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Analysis

Assessing the economic viability of alternative water resources in water-scarce regions: Combining economic valuation, cost-benefit analysis and discounting

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ABSTRACT

This paper demonstrates a comprehensive methodology for assessing the viability of an environmental management plan that has long-run economic and ecological impacts. The case study under consideration is the implementation of a water-resource management plan in a water-scarce region of the world, namely Cyprus. Specifically, this plan proposes to replenish a depleting aquifer with treated wastewater. The proposed methodology first identifies the key stakeholder groups (farmers and the general public) who are hypothesized to derive economic values (benefits) from implementation of this plan, and then uses stated-preference methods to capture the total economic value of these benefits. Benefits are aggregated over the relevant populations of these stakeholder groups and weighed against the total costs of implementing the plan in a long-run cost-benefit analysis (CBA). An econometrically estimated time-declining trajectory of discount rates is used for the CBA in order to assess the long-run sustainability of the plan. The results reveal that the net benefit trajectory estimated with the time-declining discount rate takes one and a half to three times as long to come to a plateau compared to the constant discount rates of 3.5 and 6%, emphasizing the importance of using declining discount rates and capturing the entirety of the benefits generated by such plans. This methodology is particularly recommended for providing much needed information to support the implementation of the EU Water Framework Directive, which advocates the use of CBA with consideration of the notion of sustainability for achieving the "good water status" for all European waters.

1. Introduction

The estimation of all values generated by environmental goods and services for the cost-benefit analysis (CBA) of policies and projects has long been advocated (Pearce, 1993). The need for this overall figure, termed the total economic value (TEV), is based on the argument that environmental goods and services generate not only use values such as direct, indirect and option use values, but also non-use values, such as existence, bequest and altruistic values (Freeman, 2003). For comprehensive CBA of projects and policies that involve environmental goods and services, the TEV should be captured, i.e., the economic benefits generated by environmental goods and services should be quantified in monetary units, and weighed against the costs of conserving or providing such goods and services.

The "sustainability" context pertaining to long-run and intergenerational equity issues requires appropriate discounting of the costs and benefits of conserving or providing environmental goods and services. Recent reports in the discounting literature have proposed the use of an econometrically estimated time-declining trajectory of discount rates for better assessing the sustainability of policies/projects that propose to conserve or provide such environmental goods and services (Gollier et al., 2008).

The aim of this paper is to document a comprehensive methodology for assessing the viability of an environmental management plan that has long-run economic and ecological impacts. The plan under consideration is an aquifer management plan to replenish a depleting aquifer with treated wastewater in a water-scarce region of the world, namely Cyprus. It is expected that the results of this study will provide decision makers with recommendations that may help the sustainable management of Cyprus' scarce water resources and the timely implementation of the European Union's (EU) Water Framework Directive (WFD, 2000/60/EC).

To this end, one of the main aquifers in Cyprus, the Akrotiri aquifer, is herein used as a case study. Based on a comprehensive literature review, focus group discussions (FGDs), and informal interviews with local experts, policy makers, farmers, and members of the general public, we identified local farmers and the residents of the nearby city of Limassol as the main stakeholders that would benefit from such a plan. Farmers located in the area derive both direct use and option values from the aquifer, as they irrigate their farms with water from the aquifer. Limassol residents, on the other hand, derive indirect use values through the

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consumption of locally produced vegetables, as well as non-use values from the ecological status of the local environment and the employment of locals in agriculture, both of which are supported by the aquifer.

In our analysis, two distinct choice experiments (CEs) are performed on randomly selected members of these two key stakeholder groups, allowing us to estimate the use and non-use economic benefits that may arise as a result of the proposed aquifer management plan. These estimated benefits are aggregated over the relevant populations and weighed against the costs of providing such an intervention. Since the costs and benefits of this plan are expected to have impacts well into the future, a long-run CBA is conducted under different discount rate schemes (constant and declining discount rates). The results of this long-run CBA reveal that the net benefit generated by the aquifer management plan is positive and significant well into the future, regardless of the utilized discount rate scheme. However, the net benefit trajectory estimated with the declining discount rate is higher than those estimated with constant discount rates. Moreover, the net benefit trajectory under the declining discount rate trajectory takes one and a half to three times as long to come to a plateau compared to the constant discount rates of 3.5 and 6%. Our results, therefore, have implications for the use of declining discount rates for evaluating projects or policies with long-term ecological and economic impacts in general, and in terms of informing efficient water-resource management in Cyprus in particular. The methodology developed herein will especially benefit EU member states that are obligated to implement the WFD, since the Directive specifically calls for the application of long-run CBA and consideration of the sustainability criterion when developing and adopting measures aimed at achieving good water status for European water resources.

The rest of the paper unfolds as follows: the next section describes the case study. Section 3 introduces the CE approach, the design and implementation of the two experiments, and their results. Section 4 reports the results of the CBA and discusses the use of different discount rates for public projects and policies having long-run impacts. The final section concludes the paper and draws policy implications.

2. The Akrotiri Aquifer Case Study

Efficient management of its scarce water resources has historically been one of the most important resource challenges facing Cyprus (Koundouri, forthcoming). As a member of the EU, Cyprus is obligated to adopt and implement the WFD, which aims to achieve "good [ecological, chemical and physical] status" for all European waters by 2015 (WFD, 2000/60/EC). Article 11(3)(c) of the Directive emphasizes the need to find sustainable solutions, and specifies that measures to promote efficient and sustainable water use must be introduced in order to safeguard environmental objectives. Furthermore, the Directive calls for economic estimation of the costs and benefits of various measures (both economic and technological), and the use of a thorough CBA to determine the most efficient, effective and equitable means of achieving good water status. In Cyprus, the key elements of the WFD have been adapted into national legislation through the "Water Protection and Management Law of 2004," and (as is the case in several other member states) implementation of the Directive is currently underway (Koundouri, forthcoming).

The case study presented herein is that of the Akrotiri aquifer, which is a common-pool resource and the third largest aquifer in Cyprus. This coastal aquifer is extremely important for the local economy and ecological stability. Extending over 42 km^2, the Akrotiri aquifer not only provides local farmers with irrigation water, it also supports the largest inland aquatic system in the country and plays host to unique ecological habitats and biodiversity riches (Birol et al., 2008). The Akrotiri wetland, a product of aquifer runoff, is recognized as a wetland of national and international importance by the Ramsar Treaty (site no: 1375), as an important bird area by Birdlife International, and as a special protected area by the Barcelona Convention (Kailis, 2005). The aquifer is replenished with runoff from the Kouris River, releases from the Kouris River dam, rainfall, and agricultural return flows (Mazi et al., 2004).

The aquifer is presently facing serious water quality and quantity problems, which are expected to have significant adverse effects on the livelihoods of the local farmers as well as on the area's ecological conditions in the not too distant future. Since the construction of the Kouris River dam, the aquifer's water inflow has decreased significantly, resulting in a lower water table (Mazi et al., 2004). This has led to the intrusion of saltwater as the aquifer attempts to maintain its hydrological balance. Water quality in the aquifer has further deteriorated due to the intensive use of fertilizers and pesticides in the area's agricultural production. The quantity of water in the aquifer has been adversely affected by uncontrolled and excessive pumping, which arises through the lack of clearly defined property rights, i.e., the open access nature of the aquifer. In combination with climate change-associated decreases in precipitation, this aquifer depletion is expected to cause desertification in the future, with the associated deterioration of the area's ecological conditions.

In order to mitigate the adverse effects of reduced water availability and deteriorating water quality in this aquifer, its replenishment with treated wastewater from Limassol and nearby villages has been proposed. Among the [proposed technologies aimed at alleviating water scarcity, wastewater treatment and reuse is promising, especially in water-scarce regions (Fetter and Holzmacher, 1974; Paling, 1987; Bouwer, 1992; Barnett et al., 2000; Scott et al., 2004). Large-scale wastewater treatment was initiated in the Limassol prefecture with the construction of a treatment plant in 1995. The objective of this initiative was to provide a safe and reliable system for wastewater disposal and to improve ecological conditions and overall water-resource management (Papaiacovou, 2001). To date, the wastewater treated in this plant has been discharged into the Mediterranean Sea.

Recently, the government has begun considering a plan to recharge the rapidly depleting Akrotiri aquifer with treated wastewater, in order to reduce the effects of seawater intrusion and ensure the sustainability of the current water quality and quantity levels in the aquifer. The case study presented in this paper aims to inform decision makers by presenting a thorough assessment of the economic viability and sustainability of such a plan.

3. Valuation of the Benefits of Treated Wastewater

3.1. Choice Experiment Design and Survey Development

Focus group discussions (FGDs) with local farmers and members of the public, expert consultations with water policy makers and scientists who have been working in the area (hydrologists, ecologists and agronomists), and a thorough review of the literature on the use of wastewater for irrigation in general and water-resource management in Cyprus in particular revealed the existence of two main stakeholder groups that are projected to derive significant economic benefits from the Akrotiri aquifer. The first is comprised of the local farmers, who use the aquifer as an irrigation source. This stakeholder group derives mainly direct use and option values from the aquifer. The second group is the public located in the nearby city of Limassol. This stakeholder group derives indirect use values through the consumption of locally produced food, as well as non-use values from conservation of the local environment and agricultural employment, both of which are supported by the aquifer. Here, two distinct choice experiments (CEs) are carried out in order to capture the different components of economic value accrued by these two stakeholder groups.

The three key attributes of the aquifer management plan and the levels they might take with and without the aquifer's replenishment with treated wastewater were identified through consultations with hydrologists, ecologists, agronomists, and local water policy makers, as well as FGDs with local farmers and Limassol residents. Since a simple CE design was envisaged for both stakeholder CEs, only the three most