Innovative Water Resources Management Plan; Cyprus Case Study

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Abstract

Water resource management is in a state of change. The growing diversity in the type and scale of human impacts on water resources along with extreme weather/hydrological patterns put increasing pressure on the island's water bodies and ecological systems. On-going droughts, depletion of aquifers, water quality problems, and saline intrusion, are considered to be among the most pressing issues the island of Cyprus has to deal with. Gone are the days when we could assume that there would always be a plentiful supply of water to meet our growing demands.

These complex cascades of changes in the physical environment and human systems make the effective planning and management even more critical. A number of innovative technologies and practices are identified, which could help strengthen the present water resources management schemes. The Cypriot government should consider ways in which its regulatory activities can reduce barriers to, or encourage incentives for, technology innovation.

Keywords: water resource management, innovative technologies

1 Introduction

In Cyprus, water is a prerequisite for progress and by far the most precious resource. The main aim should be to "manage the island's water resources within the framework of the national water policy in a holistic way".

The main theme of the particular paper was to identify a number of possible technologies and/or methodologies, which could help in strengthening the current water resources management along the island. The following table provides 15 specific methodologies to this end. It is of great importance to point out that these are not the only measures that should be taken into account. There are numerous technologies and methodologies mentioned in the literature that have already been implemented and tested by a number of countries along the world (1; 6; 7).

The success of measures will be influenced by the choice of the right implementation strategy featuring the appropriate policy measures and incentives. Success includes the effectiveness of the measure, its acceptance by users and society, as well as the technical and economic feasibility of the action. Obviously, some actions may necessitate new organizational structures for implementation and follow-up as well as legal frameworks to be effective.

Table 1: Technologies or Methodologies proposed as measures to water resources management in Cyprus

#	Technology/Methodology	Comments
1	Natural Water Retention Measures (NWRM)	-
2	Cyprus green-blue water model	AGWATER project
3	Semi-decentralized water and wastewater management concepts	Department of Environment
4	Permitting process, investigations, data keeping	Department of Environment Department of Agriculture
5	NITRATES control	-
6	DACOM technology	DESIRAS project
7	TMDL Methodology	WATER project
8	Remote Sensing/Hyperspectral Image	-
9	Restoration/rehabilitation of non-compliant landfill sites	-
10	Combat Arsenic Concentrations in Cyprus' ground waters	-
11	Tourism water use	-
12	Combat non-licensed boreholes	Water Development Department
13	New Water Paradigm	Kentucky, Hebron, USA - EPRI 2010
14	Strategic Approach to Abandoned Mines Management	MCMPR, 2010
15	New Wind Turbine to produce Clean Drinking Water	Eole Water Company

2 Ecological status of water bodies along the island

A total of 216 river water bodies have been identified across the country, 49 of which have been categorized as "heavily modified". In other words, the ecological functions of these bodies have been changed due to human activities.

As a result of the dry Mediterranean climate, there are only five natural lakes characterized as brackish or salt lake water bodies. All other existing lakes were created by human activities as a result of both damming of a river and the creation of storage ponds. In total, 18 lake water bodies are recognized, out of which 12 have been categorized as "heavily modified" and one as artificial (e.g. Achnas lake water body).

Pressures on water bodies according to the River Basin Management Plan developed in Cyprus are outlined below:

- urban waste water: after treatment can be deposited affecting the quality of any water body in proximity,
- pollution from livestock farms including poultry, piggeries and cowhouses farming activities,
- industrial waste production from large industrial units, uncontrolled solid waste landfills,
- industrial mining activities pollution,
- fisheries, desalination plants and marine infrastructures,
- discharge and infiltration/percolation from agricultural activities, livestock farming solid waste for soil fertilization,
- urban waste water sources not connected to the sewerage system, storm water,

- overexploitation of groundwater bodies resulted to quality degradation and penetration of seawater and soil salinization.

Additionally, the most relevant trends such as climate change, population growth and increasing energy demand under full dependency on fuel imports (oil and natural gas) aggravate the situation and make the water supply more complicated.

3 Results

Specific pressures have been categorized as point and non-point sources so far. Urban waste water, livestock farming, agricultural activities, landfills, industrial mining, overexploitation of groundwater bodies and so on have been identified. These pressures necessitate the evaluation and assessment of measures and determination of adaptive strategy options in order to manage the island's water resources in a sustainable way.

Specific measures and adaptive strategies are described below:

3.1 Natural Water Retention Measures (NWRM)

Natural Water Retention Measures (NWRM) are multi-functional measures that aim to protect water resources and address water-related challenges by restoring or maintaining ecosystems as well as natural features and characteristics of water bodies, with a clear focus on natural means and processes. Their main focus is to enhance the retention capacity of soils, wetlands and other water-dependant ecosystems. The use of such green infrastructure measures facilitates the sustainable management of rivers and at the same time has a multi-beneficiary role since they serve the objectives of many Policies such as the Water Framework Directive (WFD), the Habitats Directive (HD), Birds Directive (BD), the Floods Directive (FD) and European strategies such as the Biodiversity Strategy (BS). Moreover, they can boost current ecosystem services, by enhancing nature's functions such as the infiltration of water to the aquifers, the purification of water and removal of pollutants, the reduction of flow speed and erosion, etc.

3.2 Options for sustainable agricultural production and water use in Cyprus under global change

Agriculture plays a key role in shaping the landscape of Cyprus and contributes to the preservation of the environment. In Cyprus, the demand for irrigation water exceeds the available water resources. Drought years can have especially devastating effects.

The AGWATER project was co-financed by the European Regional Development Fund and the Republic of Cyprus through the Research Promotion Foundation .The project developed the Cyprus green-blue water model to compute sustainable irrigation water supplies, agricultural water use, crop yields and economic indicators for 2020-2050. The mapping and graphing of water, production and economic indicators under different policy, economic and climate change scenarios will provide policy makers in Cyprus with the best possible scientific basis for informed decision making.

3.3 Semi-decentralized water and wastewater management concepts

Most of the rural population and many newly-built settlements are not connected to a sewerage system. They use septic tanks, which often leak into the ground and pose the risk of pollution to groundwater resources. This problem could be tackled by semi-decentralized water and wastewater management concepts which integrate wastewater treatment, water re-use, recovery of nutrients and energy.

3.4 Integrated Management of Nitrates Pollution Control

The Nitrates Directive, adopted by the European Union in 1991, aims to protect water quality by preventing nitrates from agricultural sources from polluting surface and subsurface water bodies and by promoting and embracing good agricultural practices. The Directive requires Member States to designate Nitrate Vulnerable Zones (NVZs), establish a voluntary code of agricultural practice for all farmers and a mandatory action program for farmers within NVZs, and on a regular basis to implement national monitoring and reporting activities (i.e. every four years).

3.5 Addressing desertification

Attention is turned to the DESIRAS project entitled "Addressing desertification by efficient irrigation in agriculture". In DESIRAS, the DACOM Agri Yield Management System (AYMS) was tested on three farms in Cyprus and Spain. The AYMS relies on soil moisture sensors and local weather stations to provide guidance on the optimum time and quantity of irrigation. (For more detailed information on the technology, please visit www.desiras.eu). This technology was tested on the Plataforma de Robles olive farm in Spain, the Arissandra farm in Cyprus which produces lemon balm, catnip, thyme, sideritis, verbena and lemon verbena and the Oikozoe farm in Cyprus, which produces potatoes and olives. On almost all crops, water savings of over 50% were reached compared to 2010. The AYMS was tested within the framework of the European Water Stewardship (EWS), which provides a practical holistic tool to evaluate the impact of the technology, not just on the farm, but also on the wider river basin.

3.6 TMDL Development

Water quality as well as water availability are becoming the major limiting factors for the preservation of good ecological status in many of the Cyprus national water bodies. In addition, climate change and urban development threaten to alter the hydrological balance of the lakes with potentially detrimental impacts on its ecosystem.

Specific attention has been given to TMDL methodology in the European Union-funded project WATER (a LIFE+ project). A number of measures/technologies have been proposed during the course of the project, which are presented in the following Table 2.

Table 2: Countermeasure Technologies proposed within the LIFE+ WATER project for the Kalo Horio Catchment

#	Countermeasure Technology
1	CSO Retention Basins
2	Constructed Wetland
3	Water Quality Inlet
4	Infiltration Drainfields
5	Street Cleaning
6	Filter Strip
7	Porous Pavement
8	Grassed Swale
9	Removal of Farming Zones
10	Abandonment of cultivation

3.7 Remote Sensing for Water Quality Surveillance in Inland Waters

The principal benefit of satellite remote sensing for inland water quality monitoring is the production of synoptic views without the need of costly in-situ sampling. Synoptic, multi-sensor satellite data products and imagery have become increasingly valuable tools for the assessment of water quality in inland and nears-shore coastal waters.

Hyperspectral imaging is a method of optical sensing across a large number of narrow electromagnetic spectral bands. The resulting information allows for an accurate and precise identification of materials, as well as for a characterisation of their chemical and biological properties based on the analysis of their spectral signature. This technology allows stakeholders to further their understanding of hydrological and biological processes in inland waters (1).

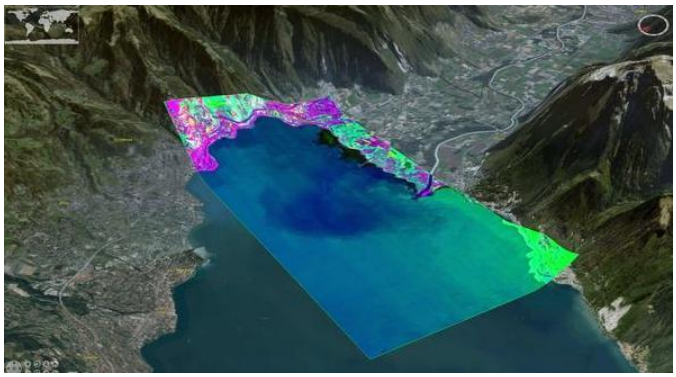

Figure 1: Ortho-rectified and geo-referenced hyperspectral map of the mouth of river Rhône (1).

3.8 Solid waste management and restoration/rehabilitation of non-compliant landfill sites

A number of plans for investment with regard to waste management in Cyprus have been scheduled. Studies have been undertaken in all districts for the rehabilitation of all uncontrolled landfills and the development of Integrated Solid Urban Waste Treatment Facilities for the five main districts throughout the island. At present, the rehabilitation of uncontrolled landfills in Larnaca-Famagusta and Paphos districts are under-way.

3.9 Combat non-licensed boreholes

The enforcement of the new Law on Integrated Water Management (LAW 79(I)/2010) provides for registration of all boreholes, groundwater extraction control by way of requiring the installation of a meter on every single borehole and heavy fines in cases where licensed quantities are exceeded. The enforcement of the Law along with the water pricing policy on agriculture is expected to alleviate the diminishing of the aquifers.

3.10 Tourism water use

To address current and future water conflicts, tourism businesses should be advised to not only focus on their own operations and efficiencies, but to take a broader destination perspective that integrates business needs with those of the local communities. Water management and governance schemes need to carefully consider the geographic scale, the fundamental question of water as a common or a commodity, and the specific mechanisms (e.g., privatisation, permit schemes) that ensure the best outcomes for tourists, communities, businesses and the environment (3).

3.11 Combat Arsenic Concentrations in Cyprus' groundwaters

The systematic and effective water quality programme is essential to identify as early as possible emerging problems relating to changes in climatic conditions, agricultural practice and increased incidences of local health problems as was the case with the rural area in the Nicosia district (5).

3.12 New Water Paradigm from Kentucky, Hebron, USA (EPRI, 2010)

The New Water Paradigm identifies and evaluates the foundation and requirements for a sustainable water infrastructure at the community and watershed scales. Communities face many challenges with respect to meeting their water needs.

The following opportunities have been identified by the New Water Paradigm

- green infrastructure (green roofs, rainwater harvesting etc)
- water conservation
- stream restoration
- high efficiency pumps
- decentralized water/wastewater treatment
- resource recovery
- link land use planning with system architecture to be more water-centric
- bring demand closer to the supply of locally available water; where facilities are not close to the existing reclaimed system, a sub-regional reuse system could be developed
- establish water conservation in the mining and agricultural communities
- repurpose flood control to provide resource water; develop better technology for desert treatment of stormwater including protection of cisterns from first flush
- integrate smart systems in homes and businesses to take advantage of the conservation ethic in the region
- develop greater understanding of arid and ecology to support greater use of biomimicry technologies

- consider new bio-solids options such as co-composting with garbage, environmental reclamation, or co-generation
- educate developers on the benefits of sustainable technologies and conservation of protection sensitive areas
- establish a platform/forum for planning across community programmes
- have community define tactical principles reflecting desired outcomes and communicate them simply and clearly to the public
- implement an adaptive management approach and develop tools that support integrated planning including life cycle costs and risk assessment
- link water infrastructure planning to land use planning
- use public demonstration projects incorporating sustainability principles and addressing multiple objectives
- water awareness campaigns

3.13 Strategic Approach to Abandoned Mines Management

According to the annual report of the Mines Service, a total number of 129 abandoned mines are operated along the island whereas 25 of them are in the final stage of restoration of mines activities areas. An abandoned mine lands program should be developed to coordinate the management of abandoned mine sites. The broad aims of the program should be the following (7):

- remove risks to public health and safety
- stabilize abandoned mine sites and reduce the impact of contamination, erosion and mass movement
- reduce impacts on the biological diversity of species in the vicinity remove or ameliorate sources of site contamination
- achieve an acceptable land use for the site compatible with rehabilitation strategies adopted
- improve the visual amenity of the site and its surroundings preserve cultural and indigenous values associated with any site

3.14 New Wind Turbine for Clean Drinking Water Production

A wind turbine has been developed by the French engineering firm Ecole Water that can produce 1,000 liters of clean water every day by filtering and collecting moisture out of the air.

One wind turbine, according to the company, could provide water for a village of 2,000 to 2,000 people every day over the course of its 20-year life expectancy. Forced by gravity, the water then travels down to stainless steel pipes into a storage tank. Therefore, after some filtering and purification, the water is ready to use for drinking, washing and cultivating (4).

4 Conclusions

Last but not least, although a significant number of research programmes under European Union or National funding have been completed or are running in Cyprus, both Cypriot authorities and European Union fail to utilize these

results in order to improve the current environmental concerns. Many results have been drawn from these projects, which can be utilized for water resources management across the island, can help in water quality and quantity status and strengthening the management of water resources.

There are many barriers to innovation that are often cited (e.g. institutional, cultural, financial, and regulatory). Cyprus government should consider ways in which its regulatory activities can reduce barriers to, or encourage incentives for, technology innovation. For example, sustainable and innovative technologies and measures should be included when developing national standards for controlling water and waste discharges. A broad set of questions about the best available technology might include consideration of energy use, sludge generation and disposal, process changes or green chemistry alternatives, water conservation and re-use opportunities, and by-product and pollutant recovery prospects (6).

Additionally, government should find ways in which disposal permits could be tailored to foster technology innovation within existing legal and regulatory authorities. Examples of permitting innovation might include watershed-based permitting, opportunities to foster process optimization or use of existing excess treatment capacity, derivation of long-term average limits for nutrients, opportunities to explore alternative technologies, and performance testing of those technologies, or implementation of integrated planning (6).

External parties such as NGOs, universities, environmental consulting companies and other environmental experts can participate and contribute to these efforts to explore regulatory and/or policy strategies to identify and overcome barriers to the acceptance of innovative and new technology.

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