

ANNALS OF “DUNAREA DE JOS” UNIVERSITY OF GALATI
MATHEMATICS, PHYSICS, THEORETICAL MECHANICS
FASCICLE II, YEAR XI (XLII) 2019, No. 2
DOI: <https://doi.org/10.35219/ann-ugal-math-phys-mec.2019.2.02>

WASEC – INNOVATIVE EDUCATIONAL TOOLS FOR THE SUSTAINABLE MANAGEMENT OF SEMI-AQUATIC ECOSYSTEMS TO PROMOTE WATER SECURITY IN THE EASTERN MEDITERRANEAN

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Abstract

Water is the most valuable and rare resource in the Eastern Mediterranean. The potential climate change impacts in the region require a new generation of water managers to learn and utilize new and innovative methods and techniques to achieve water sustainability. A key to provide adequate water supplies in the region is the sustainable management of semi-aquatic ecosystems such as wetlands, riparian areas and deltas. These ecosystems provide many services to humans, particularly in semi-arid and arid regions. Some of the services are directly connected to water supply and water quality. Through the WaSec project the awareness of the importance of these ecosystems for water security in the Eastern Mediterranean will be promoted. In addition, it will develop material that will train science-based water management graduates with the necessary tools on the proper management of these ecosystems to provide services for water security of the region. This will be accomplished by five main actions: a) Mining Stakeholders Views, b) a Neighborhood Network, c) University Courses, d) Establish University-Enterprise Collaborations and e) Dissemination Activities. Through these actions, water security in the Eastern Mediterranean will be promoted because the awareness by policymakers and the general public on the importance of semi-aquatic ecosystems will be enhanced and a new generation of water managers will be trained. This paper was presented at the *MONITOX International Symposium “Deltas and Wetlands”*, Tulcea, Romania, 15-17 September, 2019.

Keywords: riparian areas, deltas, terrestrial wetlands, water security, climate change, innovative educational programs

1. INTRODUCTION

Semi-aquatic ecosystems provide multiple services essential for the water security and socio-economic development, especially in semi-arid and arid environments [1]. Water is an essential resource for human life and civilizations [2]. Problems associated with “Water” are particularly severe in semi-arid and arid regions (e.g. Eastern Mediterranean). The lack of sufficient water supplies is one of the

reasons that hinders the economic development and social welfare of these regions. In addition, in this Eastern Mediterranean region, climate change is expected to negatively affect the quantity and quality of water resources. Global, regional and national studies have shown an increase in mean and extreme temperatures as well as changing precipitation patterns [3]. The continuing forecasted trend towards decreased and more intensive precipitation events along with increased evapotranspiration as a result of temperature combined with the increased other anthropogenic stressors, will act to substantially reduce surface and ground water availability [4]. Two of the major anthropogenic stressors that will impact water availability in the region include: a) increase in the population that also leads to agriculture practices that are more intensified and b) high number of tourists that the region receives, especially during the summer when the water resources are the least [5].

The term semi-aquatic ecosystems refer to ecosystems such as riparian areas, deltas and terrestrial wetlands. These ecosystems are also called ecotones, as they are transitional zones between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota [6]. Their importance has been recognized because of the many important ecosystem services they offer such as water supply for drinking, agriculture and industries, water purification, erosion control, recreation, tourism and flood mitigation [7-10]. Most great civilizations develop in and near such ecosystems such as the Egyptian Empire that thrived along the banks and delta of the Nile River, and the Persian Empire that flourished along the banks of the Tigris and Euphrates Rivers. Even today most of the world's greatest cities are along the banks of rivers [11]. In the Mediterranean the intensified agriculture, increased urbanization and tourism has led to the significant loss and degradation of wetlands, deltas and riparian areas [12]. A priority in the region should be the protection, conservation and re-establishment of these unique and valuable for the region ecosystem that can help promote water security.

To achieve water resources security and sustainability in the region, which already is facing water scarcity, science-based and well-trained professionals specialized for the Mediterranean that know how to conserve and eliminate the waste of water and protect the semi-aquatic ecosystems while considering potential climate change impacts are a requisite. To further enhance water resources sustainability, management plans based on new and innovative tools and methods need to be developed, implemented and utilized. Accordingly, an improved understanding of such water resources management plans needs to be addressed in comprehensive, practical and modern courses.

This is the main aim of the WaSec project that focuses in the Eastern Mediterranean region (primarily Jordan and Palestine). It also wants to develop a new culture of working collaborations among universities and enterprises in the water sector of the region. Such collaborations will allow universities to be better integrated within the larger society. The title of the WaSec project is “Innovations in Water Education Programs: Enhancing Water Security and Socio-economic Development in the Eastern Mediterranean under Climate Change” and is funded by the ERASMUS + Programme of the European Union (please see for specific details the link <https://ec.europa.eu/programmes/erasmus-plus/projects/eplu-project-details/#project/598480-EPP-1-2018-1-PS-EPPKA2-CBHE-JP>).

The WaSec project is very collaborative, interdisciplinary and international since 13 partners, comprised with a mix of universities, public organizations and private companies, are involved that originate from a total of six countries; four from the European Union (Cyprus, Greece, Jordan, Netherlands) and two from the Eastern Mediterranean (Palestine and Spain). The project is led by the Palestinian Technical University of Kadoorie. In this paper the approaches of the WaSec project are presented to enhance water security and foster socio-economic development while considering climate change impacts through the water education programs. The novelty of the project is the utilization of the stakeholders' views and the collaboration with public organization and private companies when developing the innovative educational material.

2. STUDY REGION

The region of interest is the Eastern Mediterranean that includes the following countries and territories Cyprus, Greece, Lebanon, Syria, Israel, Palestine, Turkey, Egypt, Libya, and Jordan. The project has partners from 4 of these countries and territories (Cyprus, Greece, Palestine and Jordan). The region is generally dry, with typical Mediterranean climate that faces water-scarcity issues, especially during the summer. This is the reason why sustainable management through education is a necessity. In the project emphasis was given to meet the needs of water sector of Jordan and Palestine although the projects results could also be applied in neighbouring countries such as Lebanon, Syria, Israel, Egypt and Libya.

3. MEDITERRANEAN SEMI-AQUATIC ECOSYSTEMS

These semi-aquatic ecosystems (riparian areas, deltas and terrestrial wetlands) can be found in all biomes and some of their characteristics vary from region to region leading to many differing definitions. In the Mediterranean that is a water scarce region their conservation and utilization is essential for human welfare and security. In the following subsection the best description of each of these ecosystems based on the current literature is presented.

3.1. Description of the semi-aquatic ecosystems

Riparian areas are adjacent to perennial, intermittent, and ephemeral streams, rivers and torrents, lakes, and estuarine–marine shorelines, where surface and subsurface hydrology connects waterbodies with their adjacent uplands [13, 14]. The three main characteristics of these areas are a) water, b) soil/geomorphology and c) vegetation that make them distinctive and unique compared to the adjacent ecosystems. The combination of the water-soil-vegetation characteristics of these areas reflects the influence of the higher available moisture quantities compared to their adjacent terrestrial upland ecosystem [15]. Common Mediterranean riparian tree species are *Salix* spp., *Populus* spp., *Platanus orientalis*, *Alnus glutinosa*, *Fraxinus* spp., and shrubs species are *Salix* spp., *Tamarix* spp., *Frangula alba*, *Sambucus nigra*, *Cornus* spp [1].

Wetlands have constant or recurrent shallow inundation or saturation near the surface of the soil and are characterized by hydric soils and hydrophilic vegetation [16]. These characteristics are present unless specific physicochemical, biotic, or anthropogenic factors have removed them or prevented their development. These “wet” conditions lead to obligate wetland species present, such deeper water submerged aquatic plants *Potamogeton* spp., *Nymphaea alba*, *Lemna* spp., *Trapa natans* and *Nympoides peltata*, as well as shallow water plants such as *Phragmites australis*, *Carex* spp., *Typha* spp., *Juncus* spp. and *Scirpus* spp [1].

Deltas are ecosystems develop on landforms located at the endpoints (mouth) of a river [17]. The sediment that originates from the rest of the watershed are carried by the river and deposited at its mouth that is located at the interface with an ocean, sea, estuary, lake and reservoir [18]. Sometimes it can also occur at the interface with a larger river [18]. The slower moving or standing waters at the mouth lead to the sediment being deposited and the formation of the delta. The supply of sediment and the watershed processes control the size and shape of the delta [19]. Important for the evolution of the delta ecosystem are the watershed characteristics such as its size, location, slope and land-uses [19].

As previously mentioned all three ecosystems have semi-aquatic characteristics and are ecotones between aquatic and terrestrial ecosystems. In addition, they are disturbance driven, since flooding quite frequently occurs, and they also experience long periods of drought while they also have greater soil water availability compared to their adjacent upland ecosystems leading to vegetation that is more hydrophyllic. These commonalities have led, in the past in many cases these terms “riparian areas,” “wetlands” and “deltas” to be used interchangeably. In some cases, riparian areas and deltas were considered a type of wetlands [20]. Today with the advancements in ecology, most scientists considered them as different ecosystems [13]. Onlooking in the ecosystem details of the previous description it is obvious that each ecosystem in some cases can be more restrictive, more expansive or the same with the other two ecosystems. For example, riparian areas might be more expansive because

they include terrestrial areas that are saturated or inundated with water for short periods of time and cannot be considered wetlands. In contrast, wetlands can also include areas that are under water year around that are not considered riparian. The longer water inundation and saturation periods of wetlands lead to soils that are always hydric, while riparian areas can also include areas that have non-hydric soils. Most riparian areas are highly connected with each other (because of the stream corridor) and linear in shape. In contrast, wetlands are very lightly connected with each other, are oblong or circular in shape. Finally, deltas appear to be the most restrictive, since they are very site specific located at on the landform at the mouth of rivers and streams.

3.2. Climate change and semi-aquatic ecosystems

In the Mediterranean region, climate change is expected to severely increase the temperature and evapotranspiration rate, increase the concentration of rainfall in shorter periods of the year, decrease precipitation up to over 50% in summer, and thus increase the drought frequency and strength that will intensify the hydrological cycle and alter water availability [21, 22]. These changes should lead to substantial hydrologic alterations with an increase in frequency, intensity and duration of extreme events, such as floods and droughts [23]. In the Eastern Mediterranean a region where water stress is already high, the combined impact of increased needs and decreased water availability due to climate change will lead to severe water shortages and major water use conflicts [24]. This expected decrease in runoff in the Mediterranean is explained by the decrease in winter precipitation in the upstream areas and by the increase of water withdrawals and evapotranspiration in the downstream areas in the summer [25]. Based on these forecasted scenarios hydrological connectivity of surface water bodies will be decreased, concentration of pollutants will be increased during droughts, biological communities will change as a result of harsher environmental conditions, and biological processes like nutrient uptake, primary production, or decomposition will also increase [23]. The significant changes in the hydrologic regimes along with the increased anthropogenic pressure on shrinking water resources will firstly and severely impact semi-aquatic ecosystems and impact the ecosystems services they offer. It is very likely that the natural resilience boundaries of these semi-aquatic ecosystems in regard to flooding and drought will be exceed under the new condition because of climate change and along with the increased anthropogenic pressures will further degrade or lead to the unsustainable utilization of the last remaining natural and protected riparian areas, deltas and terrestrial wetlands of the region. The overall decrease in soil moisture can lead to the transition from hydrophilic species to more drought tolerant species [26]. Even the higher frequency and spatial extent of wildfire at the watershed will alter hydrologic regimes and affect semi-aquatic ecosystem species composition [26].

4. WASEC PROJECT CURRENT AND FUTURE ACTIONS

To achieve the objectives of the WaSec project five different main actions will take place that are: a) Mining Stakeholders Views, b) Establish a Neighborhood Network, c) Develop New Innovative University Courses, d) Establish University-Enterprise Collaborations and e) Dissemination Activities. These actions are described in detail in the following sub-sections.

4.1. Mining Stakeholders Views

The first action includes online questionnaires to mine the stakeholders' views on the water sector of the Mediterranean. The online questionnaires through a series of questions addresses the needs and existing gaps in water education. Specifically, the first type of questionnaires (total of two) mined what the current curricula on water management in the European Union and in Eastern Mediterranean area are. The second type of questionnaires addresses how to better enhance the collaboration between university and enterprises in the water sector. Three different questionnaires were developed for a) university faculty, b) private sector employees and c) public sector employees working in the water

sector. Each questionnaire had 20 questions. A list of potential stakeholders was developed by each partner and afterwards these stakeholders were invited to complete the online questionnaire. The online questionnaire was available for approximately three months. Stakeholders views help develop material and tools more user-friendly and more likely to be adopted by the practitioners of the region [27].

4.2. The “WaSec” Neighborhood Network

A Network with water professionals (universities, public organizations, companies and enterprises) will be established for the Eastern Mediterranean region. This network will provide feedback on the new state of the art courses that will be developed and taught in Jordan and Palestine to enhance the knowledge, tools and skills of the graduates and increase their attractiveness to enterprises. To select the appropriate stakeholders the partners from Jordan and Palestine have been compiling a list of enterprises, authorities and organizations from their countries and potential neighboring countries that are involved or interested in Water Management. Once these lists are finalized an official invitation will be sent to these potential members of the WaSec Network. In addition, emphasis will be given to inviting policymakers. Those that accept the invitation will be part of the Network that should be operational in November 2019 and function until the end of the project. The network will meet online every 6 months to discuss the project’s issues and results providing valuable feedback. In addition, a web portal will be developed for the WaSec Network on the project's website. The members will have access to documents of the project before they are placed on the website so they can provide feedback to improve them. Finally, an official document regarding the network's purpose, responsibilities and obligations will be written and also posted Network portal.

4.3. New and Innovative University courses on Water Management

The developed courses and material will incorporate the latest and newest technologies on water management. Some of these courses will focus on the sustainable management of wetlands, riparian areas and deltas. The final topics will depend on the analysis of the questionnaires in the “Mining Stakeholders Views” action. The courses will utilize new pedagogical approaches with interactive exercises, use of videos, social networks, flexible learning path, blended courses etc. to enhance learning capacities. The courses will also be specific for the water needs while also taking into consideration the culture of the Eastern Mediterranean region with an emphasis on Jordan and Palestine. An active involvement of enterprises in the courses is a priority.

In this context, the main scope is to teach new technologies and methods to students that will incorporate them in water resources management plans with an emphasis on conserving and protecting semi-aquatic ecosystems that eventually will be adopted in the water relevant organizations and businesses. Another major concern are the many different services that water can offer. This, in many cases can lead to conflict among the stakeholders, making water management a very difficult task. Through these courses, students will get a holistic prospective on water issues that will enable them to find the optimum solutions based on the specified objectives for water management and by taking into consideration all interested parties. Water involves many different sectors, e.g. water for municipalities, agriculture, recreation, but also is necessary the environmental needs. The proposed courses will teach how to develop water resources management plans that satisfy as best possible all these different sectors. Major emphasis in these courses will be given in understanding the principles of integrated water resources management along with water conservation and recycling techniques. In addition, the impending climate change impacts will put more pressure on water resources. Understanding and incorporating its potential impacts in management will be a focal point of the program (understanding climate change forecasts and learning climate modeling). Finally, the involvement of many different countries in the development and teaching of these courses will lead to their internalization.

4.4. University-enterprise collaboration

In many cases, students that graduate do not always learn the tools that are required for the job market. To help graduates acquire the necessary tools to get more easily hired by companies and organizations that deal with “water,” these will be involved. Firstly, they will provide ideas on how to best support student’s practical placement, entrepreneurship, employability of graduates etc. In addition, they will offer practical training opportunities and internships to the students of the WaSec courses. This collaboration regarding the courses will be further advanced with courses that have real life water management case studies from enterprises and a series of seminars with presenters’ representatives of enterprises. The goal is to establish university-enterprise collaborations that should be long-term and beneficial to both parties involved. This is also the reason why organizations and companies dealing with water are involved either as partners or associates in the WaSec project. Overall, the companies and organizations will also be involved in the other phases of the project not just the courses. Finally, the Water Network will help sustain and further this university-enterprise collaboration after the completion of the project.

4.5. Dissemination Actions

Many dissemination actions will take place to enhance the awareness of the project, the main project results and in general the importance of sustainable water management and the conservation of semi-aquatic ecosystems to promote water security in the Eastern Mediterranean. Specifically, the dissemination actions will include four dissemination seminars and four tester workshops in Jordan and Palestine and a conference on innovative water management. Additional activities will include a project website, active social media (e.g. facebook, twitter, LinkedIn, ResearchGate), printed material (e.g. brochures, pamphlets, press releases to newspapers) and electronic material (press releases in electronic media, electronic newsletters, video presentation). These diverse activities should promote the awareness on the importance of wetlands, riparian areas and deltas conservation for achieving sustainable water management.

5. CONCLUSIONS

The WaSec project relies on the extensive involvement of stakeholders from the water sector (e.g. companies, policy makers in the water sector), by mining their views with questionnaires, by their participation in the WaSec Network and establishing university-enterprise collaborations. Their involvement along with inputs from university professors will help modernize the curricula and provide new courses or curricula with innovative technologies for water resources management, specific for the Eastern Mediterranean. Emphasis will be given to the conservation and sustainable use of semi-aquatic ecosystems. In addition, in these courses, students will solve real-life water case studies provided by companies, have practical placement and internship opportunities in the private and public sector while seminars will be taught by water professionals outside the academic community that will promote graduates’ employability and their entrepreneurship spirit. Overall, the purpose of the project through these series of educational actions will sustain the semi-aquatic ecosystems while helping achieve water security in the Eastern Mediterranean.

ACKNOWLEDGEMENTS: This project is funded with support from the European Commission through the ERASMUS+ Program. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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