THE ECONOMICS OF GROUNDWATER. THEORY AND APPLICATIONS IN SELECTED COUNTRIES

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Abstract
The aim of the paper is to present fundamental aspects of the economics of groundwater. It includes considerations about costs and valuation of groundwater sources. The work also presents an overview of the water management issues in selected European countries. It is mainly focused on the application of economic instruments for groundwater management.

The Economic Value of Groundwater
The total value of any good or service should reflect information about the economic, social and environmental characteristics that make this good eligible to cover a certain demand (necessity).

Next diagram (Figure 1) illustrates water functions of the uses (values) of water sources for an economic system. These approaches belong to the subjective theory of value which focuses on the study of economic value of goods and services. For this economic perspective the values observed should be sensitive to monetary expression. Intrinsic and other kind of values are not considered into this kind of analysis.

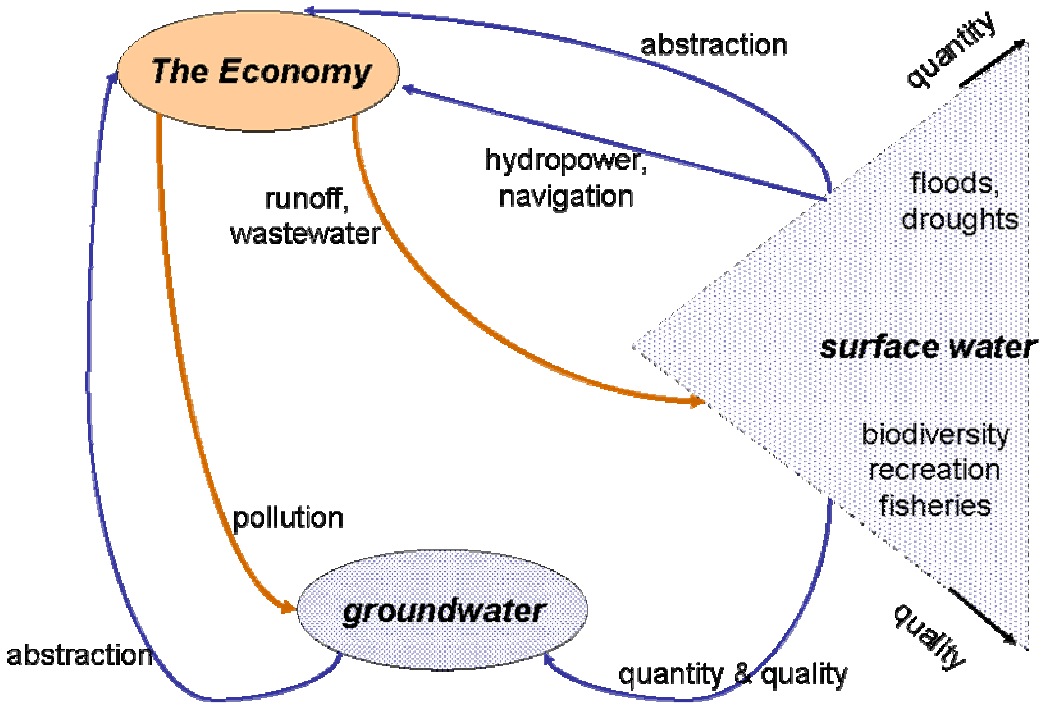

Figure 1. Interaction between the economy and the water environment

Source:[4].

From the economic and social level, groundwater can be directly used for one ore more of the following purposes: Drinking water, irrigation water, industrial water use, and recreational use. There are also some other functions that groundwater can comply for environmental purposes and also indirectly for social purposes, as follows: discharge to ecosystems, maintenance of biodiversity, contribution to climatic issues, human health. [5] illustrate how groundwater aquifer may help to maintain water environments ready to contribute to the supply of resources for economic purposes. According to his illustrations, groundwater qualitative sources might be mostly obtained from deeper aquifers where polluted soil has less contact to water.

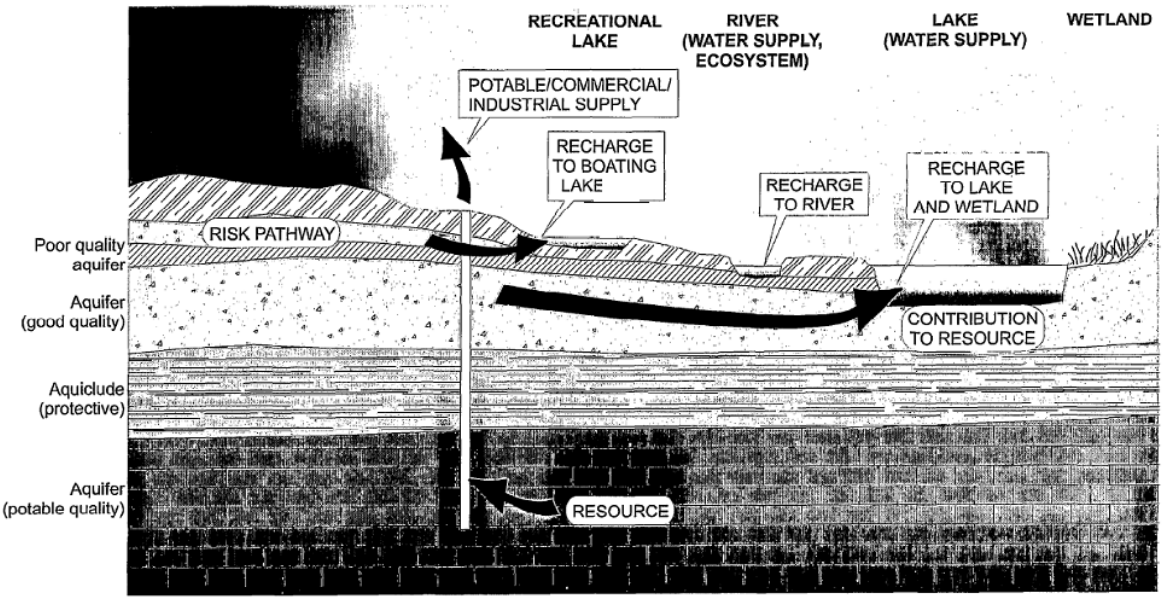

Figure 2. Groundwater. Contributions to the Economic Value

Source: [5]

It can be also the case, in which one decides not "to use "the water. So, the source of water is left the way it is or it is protected thinking of preserving it its environmental value for the future generations, who will potentially make use of it. In other words, the water will fulfill the function of existence and option value.This array of services shows why groundwater can be such a valuable natural resource. The sum of all above listed functions of groundwater will give use its TOTAL VALUE. In other words, the total value of groundwater equals the total economic value plus the environmental value. [1] 0 gives examples from water functions and their different values.

[1] There is no uniformity in the nomenclatures of the terms related to values. [9] divide Total Sustainable Value as Total Economic Value plus intrinsic Value, many other authors (see for example [3]) mention just total economic value divided into use and non use values.

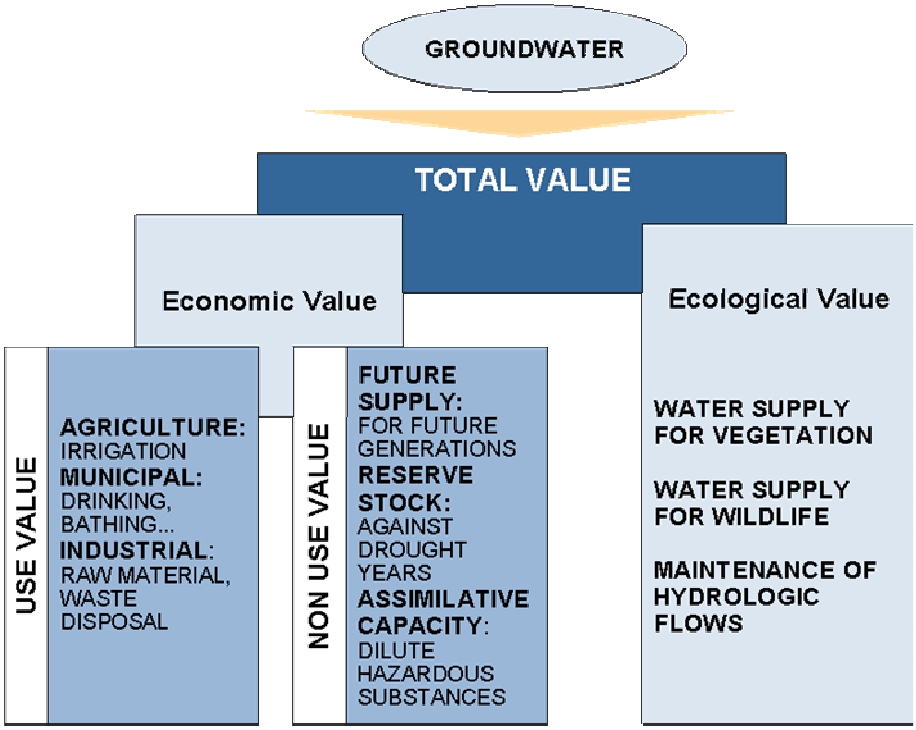

Figure 3. Groundwater. Examples of Economic and Ecological Value

Keeping a reasonable balance of the quantity and quality of groundwater may represent not only to ensure a compliance with its services to the economy, but also avoidance of potential damages caused by higher levels of pollution or unsustainable abstraction rates. Protection, remediation, operation and maintenance of water sources will be, analogically translated in various costs.

Costs related to (ground) water issues may be divided into costs for the utilization and supply of water depending on its purposes and the cost of protection and remediation, thus the full economic cost, plus the cost of internalizing ecological externalities.
Values in terms of benefits and costs are fundamental components of the cost-benefit analysis of groundwater sources.

Cost-Benefit Analysis assesses the feasibility of a specific project by observing how well balanced are the expected results (benefits) due to the inputs (costs). The calculation of economic costs corresponds to particular characteristics of the available remediation methodologies.

Opportunity costs might reflect the alternative options of the groundwater sources that are for example, being cleaned-up. In the case of historical contamination, economic externalities become a key component since liability is assigned to parties out of the original pollution process.

The monetary expression of the value and estimation of the benefits is traditionally based on different valuation techniques. Groundwater as natural resource represents also raw material for drinking water, it is mostly a good, for which there is no monetary value, when there is no market for it. The quality of a good provides different levels of satisfaction and can affect individuals depending on the use made of one good, and

hence the value put on it. There are different ways how to measure the value of water in endangered locations. Damage valuation instead of directly valuation of groundwater benefits seems to be the most common approach.

Damage can be defined as the direct perception of the decrement on the quality of a good or service. Valuation of groundwater damages requires a determination of injury, quantification of injury and damage assessment [1]. In other words, we could conclude that one way to estimate damages is equivalent as estimating the loss on value. The final purpose of valuation methods is not to create a „water market", but a mechanism for which the value of such sources can be expressed in monetary means, so it can be then more useful in order to make comparisons and for decision making processes concerning water management and policy. In [3] the most cases studied for valuation of groundwater presented stated preferences and contingent valuation methods. Willingness to pay of different stakeholders corresponds to cases of direct values of water services such as the present satisfaction of consumptive and industrial functions. Cases presented by [8] focused on the observations of changes in value of properties where drinking water sources were found to be contaminated in different regions of the U.S.A. Other cases also presented the bequest and option value reflected in the willingness to pay for the consumption and use in the future or for future generations. Cases focusing on the ecosystem functions of groundwater showed that certain stakeholders were able to pay for the protection of groundwater sources just because of the intrinsic value of these kinds of amenities (ecological value).

Other methods focus on the calculation of the use value of groundwater reflected changes in prices and production costs as the subject of valuation. For this method to be applicable, it is necessary to have already established and well defined water markets and other related production processes (for instance the agricultural sector). The methods of avoided damage and averting behavior can lead to results extracted from the decisions of people investing in alternative drinking water goods as substitutes of current groundwater sources due to the aversion of existing health risks. Replacement costs methods are more frequently found in cases where the benefit of the protection or remediation is gained by third parties such as other natural sources. The benefits use for human beings is, in these cases, from an indirect nature and cannot be still estimated. The calculation of the cost of replacement of water ecosystems is taken as an equivalent of its value for the nature and society.

Economic Instruments for Water Management in Europe

The experiences of some European countries show a trend to follow the principle of sustainable use of water resources and the principle of cost recovery. As illustrated Table 1, the most common economic instruments used are oriented to cover operation and maintenance costs of public water supply, some other instruments as abstraction fees and taxes are oriented to the protection of water sources.

The information presented in this table shows an approximate of the use value of groundwater sources for drinking, agricultural and industrial purposes. It can be noticed that the numbers do not reflect the total value of these sources, because of the fact that the economic instruments listed intend to cover costs related mainly to use values of groundwater sources and not their intrinsic or ecological value.

Conclusions

Economic theory, specifically the neoclassical approach and its subjective theory value, can be useful to understand the various components of the value and costs of groundwater. The approach is limited by the fact that it just covers the use and option value of goods. Ecological value and intrinsic value of water ecosystems are extremely difficult to measure and express in monetary terms. The practical experience of European countries reflect that in the application of economic instruments for groundwater management aim at cost recovery and protection of drinking sources for future generations.

Main Sources

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Table 1. Water Management. Economic Instruments in Selected European Countries [2]

Country, Year	Wastewater/ Pollution charges/ Limits	Drinking Water Prices/ m3	Water Charges/Taxes / m3		
		EUR	Standard Rate EUR/m3	Exemptions, Discounts	Results for the Environment
Czech Republic, 2006	0.23 EUR/kg treated wastewater, 2.03 EUR/kg phoshorus,1.16 EUR kg Nitrates	1.54 (2006)	0.04-0.07		No available data.
Denmark, 2003	2.7 EUR/kg treated wastewater, 14.7 EUR/kg phosphates, 1.5 EUR/kg org. mat.	1.538812		Industry and Agriculture exempt	Household water consumption and leakage rates decreased
France		1.23 (2003)	0.00071 to 0.04 (1994)	Small municipalities exempt, industrial sector just partly.	Effective in raising revenues but no incentives.
Germany, 2003	36 EUR per damage unit; 25 kg nitrates,20 kg mercury.(1998)	1.77	0.05-0.06	Some sectors eligible for reductions	Rate to low to have any significant incentive effect
Netherlands	20% of pollution permitted (1995)	1.23 (2002)	0.08 (1995) – Agriculture.	Agriculture almost exempt	Water consumption declined. 2-2%

[2] Sources: [2], [3], [6].