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AGGREGATE BENEFITS FOR IMPROVED IRRIGATION WATER MANAGEMENT: LABOR PAYMENT VEHICLE IN WONDO GENET AREA, SNNPR, ETHIOPIA

Alem Mezgebo
College of Agriculture and Environmental Science, Haramaya University, Ethiopia;

Worku Tessema
College of Business and Economics, Hawassa University, Ethiopia

Zebene Asfaw
Wondo Genet College of Forestry and Natural Resources, Hawassa University, Ethiopia;

ABSTRACT: *This study conducted a contingent valuation survey in Wondo Genet area to elicit households' willingness to pay for improved irrigation water management. A sample of 154 households were randomly selected and interviewed. Probit models were applied to determine the mean and factors affecting willingness to pay. The econometric result shows that the total willingness to pay estimated from the double bounded elicitation method was computed at 1,476,916 labors per annum for five years (i.e. $3,203,721.8 per year). While, from the open ended elicitation method willingness to pay was computed at 833,144 labors ($1,807,253.96 per year). The total annual WTP from double bound elicitation method was greater than from open ended elicitation method. This might be due to anchoring effect from the double bounded method. This study also empirically proved that monthly income, age, total farmland holding, initial bids, perception, total family size and tropical livestock units are the key determinants of demand for the resource. Therefore, significant socio-economic variables should also be considered while designing water related projects at household level.*

KEYWORDS: Contingent Valuation Method, Irrigation Water, Willingness to Pay

INTRODUCTION

Water is one of the natural resources which are very vital for sustaining human life, achieving sustainable development and maintaining ecosystems services (Savenije 2001; UNESCO 2006). It has unique characteristics that determine both its allocation and use as a resource in agriculture. Irrigation is a vital component of agricultural production in many developing countries (Chandrasekaran *et al.* 2009). Globally, 2.5% of the surface water is fresh water, and it is suitable for drinking, agriculture (Devi *et al.* 2009), recreational and environmental activities. However, the fresh water has been treated as an almost free resource (Turner *et al.* 2004; Sadeghi *et al.* 2010). As a result, with rapid economic and population growth many water sources have become depleted, therefore, now water has become a scarce good (Ahmad *et al.* 2010). Due to increasing scarcity of water resource competition and conflicts among uses and users arise. It is therefore necessary to make decisions about conservation and allocation of water that are compatible with economic efficiency, sustainability and equity (Agudelo 2001). Therefore, pricing of water can be considered as a tool to improve sustainable use of water resources (Chandrasekaran *et al.* 2009). Economists' uses individual willingness to pay (WTP) to determine the amount of money that consumers are willing to pay to improve the irrigation water and other environmental resources.

In Ethiopia, there is ground water potential of 2.6 billion m^3, eleven major lakes with a total area of 750,000 ha and total annual surface runoff of 123 billion m3 (MoWR, 2002). These freshwater provides many environmental goods and services (drinking-water, irrigation water, hydroelectricity generation, and recreation services) that are of economic benefit to society. However, in some part of Ethiopia like Wondo Genet area the economic value of the freshwater like irrigation water has been poorly estimated. Failure to estimate the economic value of improved irrigation water management may enhance the complexity of management decision of the environmental resource. In general, the marginalization of the economic values of the resource, and the associated degradation or loss of the resource may result in economic costs in terms of declining profits and lost opportunities. Specifically, farmers are facing shortage of irrigation water for agricultural production, and hence conflict is arising.

This study therefore, believed that the study plays a key role in formulation of a successful water policy in the study area and other area with similar characteristics. Besides, the study plays role in determination of the real contributions of irrigation water to sustainable economic development. A contingent valuation method (CVM) was used to estimate household preferences for improved irrigation water management. A respondent was introduced to a hypothesized market scenario and a WTP value in the form of double bounded elicitation method with follow up open ended questions. The study assessed the level of households' perception to the problems of irrigation water degradation, and determined the factors affecting households WTP.

MEASURING WELFARE CHANGE

Economic values of ecosystem goods and services (like irrigation water resource) are anthropocentric notions. In economics a good or service is valuable if it increases human well-being. This implies that the values of goods and services defined in the context of human welfare (Agudelo, 2001; Krieger, 2001). Economists classify the values derived from water resource and other environmental resource into use values and non-use values (Agudelo, 2001; Turner *et al.,* 2004; CAWMA, 2007). The use values arise from the direct use of water by consuming it or its services. While, non-use values are values arise from the mere existence of a resource, and they are not associated with any specific use of the resources (Agudelo, 2001). The term total economic values (TEV) was used to refer to the various benefits (use values and non-use values) derived from environmental resource such as water (Merlo and Croitoru, 2005). TEV measures the extent to which goods and services provided by water touch on the welfare of society, as direct determinants of individuals' wellbeing or via production processes (Turner *et al.*, 2004). However, TEV is not an absolute value because economics provides valuations only in comparative terms. When they say they are valuing an environment, economists are really defining a trade-off between two situations involving a change: e.g. improved management and not improved management of the renewable but exhaustible resource like irrigation water management.

In such change there are two possible choice situations. Either the individual gives something up to receive the object of choice that will affect his/her utility or well-being or the individual receives something to give up the object of choice that could affect his/her utility or well-being. The former situation corresponds to Willingness to Pay (WTP) and the latter to Willingness to Accept (WTA) and these are the fundamental monetary measures of value in economics.

These welfare measures (that is, WTP and WTA) applied to non-market transacted objects of choice as is the case of ecosystems were first proposed by Mäler (1971; 1974) as an extension of the standard theory of welfare measurement related to market price changes formulated by Hicks (1943). The analysis of this type of problems that involve changes in either the quantities or the qualities of non-market environmental goods and services rather than changes in prices or income is often referred to as the theory of choice and welfare under quantity (Johansson 1987, Lankford 1988).

According to Mäler if the object of choice generates an improvement in individual well-being (like in the case of this study) the individual is WTP an amount to secure that change (Compensated Willingness to Pay (WTP^C)) or he/she is willing to accept a minimum of compensation to give up it (Equivalent Willingness to Accept (WTA^E)). In the contrary, if the object of choice generates deterioration in well-being the individual is WTP to avoid this deterioration (Equivalent Willingness to Pay measure (WTP^E)) or he/she is willing to accept a compensation to tolerate the damages suffered (Compensated Willingness to Accept (WTA^C)). When economists talk about the value of an environment they are referring to an individual TEV measured by one of these four welfare measures mentioned by Mäler. The change of the quantity/quality of the environmental resource matters to the individual as well as the environmental existence or non-existence. Such changes must be shown up either in the individual utility function or in a constraint function.

According to (Freeman, 1993) let u(**x, q**) be the utility function of an individual with vector of market commodities are denoted **x**, and q is vectors of non-market environmental goods. It is also assumed that preferences represented by the utility function are continuous, non-decreasing and strictly quasi-concave in **x**. The individual faces a budget constraint based on their disposable income m, and the vectors of market commodities prices, **p**. Besides, the price of the elements of **q** are assume zero. The individual maximisation utility problem of decision is then specified as:

$$\max u(x,q) \qquad (1)$$

$$\text{subject to} \sum p_i x_i = m$$

The solution of this problem yields a set of conditional demand functions for **x** denoted as

$$x_i = x_i(p,m,q) \qquad (2)$$

for i = 1, …, n market commodities, and an indirect utility function also denoted as

$$V = V(p,m,q) \qquad (3)$$

The dual is an expenditure minimisation model defined by:

$$\min \sum p_i x_i \qquad (4)$$

$$\text{subject to } u(x,q) \geq u_0$$

The solution to this problem gives the restricted expenditure function denoted as

$$e = e(p, q, u^0) \qquad (5)$$

This is the total expenditure on all goods, including q, necessary to achieve u^0 given p and q. If the proposed change is welfare increasing through changes in the quantity of environmental goods, which is the focus of this study, the appropriate welfare measure is the compensating surplus (CS). This measure can be interpreted as the consumer's WTP in order to gain the quantity increase and still maintain their initial utility level (Mitchell and Carson 1989). Given the duality between the indirect utility function and the expenditure function, CS can be written in terms of the expenditure function as:

$$WTP = CS = [e(p_0, q_0, u_0)] - [e(p_0, q_1, u_0)] = \int_{q_0}^{q_1} \frac{\partial e(p,q,u^t)}{\partial q} dq \qquad (6)$$

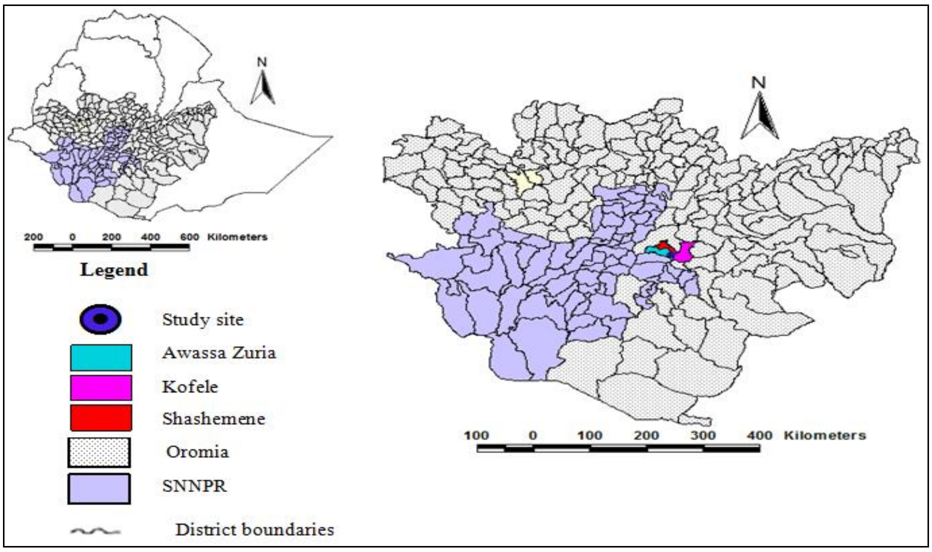
In equations (6) $\frac{\partial e(p,q,u^t)}{\partial q}$ is the derivative of the expenditure function with respect to public goods (q), where t = 0 refers to the initial level of utility and t =1 the final level of utility after the change in public goods (q). The result of the derivative represents the marginal value of a small change in q and is equal to the income variation that is just sufficient to maintain utility at its initial level. In geometrical terms, the absolute value of the derivative of the expenditure function with respect to q is equal to the slope of the indifference curve through the point at which the welfare change is being evaluated. Within the same equations, the integral is the value of a non-marginal change in q for the relevant range in the environmental goods like improved irrigation water management.

RESEARCH METHODOLOGY

Descriptions of the Study Area

The study was conducted in Wondo Genet area located about 260 kms far from Addis Abeba between 38^0 37' to 38^0 42' Longitude East and 7^0 02' to 7^0 07' Latitude North(see figure 1 below). The landscape of the study area varies with an altitude ranging between 1600 and 2580 masl. The annual rainfall and temperature is ranges between 700mm-1400mm and 17°c-19°c, respectively. The livelihood of the population typically depends on the combination of woody perennials with crops and animals on the same unit of land management. The study area uses Wosha, Werka, Hallo and Lango rivers for irrigation and other domestic uses.

Figure 1: Location of the study area



Sample Size and Data Collection Methods

A two-stage sampling technique was used when selecting respondents. In the first stage three kebeles (Wetera-Kechema and Wosha-Soyama and Shashe-Kekele) were purposively selected out of the 18 kebeles based they are identified as intensive users of water resources for irrigation purposes. In the second stage, a total 154 households were selected using random sampling techniques. Both secondary and primary data were used. The primary data were collected using face to face interviews. A CVM method in the form of double-bounded dichotomous choice elicitation method with open ended follow up question was also employed to elicit households' WTP for improved irrigation water management. The double-bounded dichotomous choice format makes clear bounds on unobservable true WTP and sharpens the true WTP (Haab and McConnell 2002). Finally, the double-bounded dichotomous choice format help to elicited more information about respondent's WTP than single bounded format (Hanemann *et al.* 1991; Arrow *et al*. 1993).

Based on the pilot results the starting point prices identified for WTP in terms of labors were also 32.5, 65 and 100 labors per year. Given this, the actual survey was undertaken by dividing the total sampled households randomly into three groups (about 51 households). The field survey was successfully completed with relatively small number of protest zeros (about 2%). The criteria for selecting protest zero was based on the report of the NOAA Panel on contingent valuation by Arrow *et al*. (1993). After checked for sample selection bias the protest bidders were excluded from the data set.

Empirical Model

When the dependent variable in a regression model is binary the analysis could be conducted using linear probability or logit or probit models (Pindyck and Rubinfeld 1981). But, the results of linear probability model may generate predicted values less than zero or greater than one, which violate the basic principles of probability (Gujarati 2004). However, logit or probit models generate predicted values between 0 and 1, and they fit well to the non-linear relationship between the probabilities and the explanatory variables (Pindyck and Rubinfeld 1981; Gujarati 2004). Besides, the probit model works well for bivariate models than logit model (Park 2008). Therefore, in this study probit model was used to determine the factors that affecting the WTP of households. Following Cameron and Quiggin (1994), the probit model was specified as:

$$y_i^* = \beta' x_i + \varepsilon_i \qquad (7)$$

$$y_i = 1 \; if \; y_i^* > I_i^*$$

$$y_i = 0 \; if \; y_i^* < I_i^*$$

Where: β'= vector of unknown parameters of the model

x_i= vector of explanatory variables

y_i^*= unobservable households' actual WTP for improved irrigation water management

y_i= discrete response of the respondents for the WTP

I_i^*= the offered initial bids assigned arbitrarily to the i^th^ respondents

ε_i= unobservable random component distributed $N(0,\sigma)$

The bivariate probit model was used to estimate the mean WTP from the double bounded dichotomous elicitation method. According to Greene (2003), a bivariate probit model was specified as:

$$y_1^* = \beta_1 x_1 + \varepsilon_1$$

$$y_2^* = \beta_2 x_2 + \varepsilon_2$$

$$E(\varepsilon_1/x_1,x_2) = E(\varepsilon_2/x_1,x_2) = 0 \qquad (8)$$

$$Var(\varepsilon_1/x_1,x_2) = Var(\varepsilon_2/x_1,x_2) = 1$$

$$Cov(\varepsilon_1,\varepsilon_2/x_1,x_2) = \rho$$

Where: y_1^*= i^{th} respondent unobservable true WTP at the time of the first bid offered. $WTP = 1 \text{ if } y_1^* \geq \beta_i^0 \text{ (initial bids)}, 0 \text{ otherwise}$

y_2^*= i^{th} respondent implicit underlying point estimate at the time of the second bid offered.

$x_1 \; and \; x_2$ = The first and second bids offered to the respondents respectively.

$\varepsilon_1 \; and \; \varepsilon_2$= Error terms for the first and second equations of equation 4 above

$\beta_1 \; and \; \beta_2$= Coefficients of the first and second bids offered

RESULTS AND DISCUSSION

Why Irrigation Water degradation

Awareness about the availability of irrigation water is very essential to elicit households WTP. The result showed that 92.05% of the respondents have an experience of using the water resources for irrigation to produce crops and vegetables. However, a majority of the sample respondents (92.05%) reported that the irrigation water received from the two rivers was inadequate. 39.74% of the respondents frequently mentioned population pressure as the first environmental problem followed by deforestation (27.81%), illegal settlement in the forest area (14.57%), Soil and water degradations (5.76%) and Inequitable water distribution (5.03%). Suggestions were also elicited from the respondents to overcome the irrigation water problems. A majority of the respondents suggested that planting and maintaining trees (43.89 %) was the first frequently mentioned protection measure followed by soil and water conservation (28.78%), punishing illegal dweller (20.14%) and training irrigation water users (7.195%).

Households WTP for Improved Irrigation Water Management

The mean willingness to pay for improved irrigation water management was computed at 62.47 labors per year for five years. At 95% confidence interval the WTP varies from 68.06 to 56.87 labors (see Table 2 below). This mean WTP from double bound format was greater than the mean value from the open ended response which was computed at 35.24 labors per year for five years. This may indicate the existence of anchoring effect from the double bounded elicitation method. This result is consistent with the various studies (Köhlin, 2001; Carlsson *et al*., 2004 and Solomon, 2004).

Table 1: Estimation results of the bivariate probit model

Variable	Coefficient	Std. Err	z
Initial bid	-0.0115	0.0027	-4.19
constant	0.7827	0.2242	3.49
Second bid	-0.0093	0.0022	-4.14
constant	0.5289	0.1933	2.74
ρ***	0.9676	0.0516	
Log- likelihood= -177.69			
Wald chi2(2)= 21.59			
Prob> chi2=0.000			
Likelihood-ratio test of rho=0: chi2(1) =33.26 Prob > chi2 = 0.000			
Mean WTP[1]= 62.47 labors (At 95% CI, 68.06 to 56.87 labors)			

[1] The mean WTP from bivariate probit model was computed using the formula specified by Haab and Mconnell (2002) that is, mean WTP $= -\frac{\alpha}{\beta}$; α is a coefficient for the constant term, and β is a coefficient for offered bids to the respondents

The willing respondents were also asked to point out their reasons for maximum WTP. The reasons for maximum WTP were about 58.14% of the respondent reported that they could not provide more because of labor shortage. While 41.86% reported that the amount they decided to pay was enough.

Determinants of Households' WTP

Estimate of the parameters of the variables expected to affect willingness to pay for improved irrigation water management are shown in Table 3 below. The result shows that out of the total 13 explanatory variables, 7 explanatory variables (i.e. monthly income, total farm land holding, total family size, age, initial bids, tropical livestock unit and perception) were statistically significant variables. However, the marginal effects cannot be adequately explained from the estimated coefficients of the probit model. In order to analyze the effects of each explanatory variable on the probability that respondents accept or reject the initial bids from the probit model, we have estimated the marginal effect of the probit model. Specifically, keeping the influences of other factors constant at their mean value, a one birr increase in income of the respondent the probability of accepting the first bid increase by about 0.04%. This indicated that household with higher income is willing to pay more for improved irrigation water management than households with lower income. Households' perceptions were also more likely willing to pay for improved irrigation water management. That is, keeping other things constant, changing the dummy from 0 to 1 will increase probability of accepting the initial bid by about 25%.

Table 2: The probit model estimation results of households' WTP

Independent variables	Coefficient	Marginal effect	Std. Err.	z-value
Monthly income	0.001	0.0004	0.0003	3.00***
Age	-0.023	-0.0087	0.0114	-2.00**
Sex	-0.091	-0.0346	0.3444	-0.26
Marital status	0.003	0.0011	0.381	0.01
Education level	0.043	0.0165	0.0477	0.91
Status of respondents	0.068	-0.026	0.3361	-0.2
Total family size	0.108	0.0411	0.0496	2.17**
Total farmland holding	1.731	0.6615	0.7605	2.28**
Distance from water source	0.076	0.029	0.2098	0.69
Level of satisfaction	-0.051	-0.0194	0.3334	-0.15
Initial bids	-0.013	-0.005	0.0057	-2.27**
Perception	0.647	0.2491	0.3397	1.90**
Tropical livestock unit	-0.236	-0.0901	0.1101	-2.14**
Constant	-0.646		0.8889	-0.73
Number of observation	151			
Log likelihood	-59.55			
Pseudo R^2	0.43			
LR $chi^2(13)$	89.9			
Prob > chi^2	0.000			

***, ** & * indicate significant level at 1%, 5% and 10%, respectively
(Source: own survey)

Aggregate WTP for Improved Irrigation Water Management

An important issue related to the measurement of welfare using WTP is aggregation of benefit. According to Mitchell and Carson (1989) there are four important issues to be considered regarding sample design and estimating a valid aggregation of benefits: population choice bias, sampling frame bias, none response bias and sample selection bias. Random sampling method was used in this study using a list of households. Face to face interview methods was used and protest zero responses were excluded from the analysis and expected protest zeros was accounted in the estimation of the total aggregate benefit of improved irrigation water management. Hence, none of the above biases was expected in this study. Mean WTP was used as a measure of aggregate value of improved irrigation water management in this study. As it is indicated in Table 4 below, the aggregate WTP was calculated from both elicitation methods using the mean WTP and total number of households in the population. From double bounded elicitation method the aggregate WTP for improved irrigation water management was computed at 1,476,916 labors per year (which is equivalent to 59,076,630 birr), whereas from open ended format it is estimated at 833,144 labors per year for five years (which is equivalent to 33,325,763 birr).

Table 3: Aggregate Benefits of improved irrigation water management

Total households (Y)	Expected households to have a protest zeros (X)[2]	Expected households with valid responses (Z)[3]	Mean WTP(W)[4]	Aggregate Benefit[5]
24124	482	23642	62.47	1,476,916
24124	482	23642	35.24	833,144

Source: Own survey

CONCLUSION AND RECOMMENDATIONS

The study revealed that the water resource is inadequate and would be insufficient for productions of cash crops and livestock watering. This is because of population pressure, deforestation, soil and water degradations, and inequitable water distribution. The total WTP from the double bounded dichotomies choice was computed at 1,476,916 labors per year for

[2] 3(2%) of 151 sampled households were protest zeros. We excluded those protest zeros from further analysis after we have tested for sample selection bias. So X is the expected number of households which are expected to protest for the proposed project. It is calculated by the percentage of sampled protest zeros (2%) by the total population 24124 (Y).
[3] Y-X is the total households in the study area which are expected to have a valid response
[4] Is the mean willingness to pay per year
[5] Is mean multiplied by the total households which are expected to have valid response (Z*W). The local wage rate used was 40 birr which is the minimum wage rate for person day per day (personal communication)

five years. Whereas, from open ended format was also computed at 833,144 labors per year. This showed that the value of improved irrigation water management from open ended format was lower. This might be due to anchoring effect from the double bounded method. Thus, in estimating the value of improved irrigation water management at household level, it is important to use CVM in the form of open ended elicitation format. Besides, small respondents were recorded as protest zero, and imply that contingent valuation method is appropriate method to value improved irrigation water management. The empirical findings on the determinants of WTP indicated that monthly income, age, total farm land holding, initial bids, perception, total family size and tropical livestock unit were key factors influencing the WTP. Therefore, understanding of socio-economic characteristics that influenced households WTP is a necessary and first step to achieve improved irrigation water management.

REFERENCE

Agudelo, J.I. (2001) *Economic valuation of water: principles and methods*. Value of water. Research Report Series No. 5. The Netherlands

Arrow, K., R., Solow, P.R., Portney, E. E., Leamer, R., Radner, H., Schuman (1993) Report of the NOAA panel on contingent valuation. *Federal Register*, 58:4601-4614pp

Cameron, T. A. and Quiggin, J. (1994) Estimation using contingent valuation data from a dichotomous choice with follow-up questionnaire. *Journal of Environmental Economics and Management*. 27(3):218-234pp

Central Statistical Agency (CSA) (1995) Report on land utilization, statistical bulletin 132, Addis Ababa, Central Statistical Authority, Addis Ababa.

Comprehensive Assessment of Water Management in Agriculture (2007). Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan, and Colombo: IWMI.

Devi, J.S., B. Joseph, K. Karunakaran, B. Anurdha and K. R. Devi (2009) People's attitudes towards paying for water: India Review Article, *Current Science*, 97(9)

Federal Democratic republic of Ethiopia Population Census Commission (FDREPCC), (2008) Summary statistics and statistical report of the 2007 population and housing census: population size by age and sex. Addis Ababa, Ethiopia.

Freeman III.A.M.(1993). The Measurement of Environmental and Resources Values: Theory and Methods, Resources for the Future, Washington, DC.

Greene,W.H. (2003) *Econometric analysis*. 5th edition. Pearson education, Inc., Upper Saddle River, New Jersey, 07458

Gujarati, D.N.(2004) *Basic econometrics*. 4rd Edition. McGraw-Hill, Inc.

Haab, T.C. and K. E. McConnell (2002) *Valuing environmental and natural resources, the econometrics of non market valuation*. Edward Elgar, Cheltenham U.K

Hanemann, M., J., Loomis and B., Kaninen (1991) Statistical efficiency of double bounded dichotomous choice contingent valuation. *American Journal of Agricultural Economics*, 73(4), 1255-1263pp

Johansson P-O. 1987. The Economic Theory and Measurement of Environmental Benefits. Cambridge University Press: Cambridge UK.

Krieger, D.J.(2001).The Economic Values of Forest Ecosystem Services: A Review. The Wilderness society, 1615 M Street, NW, Washington, D.C. 20036.

Lankford RH. (1988). Measuring Welfare Changes in Settings with Imposed Quantities. *Journal of Environmental Economics and Management* **15**(1): 45-63.

Mäler KG. (1971). A Method of Estimating Social Benefits from Pollution Control. *Swedish Journal of Economics* **73**: 121-133.

________ (1974). *Environmental Economics: a Theoretical Inquiry*. Johns Hopkins University Press: Baltimore.

Merlo M, Croitoru L (2005). Valuing Mediterranean Forests: Towards Total Economic Value, CABI Publishing.

Mitchell, R.C., Carson, R.T.,(1989). Using surveys to value public goods: the contingent valuation method. *Resources for the Future*, Washington, 463 p.

Park, H.M.(2008) Estimating regression models for categorical dependent variables using SAS, STATA, LIMDEP, and SPSS. The Trustees of Indiana University

Pindyck, R.S. and D.C. Rubinfeld(1981) *Econometric models and econometric forecasts*. 2nd Edition. Mcgraw-Hill Book Co. New York

Sadeghi, A., M. G. Mohayidin, Md A. Hussein and A. Baheiraei (2010) Determining the economic value of the irrigation water in production of wheat in Iran**.** University Putra Malaysia. *Australian Journal of Basic and Applied Sciences,* 4(6): 1391-1402p

Savenije, H.H.G. (2001) Why water is not an ordinary economic good. Value of Water Research Report Series No. 9, the Netherland

Turner, K., S. Georgiou, R. Clark, R. Brouwer, and J. Burke (2004) Economic valuation of water resources in agriculture: from the sectoral to a functional perspective of natural resource management, FAO 2004, Rome, Italy

UNESCO (2006) Water: a shared responsibility. United Nations second world water development report, United Nations Education: New York.