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Impact Analysis of Irrigation Projects: an Application of Contingent Valuation Method

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Abstract: Water supply in rural and urban areas is an issue of primary concern, especially in developing countries. The objective of this study is to estimate some socioeconomic and environmental values of three irrigation lakes, constructed at *Panagitsa* village (Region of Central Macedonia, Prefecture of Pella). The study area is characterized, especially during the summer session, of limited water supply for irrigation purposes. Although the majority of Contingent Valuation Method (CVM) studies have been restricted to environmental goods, this method can applied to public goods in general. It is assumed that the consumers' satisfaction of water supply service, their opinions about the water management system and its affordability might have an impact on their Willingness to Pay (WTP).Various outputs were defined and each one's economic value was estimated. Water supply, recreation, health effects, social impact, environmental consequences and some more outputs were valued through the CVM. These values can assist managers and policy makers in making decisions regarding the opportunity cost of the irrigation projects, their management options and the project's alterations or preservations. These values of the irrigation projects' outputs are estimated under the assumption that all other wetlands or water resources in the region remain unchanged.

Key words: Irrigation projects, Socioeconomic, Environmental, Impacts, Contingent Valuation Method, Level of satisfaction, Water Resources

INTRODUCTION

Most of the elements that the natural landscape offer, such as wildlife habitat and aesthetics, are not expressed in market prices. Up to a point, these elements are overlooked in decision making, partly because the social outputs are not recognized by private landowners. Consequently, a value of zero (or infinity) is often assigned to them. When development outputs (e.g., agriculture, industry, construction) are marketable and the opportunity costs of natural services are undervalued or not valued, decisions may be biased toward development[1]. When the values of non-market goods are unknown, as in the case of public water resources projects (dams, lakes and wetlands), inefficient use of resources can be caused.

The main aim of this paper is to approximate some economic values of *Panagitsa* irrigation lakes as well as to provide information about it. The presentation of some methods for water resource evaluation and the promotion of a more efficient and effective management of the *Panagitsa* irrigation project are also examined in this paper. The three lakes of *Panagitsa* and their associated irrigation canals have been constructed within the borders of *Prefecture* of *Pella*.

The value of each output depends on personal perspective; there is no single, universal value measure. Water resources projects, for example, can be valued from at least four perspectives leading to four types of values: owner, user, region, and society[2]. Owner values derive from marketable water resources products and services (e.g., forage, water, aquatic plants). Owner value is the market return (monetary or non-monetary) from water resources' outputs along with the owner's personal values. User values capture the benefits from consumption or use of water resources-related outputs (e.g., recreation, water quality enhancement). Net worth of a water resource project is the amount users are willing to pay for the satisfaction provided by its products or services (i.e., outputs). Regional values (e.g., gross business volumes, employment) derive from water resources-related business activity. Social value is the net value of a water resources project's outputs to "society". Social value can be measured by aggregating user values and owner values[2]. Social and owner values were estimated as one, since *Panagitsa* irrigation project is publicly owned[3].

EVALUATION METHODS

Economic values of water resources projects have been discussed in detail and also estimated at many locations[4]. Evaluation techniques are similar to those routinely used by resource and environmental economists for many non-market goods and services. The main disadvantage of natural resource valuation methods is often the physical, biological, and natural sciences' lack of data.

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There are many examples of water resources valuation in the literature[4]. For example, Lyne *et al.*[2] evaluated the economic productivity of Florida's Gulf Coast blue crab fishery in relation to the availability and characteristics of the marsh's (i.e., wetland) acreage by using a bio-economic model. Batie and Wilson[5]examined the economic value of Virginia's coastal wetlands in relation to oyster production by estimating a physical production function for oyster harvest in coastal wetlands in Virginia. Gosselink *et al.*[6] estimated the monetary value of marsh on the Atlantic and Gulf coasts for production, aquaculture development, waste assimilation, and total "life support" as a value ranging from $2,000 to $82,000 per acre. Their methods included reviewing the dollar value of shell fisheries and sport fishing activities, evaluating the potential for aquaculture development by using dollar values and an income capitalization approach, and estimating the cost of the nest best alternative wastewater treatment option[6]. Life support value of wetlands has been estimated using energy content per acre[1]. Farber and Costanza[7] estimated the economic value of a water resource system in Terrebonne Parish, Louisiana to be from $0.44 to $590 per acre (1983 dollars) using a WTP approach for commercial fishing and trapping, recreation, and wind damage protection. Bell[8] used marginal productivity theory to value Florida fisheries. The marginal value product of a Florida salt marsh was estimated to be $27.48 per acre.

The Contingent Valuation Method (CVM) was used to assess people's preferences for non-market, water resources[12]. Net benefits were estimated by asking people directly how much they value non-market goods. CVM, a stated preference method, is an alternative to other indirect valuation methods which estimate the value of resources by using market data[13].

The CVM has been used by economists to value a wide variety of non-market goods and services, especially those with public good and non-use characteristics. Mitchell and Carson[12] noted that over 5,000 contingent valuation studies have been performed. These studies have employed either Willingness-to-Pay (WTP) or Willingness-to-Accept (WTA) measures (in some cases both) to elicit valuation measures. In this paper, we derive WTP contingent value estimates for the impacts of the construction and function of *Panagitsa* irrigation project.

The travel cost, contingent valuation, and hedonic pricing methods are the ecosystem valuation methods most commonly used[9,10]. There are different strengths and weaknesses for each method and specific applications where one is more useful than the others. The travel cost is most effective in valuing recreational areas, contingent valuation is most valuable for public goods, and hedonic is most useful for valuing specific attributes of environmental quality between two sites. A study by Wilson and Carpenter[11] of freshwater ecosystem services compared the three methods of valuation. Their research reports that the travel cost method and hedonic pricing method are most effective for private goods and services. The contingent valuation method is effective since the nature of the survey allows for many different scenarios to be presented for valuation. All of the methods are somewhat limited because the public has a difficult time placing a value on economic services that they do not clearly understand or recognize.

FIELD RESEARCH

Field research was conducted, based upon interviews with a random sample of 108 households, 317 producers and 25 hotel or rooms to let employees (total 450 questionnaires), during December 2003. The questionnaire was organized in such a way to (1) familiarize respondents with the location of the *Panagitsa* irrigation project; (2) pose WTP questions regarding the research outputs; (3) pose behavioural questions about water supply and (4) to define personal characteristics of the respondents. The evaluated outputs of the *Panagitsa* irrigation project, that represent the total WTP, are divided in eight separate categories: five positive (households, agricultural-irrigation, tourism, water quality and recreation) and three negative ones (health, environmental and social).

RESULTS

Values for each one of the selected outputs are estimated independently with the assumption that all other conditions remain unchanged. Values are more likely to change over time, as other landscapes are modified.

Household outputs: The study area characterized, especially during the summer session, by limited water supply for household and municipal purposes. The current water supply satisfies only the 75 percent of the total needs. After the construction and working of the *Panagitsa* project, the water supply expected to fully satisfy the total needs for household and municipal purposes.

Survey participants were asked "if *Panagitsa* project was managed primarily for household and municipal purposes, what would you willing to pay through an annual use?" In response to this "use value" question, most respondents (80.3 percent) stated €1 to €25 annually, followed by 10.7 percent stating €0 (nothing), 4.9 percent saying from €26 to €50, and 4.1 percent willing to pay more than €50. The average willingness to pay in this case has been estimated €17.6 (standard deviation is equal to 12.8) in a year basis. This value reflects the difference between costs of water supply from the project and from alternate sources.

Respondents chose €0 (nothing) primary because they do not believe the hypothesis above "*Panagitsa* project will be managed primarily for household and municipal purposes" (50.3 percent). 19.7 percent stated that "I would not care about water supply", 15.2 percent stated that "water supply does not have any value to

me", and finally 14.8 percent appealed "low income" reasons.

Negative values were not provided as choices on the questionnaire, although some respondents might have chosen a negative euro amount for use, option, or existence value(s).

Agricultural and irrigation outputs: In the study area, agriculture mainly involves apples, cherries and pasture. The study area characterized, especially during the summer session, by insignificant water supply for agricultural purposes. The current water supply (especially through small private drills) satisfies only the 25 percent of the total agricultural needs. After the construction and working of the *Panagitsa* irrigation project, the water supply expected to fully satisfy the total agricultural and irrigation needs.

Survey participants were asked "if *Panagitsa* project was managed primarily for agricultural purposes, what would you willing to pay through an annual use?" In response to this "use value" question, most respondents (40.8 percent) stated €175 to €200 annually, followed by 15.1 percent saying from €1 to €25, 11.1 percent willing to pay more than €200, and 8.4 percent stating €0 (nothing). The average willingness to pay in this case has been estimated €132.9 (standard deviation is equal to 109.2) in a year basis. This value reflects the difference between costs of water supply from the project and from small scale alternate sources (private drills). Also represents the production increase of agricultural products caused by the irrigation process.

Respondents chose €0 (nothing) appealed primary "low income" reasons (58.2 percent). 20.6 percent noticed that they do not believe the hypothesis above "*Panagitsa* project will be managed primarily for agricultural and irrigation purposes", and finally 21.2 percent stated that "irrigation water supply does not have any value to me".

Tourism outputs: The study area characterized, especially during the winter session, by increased water needs to satisfy the significant tourism activities. The current water supply satisfies only the 30 percent of the total tourism needs (about 200,000 m^3). After the construction and working of the *Panagitsa* project, the water supply expected to fully satisfy the total tourism needs.

Survey participants were asked "if *Panagitsa* project was managed primarily for tourism purposes, what would you willing to pay through an annual use?" In response to this "use value" question, most respondents (60.8 percent) stated €0 (nothing). 6.6 percent stating €75 to €100 annually, followed by 5.4 percent saying from €100 to €125, and 3.2 percent willing to pay more than €125. The average willingness to pay in this case has been estimated €30.4 (standard deviation is equal to 29.5) in a year basis. This value reflects the difference between costs of water supply from the project and from alternate sources (especially through water wagon transportations from vicinage).

Respondents chose €0 (nothing) stated primary that "water supply for tourism purposes does not have any value to me" (93.2 percent). 5.2 percent appealed "low income" reasons, and finally 1.6 percent noticed that they do not believe the hypothesis above "*Panagitsa* project will be managed primarily for tourism purposes".

Water quality: Irrigation projects may affect the water quality in a number or ways[14]. Excess nitrogen or phosphorus may promote algal blooms and increased growth of undesirable aquatic plants which may affect drinking water quality, recreational activities, and dissolved levels[15]. While considerable work has been done on dams, lakes and wetlands[15,16,17]. the economic benefits of water quality change have not been well established.

Survey participants were asked directly how much they value (negative or positive) water quality change in a year basis. In response to this "value" question, most respondents (82.3 percent) stated €0 (nothing). 6.7 percent stating €25 to €30 annually, followed by 4.3 percent saying from €30 to €35, and 1.1 percent willing to pay €50 or more. The average willingness to pay in this case has been estimated €11.0 (standard deviation is equal to 4.9) in a year basis. This value reflects the water quality change before and after the construction and working of the *Panagitsa* irrigation project. None of the respondents choose a negative euro amount for the water quality change.

Respondents chose €0 (nothing) stated primary that "water quality change does not have any value to me" (57.7 percent). 31.6 percent appealed "low income" reasons, and finally 7.1 percent noticed that they do not believe the hypothesis above "*Panagitsa* project will be change the water quality characteristics".

Recreation: Recreational values of reservoirs, dams and irrigation lakes are often the most readily recognized values[14] Recreational uses may include sightseeing, fishing, photography, wildlife observation, boating, bird-watching, nature walks and picnicking[18]. The operation of the dam and reservoir can enhance tourism. Inland navigation is also a goal of comprehensive basin planning and development utilizing dams, locks and reservoirs that are regulated to provide a vital role in realizing regional and national economic benefits.

Survey participants were asked directly how much they value (negative or positive) recreation and aesthetics goods in a year basis. In response to this "value" question, most respondents (37.8 percent) stated €50 to €60 annually, followed by 21.1 percent saying from €60 to €70, 16.8 percent stating €0 (nothing) and 12.6 percent willing to pay more of €70. The average willingness to pay in this case has been estimated €46.1 (standard deviation is equal to 31.6) in a year basis. This value reflects the recreational value change before and after the construction and working of the "*Panagitsa"* irrigation project. None of the

respondents choose a negative euro amount for the recreation and aesthetics change.

Respondents chose €0 (nothing) noticed primary that they do not believe the hypothesis above "*Panagitsa* project will be produce recreation and tourism activities" (62.4 percent). 19.6 percent stated that "recreation does not have any value to me", 14.2 percent appealed "low income" reasons, and finally 6.9 percent stated that "I do not care about *Panagitsa* irrigation project".

Health impacts: Large dams and lakes influence health at not only the reservoir site but also upstream, downstream, and at national or even regional levels. Increases in the prevalence of schistosomiasis, malaria, encephalitis, hemorrhagic fevers, gastroenteritis, intestinal parasites, and filariasis (including onchocerciasis and bancroftosis) have been documented after dam and irrigation projects. Although not dealt with in this paper, large water projects also influence the health of animals through increases in diseases such as river fluke in cattle and changes in the distribution of trypanosomiasis. Changes in water flow, river ecology and salinity, easier travel due to navigable dams and rivers, human proximity, pollution, canalization, and agriculture allow vector-borne diseases to flourish in the tropical or subtropical environments of less-developed countries, where most current water projects building is taking place.

Survey participants were asked directly how much they value health impacts in a year basis. In response to this "value" question, most respondents (90.1 percent) stated €0 (nothing). 3.7 percent stating €0.1 to €5 annually, followed by 2.6 percent saying from €5 to €10, and 1.4 percent willing to pay more than €10. The average willingness to pay in this case has been estimated €2.9 (standard deviation is equal to 1.7) in a year basis. This value reflects the estimated negative health impacts caused by the construction and working of the "*Panagitsa"* irrigation project.

Respondents chose €0 (nothing) primary because they do not believe the hypothesis above "*Panagitsa* irrigation project will be cause negative health impacts" (93.2 percent). 3.1 percent stated that "I would not care about health impacts", 1.0 percent stated that "I do not have children", and finally 0.8 percent appealed "low income" reasons.

Social impacts: The social impacts of large dams and reservoirs are an integral part of their performance record. The impacts on people displaced from their homes and livelihoods, indigenous peoples, downstream communities, gender, cultural heritage are some of the social impacts may caused by water project construction and working.

Survey participants were asked directly how much they value social impacts in a year basis. In response to this "value" question, most respondents (72.8 percent) stated €0 (nothing). 14.1 percent stating €0.1 to €5 annually, followed by 9.2 percent saying from €5 to €10, and 1.1 percent willing to pay more than €10. The average willingness to pay in this case has been estimated €10.2 (standard deviation is equal to 8.8) in a year basis. This value reflects the estimated negative social impacts caused by the construction and working of the "*Panagitsa"* irrigation project.

Respondents chose €0 (nothing) primary because they do not believe the hypothesis above "*Panagitsa* irrigation project will be cause negative social impacts" (94.1 percent). 2.8 percent stated that "I would not care about social impacts", and finally 1.3 percent appealed "low income" reasons.

Environmental impacts: The construction of a reservoir and the resulting environmental impacts are not limited to downstream opportunity cost of water. Dams and lakes may degrade water quality and the aquatic environment, with consequent effects on biodiversity, such as fish and waterfowl. Dams also have terrestrial atmospheric impacts as well, as they involve the loss of land and its associated recourses and environmental services.

Survey participants were asked directly how much they value environmental impacts in a year basis. In response to this "value" question, most respondents (60.3 percent) stated €0 (nothing). 20.1 percent stating €0 to €5 annually, followed by 11.3 percent saying from €5 to €10, and 2.7 percent willing to pay more than €30. The average willingness to pay in this case has been estimated €11.9 (standard deviation is equal to 13.1) in a year basis. This value reflects the estimated negative environmental impacts caused by the construction and working of the "*Panagitsa"* irrigation project.

Respondents chose €0 primary because they do not believe the hypothesis above "*Panagitsa* irrigation project will be cause negative environmental impacts" (78.2 percent). 15.1 percent stated that "I would not care about environment", 2.3 percent stated that "environmental change does not have any value to me", and finally 2.0 percent appealed "low income" reasons.

CONCLUSIONS

Even though the results of this study are first approximations and rest on some bold assumptions, on the one hand, they can provide useful tools for water resource managers and, on the other hand, they can encourage others to develop better estimates. Assumptions are made to develop plausible estimates and to provide approximate economic value estimation for the various water resource outputs of the *Panagitsa* irrigation project. It is difficult to evaluate the water resource outputs of controlled areas. *Panagitsa* project is managed primarily for irrigation purposes, a fact that makes it extremely difficult to separate from the reservoir and the "water resources" contribution.

Although not all reservoirs are the same, and the outputs vary according to physical characteristics (i.e., landscape, vegetation, water depth), this paper in combination with the applied techniques should assist other researchers in future water resources valuation studies. This research should also aid water resource

managers to make better decisions regarding reservoir schedules and the effects on habitat, waterfowl, and water quality.

One implication of this study is that water resource projects might have negative outputs, which need to be analyzed along with the positive ones in order to extract a comprehensive net social value.

This was a static valuation study. Changes in environmental factors, management decisions (e.g., flood control strategies, drainage, and wildlife management), demographics, or social values may affect the estimates of economic values of this area. The estimated economic values may also change if the total number of reservoirs increases or decreases or if the quality of water resources changes. Additional water resources valuation studies are needed to provide a broader sample of locations, specific site characteristics, and water resource types in order to develop better valuation methods.

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