JOURNAL OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT **31,** 129–144 (1996)
ARTICLE NO. 0036

# Tropical Forest Protection: An Empirical Analysis of the Costs Borne by Local People[1]

PRIYA SHYAMSUNDAR

*John D. and Catherine T. MacArthur Foundation, 140 S. Dearborn Street, Chicago, Illinois 60603-5285*

AND

RANDALL A. KRAMER

*School of the Environment, Box 90328, Duke University, Durham, North Carolina 27708*

Received July 8, 1994; revised July 7, 1995

Contingent valuation is used to value tropical forest resources for a rural population in Africa. Welfare losses from land-use restrictions associated with a newly established national park in Madagascar are estimated with a willingness-to-accept format. Because of a limited local cash economy, the contingent valuation question is denominated in baskets of rice. The analysis indicates that contingent valuation can be successfully applied to rural households within the developing country context. The econometric analysis undertaken reveals a systematic association between various socioeconomic variables of interest and the expressed willingness-to-accept compensation for foregone land use. 

## INTRODUCTION

The loss of tropical forests is currently a cause of global concern. Preliminary results from a Food and Agriculture Organization study indicate that tropical deforestation occurred at an annual rate of 0.9% during the 1980s, which was an increase over the 0.6% annual rate of deforestation estimated for the 1976–1980 period [36]. In an effort to stem tropical deforestation, several initiatives have been undertaken at the national and international levels. One response has been to set aside certain areas of land as protected areas.[2] In developed countries, the establishment of a national system of parks and preserves has been a fairly successful strategy for protecting natural areas from exploitation. However, over the last decade, it has become increasingly apparent that this strategy for conservation does not work as well in poor tropical countries with high population growth rates.

A primary factor acknowledged as a constraint to the successful establishment of protected areas in tropical countries is the lack of clear linkages between the

[1]We thank Paul Ferraro, Tom Holmes, Evan Mercer, Mohan Munasinghe, Narendra Sharma, Kerry Smith, other colleagues, referees, and workshop participants at the World Bank, North Carolina State University, and Duke University for their comments and contributions. We also thank the survey team from SA.FA.FI. for administering the survey and we thank the survey participants.

[2]As of 1990, 4.8% of national land area in the world was protected [36].



0095-0696/96 $18.00

well-being of local residents and conservation efforts undertaken in protected areas [29, 6]. Historically, protected areas were established (often by colonial powers) with little regard to local conditions. However, over time, it has become evident that successful protection is unavoidably linked with the satisfaction of local needs. Local residents are dependent on protected areas for a variety of reasons. Very often conservation efforts conflict with local subsistence demands, and this erodes any protective measures undertaken.

This paper presents the results of a study undertaken to develop and test a methodology for understanding the economic linkages between the use of tropical forests by local residents and institutional measures taken to protect these forests. The results are reported from a contingent valuation study of households in villages around the Mantadia National Park in eastern Madagascar. More specifically, a willingness-to-accept (WTA) format is used to estimate the loss to rural households from no longer having access to a large area of forest lands.

Contingent valuation is a commonly used methodology for estimating the value of environmental and public goods in western economies. The fastest growing literature in non-market valuation is on the contingent valuation method (CVM) [27]. However, there are very few examples of the use of the CVM in developing countries. Studies by Whittington *et al.* [30, 31], and Briscoe *et al.* [2] on the demand for water supplies are some of the few contingent valuation experiments undertaken within developing economies. This paper seeks to explore further the potential for undertaking valuation exercises in a developing country context. This is done by using baskets of rice, and not money, as a numeraire for asking survey questions and assessing welfare loss. The possibility of using a well accepted, though non-monetary, numeraire allows us to expand the scope of non-market valuation techniques to parts of the world that are primarily rural and relatively less monetized.

## STUDY SITE

Located off the southeast coast of Africa, Madagascar is the fourth largest island on earth. The population of Madagascar is 12 million and growing at a rate of 3.18% per annum [36]. With a GNP per capita of $190 per annum, Madagascar is the twelfth poorest nation in the world [9]. The agricultural sector in Madagascar employs 85% of the labor force. Agriculture also constitutes 80% of Madagascar's exports and 35% of its GDP [33].

While economically poor, Madagascar is considered one of the biologically richest countries in the world. It is primarily known for its high rates of endemism. It is estimated that 150,000 of Madagascar's 200,000 species are found nowhere else on this planet [35]. However, Madagascar is fast losing this biological wealth due to rapid deforestation [12].

This study focuses on the Mantadia National Park, which covers an area of 9,875 hectares representative of the eastern humid tropical forests. The park contains a number of threatened species of flora and fauna, including a population of the indri (*Indri indri*), the largest known extant lemur in Madagascar [16]. While there are no human settlements currently within the park boundaries, several villages lie in close proximity. There are approximately 10,366 people who live within the *fokontony* (clusters of villages) closest to the park [25]. These people are primarily forest farmers; i.e., they depend on forested lands for swidden agriculture (shifting cultivation) and for foraging forest products [8]. The area within the newly established park is no longer available for these activities. As a result, villagers have lost access to a large area of land used or potentially used for economic activities [34].

## THEORY AND METHODS

### *Theoretical Framework*

The establishment of the Mantadia National Park resulted in a change in the total area to which households had access for agricultural purposes and for obtaining forest products. Without the park, the average household is assumed to have had access to $T_0$ hectares of land. With the establishment of the park, the household retained access to only $T_1$ hectares of land. This loss in accessible land can be expected to have had a direct impact on production and consumption, and therefore on welfare.

The welfare loss as a result of the park can be established by considering the household's expenditure function. The expenditure function is defined as

$$e(p, U_0, T_0) \tag{1}$$

where $U_0$ is the maximum obtainable utility without the park, given a vector of prices $p$, and land availability $T_0$. Thus, the expenditure function $e(\cdot)$ gives the minimum amount of income required by the household to obtain the "without park" utility level. A change in accessible land from $T_0$ to $T_1$ results in a change in the maximum utility obtained by the household, and therefore in a change in the minimum expenditure required to obtain the utility level $U_0$. One money measure of the welfare change attributable to a quantity change in a publicly supplied or regulated good is the difference in the minimum expenditure required to maintain the original level of utility [1, 23]. This welfare change, commonly referred to as the Hicksian compensating surplus [23], is given by

$$e(p, U_0, T_0) - e(p, U_0, T_1), \tag{2}$$

where $e(p, U_0, T_1)$ is the minimum expenditure required to obtain the "without park" utility level $U_0$, given that the park is established and the amount of land available is $T_1$ and not $T_0$.

If a market for land existed, the loss in welfare could be approximated by considering land prices. However, because of the lack of trade in land, the value of the welfare loss from lost access to land is established by using contingent valuation. Let $\mathrm{WTA}_i$ be the amount of income household $i$ will need as compensation to make it as well of without the park as it was with the park. Thus $\mathrm{WTA}_i$ is defined by the relationship

$$\mathrm{WTA}_i(\cdot) = e(p, U_{0i}, T_{1i}; s_i) - e(p, U_{0i}, T_{0i}; s_i) + \epsilon_{1i} - \epsilon_{0i}, \tag{3}$$

where $s_i$ refers to a vector of socio-economic characteristics of household $i$. The household expenditure function is assumed to be known to households, but is known with a margin of error $\epsilon_i$ to investigators. Consequently, $\mathrm{WTA}_i$ can be specified as a random variable that is a continuous function of a number of different variables that appear in the expenditure function. $\mathrm{WTA}_i$ can be expressed as

$$\mathrm{WTA}_i = X_i \beta + \eta_i \quad \eta_i \sim (0, \sigma^2), \tag{4}$$

where $X_i$ is a vector of explanatory variables. The error term $\eta_i$ ($\eta_{1i} = \epsilon_{1i} - \epsilon_{0i}$) is distributed normally with mean 0 and standard deviation $\sigma$. The variables hypothesized to explain changes in the WTA function include household size $X_1$; a dummy variable $X_2$ that reflects preference for forests over buffer zones around the forests; a dummy variable $X_3$ that reflects gender differences in the collection of a forest product; annual household coffee production $X_4$, which acts as a proxy for household money income; and a series of dummy variables ($X_5$ to $X_9$) reflecting locational differences of households.

All of the explanatory variables are hypothesized to influence the valuation function $\mathrm{WTA}_i$ by affecting household utility. Furthermore, because of the subsistence nature of this economy, the explanatory variables can also influence the WTA bid function by influencing the price vector $p$ [26]. For example, household size ($X_1$) can influence the expenditure function by resulting in an increase in labor supply, which has a direct impact on household production and income, and by increasing household consumption demand through any shadow prices that affect demand. The overall effect of household size is therefore difficult to establish a priori.

$X_2$ refers to household preferences toward buffer zones around the park that the government had plans to establish. These buffer zones could potentially allow households to undertake traditional and new income generating activities in areas outside the park.[3] Households willing to use buffer zones are more likely to be willing to accept compensation.

The dummy variable $X_3$ refers to a gender specific activity related to forest use. In particular $X_3$ refers to whether or not male heads of household collected bamboo, a forest product used for house construction and water storage. Because it reflects prevailing cultural attitudes and household labor allocation practices, its effect on the WTA bid is difficult to sign. Next, the effect of an increase in coffee production on WTA can be expected to be positive because of the higher opportunity costs involved. Finally, the different locational dummy variables will affect the WTA bid depending on the extent to which regional differences exist in loss of access to park lands.

### *The Contingent Valuation Format*

There are two important methodological considerations that emerge because of the subsistence nature of the economy. These relate to the use of the WTA format rather than the WTP format, and the choice of the method used to elicit the CV response.

There has been considerable debate in the CVM literature about the discrepancy between theoretical predictions and empirical findings on WTA and WTP [18,

[3]At the time of this study, the Forest Department had started projects in some villages to engage people in non-traditional ‘‘buffer zone’’ activities.

19, 24, 32]. Robert Willig [32] first demonstrated that for price changes there were theoretical grounds to expect WTA and WTP to be fairly close to each other. Kahneman and Tversky [18, 19] provided an alternative psychological explanation based on how humans value gains and losses, and argued that WTA would be greater than WTP. In 1980, Randall and Stoll [24] used the standard utility maximization paradigm to extend the Willig results to quantity changes. More recently Hanemann [15] showed that for quantity changes the difference between WTA and WTP depends not only on income effects but also on substitution effects. This enduring theoretical debate has been fueled by a considerable amount of empirical evidence (largely originating from experimental studies) that is indicative of significant differences between WTA and WTP bids [21].

In this study, there were several reasons why a WTA format was chosen. Theoretically, WTP and WTA will differ if the (Hicksian) elasticity of substitution between the public good and market goods is zero or small [15]. In the Mantadia case, the elasticity of substitution, between the forested lands to which the villagers have lost access and other lands to which they do have access, is not zero. However, households prefer lands currently within the park because these lands have been more recently deforested and are perceived to be more fertile. Thus, the two types of land are not perfect substitutes. This suggests that WTP may differ from WTA, which in turn made the choice of the correct format important.

A second issue pertained to whether villagers obtained any benefits from conservation. For instance, Carson [5] has argued that WTP is more appropriate than WTA if a quantity or price change of a public good affects the same group of agents from both sides of the transaction. Thus, with the Mantadia National Park, WTP would be appropriate if losing access to the park area resulted in an increase in non-use benefits (e.g., existence values for forest protection) to the villagers, and they were willing to pay for these benefits emerging from conservation. The pre-survey information did not suggest this was the case. In a pre-test of the survey instrument, a WTP format was tested. Some respondents seemed to be willing to pay for forest protection, but it later became clear that the positive responses were more a result of a perceived sense of coercion than because respondents were actually willing to pay for conservation.[4]

Perhaps the most important criterion for choosing between the WTP and the WTA formats is that of property rights. WTA is the appropriate format if the rights to the good under consideration are held by the surveyed population. The rural households in this region have lived amidst the Mantadia forests for a very long period of time. Therefore, while property rights over forested land are in reality held by the state, people perceive traditional rights to the land. Mitchell and Carson [23] suggest that perceived property rights may be more important than actual rights. The households in the Mantadia region clearly considered loss of access to forests within the park boundaries as a decrease in welfare. In conjunction with the property rights issue and the severe income constraints faced by the respondents, this suggested that the WTA format was more appropriate.

[4] In the pre-test a number of villagers indicated that they were willing to sacrifice labor time to walk an additional distance in order to obtain forest products or for swidden agriculture. However, there had been cases in the past when villagers had been arrested for undertaking swidden agriculture. Further discussions with the villagers indicated that the positive responses to the WTP question were because they felt compelled to do so, and not because they perceived non-use benefits from protection.

The elicitation method used in this study was the dichotomous choice method, also known as the discrete choice method. This method solicits simple ''Yes'' and ''No'' responses to an offered bid, and therefore mimics market type everyday behavior. The dichotomous choice method was preferred over other methods for two primary reasons. First, the simple yes/no format made it easier for villagers to respond to the question. Second, since a WTA format was used instead of a WTP format, it was important to ensure that households responded with a budget constraint in mind. By soliciting responses to offered bids, the upper bound on the bids could be controlled (in contrast to an open-ended format).

With the dichotomous choice format the true valuation function, $\mathrm{WTA}_i$, is not observed because respondents do not provide a value. Instead, they provide yes/no responses to offered bids. Thus, $\mathrm{WTA}_i$ is manifested through a discrete indicator variable $I_i$ such that

$$\begin{aligned} I_i &= 1 \qquad \text{if } \mathrm{WTA}_i < t_i \\ &= 0 \qquad \text{otherwise}, \end{aligned} \tag{5}$$

where $t_i$ is the bid offered to household $i$. If the minimum compensation required by household $i$ is less than the offered amount $t_i$, then the household is willing to accept the offered bid, and $I_i$ equals 1. If the minimum compensation required is higher than the amount offered, the respondent refuses the bid and $I_i$ equals zero. Only these responses are known to the investigator. Based on the indicator variable, the magnitude of $\mathrm{WTA}_i$ is inferred by estimating a joint probability or likelihood function and then re-parameterizing the estimated coefficients [3, 4, 10].

### *The Welfare Measure and Error Bands*

A number of different approaches have been suggested for estimating the appropriate WTA or WTP value for use as a welfare measure [3, 13, 7]. Alternative methods to estimate the mean bid, and the appropriateness of using the mean as a summary measure of WTP or WTA are also extensively discussed in the literature on the CVM [13, 14, 17]. In this case, the linear specification of the WTA function together with the standard normal distribution of the error term implies that the two commonly used welfare measures, the mean WTA and the median WTA, are identical [17, 13, 14].

The mean WTA can be obtained by calculating the predicted value of the willingness to accept function estimated at mean values of the covariates [3]. More specifically, the predicted mean value of the WTA bid is given by

$$\begin{aligned} E(\mathrm{WTA}_i) &= E(X_i \beta + \eta_i) \\ &= \bar{X}b + E(\eta_i) \\ &= \bar{X}b. \end{aligned} \tag{6}$$

While a point estimate of the mean WTA bid is a necessary and policy-relevant statistic, it is important to also establish the ''robustness'' of the fitted WTA function. Early dichotomous choice studies did not present confidence intervals for the mean bid because of the econometric difficulties involved. In this study, an analytical procedure developed by Cameron is used for constructing confidence intervals [4]. The variance−covariance matrix from the maximum likelihood probit estimation is employed to obtain $\Sigma_b$, the variance−covariance matrix for the (re-parameterized) coefficients of the valuation function $\mathrm{WTA}_i$. This information is then utilized to estimate the variance of the mean predicted WTA bid. The 95% confidence intervals for the mean bid are given by [4]

$$\mathrm{CI}_{.95}\left[E(\mathrm{WTA}_i)\right] = \bar{X}'b \pm t_{.025}\sqrt{\bar{X}\Sigma_b\bar{X}'}\,. \tag{7}$$

## SURVEY DESIGN AND DATA COLLECTION

Development of the survey instrument is perhaps the most important factor in a contingent valuation study. If contingent valuation is to be successfully used in developing countries, it is critical that the processes involved in undertaking the study be understood, experimented with, and improved. Therefore, this section provides details on how the study was conducted and what was involved in developing the survey.

The first phase of the study involved a rapid appraisal of village households living on the periphery of the Mantadia National Park. This pilot study was conducted by SA.FA.FI., a nongovernmental agricultural development organization that later provided interviewers to administer the final survey. The pilot was used to identify the sample population, establish the appropriate cultural protocol, and clarify certain logistic details required for the research tasks that followed.[5]

The initial survey instrument was based on theoretical considerations, secondary data and the pilot study. The questionnaire was translated from English into French and Malagasy, the two languages spoken in Madagascar. Subsequently, the Malagasy version of the questionnaire was re-translated into English to verify the accuracy of the translation. The questionnaire was refined and critically examined for cultural and language-related flaws with the help of expert group and focus group discussions.[6] Based on these consultations, the survey instrument was shortened and modified to ease comprehension, to lessen respondent fatigue, and to reflect local words employed for key concepts such as secondary forests, buffer zones, etc. Furthermore, as a token of goodwill and to facilitate participation in the survey, a medical team was hired to join the interviewers. This team offered free medical consultations in the surveyed villages.

The most critical and useful step in developing the questionnaire was the pre-test of the revised survey instrument, which was administered to 25 households. The pre-test motivated several additional changes in the questionnaire. For example, the use of photographs was tested and rejected. Photos attracted so much attention and excitement that they were detrimental to the survey process. Based on the pre-test, the CV format was changed from a willingness-to-pay to a willingness-to-accept format (for reasons discussed earlier). The codes and instruc-

[5] Many of the villages are very isolated and could only be reached by walking for several hours. Letters had to be hand delivered in advance to village leaders and to elected officials seeking permission to conduct the study.

[6] Experts who reviewed the survey included a cultural anthropologist, an expert on socio-economic surveys of rural forest-based households, and members of the agricultural extension agency, SA.FA.FI., who administered the survey. The focus group discussion was held in Andasibe, a small town next to the Mantadia National Park, and included 15 residents.

tions used in the questionnaire were revised. The pre-test also served as a further training session for the interviewers, and helped the interviewers better understand the CV method.

Thus, the final survey instrument was significantly different from the original, and reflected input from experts, the survey administrators, and local villagers. Prior to the contingent valuation question, households were asked several questions about their perceptions and attitudes towards forests. These questions motivated the villagers to think about their preferences. Extensive information was collected about the different economic activities they undertook.

In July 1991 the survey was administered over a 2 week period to 351 households in 17 villages. The surveyed villages were chosen to reflect regional differences in villages impacted by the park. The larger villages were sampled to reflect all income classes. However, some of the smaller villages were fully sampled because they contained as few as five households. The village that was used for the pre-test was not included in the final survey.

Rice was used as the numeraire in the contingent valuation question. This is a major departure from other contingent valuation studies that have used money as a payment device. The subsistence nature of the economy suggested that money would not be an effective numeraire. However, rice had several attractive features. It is the most important crop in this region and its value is well established. Though primarily a subsistence crop, some amount of rice is invariably sold, and transactions in rice are well understood. The unit of measure employed in the survey was a "vata," a locally used unit for rice transactions. One vata equals 30 kgs of rice.

The contingent valuation question used was:

> *Suppose you are asked to use only the buffer zone, set aside for collecting forest products and for growing crops and are asked not to use the rest of the forests any more. Suppose in order to make up for asking you not to use the forests in the park, you are given __ vata of rice every year from now on. Would this make you as content as before when you could use the forest in the national park?*
>
> *If YES, would __ vata of rice make you as content?*
> *If NO, would __ vata of rice make you as content?*

Respondents were randomly assigned to seven groups, corresponding to the seven different amounts of vata (1 to 7 vata) used as the offered bid levels. Each respondent was then asked to provide a yes or no response to the offered bid.[7] The range of 1 to 7 was based on a prior understanding of the average amount of rice annually consumed per household. Though the respondent was confronted with only one offered bid between 1 and 7, he or she was asked a follow-up question, in which the bid was increased by one unit if she/he had answered "No," or decreased by one unit if she/he had answered "Yes." Of the 351 people who were interviewed, 278 responded to the contingent valuation question.

[7] Not all of these households had lost access to lands because of the Mantadia National Park. Therefore, some of the households may have treated the contingent valuation question as a more general question on loss of access to lands, rather than specifically to lands within the Mantadia National Park.

TABLE I
Education and Age Distribution of Sample Population

| Variable | *N* | Average |
|---|---|---|
| Number of household members | 351 | 4.55 |
| Education of sample population (years) | 1542 | 2.36 |
| Number illiterate (percent of surveyed population above the age of 15 without schooling) | 399 | 0.48 |
| Age of sample population (years) | 1599 | 22 |
| Number younger than 20 years (percent of surveyed population) | 911 | 0.57 |

## RESULTS AND DISCUSSION

### *Socio-economic Status of the Surveyed Population*

The average household size in the villages surrounding the Mantadia National Park is 4.6 persons. Approximately half the population of households surveyed was female [22]. The villages in this region do not have direct access to medical facilities, running tap water, or electricity. Several of the villages have primary school facilities and the literacy rate is relatively high at 52%. However, the average number of years of schooling per person is only 2.36 years (see Table I).

The villages are subsistence economies dependent on agriculture and forest products. The average household grows 487 kg of rice every year. Valued at 500 fmg (Malagasy francs) per kg, this amounts to an annual gross income of 243,500 fmg ($133).[8] The average annual total household income in this region is estimated to be $279. Of this income 54% comes from subsistence agriculture, 31% from the subsistence use of forest products, and the rest from other forms of labor. In summary, it is safe to conclude that the population in this region is very poor and completely dependent on the land and forest resources in the area.

### *Probit Maximum Likelihood Estimation*

In order to estimate the valuation function, the yes/no responses to the CV question are regressed on a number of socio-economic variables discussed earlier. Table II defines the variables used, presents related means and standard deviations, and specifies the names employed for each variable in the estimated probit model. Table III provides the maximum likelihood estimates of the parameters of the fitted probit function.[9] The first column in the table indicates the names of the variables, the second column presents the maximum likelihood values of the estimated probit coefficients, the third column presents the standard errors

[8] The exchange rate used is the 1991–1992 rate of fmg 1835/$1.

[9] LIMDEP software was used in estimating the probit maximum likelihood function [11]. SAS software was used to check for multicollinearity among the right hand side variables. In addition, a GAUSS routine for estimating double-bounded dichotomous choice models was utilized to take advantage of the follow-up questions to the CV question. Unfortunately, the authors were unable to obtain convergence for a double-bounded model.

TABLE II
Definition of Variables

| Household level variables used in dichotomous choice analysis | Names used for the variables in the probit model | Mean values | Standard deviations |
|---|---|---|---|
| Yes/No responses to the bid (the dependent variable) | INDICATOR | 0.462 | 0.500 |
| Offered bid (ranging from 1 to 7 vata of rice) | BID | 3.916 | 2.005 |
| Number household members | HHMEM | 4.361 | 2.188 |
| A dummy representing preference for buffer zones over forests (Buffer Zones = 1 Forests = 0) | PREFDUM | 0.691 | 0.463 |
| A dummy variable representing collection of bamboo, a forest product (Collected by male head of household = 1 Others = 0) | BAMW | 0.233 | 0.424 |
| Annual household production of coffee (kilograms) | CAFTOT | 42.711 | 185.47 |
| A dummy for households in villages in group 1 | GROUP 1 | 0.213 | 0.410 |
| A dummy for households in villages in group 2 | GROUP 2 | 0.145 | 0.352 |
| A dummy for households in villages in group 3 | GROUP 3 | 0.137 | 0.344 |
| A dummy for households in villages in group 4 | GROUP 4 | 0.233 | 0.424 |
| A dummy for households in villages in group 5 | GROUP 5 | 0.273 | 0.447 |

of the coefficient estimates, the fourth column presents the estimated $t$-ratios, and the fifth column presents the marginal effects of the socio-economic variables on willingness to accept.[10] As indicated by signs, significant coefficients, and goodness of fit measures, the probit model performs well in explaining variations in responses to the contingent valuation question.

The maximum likelihood coefficient estimates indicate how the probability of accepting a certain bid amount is affected by explanatory variables.[11] The offered bid level is significant and has the expected sign; i.e., with an increase in the offered bid amount, the probability that the respondent would say ‘‘Yes’’ to the bid increased. With regard to the other independent variables, the parameter estimates which are significant at the 0.05 level are the coefficient associated with PREFDUM, the variable that reflects household preference for buffer zones over lands within the park; the coefficient associated with BAMW, which reflects household collection of bamboo; and coefficients of three of the locational dummies—GROUP 2, GROUP 3, and GROUP 5. The coefficients of HHMEM, which reflects household size, and CAFTOT, which is a proxy for money income, are not significant.

The coefficient on the dummy PREFDUM is positive as expected. Respondents who found buffer zones acceptable were more likely to agree to the offered bid. Thus, if people perceived that they could undertake their economic activities outside of the protected area, they were more willing to accept compensation. The coefficient on BAMW is negative, which suggests that when male heads of the household are primarily responsible for collecting bamboo, it is less likely that the

[10] The probit coefficients are re-parameterized in order to obtain the coefficients of the valuation function, $WTA_i$, in the following manner: $b = -(\gamma/\alpha)$, where $\gamma$ is the vector of estimated coefficients other than the coefficient for the bid variable and $\alpha$ is the estimated coefficient of the bid variable [3, 4].

[11] The probit coefficients cannot be interpreted as the marginal effects on the probability of saying ‘‘yes.’’ However, the signs of the coefficients are indicative of the direction of the marginal effects [10].

TABLE III
Probit Regression of Contingent Valuation Responses

| Variable | Coefficient MLE | Std. error | t-ratio | Re-parameterized coefficients of the WTA function |
|---|---|---|---|---|
| Constant | −0.294 | 0.368 | −0.798 | 3.069 |
| HHMEM | −0.047 | 0.043 | −1.103 | 0.488 |
| BAMW | −0.634 | 0.250 | −2.538 | 6.617 |
| PREFDUM | 0.869 | 0.227 | 3.81 | −9.064 |
| CAFTOT | −0.003 | 0.002 | −1.392 | 0.033 |
| GROUP 2 | −1.191 | 0.365 | −3.267 | 12.441 |
| GROUP 3 | −1.112 | 0.353 | −3.149 | 11.612 |
| GROUP 4 | 0.344 | 0.319 | 1.079 | −3.593 |
| GROUP 5 | −0.606 | 0.301 | −2.015 | 6.325 |
| BID | 0.096 | 0.046 | 2.094 | −1.000 |
| Log-Likelihood | | −126.591 | | |
| Restricted (Slopes = 0) Log-Likelihood | | −171.868 | | |
| McFadden's $R^2$ | | 0.26 | | |
| $n$ | | 249 | | |

offered bid is accepted. This implies that there are gender-related differences in tasks associated with forest use that have implications for compensation. A possible explanation is that local traditions assign higher values to goods associated with certain gender-specific responsibilities. Regarding CAFTOT, some groups of households did not have any coffee plants, which explains the insignificance of the associated coefficient.

The significance of three of the locational dummies suggests that there are regional differences that affect willingness to accept. GROUP 2 and GROUP 3 are a set of villages to the northeast of the park, while GROUP 4 and GROUP 5 refer to households to the south of the park. The MLE estimates indicate that households in the GROUP 2, GROUP 3, and GROUP 5 villages are less likely to accept compensation relative to households in GROUP 1, the control dummy. Households in GROUP 4 lie further away from the park relative to the rest of the sample, which may be why the coefficient associated with GROUP 4 is insignificant.

One way to derive a goodness of fit measure for dichotomous choice models is to estimate McFadden's $R^2$, also known as the Likelihood Ratio Index [10], which reflects how well the independent variables can explain the variation in the dependent variable. The McFadden $R^2$ is 0.26, which is reasonably good for cross-sectional data. A second goodness of fit measure often used for probit models is the proportion of correctly predicted responses. This model predicts 182 of the 249 observations correctly, or 73%.

Another method of examining the responses to the CV question is by considering a graphical representation of WTA. Figure 1 presents a graph of the percentage of respondents willing to accept the offered bid. The graph suggests that there was an increasing willingness to accept the bid as the value of the offered bid increased from 1 to 7. However, the peak at the bid value of 2 vata indicates that at lower values there may have been some random responses.

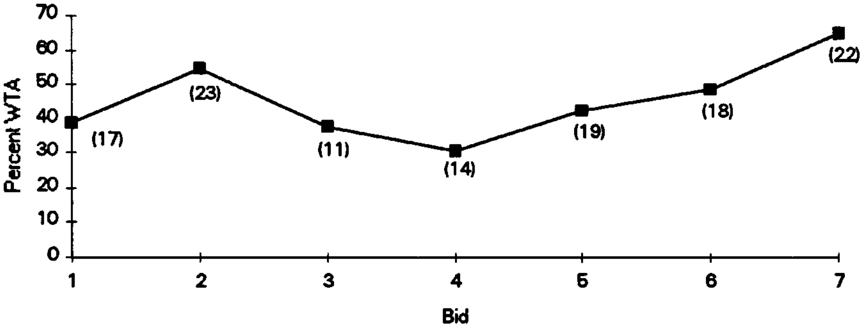


FIG. 1. Willingness to accept by offered bid. The number of respondents who said ''Yes'' for each bid level is presented in parenthesis. The bid levels were initially distributed equally across respondents, but due to different rates of nonresponse the percentage of respondents for each bid level differed as follows: bid 1—16%, bid 2—15%, bid 3—11%, bid 4—17%, bid 5—16%, bid 6—13%, bid 7—12%.

### *Non-response and Sample Selection Bias*

Since 73 interviewees (20%) did not respond to the CV question, it becomes important to ascertain whether or not the people who did respond differed in any manner from those who did not. If there is a systematic difference between the group of respondents who answered the CV question and those who did not, it would be inaccurate to assume that the values ascribed to the resource under consideration by both groups were the same. Furthermore, if some of the respondents self-selected themselves out of the sample, i.e., if there is a systematic relationship between the TWA bid and the non-response to the CV question, then the univariate probit analysis reported in the previous section does not provide consistent parameter estimates.

To check if there was a systematic difference between the two groups, the mean values of several socio-economic characteristics of those who responded to the WTA question and those who did not were compared. These comparisons are presented in Table IV. The results indicate that the null hypothesis of equal means cannot be rejected at the 5% level of significance for the four primary socio-

TABLE IV

Comparison of Socio-economic Characteristics of Respondents and Non-respondents to the CV Question

| Socio-economic characteristic | Mean value for respondents | | Mean value for non-respondents | | |
|---|---|---|---|---|---|
| | *n* | Mean | *n* | Mean | *t*-statistic[a] |
| No. of household members | 278 | 4.4 | 73 | 5.1 | 1.93 |
| Land cultivated (ha) | 253 | 2.1 | 59 | 1.78 | −1.2 |
| Coffee production (kg) | 251 | 42.4 | 67 | 24.6 | −1.32 |
| Frequency of fuelwood collection (days per year) | 277 | 329 | 73 | 322 | −0.5 |

[a] The mean values were first checked for equal and unequal variance, which determined the appropriate *t*-statistic used.

economic characteristics that were compared. This suggests that the group that answered the CV question did not systematically differ from the group that declined to answer. However, at the 10% level of significance, the number of household members was different across groups.

In order to further explore the possibility of sample selection, a probit analysis of households' willingness to respond to the CV question was undertaken [10, 28].[12] If there is sample selection, it can be hypothesized that there are factors that affect the household's propensity to respond to the CV question that also affect the household's WTA. In other words, the error term associated with a response propensity index, $\nu_i$, is likely to be correlated with the error term associated with the WTA equation, $\eta_i$. Thus, one can test for sample selection by determining whether or not the correlation coefficient between $\nu_i$ and $\eta_i$, $\rho$, is zero. This is undertaken by estimating a bivariate probit function following a methodology developed by van de Ven and van Praag [28].[13]

The coefficient estimate obtained for $\rho$ is $-0.05$ with an estimated $t$-ratio of $-0.238$. Thus the hypothesis that $\rho$ equals zero cannot be rejected, suggesting that there is no sample selection bias. The implication is that the univariate probit analysis undertaken in the previous section is appropriate, and the previously obtained parameter estimates do not have to be corrected for sample selection bias.

### *The Welfare Measure and Aggregation*

A final step in this study is to estimate a welfare measure. Using the estimated values of the marginal effects (column 5 in Table III), the mean willingness to accept is estimated to be 6.15 vata of rice. A vata of rice is equal to 30 kgs of husked rice and each kg of rice is worth 500 fmg. Translating this to dollar terms, the mean WTA is estimated to be \$50 per household per year. These results lie within the same order of magnitude as the results from a cash flow analysis of the production losses incurred by the respondents as a result of lack of access to the park [22].

[12] Let $\delta$ be a variable that indicates whether or not the household responded to the CV question, and let $R$ be an unobserved index of response propensity. Thus,

$$\delta_i = 1 \quad \text{if } R > 0$$
$$\delta_i = 0 \quad \text{otherwise}.$$

$R$ is influenced by a number of exogenous variables such that

$$R = \pi Z_i + v_i$$

where $\pi$ is a vector of unknown parameters, $Z_i$ is a vector of exogenous variables that are hypothesized to influence the household's response propensity index, and the error term $v_i$ is distributed normally with mean 0 and standard deviation 1.

[13] The independent variables used to estimate the response propensity equation were number of household members, education level of the head of the household, a dummy variable reflecting gender difference in the collection of non-construction wood, a dummy variable reflecting whether or not construction wood was obtained from primary forests, a dummy variable reflecting whether or not vakoana, a grass used in house construction, was obtained from primary forests, and the four previously defined locational dummy variables: GROUP 2, GROUP 3, GROUP 4, GROUP 5.

Before aggregating the mean WTA over the relevant population in the area, it is important to ask whether or not the population that was not surveyed was identical to the surveyed population. This is difficult to establish without complete information about the characteristics of the non-sampled villages. However, at the time of the survey there was no evidence that the non-sampled households differed systematically from the sampled households. Assuming a 20 year project life at 10% discount rate and aggregating the mean over the relevant population of 729 households, the total net present value of the welfare loss to villagers in the periphery of the Mantadia National Park is estimated to be $312,331.

The estimated standard error for the mean WTA bid is 2.5 vata. Based on the estimated variance, 95% of the time, the mean WTA bid is bounded above by 11.1 vata and below by 1.3 vata. This implies that 95% of the time the predicted mean bid per household per year lies between $90 and $10.

## CONCLUSIONS

This study was undertaken with the primary purpose of testing the contingent valuation method within a developing country context. A secondary but important aim was to assess the welfare loss to local residents resulting from the Mantadia National Park. There are several important conclusions that can be drawn.

The analysis indicates that the CVM has potential for estimating the value of non-market goods within a developing country context. Some skepticism has been expressed in the literature on non-market valuation about the usefulness of contingent valuation in developing countries [6]. However, the analysis undertaken in this study indicates that the responses to the valuation question were non-random. The econometric analysis is indicative of a systematic association between various socio-economic variables of interest and the expressed willingness-to-accept compensation.

There are several key factors that are of importance if the CVM is to be successfully used in non-market economies. Where money is not well established as a medium of exchange and measure of value, it is critical that there be at least one other good that is traded, valued, and acceptable to the relevant population. In this study rice was the common denominator. The responses to the bids indicate that the respondents did treat rice both as a measure of value and as a means of exchange and responded as predicted by theory.

A strong use value associated with the good under consideration is important for obtaining meaningful responses. Following the pre-test, it became clear that household welfare had declined because of loss of access to lands that could satisfy subsistence needs. Thus, even though the respondents worked in a rural non-market economy, they could certainly be expected to understand and evaluate the loss of an asset as significant as land.

Pre-tests and focus group interviews are perhaps even more important in subsistence economies than in Western countries because of cultural differences in responses to questionnaire techniques and simulated market situations. For example, the use of photographs was rejected after it became clear that photographs were distracting because of their novelty. The use of the CVM in non-market economies also requires a very well trained set of interviewers. Pre-tests need to be undertaken, not only to fine tune and develop the questionnaire, but also to train the interviewers and ensure that they are not intentionally or unintentionally influencing the responses to the CV questions.

An in-depth understanding of household socio-economic characteristics and attitudes toward the good being valued is required. Variables considered important in market economies, such as wage income, may not be as relevant within rural economies. Instead, information on subsistence activities and goods may need to be collected.

Finally, the analysis provides certain policy insights. Households in the vicinity of the Mantadia National Park bear considerable costs as a result of the park. Since these are communities that are already under significant economic hardship, some form of compensation is warranted. Furthermore, because of the economic burden the park places on them, households may be less willing to cooperate with park authorities. Thus, the costs borne by local households may have important implications for the park's future.

## REFERENCES

1. N. E. Bockstael and K. E. McConnell, Welfare measurement in the household production framework, *Amer. Econom. Rev.* **73**, 806–814 (1983).
2.. J. Briscoe, P. F. de Castro, C. Griffen, J. North, and O. Olsen, Toward equitable and sustainable rural water supplies: A contingent valuation study in Brazil, *World Bank Econom. Rev.* **4**, 115–134 (1990).
3.. T. A. Cameron, A new paradigm for valuing non-market goods using referendum data: Maximum likelihood estimation by censored logistic regression, *J. Environ. Econom. Management* **15**, 335–379 (1988).
4.. T. A. Cameron, Interval estimates of non-market resources values from referendum contingent valuation surveys, *Land Econom.* **67**, 413–421 (1991).
5.. R. T. Carson, Constructed markets, *in* ''Measuring the Demand for Environmental Quality'' (J. B. Braden and C. D. Kolstad, Ed.), Elsevier, Amsterdam, 1991.
6.. J. A. Dixon and P. B. Sherman, ''Economics of Protected Areas,'' Island Press, Washington, DC, 1990.
7.. J. W. Duffield and D. A. Patterson, Inference and optimal design for a welfare measure in dichotomous choice contingent valuation, *Land Econom.* **67**, 225–239 (1991).
8.. A. Dufresne and A. Cloutier, ''Plans de Gestion. Parc National Andasibe. Parc National Ankarafantsika. Project GPF. Volet Conservation et Protection,'' International Union for the Conservation of Nature, Antananarivo, 1989.
9.. Economic Intelligence Unit (EIU), ''Country Profile: Madagascar, Comoros,'' The Economist Group, London, 1991.
10.. W. H. Greene, ''Econometric Analysis,'' MacMillan Company, New York, 1990.
11.. W. H. Greene, ''LIMDEP. Users Manual and Reference Guide,'' Econometric Software, New York, 1991.
12.. G. M. Green and R. W. Sussman, Deforestation history of the eastern rain forests of Madagascar from satellite images, *Science* **248**, 212–215 (1990).
13.. W. M. Hanemann, Welfare evaluations in contingent valuation experiments with discrete responses, *Amer. J. Agr. Econom.* **66**, 322–341 (1984).
14.. W. M. Hanemann, Welfare evaluations in contingent valuation experiments with discrete response data: Reply, *Amer. J. Agr. Econom.* **71**, 1057–1061 (1989).
15.. W. M. Hanemann, Willingness to pay and willingness to accept: How much can they differ? *Amer. Econom. Rev.* **81**, 635–647 (1991).
16.. C. Harcourt and J. Thornback, ''Lemurs of Madagascar and the Comoros. The International Union for the Conservation of Nature Red Book,'' IUCN, Gland/Cambridge, U.K., 1990.
17.. P. Johansson, B. Kristrom, and K. G. Maler, Welfare evaluations in contingent valuation with discrete response data: Comment, *Amer. J. Agr. Econom.* **71**, 2054–2056 (1989).

18.. D. Kahneman and A. Tversky, Prospect theory: An analysis of decisions under risk, *Econometrica* **47**, 160–173 (1979).
19.. D. Kahneman and A. Tversky, The psychology of preferences, *Sci. Amer.* **246**, 160–173 (1982).
20.. D. G. Kleinbaum, L. L. Kupper, and K. E. Muller, ''Applied Regression Analysis and Other Multivariate Methods,'' PWS-Kent, Boston, 1988.
21.. J. L. Knetsch and J. A. Sinden, Willingness to pay and compensation demanded: Experimental evidence of an unexpected disparity in measures of value, *Quart. J. Econometrics* **94**, 507–521 (1984).
22.. R. Kramer, N. Sharma, P. Shyamsundar, and M. Munasinghe, ''Cost and Compensation Issues in Protecting Tropical Rainforests: Case Study in Madagascar,'' Environment Department Working Paper No. 62, World Bank, Washington, DC, 1994.
23.. R. C. Mitchell and R. T. Carson, ''Using Surveys to Value Public Goods: The Contingent Valuation Method,'' Resources for the Future, Washington, DC, 1989.
24.. A. Randall and J. R. Stoll, Consumer surplus in commodity space, *Amer. Econom. Rev.* **70**, 449–455 (1980).
25.. P. Shyamsundar, ''Economic Implications of Tropical Rain Forest Protection for Local Residents: The Case of the Mantadia National Park in Madagascar,'' Ph.D. Dissertation, School of the Environment, Duke University, 1993.
26.. I. Singh, L. Squire, and J. Strauss, ''Agricultural Household Models. Extensions, Applications and Policy,'' International Bank for Reconstruction and Development, Johns Hopkins University Press for the World Bank, Baltimore, MD, 1986.
27.. V. K. Smith, Nonmarket valuation of environmental resources: An interpretive appraisal, *Land Econom.* **69**, 1–26 (1993).
28.. W. P. M. M. van de Ven and B. M. S. van Praag, The demand for deductibles in private health insurance, *J. Econometrics* **17**, 229–252 (1981).
29.. M. Wells, K. Brandon, and L. Hannah, '''People and Parks. An Analysis of Projects Linking Protected Area Management with Local Communities,'' World Bank, World Wildlife Fund and U.S.A.I.D., International Bank for Reconstruction and Development, Washington, DC, 1992.
30.. D. Whittington, J. Briscoe, X. Mu, and W. Barron, Estimating the willingness to pay for water services in developing countries: A case study of the use of contingent valuation surveys in southern Haiti, *Econom. Development Cultural Change* **38**, 293–311 (1990).
31.. D. Whittington, V. K. Smith, A. Okorafor, A. Okore, J. L. Liu, and A. McPhail, Giving respondents time to think in contingent valuation studies: A developing country application, *J. Environ. Econom. Management* **22**, 205–225 (1992).
32.. R. D. Willig, Consumer surplus without apology, *Amer. Econom. Rev.* **66**, 587–597 (1976).
33.. World Bank, ''The Democratic Republic of Madagascar Country Economic Memorandum,'' World Bank, Washington, DC, 1986.
34.. World Bank, ''Staff Appraisal Report: Democratic Republic of Madagascar. Forests Management and Protection Project,'' Report 6994-MAG, World Bank, Washington, DC, 1988.
35.. World Bank, ''Staff Appraisal Report: Democratic Republic of Madagascar Environment Program,'' Report No. 8348-MAG, World Bank, Washington, DC, 1990.
36.. World Resources Institute (WRI), United Nations Environment Program (UNEP), and United Nations Development Program (UNDP), ''World Resources 1992–93. A Guide to the Global Environment. Toward Sustainable Development,'' Oxford Univ. Press, New York, 1992.