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ORIGINAL PAPER

Estimating willingness to pay in order to prevent external intangible effects of dust in Yazd-Ardakan plain

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Abstract Although intangible effects on natural environments are not visible and only become apparent over a long period of time, they may cause irreparable damages whose estimation is not always feasible. However, people's willingness to pay (WTP) for the prevention of adverse environmental effects can be determined. The present study addresses the issue of the effect of dust in Yazd-Ardakan Plain. It aims at the valuation of local people's WTP in order to prevent extra-regional intangible effects of dust in Yazd-Ardakan Plain in 2010. The study was based on data collected from 479 questionnaires completed by people in the affected area. Factors affecting local people's WTP and their expected WTP were estimated by logit regression model. It was revealed that among the studied variables, income, education, and environment importance had significant positive effects, and that household size, type of residence, and bid had significant negative effects on people's WTP. Also, the WTP for the conservation of the region was estimated as to be 93.4 billion Iranian Rials (IRR) per year. In other words, it is necessary to invest at least 93.4 billion IRR to prevent the adverse impacts of dust on the plain. Given the 183 billion IRR expenditure for stabilizing sand in the region and the estimated 93.4 billion IRR protection value for the plain, 50 % of expenses would be paid by people living in the region, which paves the way for the fulfillment of conservation programs by experts using public contributions.

Keywords Willingness to pay · Dust · External effects · WTP · Yazd-Ardakan plain

Introduction

Dust is a major cause of environmental damage in a country like Iran with arid and semiarid climate that is located on dry belt. In general, soil of dry regions is vulnerable to erosion especially from wind because of its deficiency of organic and colloidal substances. Hence, most towns in dry regions suffer from dust with natural or human-made sources as the main air pollutant (Azimzadeh et al. 2010).

Economically talking, dust causes two kinds of expenditures: domestic expenditure resulting from performance loss and higher production expenses, and external or extra-regional expenditures resulting from environmental pollution that brings about different kinds of intra-regional and extra-regional damages. The harmful effects of this phenomenon, which is considered as one of the most serious environmental crises in modern time, are divided into two categories: tangible (direct and indirect) and intangible. Tangible values are those that should be used by humans. Intangible values do not include any kinds of observable behavior and represents a simple mental experience. In other words, they cannot be observed in market purchases or manifested as deduced functioning. Damage can be categorized and prioritized as follows:

(1) Direct tangible effects including damage to agricultural and livestock production, general economic effects (land price reduction, impact on occupation, investment, migration and food security), damage to water resources, damage to the transportation

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industry, damage to infrastructures, and extra costs of cleaning of houses, streets and roads.

(2) Indirect tangible effects including damage to the tourism industry and to plant and animal species.

(3) Intangible effects including damages to human health and quality of life.

The valuation of all these aspects of damage is difficult and some of these aspects, e.g., those endangering people's health and monetary valuation are impossible. Even though intangible effects are not visible and will emerge gradually over a long period of time, it is impossible to estimate the irreparable damages. Recent studies at New York University show that long-term exposure to small particles of dust contributes to increased death rates from lung cancer and heart disease. Inhalation of air polluted with dust particles results in the penetration of particles into air sacs of the lung, irregular heartbeat, heart attacks and respiratory problems, chronic and severe headaches, several allergic reactions, eyesight weakness, and skin diseases (Karimi et al. 2010).

Undoubtedly, informing people of the potential harmful effects of exposure to dust and techniques of dealing with them leads society to increasingly object to the cause of the problem and may stimulate attempts to curb this type of air pollution. There have been many articles in this field up to now, but it is important to study the reaction and willingness of a society to lessen the intangible effects of dust. Without due consideration of this issue, protective planning and strategies will be meaningless. One way to estimate this willingness is to determine the extent to which a society is willing to pay for the protection against the effects of dust.

Due to the fact that there is no market for most ecosystem services, these profits are valued in terms of artificial markets in the absence of a market. This method directly depends on consumers' willingness to pay (WTP). The most common method of this kind is the 'contingent valuation' (CV) method. This method was introduced in academic and institutional forums in the 1990s. The National Oceanic and Atmospheric Administration (NOAA) formed a panel of economists called Blue Ribbon to evaluate the use of contingent valuation in estimating unconsumed values. The panel published a report in 1993 in which a framework was introduced for the application of contingent valuation (Adamowitz et al. 1998). This method can be applied in valuations of weather quality, national parks' profits, fishing, the WTP for protection against harmful environmental effects, etc.

Many studies have used contingent valuation method for estimating the conservative value of natural ecosystems. Hadker et al. (1997) concluded that total monthly WTP by Mumbai residents for conservative values and the maintenance and conservation of Mumbai National Park amounted to 440,000 dollars, which would provide an annual amount of 5.5 million dollars to conserve this national park. In an attempt to value the performance of biodiversity of Mabira forest ecosystem in Uganda by CV, Muramira (2000) estimated the WTP for 72 hectares of regional evergreen forests as to be 306 US$. In an attempt to calculate the conservative value of Miankaleh birds habitant by CV method, Tabatabe (2001) estimated the maximum mean WTP by native and non-native families as to be 24,752 and 73,440 Iranian Rials (IRR), respectively. Using CV method for forest conservation of southern Finland, Lehtonen et al. (2003) found that 73.8 % of respondents were interested in increasing the level of protection and were ready to pay for the forest's conservation, 15.8 % supported the increased cost of conservation but were not willing to pay, 5.5 % were apathetic, and 4.9 % wanted a decrease in conservative measures.

Rafiee and Salami (2010) examined the effect of people's moralism on the valuation of Miankaleh international pond. They found that monthly WTP to protect this pond was 18,617 and 12,327 IRR among functionalist and pragmatist families, respectively. Fatahi (2010) estimated the WTP by households living in the Yazd-Ardakan plain to conserve its underground water supply as to be 248,960 IRR. Using logit function estimation, Rafiee and Amirnejad (2011) estimated individual's monthly WTP as to be 7360.1 IRR for the protection Tangeh Solomon forests of Sari.

Governmental institutions and organizations have conducted studies on similar estimations such as the damage of wind erosion in different regions of Iran. One example of these estimations in Yazd-Ardakan plain shows that 183 billion IRR have been invested on stabilizing sand dunes in the suburbs of Yazd with considerable return which stimulated people's livelihoods, production and economic activities in the region. Despite these widespread activities, these sand dunes annually impose over 6.5 billion IRR damage including decreased soil fertility, decreased visibility and higher rate of fatal accidents resulting in death, paralysis and financial damage, environmental pollution, and lower durability of industrial machineries. (Ekhtesasi 1993).

Tahmasebi Birgani et al. (2005) calculated the cost of damage from areas prone to environmental damage to economic organizations of the country at 68.82 billion IRR (based on statistics of 2001). Damages mostly occurred in residential regions, transportation roads, farmland, and industrial facilities. Miri et al. (2008) estimated damage of wind erosion in the Sistan region as to be 96.7 billion IRR during 2000–2004 and that the highest damage rate was related to respiratory diseases among the local population, and the lowest rate was related to flight cancellations.

Kyophilavong and Bennet (2011) estimated residents' WTP for cleaning up road dust in urban areas of Vientiane, Laos by the Contingent Valuation Method (CVM) aimed at identifying the factors affecting the WTP. Based on a sample of 6590 respondents, they showed a mean WTP of 7069 kip (USD0.86) per person per month which amounted to 4.7 % of residents' average monthly income. Education and income had a statistically positive impact on the WTP.

Wang et al. (2015) used CVM to qualitatively and quantitatively measure the WTP for reducing children's RDs through air quality improvement. They carried out 975 face-to-face interviews with parents in a community-based and a hospital setting in Shanghai between April and May, 2014. Multiple imputation and the probit models were used to determine the relationship between the WTP and the related environmental factors, child health factors, and the socioeconomic status. Most respondents reported being willing to make a financial contribution to improve air quality in both the community (52.6 %) and hospital (70.2 %) samples. Those in the hospital setting were willing to pay significantly more ¥504 (USD$80.7) compared to the community sample ¥428 ($68.5) as expected. Reasons for those not being willing to pay included lack of disposable income and believing that responsibility of the air quality was a community issue. These did not differ by sample. Annual household income and education were related to the WTP.

As can be seen, there have been no scientific studies on people's WTP in order to prevent the negative side effects of environmental degradation in Iran. The present study aimed at the investigation of this issue in Yazd-Ardakan plain. The area includes settlements of Yazd, Taft, Mehriz, Ardakan, Meybod, and Sadoogh located at the geographical location of 32° 48′–31° 13′ N and 59′–52° 57′ E. Yazd-Ardakan plain is considered as one of the arid and hyper-arid centers of Iran that covers an area of about 1595,070 hectares where more than 80 % of the population of the province, i.e., over 700,000 people, live. Imagery and territorial surveys show that more than three villages have been entirely buried under sand dunes in the last 100 years and at the present time more than 20 villages, and three big cities are directly exposed to the risk of sand dune cover and other residential regions are indirectly threatened by sand storms and wind erosion (Ekhtesasi et al. 2004). Azimzadeh et al. (2010) showed that in only 3 months of summer 13,661.61 tons of dusts (equivalent to 13 10-ton trucks) fell on Yazd.

Given the previous studies and the necessity for exploring dusts in Yazd-Ardakan Plain, Iran, the present study aimed at analyzing people's cooperation and estimating the WTP for preventing intangible off-regional impacts of dust in this plain. To the best knowledge of author, no study has been carried out in Iran to quantify people's cooperation in the prevention of off-regional intangible effects and to express urban and rural area residents' contribution in monetary term. So, the present study is a novel and pioneering work in Iran which can pave the way for future research (Abedi et al. 2014).

Materials and methods

According to literature review, the contingent valuation (CV) method and double-bounded dichotomous choice questionnaire were used to estimate the value of prevention of external effects of dust. Bishop and Heberlein (1979) introduced an acceptance/rejection technique (dichotomous choice technique). In order to calculate the WTP for conservation of natural resources, economists often assume that the dependent variable is a set of continuous quantities. But, there are several cases in which decision-maker's behavior is summarized in a closed set. Models used for such aims are called qualitative dependent variable models. The simplest models are those in which a dependent variable is dichotomous, i.e., dependent variable can take merely two values: 1 or 0.

The contingent valuation method was practically used for the first time in experiments by Davis (1963). This method can be used commonly for two main and principle values: an existence value and a choice value. This method determines individuals' WTP in hypothetical terms. One of the ways to improve the performance of the single-bounded dichotomous choice method is by asking serial questions that depend on respondent's response to the previous bid. If the response to the first bid is negative, the second bid, which is less than the first bid, is offered. Bateman (1991) and Cameron and Quiggin (1998) recommended that higher bid should be twice as much as the first bid and lower bid should be half as much as the first bid.

In order to gauge the model for the measurement of the WTP, it is assumed that a person accepts or rejects a bid to determine non-market values of a natural resource according to maximizing the utility (U) of itself under certain conditions (Eq. 1):

$$U(1, Y - A; S) + \varepsilon_1 \geq U(0, Y; S) + \varepsilon_0 \quad (1)$$

where U is the indirect utility that a person obtains, Y and A are the person's income and the bid, respectively, S represents other socioeconomic features affected by a person's tastes, ε_0 and ε_1 are random variables with the average of 0 (zero) which have been distributed equally and dependently. The utility difference ΔU can be described as the following equation:

$$\Delta U = U(1, Y - A; S) - U(0, Y; S) + (\varepsilon_1 - \varepsilon_0) \quad (2)$$

If the difference utility (dU) is greater than zero, a respondent maximizes his utility by agreeing to pay an amount of money to obtain the production. Thus, there is a response of 0 or 1 for each respondent. As mentioned above, factors affecting the answer (Yes/No) are S, Y, and A. Therefore, we face an econometric model whose dependent variable is 0 or 1. In order to estimate models with dichotomous dependent variables, logit and probit models are used. Given its simplicity and reliability of calculations, logit model as demonstrated in Eq. (3) and Fig. 1 was used in the present study (Judge et al. 1988).

$$P_i = \Pr(Y_t = 1) = F(X_i'\beta) = {}^{1}\!/\!_{1 + \exp(-X_t'\beta)} \quad (3)$$

If the cumulative probability distribution of dU that shows the possibility of bid acceptance is defined as $F(Du)$, the cumulative probability distribution is calculated in order to estimate mean WTP (mathematical expectation of the WTP) in definite integral extraction methods (Eq. 4).

$$E(\text{WTP}) = \int F_i(dU)\mathrm{d}A = \int {}^{1}\!/\!_{1 + \exp(-X_t'\beta)}\, \mathrm{d}X' \quad (4)$$

After estimating the logit model, the expected amount of the WTP is calculated by numerical integration in the range of zero to the highest accepted bid as follows (Hanemann 1994; Lee and Han 2002).

$$E(\text{WTP}) = \sum_{i=1}^{n} p_i wtp_i = \int_0^{\text{Max.BID}} \left({}^{1}\!/\!_{1 + \exp\{-(\alpha^* + \beta\text{BID})\}}\right) d\text{BID} \quad (5)$$

where $E(WTP)$ is the expected amount of an individual's the WTP for the protection, BID variable actually represents an individual's the WTP in the model, and α^* is the modulated interception that has been added to the main interception (α) by socioeconomic term.

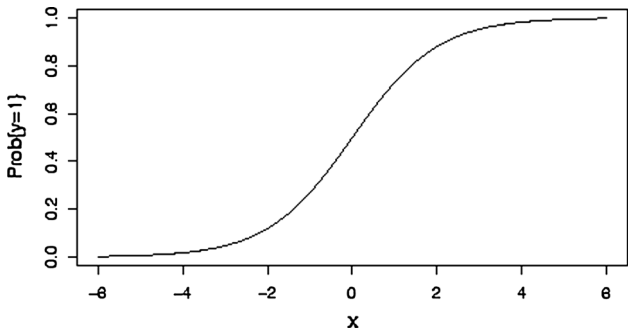

Fig. 1 Logit model

In the logit model estimations, predicting the effects of the variations of explanatory variables on the probability of accepting a bid by ith person is crucially important. The marginal effect (ME) indicates the changes in bid acceptance probability per one unit change in each explanatory variable and can be calculated from Eq. (6):

$$\text{ME} = \frac{\partial P_i}{\partial X_{ki}} = F(X_i'\beta_K)\beta_K = {}^{\exp(-X_i'\beta)}\!/\!_{\left[(1 + \exp(-X_i'\beta)\right]^2}\, \beta_k \quad (6)$$

where β_k is the estimated parameter of kth explanatory variable. In this study, using pretest data and Mitchell and Carson (1989)'s method at the 5 % significance level and actual and estimated WTP difference of 10 %, 479 questionnaires were completed in the region, and the data were extracted. Mitchell and Carson believe that researchers who use contingent valuation are intending to subtract the estimated derivation percentage of the WTP from the actual WTP (not to subtract the absolute amount of estimated WTP from the actual WTP). In such circumstances, they need to have a preliminary estimation of the coefficient of variation of the WTP (Mitchell and Carson 1989).

$$V = {}^{\delta}\!/\!_{\text{TWTP}} \quad (7)$$

where V is the coefficient of variation and $TWTP$ is the actual WTP. The coefficient of variation can be obtained from previous studies. The less the coefficient of variation is, the closer the WTP estimation will be to its actual amount in the society. Having the coefficient of variation, sample size can be calculated by the following equation (Mitchell and Carson 1989).

$$n = \left[{}^{(t \times \hat{\delta})}\!/\!_{(d \times \text{RWTP})}\right]^2 = \left[{}^{(t \times \hat{V})}\!/\!_{d}\right]^2 \quad (8)$$

where n is sample size, t is t-student statistic, $RWTP$ is the estimated amount of the WTP, and d is the percentage of the difference in RWTP from TWTP. The quantity of d was determined by the researcher showing how much deviation from the actual WTP is acceptable by the researcher.

Results and discussion

The explanatory results of quantitative variables of the tourists visited the surveyed regions are presented in Table 1 including individuals and household incomes, age, and education level.

According to Table 1, respondents had an average age of 37 (a relatively young population). Most respondents had diploma, and there was no illiteracy showing that an

Table 1 Descriptive results of quantitative variables

Variable	Mean	Min	Max	Standard deviation
Age	37	16	75	11.7
Household size	3.2	1	8	1.6
Education	13.6	0	20	3.5
Individual's income (IRR)	4,807,098.1	0	120,000,000	6,360,681.9
Family's income (IRR)	8,429,603.3	500,000	250,000,000	17,243,338.7

Table 2 Qualitative variables results

Variable	Gender		Marriage		Familiarity with dust		Offer acceptance	
	Male	Female	Married	Single	Yes	No	Yes	No
Number	322	157	379	100	346	133	334	145
Percentage	67	33	79	21	72	28	69.7	30.3

inclination to value the prevention of extra-regional intangible effects of dust and the protection value of the plain is higher among individuals with higher levels of education.

The results of tourists' quantitative variables are presented in Table 2. As can be seen, 67 % of respondents were men and 79 % were married. In other words, they contribute in conservation valuation with their families. Among respondents, 72 % were familiar with the effects of dust demonstrating the significance of the conservative effect by the province residents. In terms of bids, 69.7 % of respondents accepted them; 30 % accepted the 120,000–IRR bid, 28.6 % accepted the 250,000–IRR bid and 11.3 % accepted the 500,000-IRR bid. Respondents' occupational status signified that they were mostly self-employed indicating residents' convergence and flexibility for conservative valuation.

According to bid acceptance/rejection presented in Table 2, the results of the logit model estimation (Eq. 3) are shown in Table 3. According to this table, all variables have expected marks and are significant. In other words, individuals' socioeconomic characteristics resulted in significant differences in the possibility of accepting the bid for the prevention of the external effects of dust.

Coefficient of income is significant at the 5 % level statistically and this positive mark complies with what expected indicating an increase in the possibility of the WTP by those with higher incomes. According to the weight elasticity of this variable, a 1 % increase in a respondent's income enhances the probability of bid acceptance by 0.06 %. By virtue of the marginal effect of this variable, the probability of bid acceptance in order to prevent external effects of dust would rise by 0.03 units if an individual's income is increased by 1 million IRR.

The coefficient of education was significant at the 5 % level and its positive mark shows that the higher the level of an individual's education, the higher the likelihood of accepting the bid. According to the weight elasticity of this variable, a 0.1 % increase in a respondent's education level will raise the probability of a bid acceptance in order to prevent external effects of dust by 1 %. According to the marginal effect, probability of bid acceptance will rise by 0.07 units per 1 year increase in respondents' education.

The mark of the coefficient of household size indicates that conservative valuation is significantly decreased with the increase in household size. In other words, given higher conservation expenses of populated households, the WTP for preventing external effects of dust will dwindle. The weight elasticity of this variable shows that 1 % increase in respondent's household size decreases the likelihood of bid acceptance by 0.6 %. In addition, its marginal effect confirms that the increase in household size by one person reduces the probability of bid acceptance by 0.000012 units.

The results of estimating the coefficients of the logit model show that the variable of bid was significant at the 1 % level and its negative mark signifies that higher bid have lower probability of acceptance by respondents.

Table 3 Results of logit model estimation in order to calculate the conservative value of desert to prevent the inappropriate side effects

Variables	Coefficient	T-statistic	Elasticity	Marginal effect
Interception	0.12	0.3	–	–
Household size	−0.5	−2.3*	−0.66	−0.000012
Bid	−0.000014	−2.6**	−0.23	−0.0000034
Income	0.000000011	2.1*	0.06	0.00000003
Education	0.29	2.1*	0.11	0.07
Age	0.18	1.6	0.0043	0.0000042
Gender	−0.16	−1.1	−0.069	−0.04
Environment importance	0.23	2.1	0.21	0.053
Residence type	−0.38	1.2	−0.24	−0.088
Prediction accuracy percentage	0.74			
Significance level	0.0000			
Maximum likelihood statistic	51			
McFadden R^2	0.24			
Maddala R^2	0.32			

** and * are at the 1 and 5 % significance levels, respectively

According to the estimation of this variable elasticity, 1 % higher bid have 0.2 % lower likelihood of its acceptance in order to prevent external effects of dust. Besides, given its marginal effects, 100,000 IRR increase in bid reduces the probability of its acceptance for the prevention of external effects of dust by 0.3 units. Therefore, according to the principles of demand theory, the higher the bid is, the lower the likelihood of its acceptance will be.

The mark of the variable of Likrit spectrum, which indicates the importance of the environment in the studied plain from by respondents' viewpoint, is significant and shows that individuals who pay more attention to the environment are more eager to pay for the prevention of external effects of dust so that the probability of bid acceptance by people who care a lot about environment is 0.053 unit higher than by others.

The coefficients of the variables of age, gender, and residence type reflect the fact that older people are more willing to pay for the prevention of the detrimental effects of dust. Women also pay more attention to prevent the effects of dust than men do so that the probability of bid acceptance by women is, on average, 0.04 unit higher than by men. It implies more important role of women in protecting the environment and avoidance of adverse side effects. In addition, as villagers are exposed to the dangerous effects of dust more than town people, they are more eager to pay.

McFadden and Maddala coefficients reveal that the explanatory variables of the model well define the variations of the dependent variable of the model (respondents' WTP). The percentage of accurate prediction is 74 % in the estimated model. Hence, the estimated model successfully predicts an acceptable percentage of dependent amounts in terms of explanatory variables. In other words, 74 % of respondents were allocated accurately according to the Yes–No-predicted willingness to pay by rendering an appropriate proportion to the information.

After estimating the logit model, the expected value of protective WTP for the prevention of the undesirable effects of dust was estimated by the following integral.

$$\mathrm{WTP} = \int_0^{50{,}000} \left[\left(\frac{1}{1+\exp(-0.9+0.000014b)}\right)\right] \mathrm{d}b = 31{,}643\ (10\,\mathrm{Rials})$$

So households' WTP for the prevention of the side effects of dust was estimated to be 316,430 IRR in the region. According to the number of households living in the plain (259,095 households), the annual conservative value of the region is 93.4 billion IRR.

Conclusion

The estimation of the present study for the monetary sum of the prevention of the effects of dust is higher than almost all studies in Iran and is approximately equal to Fatahi's study (2010) on water conservation in the studied plain. Also, this study shows that people are willing to pay considerably higher amounts for improving air quality which is in agreement with results reported by Wang

et al. (2015). The results also show that awareness of the potential destructive effects in regions exposed to dust problems deserves more attention because a considerable amount has been allocated for prevention in comparison to other studies in Iran and that 72 % of respondents were familiar with the effects of dust. Therefore, it is suggested that public awareness of the various aspects of the prevention of the effects of dust is increased in the region through different educational and extension methods. According to the results and the estimation of the elasticities, it was demonstrated that respondents' income has a significant effect on accepting the bid. Therefore, it is recommended to policy-makers to raise income level, especially among those with lower income through fair distribution of wealth because environmental payments and demand for more conservation of natural resources is a product with high elasticity and people are willing to pay for it only if their personal income is increased. Therefore, higher income and financial support, especially among low-income individuals, is an effective way to stimulating bid acceptance.

Regarding the effect of education on bid acceptance, developing public education among people would be an effective step toward more attention to the aforementioned value and is a policy that the government can adopt to preserve the plain. The estimated results of the conservative value (preserving the plain against undesirable effects of dust) show that the annual conservation value of this region is 93.4 billion IRR. In other words, it is necessary to invest at least 93.4 billion IRR per year in order to prevent the harmful effects of dust in the plain. Given the considerable value of conservation in the Yazd-Ardekan plain and the high economic value of the surveyed region, it is suggested for the National Desertification Center of Yazd to take novel actions in this field to implement methods to protect the area from dust by cooperating with natural resources organizations and to apply appropriate measures to protect the air.

Given the 183 billion IRR expense of sand stabilization in the region and 93.4 billion IRR conservation value estimation for the plain, it is clear that 50 % of expenses will be paid by residents as the WTP which is an important step toward fulfilling the conservation phases with the assistance of experts and well-timed public contributions.

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