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Management of Water Resources at Global Level

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Abstract

The significance of the role of water in the life of the Earth can be fully understood only by analysing the contribution that water has in supporting environmental systems and in supporting human society. The two aspects are interdependent, but sometimes sudden decisions are made about one of them without taking into account the possible effects on the other, as when a city withdraws water from a river without considering the consequences on fish life, or when drainage of wetlands reduces the quality and quantity of water used in urban areas. There is a permanent demand to consider and evaluate the two issues together, starting from speculation about the possible impact of global warming on water supply to one extreme of generalization, to estimates of the essential daily needs of one isolated family at the other end. The purpose of this article is to present both the complex issues of water resources management and possible solutions to solve specific situations. The main research method was the documentary analysis doubled by a realistic debate of the problems from the perspective of economists and environmental specialists. The findings have led us to highlight some of the solutions that, of course, open new approaches and debates that we will consider in future research. These are also the main limits of our research.

Keywords: management, water, globalization, lakes, natural water.

JEL Classification: Q25, Q53

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1. Introduction

The importance of water at a global scale can be perceived by examining the totality of water on Earth, how the basic concepts of the role of water in global life have evolved, how they have been at certain times in harmony or conflict, and how they are presented in miniature as well as on overall scale (Bran et al., 2018). The evolution of thought has been sporadic and has been modestly carried out since the appearance of the monumental 1864 study “Man and Nature; or Physical Geography Modified by Human Activity” (Marsh, 1864), in order to draw attention on the various ways in which the population of the world has changed the environment over time (Angheluta et al, 2019). That examination was renewed a century later by the symposium on “The Role of Man in Changing the Face of the Earth”, organized on the basis of general themes about the past, present and future (Thomas, 1959).

Regarding the approaches of human perception on the changes of ecosystems, great attention is paid to the way in which societies from different regions and time periods are interested in the knowledge of the environment, as well as the role played by changing perceptions, attitudes, social movements and scientific processes (Burlacu et al., 2018).

2. Background

In 1996, the Global Water Partnership (GWP) was founded, an international network open to all organizations involved in water resources management: government institutions in developed and developing countries, United Nations agencies, bi- and multilateral development banks, non-governmental organizations and private sector organizations. GWP was created to stimulate Integrated Water Resources Management (IWRM), which seeks to ensure the coordinated development and management of water, land and adjacent resources, to strengthen social and economic well-being without compromising the sustainability of vital environmental systems.

The Stockholm GWP Secretariat has begun distributing documents created and mandated by the TAC to form conceptual plans. These documents contain general topics, as well as those subordinated to them, such as the understanding and definition of IWRM, the water needed to provide food, partnerships between the public and private sectors, water seen as an economic good. According to these documents, the concept of IWRM attracted particular attention after the international conferences on water and environment held in Dublin and Rio de Janeiro after 1992. The general principles, approaches and guidelines relevant to the IWRM are numerous and each has its own appropriate field or areas of application.

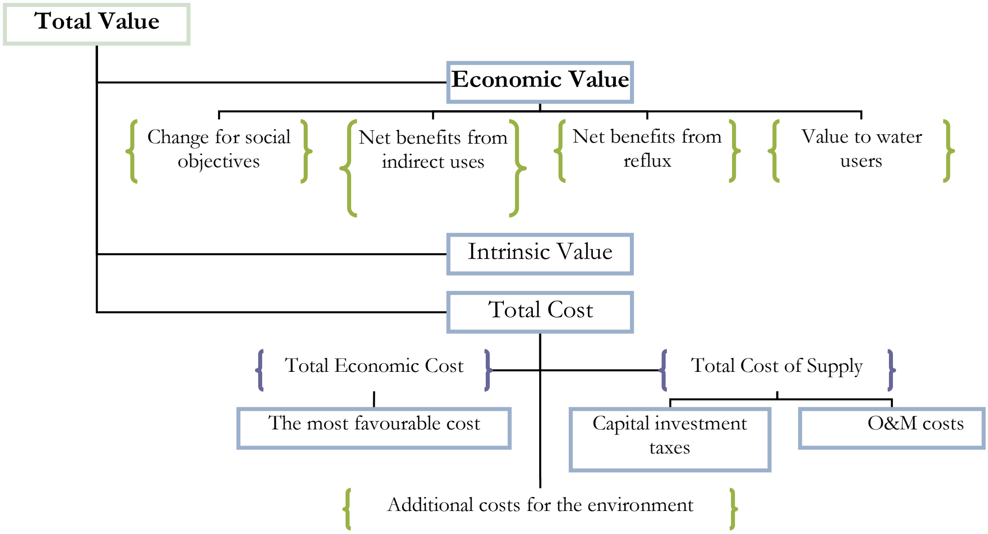

Figure 1. General principles of water assessment
Source: Adaptation from Global Water Partnership documents

The total value of water consists of the use value or the economic value and the intrinsic value (Figure 1). The economic value that depends on the water user or the way water is used includes: the value to users (direct water), the net benefits of water used in other products or processes and returned, through evapotranspiration or other leaks (e.g., reflux water) and the contribution of water to achieving social objectives. Intrinsic value includes non-use values as inherited or existing values.

The Dublin Principles are a particular set that also formed the basis of the IWRM.

The four principles of the Dublin conference are:

1. Fresh water is an exhaustible and vulnerable resource; it supports life, development and the environment.
2. Water development and management must be based on the principle of participation, involving consumers, planners and policy makers at all levels.
3. The woman plays a central role in supply, management and water security.
4. Water has an economic value in all uses in which it is involved and this must be recognized as an economic good.

Within the IWRM, the following concepts of water value were considered useful.

3. Problem Statement

Water and Dry Deficiency: a European Problem?

Water scarcity is a global problem. In underdeveloped countries, water is a limiting factor of agricultural production and implicitly of food. In these countries, population growth, water consumption, declining groundwater reserves in semiarid areas as a result of climate change, as well as water pollution are a challenge to ensure sufficient water reserves (Teutsch & Krueger 2010 apud Water CoRe, 2020). Thus, it is found that all over the world a series of conflicts arise from the decrease of water reserves, the desertification of some regions, the obtention of poor agricultural harvests, as well as the decrease in fresh water resources.

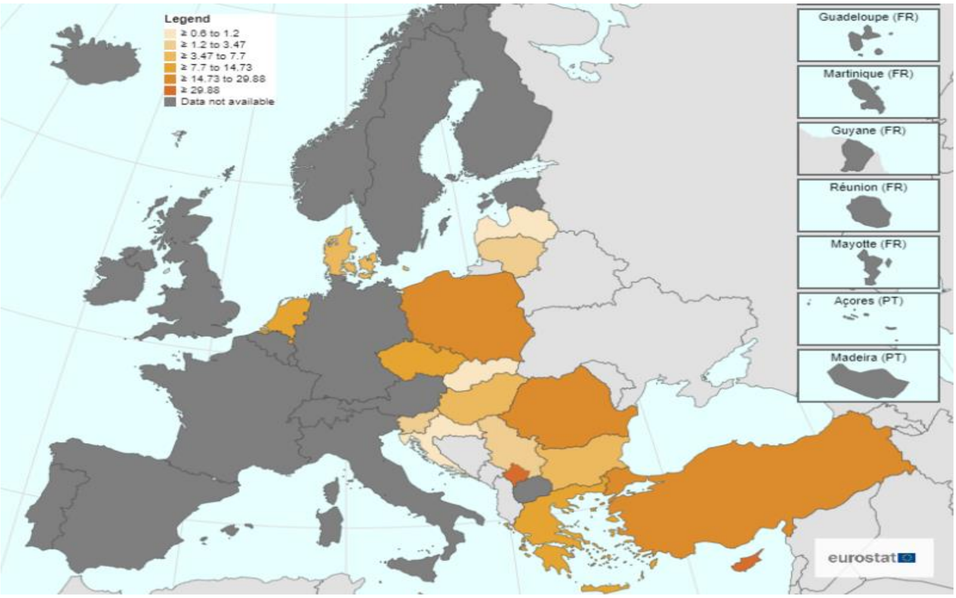

Figure 2. Water exploitation index, 2018, unit of measure: percentage
Source: https://ec.europa.eu/eurostat

The indicator shown in the figure above can be interpreted as follows:

1. it presents the total annual amount of fresh water extracted in a country, as a percentage of the annual average amount of water available from renewable fresh water resources;
2. it means the total annual groundwater abstraction expressed as a percentage of the annual average amount of groundwater in the country available for capture; and
3. it expressed the total annual amount of surface water extracted as a percentage of the average annual surface water resources available in the country for extraction.

By analysing the map of the water exploitation index (Figure 2), it results that not only the countries located in the south of Europe, but also some regions of Central and Western Europe face problems of water stress. This is not only caused by climatic conditions, but also by the increasing water demand, especially for the cooling processes in power plants.

3.1 Inventory of Natural Waters

Before analysing the management of water resources and the natural environment, we will describe the natural state of water throughout the Earth before the human alteration of its quality and quantity, although this is only possible in a small extent for a number of reasons (Burlacu et al., 2018). In a simple form, the natural waters on the globe are the sum of atmospheric humidity, precipitations, soil and depth stocks, icebergs and glaciers, oceans and moisture deposited or transposed by plants and animals (Radulescu et al., 2018).

Numerous international scientific efforts are being made to analyse the significant changes in climate, hydrology and elements related to the environment system (Negescu Oancea et al., 2019). These include the International Geosphere and Biosphere Programme (Lohmann, 2002) as well as the Intergovernmental Climate Change Organization (IPCC Intergovernmental Climate Change Organization). According to this increasingly supported theory, water resources can change significantly (Bodislav et al, 2019).

Water resources on any scale are the subject of a variety of administrative measures, and natural waters can be considered water resources outside of human intervention that alter their quality and quantity (Bran et al., 2018). Human actions have altered the initial distribution and quality of rainfall, rivers, deep water in various ways, and continue to do so (Alpopi et al, 2018). These actions not only include the direct handling of quantities within the hydrological circuit by diverting precipitation and rivers, by retaining water, altering evaporation, but also by changing the quality of air, water and soil (Dima et al, 2020).

3.2 The Deep Waters

Depth or groundwater is the continental water that accumulates in the upper part of the earth’s crust, inside the rock layers. The groundwater layer is called the aquifer; the flow and the level being influenced by the climatic conditions (precipitation regime, temperature), but also by the degree of its use by the man, for domestic and industrial consumption (Ionita et al., 2009). These groundwater formations differ from place to place. Overall, groundwater is an important source of fresh water worldwide, being used in various ways through springs or wells, through a variety of technologies.

A hydrological study estimates that approximately 29% of the world’s freshwater reserves are stored in the aquifer at any given time. About 33% of that volume is on the Asian continent, 23% in Africa, 18% in North America, 13% in South America, 6% in Europe and 5% in Australia (Aladin, 2002).

Globally, the actual extraction of deep water is affected by the use of groundwater and surface water, and the particular purpose for which it is used. In areas where extraction exceeds both natural and artificial recharge, aquifers have decreased significantly, and in some areas, they have been largely or completely depleted.

Because scientific studies on deep water are generally less extensive than research on other aspects of the hydrological cycle, understanding the effects of water management is difficult in many places. Estimating the quantity and quality of water from an underground formation differs greatly in accuracy from one place to another.

3.2.1 The Deep Waters in Europe

Deep water is a major source of drinking water throughout the European continent, so the status of the deep water in terms of quality and quantity is of great importance. Furthermore, deep water plays an important role in the environment − for both aquatic and terrestrial ecosystems. Human interventions in the hydrological cycle can have profound effects on the quality and quantity of deep water. It is necessary to identify the most important interventions on aquifers in order to understand the interrelationships between the intervention and the related side effects. Also, it is necessary to investigate the underlying causes and the measure of human intervention on the hydrological cycle in order to establish the appropriate management and planning measures.

The Environmental Assessment Report, prepared by the European Centre for Inland Waters, presents a summary of the most important problems related to the quality and quantity of the depth water, materialized in maps and other geographical applications. The report is based on the important indicators of the depth water quality: nitrate, pesticides, chlorite, alkalinity, pH value and electrical conductivity (Scheidleder et al., 1999).

The conclusions of this report showed that the application of nitrogen fertilizers is a pressure for the quality of the deep water. The commercial use of nitrogen fertilizers and the use related to the agricultural area have increased in most western European countries since 1992. Pesticides also have an impact on Europe's deep water.

In some regions, the depth of deep-water extraction exceeds the refuelling (over-exploitation) rate, but in most European countries the annual deep-water extraction has decreased since 1990. Extraction is one of the causes of deep-water exploitation, the intrusion of salt water and the endangerment of wetlands.

The quality and quantity of Europe's fresh and deep-water resources are influenced and in some cases are at risk due to the numerous human activities.

In northern Europe (Iceland, Norway and Sweden), nitrate concentrations are low, and at the country level, the scale of the Drinking Water Directive indicating 25 mg NO_3/l is exceeded in more than 25% of the investigated sites in 8 of the 17 countries that provided information. In the Republic of Moldova, approximately 35% of the sampled areas exceed the maximum allowed concentration of 50 mg NO_3/l.

Deep water pollution with heavy metals has been reported in 12 of the countries studied by the European Centre for Continental Waters, the contamination occurring through infiltration of waste areas, from mining activities as well as from industrial sources.

Many of the human pressures on deep water are widespread across the continent, so some issues regarding the quality and quantity of deep water can be addressed and resolved at European level. In general, the larger the geographical unit affected by the decisions, the greater will be the level of accumulation of the necessary information. Moreover, the larger the geographical area, the more likely it is that the database will be incomplete and heterogeneous, especially if more countries are involved. National monitoring systems are designed to provide information tailored to the domestic needs of certain countries. As a result, different countries often apply different monitoring strategies and methods.

There are a number of current European Union Directives addressing the management and protection of deep water in the European Union. These include the Deep-Water Directive (80/68/EEC) and the Nitrate Directive (91/676/EEC), followed by the Plant Protection Products Directive (91/414/EEC), which controls the use of substances that can cause side effects to deep water. However, the success of the Nitrate Directive depends on the degree to which the farmers cooperate, as the rules are difficult to apply. In the Netherlands, for example, the whole country has been designated a nitrate-sensitive area, an action plan has been developed and a Code of Good Agriculture Practice has been developed, but at the other end of the spectrum, Ireland does not intend to designate a Nitrate Vulnerability Zone.

Regarding the quality of the deep water, the report concludes that the main problems in Romania are related to the intensive contamination of aquifers with organic substances, such as ammonia and especially bacteria.

3.3 Lakes Management

Public and private agencies can exercise a variety of measures for the quality management of lake ecosystem, including controlling the amount of inflow and water leakage; measures that address the problem of eutrophication; control of pollution with toxic substances; management of organic life; sedimentation control, as well as planning of the use of adjacent land.

Regarding the water flow, in the natural lakes the quality of the water and the life of the lake can be greatly influenced by the quantity and synchronization of the control of the water inflow, the drainage of the water and the circulation within the lake.

To prevent the phenomenon of eutrophication (Annex 14 shows the European situation of this problem), the Report of the European Environment Agency on natural and anthropogenic lakes of 1998 presents a series of measures adopted by many European countries, as follows: increase in the treatment of waste water for reducing nutrients from effluents; reduction in the phosphorus used in detergents; control over the application of fertilizers; establishment of the conditions of the future anthropogenic lake for optimizing the choice of its final location (European Environment Agency, 1999).

Regarding the curative methods of the treatment of eutrophication, in the Report of the European Environment Agency are presented some measures applied in the

European lakes: ventilation within the water body, selective withdrawal of the anoxic deep water from the lakes, chemical dosing (with copper sulphate), pre-dam installation, sediment dredging, water entering, water injection, lake discharge management, biomanipulation, water mass destratification, lake layer mixing, and other types of measures.

Regarding the treatment of eutrophication, a common problem is the receipt of a large amount of phosphorus and chlorophyll from the waste treatment plants and from the sources of pollution, while the diversion of waste reduces the concentration of algae and increases the transparency of the water. From the point of view of the control of toxic substances, with the rapid increase in the production of hazardous industrial waste such as pesticides, the danger of persistent toxin accumulation in lake sediments increases.

In terms of land use planning, local regulations in the adjacent areas can have a strong influence on all activities mentioned above and on the quality of the lake environment. The character of the use allowed or encouraged in coastal or shore areas, as well as in the river basin, can have major effects on the quality of water and organisms in lakes.

4. Debates and Solutions

4.1 Management of the Mini and Major White River

The dominant administrative approach to the riverbed involves sophisticated and subtle regulations of natural flow and flood processes from prehistory to the present day. These regulations include transportation on unmodified rivers; hunting, harvesting and fishing in riparian and aquatic habitats; "Flood cultivation" and withdrawal agriculture (planting and cultivation in major wetlands); the recreational, aesthetic and spiritual dimensions of management expressed in images and oral tradition.

These low intensity uses had small impacts on the river channel, a high degree of durability and regulation in the variable flood processes, assuming that they involved a lower resilience to the social pressures of population growth, immigration and conquests, which has led to more intense forms of river basin management.

Environmental impacts of this approach on management include contamination of local water quality and habitat degradation. However, as ports and industrial developments grow in the vicinity of rivers, these environmental consequences could have a regional impact.

4.2 Best Practice Guide

The best practice guide developed within the Water CoRe project under the INTERREG IV Interregional Cooperation Programme states that economic and financial instruments focus on water demand management, through monetary mechanisms, and by applying the instruments, stakeholders can either lead to profit or loss. Thus, in the guide the technological measures of water demand management were classified into different types and the main solutions obtained by the technological approaches of water demand management were summarized in the following table (Table 1).

Table 1. Solutions obtained by the technological approaches of water demand management

THEMES	TYPES OF SOLUTIONS
Alternative sources of fresh water	Use of sea water for cooling systems
Wastewater recycling	Recycling for various uses
Distribution network efficiency and loss reduction	Location and remedy of losses Pressure reduction
Water consumption reduction equipment	Encourage of the use of water reduction devices Efficient irrigation systems Alternative industrial processes
Accounting	Evaluation of water volumes used Metering and/or measurement of residual/consumption water
Reuse	Use of rainwater for gardening Purification of wastewater for other uses

Source: Adaptation after Water CoRe, 2020

The Water CoRe Good Practice Guide argues that in water demand management, measures are designed so that existing water resources and infrastructure can be improved and also encourage consumers to use water efficiently. This dual approach could bring economic, environmental and social benefits. Knowing that resources are limited, experts say that the solution for sustainable development is based on active management of existing water reserves. According to the definition by the European Environment Agency, sustainable development must seek to balance available water at any time and space with the demand for water used for various “purposes” and with the need for sufficient water to ensure the safety of human health and the aquatic ecosystem. They take all this into account and consider that existing water resources must be of adequate quality to satisfy various consumers, including once again the safety of humans and other living things. It is concluded that the measures can be used in order to increase the accessibility of water resources (e.g., construction of storage basins and control of losses) and/or control and reduction in water demand (e.g., charging for water consumption and metering).

5. Conclusion

In natural systems, relatively unaffected by the human activity, water has at least four main functions and processes that vary in time and space: it nourishes vegetation from soils and rivers; it feeds the entire kingdom of animal organisms, including fish from rivers and lakes; it removes organic matter or alters it and transports soil or other inorganic materials.

Throughout history, there have been various human interventions on the water cycle in different ways. Initially, water existed and was extracted from natural sources − rivers, lakes, springs − to meet human needs without changing the source, and rivers.

Of the major problems for the future, the same authors mention the following: pollution and overwatering of groundwater resources must be reduced; the quality of domestic water supply in developing countries cannot keep up with the volume of extraction; a large proportion of the world's wetlands have been destroyed along with the reduction of native vegetation and fauna that needs to be restored; water continues to be administered in many sectors by separate and often independent agencies, chemical pollution of both surface and deep water is increasing in many areas.

Regarding the deep water, the Environmental Assessment Report, prepared by the European Centre for Continental Waters, indicates the following information regarding Romania: the average consumption per capita, as well as the specific consumption in industry and agriculture, is higher than in other countries, the explanation being the excessive losses of water from the supply and distribution networks; the way deep water is used has a double negative effect: high specific energy consumption, twice as high as required; the main problems related to the quality of the deep water in Romania are related to the intensive contamination of aquifers with organic substances, such as ammonia and especially bacteria. The most intensive cases of multiple quality impairment were identified in the rural area, due to the lack of the necessary sewage facilities.

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