India) with a capacity of 2,637 MW on 2,465 acres of land. The station is situated on the Dadri-Dhaulana road, 10 kilometres away from Grand Trunk road and 12 kilometres away from the National Highway 24. The project is well connected with New Delhi (60 Km) and Ghaziabad (25 Km) by rail and road.

NTPC Dadri is a thermal based power project, which emits huge amount of greenhouse gases into the atmosphere due to burning of inferior quality coal. Under the compensatory afforestation programme of the Government of India, NTPC Dadri has raised large scale tree plantations in and around their premises. About 20 % of this area was covered under plantations, having 1.48 million trees been raised during 1995-2010. A simple map of the study area is shown in Figure 1.

FIGURE 1

Location map and plantation raised around NTPC, Dadri (India)



Source: Own elaboration.

2.2. Sampling methodology

The study area comprises the total area under 10 km radius from the centre of NTPC Dadri, and covers 120 villages with 14 households per village as an average. There are about 4 persons in each household in the study area. The area was divided into two zones -inner and outer- each having a radius of 5 km so as to receive a good representation of the respondents. A total of 10 villages were selected from each zone using simple random sampling without replacement. A set of 10 households were selected from each selected village based upon different household size categories. A total of 200 households in 20 selected villages were finally identified for the survey. Each household was contacted personally and the key respondent was selected, who typically represented one household or in some cases more than one household. The knowledge through personal talks and open-ended questionnaires about all the five intangible benefits due to the plantations raised around NTPC Dadri was obtained from these respondents. Total WTP, which comprises all these five benefits, is also estimated in the present study. All the respondents were invited for a one day scheduled workshop to get further in-depth knowledge, conduct personal interviews and fill in the questionnaire.

2.3. Logit model used

In the present study, we have used utility difference model (Hanemann, 1984) for estimating mean and median WTP. When the population gives a discrete dichotomous response, the indirect utility function is defined by the function in which the individual received utility from Income (*I*) and the percentage of gain/reduction of the corresponding intangible benefit due to plantation. This can be written as:

$$U = f(j, I; S) + \varepsilon_j \qquad [1]$$

Where *S* denotes some socioeconomic characteristics that are influenced by personal tastes. The value *j* is dichotomous and takes the values

$$j = \begin{cases} 1, \text{ when the respondent would pay the bid amount (Say, Indian Rupees (Rs) A)} \\ 0, \text{ when the respondent would not pay the bid amount or does not respond} \end{cases}$$

Using Equation [1], the values of U for both values of *j* can be written as

$$U = \begin{cases} f(1, I; S) + \varepsilon_1, \text{if } j = 1 \\ f(0, I; S) + \varepsilon_0, \text{if } j = 0 \end{cases}$$

where ε_1 and ε_0 are independent and identically random variables with zero means and *I* -*A* represents balance income after the bid amount of Rs *A* to be paid[1].

In terms of utility gain, the respondent will pay the amount *A* if the utility difference $\Delta f = f(1, I; S) + \varepsilon_1 - f(0, I; S) + \varepsilon_0$ is positive. For calculation, it is assumed that Δf is logistically distributed. Therefore, the corresponding logit model for any prescribed intangible benefit will be

$$Logit(\pi_i) = \log\left(\frac{\pi_i}{1-\pi_i}\right) = \beta_0 + \beta_1 A + \beta_2 Z_1 + \ldots + \beta_n Z_n \qquad [2]$$

where $\pi_i = Prob(Yes) = (1 + \exp(-\Delta f))^{-1}$ and the *Z* variables are the socioeconomic independent variables (main variables) taken for the study. These are given in Table 1. These variables are considered as independent from each other and hence the interaction effect is omitted from the analysis. A Logit model is preferable over conventional CVM because it maintains the stability and compatibility of theoretical constraints, statistical efficiency and congregate ability (White and Lovett, 1999).

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[1] The exchange rate between Indian Rupees (Rs) and Euro (€) at the time of submission of this article is Rs 1= 0.014 €.

TABLE 1

Definition of variables

Age	Age of the respondent (scale variable)
Education	Years of education of the respondent (scale variable)
Occupation	Dummy variable on whether a respondent has a government job, a private company job, a reputed business etc. (excluding students/farmers/labourers) or not. 1 denotes Yes and 0 denotes No (Categorical variable)
Income	Average monthly household income in Rupees (scale variable)
Bid	The bid amount (in Rupees) asked to pay (scale variable)

Source: Own elaboration.

In case of unknown Δf , $\pi_i = \frac{m_i}{m}$, where m_i and m - m_i denote the number of respondents willing and not willing to pay Rs *A* respectively. In the present paper, the estimate of mean WTP (Table 2) after rounding off the integer at unit place is taken as the value of *A* for logit model. For example, the value of *A* for WTP (PC) from Table 2 is chosen as Rs 120. However, any value of *A* in the range of WTP of respondents may be taken as per the choice of the researcher.

Recognizing that WTP is a random variable with a cumulative distribution function, *G(A)*, and can be expressed as

$$WTP = \int_0^\infty \left(1 - G(A)\right) dA$$

Under the logit model, the mean and median WTP, following Hanemann (1989, p. 1059), is calculated as:

$$Mean\,WTP = \frac{Log\left(1 + \exp(\alpha)\right)}{B} \qquad [3]$$

$$Median\,WTP = \frac{\alpha}{B} \qquad [4]$$

Where α is the product of the coefficient and mean values of all the independent variables excluding the bid coefficient, and *B* is the absolute value of the bid coefficient.

For the purpose of statistical analysis and mathematical calculations we used STATISTICA and MS Excel software while Cox and Snell R^2 have been calculated using SPSS software.

3. Results

3.1. Data collection and descriptive statistics

A total of 81 respondents, representing the 200 selected households, finally participated in the one-day scheduled workshop for WTP estimation purpose. This is the effective sample size which does not contain several similar respondents. All these respondents were well aware about the intangible benefits/CVM as they had deeply gone through the literature provided to them and the presentations given by the experts before filling in the questionnaire. The respondent format as suggested by NOAA panel (Arrow *et al.,* 1993) (with some relevant modifications) was used. The format included the baseline information and the columns regarding WTP for each category under study. Only 3 respondents protested with no response about their WTP and 2 respondents were found to state zero WTP. The columns pertaining to WTP sought response through open-ended approach with questions like "What is your maximum WTP for each benefit?" Descriptive statistics of important socioeconomic variables and WTP are shown in Table 2.

TABLE 2

Descriptive statistics for socio-economic (explanatory) variables and willingness to pay stated by the respondents

Variables	Mean (St. Dev.)	Min.	Max.
Age (years)	48.5 (16.0)	18	80
Education (in years)	10.1 (3.9)	5	16
Income (annual in Rs)	105,686.4 (107,974.7)	20,000	8, 00,000
WTP (PC) (Monthly in Rs)	118.5 (54.2)	44	323
WTP (IUGWL) (Monthly in Rs)	129.4 (72.5)	39	353
WTP (SCR) (Monthly in Rs)	134.5 (70.8)	57	391
WTP (IWL) (Monthly in Rs)	110.2 (55.9)	17	306
WTP (ET) (Monthly in Rs)	114.3 (55.5)	23	301
WTP (Total) (Monthly in Rs)	606.9 (214.5)	412	1,045

Source: Own elaboration.

This table shows that the average age is 48.5 years; the number of years of education is 10.1 with household income of Rs 105,686.40 per year. The total WTP estimate per person is Rs 152 (with an average of 4 persons per household) for the plantations raised by NTPC at Dadri, out of which the WTP range among components is observed from Rs 110.2 (for IWL) to Rs 134.50 (for SCR) per month. The actual estimates and pattern of these benefits can be seen in subsequent sections, in which the improved WTP is calculated using a logit model.

3.2. Estimation and analysis of WTP responses

We began with the logistic regression model [2], in which the selected variables given in the Table 1 have been used. The results of the logit model for the estimated coefficients, the effect of independent variables on the dependent variable based on maximum likelihood estimation, are presented in Table 3. In all logit regressions, the bid variable is itself negative and statistically significant at 5 % level, indicating that as soon as we increase the proposed amount of bid and ask to pay, less respondents would be willing to do it. This proves the internal validity of CVM responses. If we focus on the total WTP, the occupation has the highest positive value (11.89) which indicates that the most important variable for accepting the proposed bid amount is occupation, except for students/farmers/labourers. This indicates that respondents identify themselves according to their occupation rather than the total income. Another important factor for accepting the bid is the age of the respondents. Older people are willing to pay more for conservation of the environment. The reasons might be the ecological and environmental security for their next generations. At the same time education does not affect much the individual's WTP, which verifies our perception that the educated people would like to migrate in search of more income generation. In addition, we have also calculated Cox and Snell coefficient of determination for each of the benefits, which suggests from Table 3 that the explanatory variables of the model explained the dependent variable very well.

We have calculated both mean and median WTP using the equations [3] and [4] based upon the principle of maximum likelihood: These values for each of the benefits are presented in the Table 4.

In Table 4, the mean and median WTP for each of the benefits are almost the same. A high value of WTP was found for SCR and IUGWL which might due to the fact that the station is surrounded by villages and most of the villagers are farmers, who cultivate agricultural crops in different seasons. Since activities like soil conservation and underground water table are directly related to agriculture and farmers' fields, the participants gave maximum importance to these components. Other important benefit is PC, because the power station is a pollution generating unit and most of the air borne diseases in the villages is caused by air pollution. WTP for ET and IWL is lower because eco-tourism is not publicly allowed in the station and wildlife is mostly confined to NTPC premises only.

TABLE 3

Estimated coefficients using logit model for all benefits

Benefits		PC	IUGWL	SCR	IWL	ET	Total
Intercept	Coefficient (SE x E 3)	467.14* (84.95)	309.66* (67.77)	1063.94* (212.74)	662.39* (152.49)	697.22* (148.00)	62.20* (22.40)
	Statistic t	-85.42	-69.29	-80.46	-62.49	-74.26	-433.43
Age	Coefficient (SE x E 3)	-0.56 (0.34)	0.52 (0.50)	-0.18* (0.58)	0.10 (0.36)	-0.39 (0.45)	0.13* (0.23)
	Statistic t	-0.02	-1.16)	2.12)	1.37	-0.28	2.07
Education	Coefficient (SE x E 3)	0.47 (1.12)	1.31 (1.67)	-5.79 (4.86)	-3.89 (4.81)	-2.64 (1.11)	-0.32* (1.27)
	Statistic t	-0.79	0.62	0.82	-1.25	0.13	-0.14
Occupation	Coefficient (SE x E 3)	-2.15 (17.01)	6.02 (5.51)	-23.87 (128.89)	-32.83 (18.36)	-6.67 (33.10)	11.89 (4.78)
	Statistic t	-0.01	0.79	-0.33	-0.71	-1.80)	-1.21
Income	Coefficient (SE x E 3)	-1.05E-05 (1.01E-5)	-1.10E-05 (1.20E-5)	1.40E-05 (1.00E-5)	-6.01E-05 (2.02E-5)	1.01E-6 (1.00E-4)	1.20E-6 (1.10E-5)
	Statistic t	0.02	-0.09	-1.76	0.84	-2.53*	-0.37
Bid	Coefficient (SE x E 3)	-4.08* (0.70)	-2.99* (0.53)	-8.56* (1.35)	-5.77* (1.19)	-6.32* (1.49)	-0.12* (0.04)
	Statistic t	27.49	24.14	22.02	21.95	24.83	61.15
-2log likelihood		3.85E-6	3.67E-6	3.97E-5	7.45E-6	7.39E-6	1.90E-7
Cox and Snell R^2		0.75	0.75	0.75	0.75	0.75	0.73

Note: $E \pm x$ denotes $10^{\pm x}$, * means significantly differ at 5 % level of significance.

Source: Own elaboration.

TABLE 4

Mean and median monthly WTP estimates for all benefits

Benefits / Monthly WTP	PC	IUGWL	SCR	IWL	ET	Total
Mean (Median)	107.47 (107.45)	114.38 (114.29)	118.45 (118.35)	96.00 (95.99)	102.99 (102.91)	572.75 (572.71)

Source: Own elaboration.

We have also used X^2 test to check the significance of the difference between the WTPs calculated by conventional CVM and logit model method. Table 5 shows that all the benefits significantly differ at 5 % level.

TABLE 5

Chi square test for different WTPs

Benefits	PC	IUGWL	SCR	IWL	ET	Total
X^2 value at 80 df	2280.73	3835.18	3565.82	2775.14	2493.22	6590.74
p value	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Source: Own elaboration.

4. Discussion and conclusion

The application of logit model to calculate individual's WTP on community plantations in and around one of the major power plants in India shows the understanding of how valuable the plantations raised by NTPC are and for which components are highly beneficial. Such an understanding has gradually been developed as the local people began to realize the extent of plantations of broad leaved species in their area and hence, the need for their conservation. As a result, people are ready to pay about 7 % of their income for the conservation of these five benefits for them and their future generations' livelihood and income. This amount may however contain some random error like part-whole bias or hypothetical error, but still people show their high keenness to value the forest ecosystem. We have found that the SCR is the largest component for WTP. This indicates that there is a linear trend of traditional perception about the dependency on soil and hence on agriculture by the local people. WTP for SCR does not depend much positively on other explanatory variables except income (which is too low). The importance of soil conservation for farmers using the WTP approach was already flagged by various researchers (e.g. Norris and Batie, 1987; Tessema and Holden, 2006; Breffle *et al.,* 1998).

The second largest component of WTP *i.e.* IUGWL may be linked to the fact that respondents having better occupation and education than those of India's average, are more aware about the role of plantations of broad leaved species in increasing the groundwater level. However, the remaining WTP components depend mostly on the traditional approach inherited from earlier generations. In general, the total WTP depends more on the occupation. Whenever the occupation status is high, the total WTP is also high and more tendency to conserve the environment is observed. Similar results were found by Tao *et al.* (2012).

The total WTP calculated by conventional CVM method is simply the sum of WTPs of all the components, which is not the case for the WTP found by the logit model. The reason is that the likelihood function of sum of explanatory variables is not equal to the sum of their individual likelihood functions. Our total WTP estimate using logit model exceeds the sum of components' WTPs, which differs from the case of Hoehn and Randall (1989), Mitchell and Carson (1989) and Bateman *et al.* (1997). This might be due to considering only the individual effects (not joint (interaction) effect) of the variables under study. The interaction effect is not part of the case, due to the assumption that the socioeconomic variables considered in the present study are independent with each other.

The results of this study may provide a great help to the policy makers on raising plantations of broad leaved tree species before the installation of power or similar projects in the state or other parts of the country. One of the important results of Amiri *et al.* (2015) shows that it is required to educate the local population about proper harvesting methods and management of the important tree plantations by trained field experts, which validates our results. Therefore, the proper management and policies, together with the necessary financial and administrative support, are an opportunity for the provincial economy and an increase in employment may be enhanced.

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