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ECONOMIC VALUATION OF CULTIVATION OF MANGROVES: A WILLINGNESS TO WORK STUDY USING ZERO INFLATED POISSON DISTRIBUTION

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SUMMARY

Mangrove forests' contribution to the coastal biodiversity is invaluable. They serve as habitat for marine flora and fauna and also cleanse the water. They act as breeding ground to many fish species. Still the mangroves are destroyed large scale for aquaculture farming and also for tourism industry. We have conducted a contingent valuation survey to study the willingness of coastal fishermen community in Uttara Kannada district of Karnataka, India to contribute towards the cultivation of mangroves. Zero Inflated Poisson model was used to estimate the number of days fishermen willing to work. We have also identified the factors influencing their decision to participate or not to participate in the program.

Keywords: *Contingent Valuation, Willingness to Work, Zero Inflated Poisson Distribution, Model Based Estimator.*

1. INTRODUCTION

Mangrove forests are one of the most productive and bio-diverse wetlands on earth. Mangroves stilt-like roots slow the water flow down, causing the water to drop its sediments and build up land along the coasts where it grows. It cleanses the water by filtering it and by causing carried materials to be stored in the mud (Gautier, Amador and Newmark, 2001). Growing in the inter-tidal areas and estuary mouths between land and sea, mangroves provide critical habitat for a diverse marine and terrestrial flora and fauna. Mangrove swamps are the breeding ground for many fish species and the little ones are partially protected from big predators by its stilt-like roots. The tree can grow in salty or brackish water that would kill almost any other plant. There it builds a rich ecosystem with different plant and animal species including migratory birds. Mangrove roots form dense matting on the ground and act like a natural coastal wall to protect the seashore from sea erosion. However, these unique coastal tropical forests are among the most threatened habitats in the world. They may be disappearing more quickly than inland tropical rainforests, and so far, with little public notice (FSI, 2001).

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In many areas of the world, mangrove deforestation is leading to fisheries decline, degradation of clean water, salinization of coastal soil, erosion as well as the release of carbon dioxide into the atmosphere. In fact, mangrove forests fix more carbon dioxide per unit than phytoplankton in tropical oceans. Mangroves are also observed to break the energy of ocean storms, winds and waves. It was observed that during the Christmas 2004 tsunami which devastated parts of Indonesia, India, Sri Lanka and Thailand, in areas where the mangrove swamps were intact along the coast, the damage was minimal or non-existent (Kathiresan and Rajendran, 2005). This has led to an increasing awareness regarding the cultivation of mangroves among the coastal regions of south India.

Many factors contribute to mangrove forest loss, including the charcoal and timber industries, urban growth pressures and mounting pollution problem. However, one of the significant causes of mangrove forest loss in the past decade has been the consumer demand for luxury shrimp, or 'prawns'. Shrimp aquaculture has been an important cause of the conversion of mangroves in India in the last decade (Holmgren, 1994). For the expansion of shrimp culture vast areas of mangrove forests have been cleared and the government stood as a silent spectator owing to the high demand for shrimp in international market and the huge revenue it earned from the shrimp export.

But the outbreaks of virus disease, mainly due to the water pollution proved that the great earnings from shrimp culture are short lived and a good environment is a vital thing for its survival. The Marine Products Export Development Authority (MPEDA) and the state of Karnataka, India have a scheme of planting mangrove trees around shrimp farms to encourage eco-friendly green shrimp farming. Some of the perceived benefits of planting mangroves around shrimp farms include improved water quality and environment, improved nutrition and breeding, reduction in health management costs and improved growth. We have carried out a contingent valuation survey among the coastal fisherman and fisherwomen from Uttara Kannada district of Karnataka, India to assess their willingness to work on mangrove cultivation and restoration project. In this paper we present the estimated willingness to work (WTW) for the cultivation of the mangroves by the fisherman community and the factors which influence their willingness to work. The main objectives of the study are; to estimate the average WTW and to build up econometric models to identify the factors which are responsible for the WTW.

In our study we collected information from the fishermen community on the number of days they are willing to work for mangrove reforestation project. Here the observations are discrete in nature. We found large number of zero observations or people not willing to contribute towards the cause. This prompted us to use an inflated zero distribution to model our data. Zero inflated Poisson distribution was used to analyze the data as we found the data follows the distribution. Although inflated distributions are not used in CV studies, they find many applications in other areas. Zero inflated distributions are used in the analysis of data on road safety (Miaou, 1994), sexual behavior (Heilbron, 1994), migration (Bohara and Krieg, 1996), species abundance (Welsh, Cunningham, Donnelly and Lindermayer, 1996). The results indicate that the fishermen and fisher women are willing to spend 0.44 days for the mangrove restoration project. Age, education and household size were observed to be two factors influencing their willingness to work and the average WTW from the zero inflated Poisson (ZIP) regression.

The organization of the paper is as follows. Section 2 describe about the sample survey and survey methodology. The average WTW using the model-based estimator is presented in Section 3. Section 4 analyses the factors influencing respondents' willingness to work. Conclusions are presented in Section 5.

2. SAMPLE SURVEY

The contingent valuation survey was conducted in the coastal district of Uttara Kannada of Karnataka state, India. The district is in the northern part of Karnataka coastal line which is 320 km in length. Kali, Gangavali and Aghanashini are three major rivers which enter Arabian Sea flowing through this coastal district. Survey respondents were selected randomly from the Aghanashini river belt comprising of Nandangadda, Sunkeri, Kadwad, Halga, Asnoti, Kanasgeri and Mavinhole villages. Data was collected from 400 fishermen and fisherwomen on their willingness to work for mangrove cultivation, their socio-economic conditions and other demographic details.

A pre-test survey was conducted in the study area before carrying out the actual survey. From the pre-test survey we decided to collect information on respondent's willingness to work rather than their willingness to pay due to their poor economic conditions. In this discrete setup we directly asked the respondents, the number of days they are willing to work for the cause, rather giving them any pre-determined bids.

During the survey it was observed that the fishermen community is aware of the utilities of mangroves. They know that mangrove forests provide marine habitat and breeding ground for fishes, crabs and shrimps. Still during the survey we detailed the respondents on the benefits of mangroves and the value it adds to the biodiversity to make sure that they answer the WTW question with complete awareness. Also it was made clear that the mangrove reforestation project will not give them any monetary benefit.

3. ESTIMATION OF THE AVERAGE NUMBER OF DAYS WILLING TO WORK

The number of days the respondents are willing to work for the cultivation of mangroves is a discrete variable. The sample mean of the survey data works out to be 0.50 and the sample coefficients of skewness and kurtosis are 1.40 and 0.36 respectively. Chi-square goodness of fit test indicated that an inflated Poisson distribution fits the data well. The calculated chi-square test statistic was 4.31 with 3 degrees of freedom. Descriptive statistics of the socio-economic variables for the survey respondents are given in Table 1.

TABLE 1. - *Descriptive Statistics of the co-variate variables*

Covariates	Mean	SD	Minimum	Maximum
Age	40.3	8.9	20.0	60.0
Annual Income	62,100	14,019	50,000	1,20,000
Household size	5.5	1.7	2.0	12.0
Education (years)	5.9	3.2	0.0	15.0

In any contingent valuation study, the primary objective is the estimation of the average number of days willing to work (or the average amount willing to pay). This average will enable us to work out the economic valuation of the project under consideration.

The mean number of days willing to work has been estimated using inflated Poisson distribution. The density function, mean and variance of the inflated Poisson distribution are;

Let $Y_1, Y_2, \ldots, Y_n$ be a sample from inflated Poisson distribution with density

$$P(Y=y) = \begin{cases} (1-p) + p\exp(-\lambda) & y = 0 \\ p\exp(-\lambda)\lambda^y/fact(y) & y = 1, 2, \ldots \end{cases}. \tag{1}$$

The maximum likelihood (ml) equation for the estimation of p and λ are given by;

$$\frac{\partial \log L}{\partial p} \Rightarrow \frac{n_0[-1+\exp(-\lambda)]}{(1-p)+p\exp(-\lambda)} + \frac{(n-n_0)}{p} = 0, \tag{2}$$

$$\frac{\partial \log L}{\partial \lambda} \Rightarrow \frac{-n_o p \exp(-\lambda)}{1-p+p\exp(-\lambda)} - (n-n_0) + \frac{\sum_{yi>0} Y_i}{\lambda} = 0. \tag{3}$$

From (2) we get,

$$\hat{p} = \frac{(n-n_0)}{n(1-\exp(-\lambda))}. \tag{4}$$

Substituting (4) in (3) we get,

$$\frac{\hat{\lambda}}{1-\exp\left(-\hat{\lambda}\right)} = \bar{Y}, \tag{5}$$

where $\bar{Y}' = \frac{\sum_{yi>0} Y_i}{(n-n_0)}$ and n_0 denotes the number of zeros.

The mean μ and variance for the inflated Poisson distribution are given by

$$\mu = p\lambda, \tag{6}$$

and variance,

$$Var(Y) = p\lambda(\lambda(1 - p) + 1). \tag{7}$$

The mean WTW estimated from the zero inflated Poisson model is 0.46.

4. FACTORS INFLUENCING THE WILLINGNESS TO WORK

Identification of the factors that are responsible for the choice of the respondents to pay or not pay for the project is also an important part of any CV study. This aspect becomes important in the studies concerning environmental issues or conservation of forest, etc., where the respondents do not get a direct benefit out of the project. Cultivation of mangroves comes in this category where the benefits are eventually transferred to the community rather than to any individual member.

In order to identify the factors influencing the number of days willing to work, regression analysis was carried out. As reported in the beginning of this paper, the observations are discrete in nature and therefore regression analysis was carried out using zero inflated Poisson (ZIP) distribution. Prior to the pioneering work of Lambert (1992), the inflated distributions were of limited applications. Since then, many papers have appeared using models based on zero inflated distributions.

In any count regression, the conditional mean $E(y_i/x_i)$ of the dependent variable, y_i is assumed to be a function of a vector of covariates, x_i. We used age, income, number of years of education and household size as explanatory variables and the number of days willing to work as the response variable.

For the logit link function for p and log link function for λ, the same explanatory variables were used to link the response variable to the explanatory variables. The logit link function for p and log link function for λ are specified as,

$$p_i = \log\left(\frac{p_i}{1 - p_i}\right) = \beta_0 + \beta_1 x_{i1} + ... + \beta_k x_{ik} + u_i. \tag{8}$$

$$\log(\lambda_i) = \gamma_0 + \gamma_1 x_{i1} + ... + \gamma_k x_{ik} + \varepsilon_i. \tag{9}$$

where u_{i} and ε_i are independently distributed with variances σ_u^2 and σ_ε^2.

Intercooled STATA version 9.2 was used for carrying out the ZIP regression analysis. The results of regression analyses are summarized in Tables 2 and 3.

Household size, age and education were found to be significant for log link function of λ. For logit link function of p, education and household size were the variables found to be significant at 10% significance level. When income was included as a covariate for the logit link function of p, the model was not converging and thus income was not considered as a covariate for p. ZIP regression analysis indicated that age and education are negatively related to mean WTW while household size is positively related. Education and age had a negative sign for the logit link function for p which indicates education and age are inversely related to willingness to work. Most of our respondents were school dropouts and thus the education they received was

TABLE 2. - *Regression coefficients and its significance from ZIP regression using log link function for λ*

Covariates	**ß Coefficient**	**SE**	**p value**
Constant	16.15	1353.09	0.99
Age	–0.04	0.02	0.07
Income	–15.55	1353.09	0.99
Household size	0.36	0.15	0.02
Education (years)	–0.17	0.09	0.06

TABLE 3. - *Regression coefficients and its significance from ZIP regression using logit link function for p*

Covariates	**ß Coefficient**	**SE**	**p value**
Constant	4.23	6.72	0.53
Age	–0.42	0.27	0.13
Household size	3.88	2.31	0.09
Education (years)	–2.30	1.31	0.08

not significant enough to influence their environmental consciousness. This might be the reason for education not having a positive influence to their willingness to work.

5. CONCLUSION

In this paper we studied the willingness of coastal fisherman to participate in a mangrove reforestation project. We have also estimated the average number of days the fishermen and fisherwomen are willing to work using zero inflated Poisson distribution. The average number of days works out to be 0.46 days. Further, the results indicate that 59% to 62% of respondents are not ready to work for the cause. One of the reasons for this moderately large percentage of fishermen and fisherwomen not willing to work may be that the benefits are transferred to the community and they are not going to get any economic benefit individually. Among those people who are not willing to work, age and the number of years of education were observed as the significant factors influencing their decision as shown by logit link function of p in zero inflated Poisson regression. Again, for those who are willing to work, age, education and household size were found to be the influencing factors (as evident from log link function of λ in ZIP regression).

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