Hydropower versus Non-market Values of Nature: a Contingent Valuation Study of Jägala Waterfalls, Estonia

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***Abstract*—**The article discusses the resource utilisation conflict at the example of Jägala Waterfall, which is the highest and greatest natural waterfall in Estonia. There are plans to build a hydro-power plant there, which would conduct most of the water past the waterfall to the power plant's turbines, reducing significantly the nature values of the waterfall. The authors carried out a contingent valuation (CV) study to identify the monetary equivalent of non-market values related with Jägala waterfall in the natural state.

***Keywords*—** Contingent valuation, nature resource utilisation, waterfall, hydropower.

I. Introduction

THE Jägala Waterfalls are located in the lower course of Jägala River, on the territory of Harju County, approximately 25 km east of the capital of Estonia Tallinn, 4 km before the river flows into the Gulf of Finland. The waterfall is 8 metres high and over 50 metres wide. The waterfall of Jägala is the highest and most powerful natural waterfall in Estonia. The photos of it illustrate many materials that present Estonia as a tourist destination. The waterfall with its roaring waters is a popular tourist attraction and is visited by 50-100 thousand people annually, both from Estonia and abroad.

A private capital based enterprise is planning to restore a hydro-power plant, which would conduct some water past the waterfall to the power plant's turbines. As a result, the waterfall will have minimal flow most of the year. The expected capacity of the power plant would be 1-2MW, which is less than 0.1% of the total electricity production in Estonia. As a result of power production the aesthetical and recreational value of the Jägala Falls will be significantly reduced.

To identify the monetary equivalent of the non-market value of the Jägala Falls in natural state, the authors conducted in Estonia a representative contingent valuation study (950 respondents) of the waterfall. To simulate a market scenario two photos of the Jägala Falls were presented to the respondents. On the first photo the waterfall has a medium natural quantity of water. The second photo depicts the waterfall as it will be when the power plant is working. The survey included an open ended question about how much individuals would be annually willing to pay for keeping the Jägala Falls in its natural state. On the basis of respondents'willingness to pay the authors identified the monetary equivalent of non-market value of the Jägala Falls in its natural state.

II. Methodology

A. Monetary value of non-market goods

Every person's judgement of his/her life quality contains an assessment of his/her living standard and of non-market values[1] perceived-valued-regarded as necessary by him/her. Theoretically every person can evaluate what (how big) part of his/her income he/she is ready to donate (how much he wants to spend) for the achievement of which non-market value – in order to improve overall value of his life quality.[2] Hence every non-market value has different and temporally changing economic equivalent for every person.

Non-market value addressed in this paper is the recreational and aesthetic value of the nature.

Valuation of recreational and aesthetic phenomena of the nature as non-market environmental goods and finding their monetary equivalent are an important stage in valuation of the nature by people. Nature's value (inc. recreational value) is revealed to us in many intertwined forms: continuing functioning of ecological systems and other attractive natural objects used for recreational purposes as the preservation value of the database thereof, living creatures and their survival as the value bequeathed to our descendants, and as the value of alternative usages in the future.

Many values of the nature are non-market. Individuals' economic judgement of these values is revealed by the willingness to pay for preserving or restoring the natural object as the bearer of value. Methodologically correctly identified willingness to pay gives information on the monetary equivalents of values of the nature.

[1] Non-market values are characterised by that they have no price developed in the purchase-sale process. Therefore the non-market values have no automatic monetary equivalent, and in order to find it specific economic research methods must be used, such as the contingent valuation method.

[2] The judgement discussed here depends on very many factors changing over time: current and desired standard of living, health, education, habits, social background of people, etc etc.

B. Contingent valuation method

The contingent valuation method was proposed by Wantrup [1] to evaluate non-utilitarian values. The first application of the technique was in 1963 when Davis [2] tried to estimate the value hunters and tourists placed on a wilderness area. In the mid-1970s, the contingent valuation method started to spread rapidly. Since then the method has grown increasingly more popular and is widely used in all advanced democracies, being a good instrument for adopting democratic decisions.

Comprehensive accounts of the method may be found in Mitchell and Carson [3], Hanley and Spash [4] and Bateman and Willis [5].

Although there are authors who have expressed doubts about the application of some aspects of the contingent valuation [6]-[8], just during the last decades the method has gained more ground due to the lack of suitable alternatives [9] especially for estimating economic value of certain territories (mainly protected areas) [10]-[14], as well as communities and ecosystems [15], [16] and certain biological species [17]. The method is an important tool in finding arguments for restoration of communities [18]. The method is widely used also in fields not so directly linked with nature protection for finding out monetary equivalent of non-market values [19], [20].

There is no standard approach to the design of a contingent valuation (CV) survey. In most cases the CV survey contains three parts: 1) simulated market scenario of availability of the surveyed environmental good upon which valuation is contingent; 2) "willingness to pay" (WTP) (for the surveyed environmental good) or "willingness to accept" (the loss of the surveyed environmental good) question, which is presented in a certain form; 3) sociometric questions about the respondent. The survey is distributed to a random representative selection of respondents.

Contingent valuation seeks to identify respondents' willingness to pay for goods, projects or programmes which are essentially hypothetical. The value attached to the object by the respondents in the form of willingness to pay is contingent in relation to the constructed or simulated market (or market scenario) in the questionnaire [21]. If there is no actual market for some goods (i.e. good is nonmarket), it has to be created hypothetically. People are asked how much they agree to pay for increasing the quality or quantity of the goods (to avoid a loss), which is regarded as willingness to pay. Most of the contingent valuation method applications are related with environmental objects and other nonmarket goods which have the characteristics of utilitarian value [19].

In Estonia an assessment of the non-market value of semi-natural grasslands was conducted in 2000,[3] which identified demand by Estonian population for semi-natural grasslands as an environmental good. Based on this research a successful application was lodged for financing investments for the preservation of semi-natural communities from EU structural funds.

[3] Ehrlich, Ü., Habicht, K., 2001. Non-Use Value and Maintenance Costs of Estonian Ecological Seminatural Communities. In: Ü. Ennuste and L. Wilder (eds.). Factors of Convergence: A Collection for the Analysis of Estonian Socio-Economic and Institutional Evolution. Tallinn, 227-263.

C. Quantified non-market value as input for cost-benefit analysis

Of increasingly greater importance in the decision-making concerning the nature use is cost-benefit analysis, and in developed countries that the cost-benefit analysis is taken closely into account while making decisions concerning administration and management of natural territories.

Cost-benefit analysis can be regarded as an information system or tool in adopting national decisions. Two issues of fundamental importance arise from that [22]: 1) What kind of relevant information a cost-benefit analysis contains and how does it function as a decision-making tool the national policies? 2) How does an information system or decision-making tool participate in the national (or public) decision-making process?

The cost-benefit criterion is directly dependent on individual public interests. Cost-benefit analysis is an empirical framework for evaluating different alternatives. Hence it is mainly an assessment tool. The current situation is projected into the future (i.e. the situation without planned project), comparing it to the situation where the project has been realised. The situations "with project" and "without project" should be addressed comprehensively, defining them first with natural science rather than economic terms. Relationships between the planned input of a natural system, environmental attributes and service flows that the input might involve, need to be quantified. Hence the impact of people's intentions on the complex system under study is to be presented so that it would be possible to monitor the development of scenarios "with project" and "without project" in physical terms. Only then economic categories may be introduced into the scenario to forecast the possibilities for people to use them in the environment "without project" and "with project," and to estimate economic costs and benefits involved in different propositions.

Accuracy and validity of economic assessments depend directly on the amount of natural science facts that are important for comprehending new, emerging relationships, which often are difficult to assess, and taking them into consideration in decision-making.

Assuming that the situations "without project" and "with project" are defined in physical terms (e.g. as services), the next task is economic assessment. Benefit is assessed on the basis of willingness to pay and willingness to accept, which both ultimately depend on individual preferences and economic well-being. According to a new consumption theory [23], willingness to pay and willingness to accept are most influenced by the co-effect of consumer technologies and individual preferences. Consumer technologies reflect the skills and opportunities of using the environment for the satisfaction of human needs.

III. CONTINGENT VALUATION STUDY OF JÄGALA FALLS

The Jägala Falls is the highest and most powerful natural waterfall in Estonia. Photos of it illustrate numerous materials presenting Estonia as a tourist destination. The waterfall is a popular sightseeing object, and 50−100 thousand people from Estonia and abroad visit it annually.

A hydro power plant in the Jägala Falls is under reconstruction currently. When it starts operating some of the water will be directed past the waterfall into power plant's turbines. As a result the amount of water in the waterfall will decrease. The designed capacity of the power plant is 1−2 MW, production less than 0.1% of the electricity produced in Estonia. The current research seeks to identify the impact of water reduction on the aesthetic and recreational value of the Jägala Falls.

A. Monetary value of the Jägala Falls

In order to identify the non-market economic equivalent of the recreational value of the natural Jägala Falls a contingent valuation survey was conducted. Two photos were presented in the survey. On the first photo the Jägala Falls was recorded with medium natural water flow. On the second photo, the amount of water falling down the falls was approximately equal to the minimal water flow the power plant has to give to the falls. The willingness to pay question was formulated as an open ended question. The respondents were asked how much they agree to pay annually for preserving the natural flow of the Jägala Falls with no ready-made answers to choose from. Every respondent could write exactly the amount he/she wanted.

The survey was conducted in spring 2009. The sample was made using the principle of random representativeness of Estonian population. A total of 950 Estonian residents participated in the survey. 60% of all the respondents were hypothetically willing to pay something; the sums were between 0,06 and 1278 €. There were two marginal values: 767 and 1278 €, other amounts were within the limits of 320 €. 373 or 40% of the respondents answered zero. The reasons for zero answers can be divided into three main groups: 1) Low income and lack of financial means; 2) it is unethical to calculate the nature in monetary figures; 3) the state must deal with this issue, not citizens.

Answers to the question whether people agree with utilisation of places with high recreational value for the purpose of green energy production show that majority of people (88%) are disagree. Taking into account the sociometric features, the logit estimations (Table 1) suggest that the agreement depends on gender, age and incomes; the level of education is not statistically significant. The most powerful indicator is gender, men compared the women are more likely agree with the green energy production is such places. Relationship between agreement and age is negative, younger people are somewhat more likely to agree, the increase of age decrease the probability of agreement. The size of income has also negatively impact, the higher the income, the lower the agreement.

Table 1. Agreement with the green energy production in scenic sites, binary logit estimations

	Coef	S.E.	Wald	Sig.
Gender	0.948	0.209	20.538	0.000
Age	-0.129	0.062	4.347	0.037
Education	0.201	0.125	2.589	0.108
Income	-0.175	0.068	6.601	0.010
Constant	-1.803	0.435	17.186	0.000

The impact of sociometric features to WTP is estimated by two step procedure. The binary logit regression allow us to assess the indicators' influence to the decision pay (WTP>0) or not pay (WTP=0). Thereafter OLS regression is used to find the relationship between sociometric indicators and the amount of pay for people with positive WTP. The logit results (Table 2) suggest, that more likely are willing to pay women and persons with higher income. The concave relationship with age implies that younger and older persons are more likely to pay compared with middle-age groups. The level of education is not statistically significant indicators.

Table 2. The influence of the sociometric indicators to the payment decision, binary logit estimations

	Coef	S.E.	Wald	Sig.
Gender	-0.565	0.146	14.908	0.000
Age	-0.505	0.232	4.740	0.029
Age^2	0.070	0.034	4.402	0.036
Education	-0.012	0.089	0.018	0.894
Income	0.111	0.051	4.717	0.030
Constant	0.964	0.377	6.516	0.011

The influence of the sociometric features to the amount of WTP is estimated as follow

$$\ln(WTP_i) = \alpha + \beta_1 gender_i + \beta_2 \ln(age_i) + \beta_3 \ln(educ_i) + \beta_4 \ln(inc_i) + \varepsilon_i \tag{1}$$

where gender is dummy variable (male=1, female=0) and all other variables are categorical variables. The results of estimation given in table 3 suggest that the amount of WTP is not remarkably affected by the sociometric features. There are not statistically significant differences in WTP amount by gender, age or level of education. The size of WTP is somewhat influenced only by the amount of income, the persons with better income tend to pay more. The decision to pay or not to pay was dependent on various indicators but as soon as the payment decision was made only the size of income influences the payment amount.

Table 3. The influence of the sociometric indicators to the WTP amount, OLS results

	Coef	S.E.	t	Sig.
Gender	0.161	0.139	1.159	0.247
Age	-0.081	0.117	-0.699	0.485
Education	0.365	0.169	2.154	0.012
Income	0.149	0.209	0.715	0.475
Constant	4.054	0.268	15.149	0.000
$AdjR^2$=0.09				

There are several different ways to find the aggregated amount of WTP. The open-ended scale and asking of the actual amount of willing to pay allow us to calculate the aggregated WTP by multiplying the average or median WTP obtained from sample with number of total working age population. However, such calculations tend to overestimate or underestimate the aggregated WTP and we decide to use the fitting of demand curve.

The construction of aggregated demand curve for take Estonian working age population is based on the actual distribution of WTP amounts obtained from the survey. The results are generalized to the whole working age population; the proportion of people with positive WTP is 60 %, i.e. 567 000 persons.

The most appropriate functional form, for presenting WTP data is the exponential model

$$WTP = \alpha e^{-\beta x} \tag{2}$$

where WTP is the amount of willingness to pay, x is the number of people willing to pay at least this amount, and α, β the parameters under estimation.

The results of regression estimation, using the least squares method are shown in table 4. The value of coefficient of determination (R^2=0.91) indicate a high goodness of fit, both parameters are statistically significant.

Table 4. WTP regression results, estimated parameters

Vari-able	Coeffi-cient	SE	t-Statistic	Prob.
α	0.23236	0.04357	53.333	0.000
β	0.02317	0.00061	38.171	0.000
R^2	0.91			

Based on the estimated parameter we can write the equation of demand curve as:

$$WTP = 0.232e^{-0.023x} \tag{3}$$

The demand curve, fitted graphically based on this equation is given in Fig. 1. The vertical axis represents the WTP amounts (thousand €) and horizontal axis the number of persons willing to pay at least this amount.

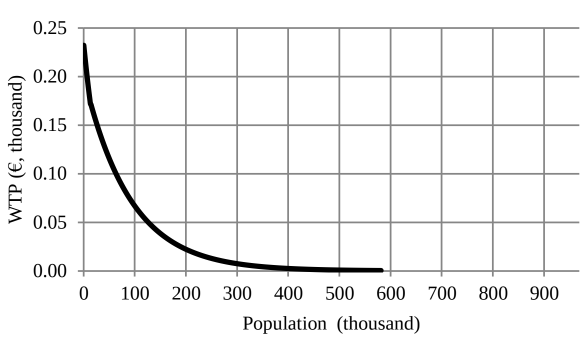

Fig 1. Estimated demand curve

The area under the demand curve represents the consumer surplus (CS) of the working age population and we can estimate it by a definite integral:

$$CS = \int_{x_1}^{x_2} WTP(x)dx = \int_{x_1}^{x_2} \alpha e^{-\beta x} dx = -\frac{\alpha}{\beta}(e^{-\beta x_2} - e^{-\beta x_1}) \cong \frac{\alpha}{\beta} \tag{4}$$

where x_1=0 and x_2 are the number of people with positive WTP (567 thousands).

Replacing the values of parameters a and b we receive that the estimated consumer surplus.

$$CS = \frac{\alpha}{\beta} = \frac{0.23236}{0.02317} \approx 10 million\,€ \tag{5}$$

Hence the annual demand of Estonian working-age population for the Jägala Falls with the natural flow of water is approximately 10 million €. Consequently also the monetary equivalent of the value of the Jägala Falls with the natural flow of water as an environmental good is 10 million € annually.

The current research enables to compare the monetary equivalent of the non-market value of the Jägala Falls and the value from electricity production (i.e. compare the non-market economic benefit from the recreational use of the Jägala Falls as the natural value to direct economic benefit from electricity production). This is essential information, for example, for local governments in the decision-making process, where they can compare the efficiency of electricity production and recreation for the society.

In order to compare the result and income from electricity production, the latter needs to be defined.

The planned capacity of the hydro-power plant at the Jägala Falls would be ca 1500 KW, annual operating time max 2000 hours and electricity purchase price approximately 0.1 € per kilowatt.

Hence the power plant would produce 3 million kilowatts of electricity annually, with the total monetary value of 0.3 million €.

IV. CONCLUSIONS

Majority of respondents disagree with the green energy production in a scenic site. Taking into account the sociometric indicators, men, younger people and lower income earners are somewhat more likely to agree with such usage; the level of education is not important. The pay or not to pay decision for the natural flow of Jägala depends also on gender, income and age but not on the level of education. Women, younger and older but not middle-aged persons, and higher income earners are more likely to pay. However, after making the decision to pay the amount they are willing to pay depends only on the size of income rather than sociometric indicators.

According to the demand curve an estimated monetary equivalent of the Jägala Falls with the natural flow of water as an environmental good is 10 million € annually. It is nearly 35 times (!) as big as the value of the waterfall for electricity production.

Comparing the importance of the Jägala Falls as a unique objet of nature and as part of the identity of many people with its modest electricity producing capacity (as a non-unique and non-deficient good), the findings of the research are in every respect as expected.

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