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Management and Protection of Mediterranean Groundwater-Related Coastal Wetlands and their Services

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MANAGEMENT AND PROTECTION OF MEDITERRANEAN GROUNDWATER-RELATED COASTAL WETLANDS AND THEIR SERVICES

TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS

AGU	American Geophysical Union
AICZMP	Alexandria Integrated Coastal Zone Management Project
B&H	Bosnia and Herzegovina
CBD	Convention on Biological Diversity
COP	Conference of the Parties
CP	Contracting Parties
EA	Ecosystem Approach
EEAA	Egyptian Environmental Affairs Agency
EIA	Environmental impact assessments
EMU	Environmental Management Units
EU	European Union
GAFRD	General Authority for Fish Resources Development
GCM–RCM	Global Circulation–Regional Circulation
GDE	Groundwater-dependent ecosystems
GEF	Global Environment Facility
GIS	Geographic Information Systems
GRACE	Gravity Recovery and Climate Experiment
GWD	(European) Groundwater Directive
GWDTE	Groundwater-dependent terrestrial ecosystems
HCI	Habitats of Community Importance
ICZM	Integrated Coastal Zone Management
IGCP	International Geoscience Programme
IHP	International Hydrological Programme
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
LIDAR	Light Detection and Ranging
MAB	Man and the Biosphere Programme
MAP	Mediterranean Action Plan
MALR	Ministry of Agriculture and Land Reclamation
MEA	Millennium Ecosystem Assessment project
MedPartnership	Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem
MedWet	Mediterranean Wetlands Initiative
MENA	Ministry of Environmental Affairs
MWO	Mediterranean Wetland Observatory
MWRI	Ministry of Water Resources and Irrigation
NCICZM	National Committee for Integrated Coastal Zone Management
NGO	Non-governmental organization
NIOF	National Institute of Oceanography and Fisheries
OECD	Organisation for Economic Co-operation and Development
Ramsar	Convention of Wetlands of International Importance
SAR	Synthetic Aperture Radars
SEPA	Special environmental protection area
SGF	Small Grants Fund
SNWI	Spanish National Wetland Inventory
SPA	Specially Protected Areas
SPA-BIO	Protocol of Specially Protected Areas and Biological Diversity in the Mediterranean
TEEB	The Economics of Ecosystems and Biodiversity
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Environmental, Scientific and Cultural Organization
WFD	(European) Water Framework Directive

FOREWORD

This Regional Report presents the data and information generated between 2012 and 2014 in the framework of the activity Implementation of eco-hydrogeology applications for management and protection of coastal wetlands. This activity is part of the component on Management of Coastal Aquifers and Groundwater executed by United Nations Educational, Scientific and Cultural Organization-International Hydrological Programme (UNESCO-IHP) in the frame of the United Nations Environment Programme-Mediterranean Action Plan/Global Environment Facility (UNEP-MAP/GEF) project Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership).

To develop the activity related to coastal wetlands, UNESCO-IHP has relied on the expertize of the university researchers and professors who are the authors of this Report, given their experience in groundwater and groundwater-surface water relationships with emphasis in wetlands, in coastal areas and in wetland classification.

The team in charge thought that, further to the due emphasis on coastal wetlands-groundwater dependence and relations, the incorporation of the ecosystem services point of view was necessary. This ecosystem approach (EA) is a highly valuable framework to analyse the relationships between humans and the environment, as well as the related actions. The framework was developed by United Nations (UN) in the early 2000s inside the international programme Millennium Ecosystem Assessment (MEA), whose first product was the "Ecosystems and human well-being: a framework for assessment" report. The EA objective is to generate a strategy for integrated land, water and living resources management in order to promote their preservation, and their equitable and sustainable use.

The EA is based on the application of scientific methods to characterize and evaluate:

- which services a given ecosystem provides to human well-being
- what is the state of functioning of those services when the evaluation is performed
- what are the factors that produce changes in the functioning of these ecosystems and their services
- how these changes will affect human well-being in coming decades
- which actions can be adopted at local, regional, national and global scales to improve ecosystem management and consequently contribute to human well-being and poverty reduction.

The conceptual framework is based on the fact that coastal wetlands are one of the most productive worldwide ecosystems and provide to humans a wide range of services. In addition, groundwater-related coastal wetlands in arid and semi-arid areas produce and provide particularly valuable services to the humans in those areas, as often they are the main or only water source for all purposes, from drinking to economic uses. They also provide food, fibres, medicines, minerals and construction materials, and help in taming local climatic conditions, reducing inundation effects, improving water quality, providing tourism-related economic inputs and generating cultural values, among other services.

Despite growing international recognition of the importance of these ecosystems and their contribution to human well-being, coastal wetlands in general – and those in the Mediterranean coastal areas in particular – are subject to many pressures, and in some areas they are still considered of small interest and even a disturbance to be deleted. In the past, this last unfortunate vision has caused destruction or irreversible damage to many coastal wetlands; large economic, social and environmental losses; and quantitative and qualitative impairment of water resources. Despite this, their evaluation – quantitative or qualitative – still remains to be done.

The preservation of these groundwater-related wetlands depends largely on land and water management, not only in the coastal area but in the whole basin contributing water to the wetland, which is often much larger than the wetland area itself, and this often ignored. The Mediterranean coastal wetland experience in recent decades shows that scientific knowledge and understanding, and specific management actions – such as maintaining a given inundation state or level, some fish species or some vegetation – are needed, but they alone are not enough to ensure the long-term preservation of these wetlands and the ecological services they provide to human well-being. Compared to partial and sectorial points of view, the identification, evaluation and quantification – to the extent possible – of the whole set of services offered by the wetlands to human well-being currently represent the most valuable tool to decision-making on management of both the wetlands and other ecosystems linked to them. In coastal wetlands, groundwater is an important aspect and often a key one. In addition to these scientific aspects, the follow up of this project should include a gender component, aimed at promoting the role of women in the preservation of groundwater-related wetlands, and collection of sex-disaggregated data in order to evaluate specific needs or actions towards gender equality.

The goal of this Regional Report is to try to introduce the relevance and potential usefulness of the EA for the preservation, fostering and restoration of Mediterranean groundwater-related coastal wetlands services offered, or that were offered in past times, to the well-being of the human societies living around and near them. This goal is best attained when earth scientists, hydrologists and hydrogeologists work together with life scientists, to share their often very different points of view and spatial and temporal scales of work. In this case, and in many others in practice, this is difficult and the results are biased to some extent; but it is useful, and results can be corrected by experts. One benefit is that the water specialists involved receive some initial training directed to reducing the bias, drawing attention to details that otherwise would be ignored or remain unrecognized and using the most appropriate wording for the new concepts.

The sample of wetlands evaluated covers a wide area, but is reduced to obtain significant quantitative statistical treatment, and thus qualitative treatment has been used. However, the sample is fully representative of the most common types of groundwater-related wetlands existing along the Mediterranean coast. In addition, the area covered is that of the GEF area for MedPartnership, which excludes from economic support the other Mediterranean countries of the European Union (EU) and Israel, which have valuable wetlands and good experience on the objectives of this Report. However, their knowledge has been used, together with that of the participating countries, for the preparation of the Report, and ad hoc mentions are included. The mentions also incorporate the experience gained in the application of the EU Water Framework Directive of 2000 and its daughter Directive on Groundwater of 2006. The UNESCO-International Geoscience Programme project Groundwater and Wetlands in Ibero-America[1] (recently closed) shared objectives and approaches with this present project, from which they have mutually benefited. It contains data on several Mediterranean coastal groundwater-related wetlands in Spain, and on many other groundwater-related coastal wetlands in semi-arid zones of Ibero-America, whose origin, fate and historical relationships with local human societies are similar to those of the wetlands reported here. Integration of the knowledge gained in different projects and other parts of the world would be useful to extend and share experiences and results, enhance systematic comparison of similar systems, strengthen scientific conclusions, guidelines and recommendations and to boost the establishment of worldwide networks of scientists which help accelerate the transfer of knowledge to developing countries and junior scientists and technicians.

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1 http://www.unesco.org/new/en/natural-sciences/environment/earth-sciences/international-geoscience-programme/igcp-projects/hydrogeology/project-604/ (accessed 21 July 2015)

Part 1.

Basic aspects to be considered for better management of groundwater-related coastal wetlands

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1.1 ENVIRONMENTAL, SOCIAL AND ECONOMIC RELEVANCE OF GROUNDWATER-RELATED WETLANDS IN MEDITERRANEAN COASTAL AREAS

Marisol Manzano

1.1.1 Aims and scope

The purpose of this chapter is to introduce the main conceptual aspects related to the contribution of groundwater to coastal wetlands services, especially to those services relevant for human well-being.

Many scientific papers deal with wetland hydrology and hydrogeology, but almost no work has been done to characterize the role of groundwater in wetlands from the point of view of the Ecosystem Approach (EA; see Millennium Ecosystems Assessment, 2005). For this reason, a section in this chapter has been devoted to highlighting the groundwater and wetland information needed for decision-making in the Mediterranean countries.

The chapter also introduces some selected results from a survey performed within the framework of this project to evaluate the main hydrogeological characteristics, ecological services and drivers of change affecting 26 representative groundwater-related coastal wetlands on the Mediterranean coast.

1.1.2 Wetland-groundwater relationships in wetlands on the Mediterranean coast

Coastal wetlands of the Mediterranean basin exhibit a great variety of types according to their origin, geographic location, hydrology, hydrochemistry, soil characteristics, sediments and dominant vegetation. Among the most abundant types are estuaries, deltas, marshes, lakes, oases, flood plains, natural and artificial saltpans (salinas) and, more recently, artificial reservoirs. In spite of their diverse origin, most are related to Quaternary coastal dynamics and sedimentation processes and to deltaic flood plain processes. Also, despite their diversity, Mediterranean coastal wetlands share some basic characteristics, such as their temporal hydroperiod (most wetlands experience large fluctuations in the supply of water flooding, and many even dry during the summer. This is a consequence of the Mediterranean climate which has well-defined seasons, warm to hot, dry summers and mild to cool, wet winters and an irregular rainfall system); a plain to barely depressed topography; and a very shallow water table.

Many groundwater-related coastal wetlands occur in areas with a shallow water table, where groundwater can discharge to the surface, but some are linked to deep groundwater flows that ascend to the land surface in the coastal zone. In a given wetland, the direction of water movement between the wetland and the ground may change over time and space depending on seasonal climatic changes, local hydrological conditions and subtle topographic changes. As a result of regional and local groundwater processes, coastal wetlands related to groundwater display a wide range of natural typologies such as springs, seepage areas, dune slacks, coastal lagoons, marshlands, abandoned stream courses, deltaic lagoons and ponds, dry ravines and gullies, peat lands, mudflats, saltpans or sebkhas, and these also present different balances between the surface water and groundwater feeding them. Artificial wetlands linked to groundwater are also abundant in the Mediterranean coastal zone; the main types are rice fields, excavated ponds and lagoons, current and abandoned channels, and salinas.

Wetlands located along the Mediterranean coastal zone are mostly groundwater discharge zones. However, the relationships between groundwater and wetlands are quite diverse. The following wetlands-groundwater flow relationship types have been considered in the present work:

- Groundwater flow-through area: wetland is connected to a shallow aquifer and the water-table slope induces groundwater discharge in the upstream part of the wetland and aquifer recharge in the downstream part of the wetland.
- Recharge area: wetland water elevation is higher than the aquifer water-table elevation (wetland may even be perched). Wetland water sources may be precipitation, overland flow, rivers, sea water or artificial supply, but the dominant outflow mechanism is infiltration by lateral or by downward flow, producing shallow or deep aquifer recharge.
- Discharge area, open: wetland receives groundwater discharge and the dominant natural mechanism of wetland evacuation is surface water outflow.
- Discharge area, closed and saline: wetland receives groundwater discharge and the dominant natural mechanism of wetland evacuation is evapotranspiration. Wetland water and sediments are increasingly saline.
- Discharge area, closed non-saline: wetland receives groundwater discharge and the dominant natural mechanism of wetland evacuation is evapotranspiration, but surface water outflow occurs from time to time, avoiding wetland salinization.
- Crypto-wetland/hidden wetland: water table is very shallow under and around the wetland, which does not have standing water but has permanent/semi-permanent characteristic phreatophyte vegetation masses. Examples: salt pans, salt and brackish marshes, dune slacks.
- Variable area: the groundwater-wetlands relationship pattern changes over time.

Human-triggered modifications of landscape and land-use activities may produce significant impacts on groundwater-wetland relationships.

1.1.3 Groundwater role in Mediterranean coastal wetlands and its contribution to human well-being

Wetlands in general deliver a wide range of ecosystem services that contribute to human well-being and poverty alleviation. Following the Millenium Ecosystems Assessment project (2005), ecosystem services can be defined as:

> The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating and supporting services such as regulation of floods, drought, land degradation, and control of diseases, soil formation and nutrient cycling; as well as cultural services such as recreational, spiritual, religious, and other nonmaterial benefits.

Some of the most evident wetland services contributing to human well-being are the supply of water, food (fish, meat, vegetables) and fibre; the regulation of floods, erosion and sedimentation processes and local climate; and the provision of recreational opportunities and tourism. In groundwater-related wetlands, the groundwater component is vital for many ecosystems, providing crucial support to plants, animals and humans, especially during droughts.

The coastal zone is the discharge area of groundwater recharged in the continent, which makes this area a likely location for groundwater-related wetlands. Some of the groundwater discharging at present in the abundant dry areas of the Mediterranean coastline may derive largely from rainfall recharged in formerly wetter times, which means that such groundwater may be thousands of years old. Present-day recharge from local rainfall in the coast is also possible, taking place in dune formations and in the surrounding areas of higher elevation. Thus, in groundwater-related coastal wetlands many ecosystem services are derived from or are supported by the presence of groundwater inflow, because of its role in regulating the hydrology of the wetland.

From a quantitative point of view, the contribution of groundwater to a wetland can vary across time and space. In some wetlands, groundwater will be the dominant source of water, whereas in others groundwater may only represent a small and variable proportion of the total water supply. However, for most coastal wetlands the presence of groundwater, even if temporary and in small proportions, is a key factor for the chemical, physical and biological characteristics of the wetland. Groundwater provides fresh, unpolluted or slightly polluted water to coastal wetlands and, in dry areas, is usually the only water source for the wetland during dry seasons, dry years and droughts. Thus groundwater quantity, quality, chemical characteristics, and spatial and temporal flow pattern variability around the wetland, as well as the variability of the water fluxes and solute exchanges with the wetland, may control the ecological features of a particular wetland and how they change over time. However, as is usual around the Mediterranean coastal zone, arid and semi-arid conditions can mask the presence of groundwater and even the presence of the wetland itself. This is the case of crypto-wetlands (seepage or hidden wetlands), where there is no surface water and groundwater is at soil level or at the reach of vegetation capable of using it. A common type of crypto-wetland around the Mediterranean coast is the saltpan, which results from the evaporation of outflowing groundwater.

With respect to the role of groundwater in Mediterranean coastal wetlands and its contribution to human well-being, two main aspects should be considered:

1. The Mediterranean basin, and especially its coastal fringe, has been home to magnificent cultures and civilizations for millennia. Most of the population of those civilizations lived on or near the coast, where they benefited from the existence of what were, at those times, permanent fresh or slightly saline lakes and lagoons. These were found in the large river deltas (e.g. Nile, Po, Rhône and Ebro) and also along the coasts of straits (e.g. east of the Italic and Iberian peninsulas, south of the Turkish peninsula and the north coast of Africa). Geological and hydrogeological data show that those permanent and large wetlands located in dominantly dry places were fed by a mixture of regional and local groundwater flow paths. This would provide permanent and very good-quality water.

2. During the twentieth century, and especially during its second half, population density in the Mediterranean coastal zone increased extraordinarily. At present, the Mediterranean coastal fringe hosts some 100 million people, living in densely populated areas. In addition to the migration of the national population to the coastal areas, tourism has also concentrated along the Mediterranean coast, which is the top tourist destination in the world (UNEP/MAP-Plan Bleu, 2009). Parallel to human concentration was intensification of human activities focusing on providing a living (e.g. paving, building and channelling), food (e.g. ploughing, fishing and hunting), energy (e.g. damming, drilling and channelling) and leisure (e.g. deforesting, foresting, paving, dragging and building dykes) for the increasing population.

The intense pressure on land and water lead to a significant decrease in wetlands and to the modification of the hydrology of those that remain. The Mediterranean Wetlands Observatory (2014) and IUCN (2015) reported that more than 50% of wetlands had disappeared in the Mediterranean basin over the past century, and their decline and deterioration continue. Groundwater-intensive exploitation contributed to the decrease in and deterioration of wetlands: piezometric and water-table drawdown decreased the amount and regularity of groundwater discharge to wetlands and phreatophytes. Agricultural, industrial and urban activities led to pollution of shallow groundwater, which in turn reduced the capacity of the aquifers and wetlands fed by this shallow groundwater to produce reactions that improve water quality. Finally, wetlands decline induced changes in the services provided by these wetlands to local populations.

Despite their deterioration, coastal wetlands in the Mediterranean basin are still hotspots of environmental, social and economic relevance because of the paramount provisioning, regulating and cultural services they provide:

- They contribute greatly to the biodiversity of the Mediterranean basin, which is characterized by high levels of species diversity and endemism (IUCN, 2015). This is mostly due to:
  - their location at the intersection of two major landmasses, Eurasia and Africa
  - the topographical diversity and altitudinal differences near the coastal fringe
  - the circumstance that Mediterranean coastal wetlands receive migrating birds from around the world, which carry seeds

- They continue being sources of water, food, and biological and mineral materials, and generate working opportunities

- Many coastal wetlands are popular locations for tourism and recreational activities such as swimming, boating, fishing, camping and birdwatching; others are well-known places of spiritual significance for local and national populations; and many of the best preserved are becoming educational elements.

There are no specific studies about the contribution of groundwater to these wetland services, but it is not difficult to expect a considerable contribution. However, within the framework of the present project a survey was performed among earth scientists of the MedPartnership countries in order to collect basic hydrogeological information on representative groundwater-related coastal wetlands. The survey was performed in 26 coastal wetlands, and although it was too small to provide statistical data, the fact that it was developed in representative coastal wetlands makes the results qualitative but comprehensive. After compiling, comparing, synthesizing and evaluating the information reported about the coastal wetlands (see UNEP-MAP, UNESCO-IHP, 2015), the following results about the role of groundwater in wetlands and about the status of wetlands services was obtained:

- Wetland-groundwater flow type: most (18) of the evaluated wetlands do not show a dominant groundwater flow type, but variable combinations of basic flow types, with the majority of the wetlands showing some areas behaving as groundwater flow-through zones, and others behaving as groundwater discharge open areas

- Groundwater role in the wetland water balance: groundwater plays a dominant role in a small number (4) of the reported wetlands; a shared role in most (19) of the wetlands; a secondary role in 2 wetlands; and a variable role in 1 of the inventoried wetlands

- Hydroperiod: a notable number (17) of the wetlands evaluated have a permanent hydroperiod; a few (2) are seasonal; and 7 have a variable hydroperiod

- Following the Millennium Ecosystem Assessment (MEA, 2005), three groups of provisioning, regulating and cultural services were assessed (see section 1.3 of this Report and UNEP-MAP, UNESCO-IHP, 2015). A main result is that most of the services evaluated within the three main categories are performing at a low level in all the wetlands. This conclusion is consistent with the results of similar evaluations performed around the world in comparable studies

- Also following MEA (2005), a set of drivers of change to wetlands performance were assessed. The full list of drivers considered can be seen in section 1.3 in this Report and in UNEP-MAP, UNESCO-IHP (2015). The drivers most often reported as causing impacts on wetlands functioning were related to three main categories: resource exploitation (mostly groundwater exploitation, both near the wetland and in the wetland basin); changes in land use (mostly urbanization and extensive agriculture); and modification of hydrological cycles (mostly the use of wetland storage and the input of urban wastewater and excess irrigation water).

Combining the information provided on the role of groundwater in these wetlands, the groundwater flow type and the hydroperiod, it can be concluded that groundwater is probably a main supporting factor to the functioning and services of most of the coastal Mediterranean wetlands.

At the same time, the perceptions among the earth scientists performing the survey that all wetland services are performing at a low level; and that wetlands behaviours are modified by groundwater exploitation, conversion of natural landscape to urban and agricultural uses, using wetlands storage, and allowing wastewater to enter the wetlands, suggest that the contribution of groundwater to wetlands functioning and resilience is decreasing.

1.1.4 Groundwater and wetland information needed for decision-making within integrated coastal management in the Mediterranean countries

Mediterranean groundwater-related coastal wetlands are not only relevant features of coastal Mediterranean landscapes, but also significant local, regional and even national sources of economic and cultural resources. As coastal wetlands behaviour is linked to groundwater and surface flows functioning, to land use and – in many cases – also to marine-littoral zone dynamics, the protection of those wetlands and of their services to human well-being is most effective when coordinated with other management programmes such as water and land management, at the minimum. Moreover, coastal wetlands performance is controlled by factors that occur at different scales and which maintain a hierarchical spatial organization: higher-order factors are influenced by geographical, geological, climatic, economic and political factors that do not act or are barely noticed at the local scale.

For those reasons, a watershed-based approach to wetlands protection is desirable. This approach considers the whole water system, including other resource management programmes that address land, air, water and energy. The concept and consideration of what is currently called Integrated Water Resources Management (IWRM) allows us to address multifaceted water resources from both the technical and the governance point of view (Martínez-Santos and others, 2014). IWRM should involve wetlands, and the services they provide, by carefully managing the available water resources, both natural (e.g. surface water, groundwater, imported water from other areas or rainfall harvesting) and industrial or artificial water (e.g. seawater, brackish water desalination or water reclamation), and it should extend to consider virtual water (hidden flow of water if food or other commodities are traded from one place to another).

To obtain the basic information needed to protect groundwater-related coastal wetlands and their relevant services to human well-being into such an integrated management scheme, there is a need to generate basic, relevant knowledge. It is necessary to understand the origin of each wetland and its relationship with surrounding and/or underlying aquifers; to assess the status and trends of the services that each wetland provides to the human populations nearby , in particular to women, since no data is currently available on this topic. To classify the pressures that can result in deterioration of the wetland functioning, its ecological status and services after their relative impact (see section 1.3); and to promote realistic and useful management plans. To gather all this knowledge the following actions should be performed:

- Identify the existence of groundwater-related coastal wetlands
- Perform geological and hydrological assessments of these coastal wetlands; design a classification system (or select one from the many methodologies that exist) and apply it to the studied wetlands, even if the degree of available scientific knowledge is variable
- Conduct a hydrochemical assessment, define a baseline and identify possible deterioration trends in water quality
- Identify the services that the wetlands are performing and assess their status and trends
- Identify the pressures that can have a negative effect upon a wetland functioning, its ecological status and services; evaluate how these pressures could change with time; and define the possible actions that could be used to stop or decrease the impact of the pressures
- Identify the protection/regulatory tools available at local, national and international scales to protect the wetlands
- Integrate wetlands management into water and land-use planning and management.
- Include systematically the consideration of the gender dimension into all type of actions related to increase knowledge on groundwater-related coastal wetlands and to preserve them and their services. Identifying the role that women's daily work plays in the preservation of those wetlands, and the contribution of wetlands' services to woman well-being in turn, will allow to preserve the relevant services for women life, which means for their economic independence, leadership, and contribution to local governance.

Those aspects are exhaustively addressed in Part 3 of the present Report. Possibilities of gender mainstreaming in follow up activities of this project should be evaluated, and production of sex-disaggregated data promoted in order to also inform water policies on this topic.

1.1.5 References

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1.2 METHODOLOGIES FOR INVENTORY, HYDROGEOLOGICAL ASSESSMENT, MONITORING AND CLASSIFICATION OF GROUNDWATER-RELATED WETLANDS FOR MANAGEMENT PURPOSES

África de la Hera, Mark Whiteman, Gareth Farr, Alex Lewis, Marisol Manzano and Emilio Custodio

1.2.1 Aim and scope

This chapter aims to provide an overview of the tasks to be carried out and of the technical and scientific tools available to acquire the knowledge needed for better management of groundwater-related coastal wetlands. The minimum tasks to be performed are: wetlands inventory, hydrogeological assessment, monitoring and classification.

1.2.2 Wetlands inventory methodologies

A wetland inventory results from the collection and/or collation of core information for wetland study and management, including the provision of basic information for specific assessment and monitoring activities. It is a working tool for the identification of conservation and management priorities and, therefore, a basic element in the tasks of planning and land management. Inventories of wetlands contain valuable information that has been compiled specifically for the purposes of the people who designed them.

Hecker and Vives (1995) define the concept of "Inventory of wetlands" as a list of sites described by a set of information comprising at least: the location; the physical (including the hydrological) characteristics and biological features; the human activities and their impacts; and the protection activities at the moment in which the inventory is realized. Usually the inventoried wetlands fit certain predetermined criteria of identification (presence of certain species or habitats, surface, ecological services, etc.).

In all the inventories the information is organized in a systematic way, habitually by means of specification sheets or forms. Both the sheets and the data they contain have to be organized in such a way that they allow at least the following objectives to be reached:

1. Identification of the location of the wetlands and the priority sites for conservation. This is now provided as geospatial information (wetlands mapper).
2. Identification of the functions and the services of every wetland (ecological, economic, social and cultural services).
3. Provision of a base of information to measure the future changes in surface area, functions and services of the wetlands.
4. Provision of a practical tool for planning and management.
5. Allowing the possibility of national and international comparison with other wetlands inventoried and other inventories.

The spatial scale used for wetland inventory is inseparable from its objective and greatly influences the selection of the method to be used. As an example, Ramsar (2010a) establishes the basis for making decisions in relation to the purpose (and objectives), and the available resources for an inventory. It provides guidance to those who are planning to undertake a wetland inventory by drawing attention to different methods and wetland classifications already in use and of proven utility under different circumstances.

Standardized inventory methods have been used successfully in different circumstances, countries or regions. Notable among these are the Mediterranean Wetlands Initiative (MedWet) inventory, the United States Fish and Wildlife Service National Wetland Inventory, the Uganda National Wetland Inventory, the Asian Wetland Inventory, the Ecuador National Wetland Inventory and the Spanish National Wetlands Inventory. These examples are comprehensive applications of existing classification methods and they illustrate differences in approaches, which could be used in different locations, for different purposes and at different scales. The closest applications in the context of this Report are:

- MedWet: a set of standard but flexible methods and tools, including a database for inventory and data management in the Mediterranean region. Although not intended as a pan-Mediterranean wetland inventory, it has provided a common approach that has been adopted and adapted for use in several Mediterranean countries and elsewhere. It has several objectives:
  - to identify where wetlands occur in Mediterranean countries, and to ascertain which are the priority sites for conservation;
  - to identify the values and functions for each wetland and to provide a baseline for measuring future change;
  - to provide a tool for planning, management and permit comparisons between sites.
- Andalusian Wetlands Plan: an open inventory accompanied by a classification system and the design of management programmes based on scientific knowledge. This inventory applies the same methodology followed by the groundwater-related wetlands inventory of Spain developed in 1995 (DGOH, 1995).

1.2.3 Methodologies for the hydrogeological assessment of groundwater-related wetlands

Many wetlands are hydrologically and ecologically linked to the surrounding groundwater bodies, but the degree and the mechanisms of interaction can vary greatly. Some wetlands may be completely dependent on groundwater discharge under all climatic conditions, as happens to sabkhas or salinas; others many have very limited dependence, for example only under very dry conditions; and others may constitute the main recharge source for some aquifers, as in some wadis or gullies. In order to integrate wetlands protection into groundwater management plans and into general water resources strategies, the specific relationship between every particular wetland and groundwater must be identified.

The degree of connectivity between wetlands and groundwater is determined by a combination of geology, regional hydrology and topography (Ramsar, 2010b). Coastal areas have the most favourable conditions for wetland-groundwater relationships, as those areas are the lower part of river basins, land elevations are close to the sea level, natural groundwater levels are very shallow and littoral geomorphological processes favour the existence of land depressions.

The methodology designed by the United Kingdom (UK) for identification of groundwater-related coastal wetlands can be illustrative. It is based upon two complementary techniques: identification of the presence of distinctive groundwater-dependent ecology, and occurrence of ground-surface water interactions (UKTAG, 2004). The dominant groundwater-related coastal wetlands in the UK are humid dune slacks. Humid dunes represent both H2190 "humid dune slacks" and H2170 "dunes with *Salix repens* spp." types, which are listed under Annex 1 of the EU Habitats Directive. Davey and others (2010) produced guidance to assist with the generic conceptualization of humid dune sites to assess if European designated features, such as the key vegetation communities at risk of significant damage. Whiteman and others (2010) further defined significant damage and how this is incorporated within the Water Framework Directive characterization process in the UK.

A three-tiered approach (Table 1.2.1) has been followed when undertaking hydrological assessments of coastal groundwater-related wetlands in the UK. The most useful part for any wetland assessment was the successful working together of hydrogeologists and ecologists, both on site and during desk-based assessments. When selecting monitoring sites, the suggestions made by Davey and others (2010) are supported, including:

- Hydrological monitoring sites should be chosen to reflect different vegetation communities.
- Long-term ecological monitoring of vegetation communities should be made in conjunction with long-term monitoring of groundwater levels and chemistry.

As with all the EU countries, the UK developed a method to assess the chemical and quantitative status of groundwater bodies in response to the requirements of the EU Water Framework Directive (UKTAG, 2012). The classification process requires that groundwater bodies are assigned either "poor" or "good" status based on a series of six tests (Figure 1.2.1). The tests are a series of "health checks" for the groundwater body and include tests for saline intrusion, general quality assessment and a catchment water balance. Information and data collected as part of site assessments help to feed into Test 3: "Groundwater Dependent Terrestrial Ecosystem". When a wetland is in unfavourable conditions due to a groundwater-mediated pressure, for example over abstraction or diffuse nutrient enrichment, it is possible that Test 3 will be failed. The failure of just one test will result in the groundwater body being assigned "poor" chemical or quantitative status.

Table 1.2.1 Three-tiered approach to risk assessment of significant damage at groundwater-dependent terrestrial ecosystems (GWDTE) Source: modified from Brooks and others (2008)

	Tier 1	Tier 2	Tier 3
	Initial characterization: basic desk study	Further characterization: detailed desk study	Evaluation and classification: site visit and data collection
Where to look?	Published papers Published maps Site managers Local experts Grey literature Other reports	Ecological maps (NVC mapping) Geological maps Borehole archive Hydrometric archive Water chemistry archive Soil maps Modelling reports Ecology reports Air pollution inventory	Site walk over with a hydrogeologist and an ecologist On-site investigations including: Basic hydrogeological parameters Collection of water quality samples Ecological observations/mapping Subsurface investigation (augering/drilling)
What to look for?	Local expert knowledge Anecdotal evidence Known pressures Ecology (NVC mapping) Topography Hydrogeology/hydrology	Ecological data and NVC mapping Bedrock & superficial geology Groundwater levels Groundwater quality Geology and soils Soil types and cover Surface water flow Atmospheric loading data	Surface water inflows Surface water outflows Groundwater discharge points: springs/flushes/seepages Flow rates of all water features Water level controls (e.g. weirs/ditches) Head difference between water features Near-surface geology Distribution of species/communities Enriched vegetation

NVC, National Vegetation Classification

Figure 1.2.1 Water Framework Directive classification tests for chemical and quantitative assessment of a groundwater body in the United Kingdom. The Groundwater Dependent Terrestrial Ecosystems test is a useful tool for identifying when designated wetlands can be at risk from groundwater-mediated pressure Source: UKTAG(2012)

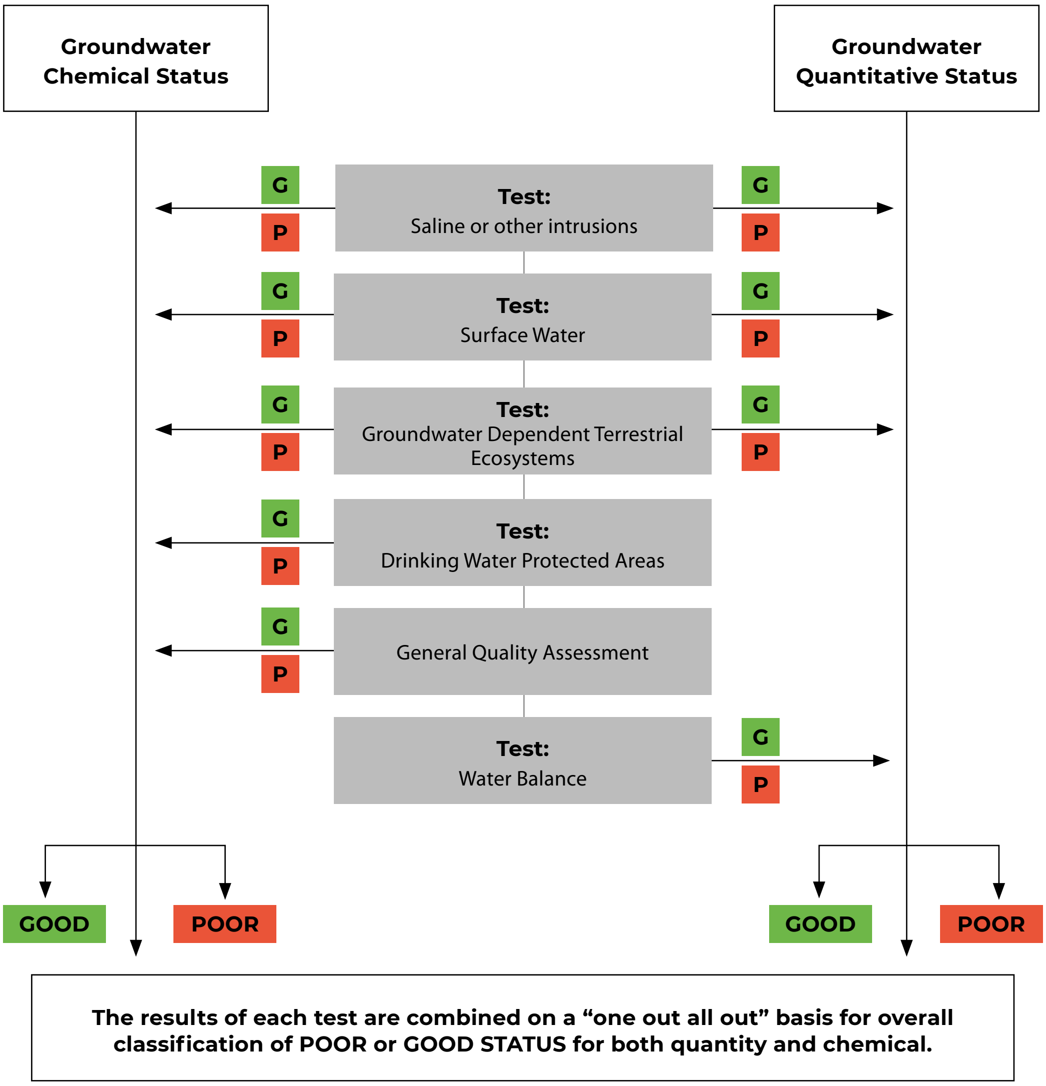
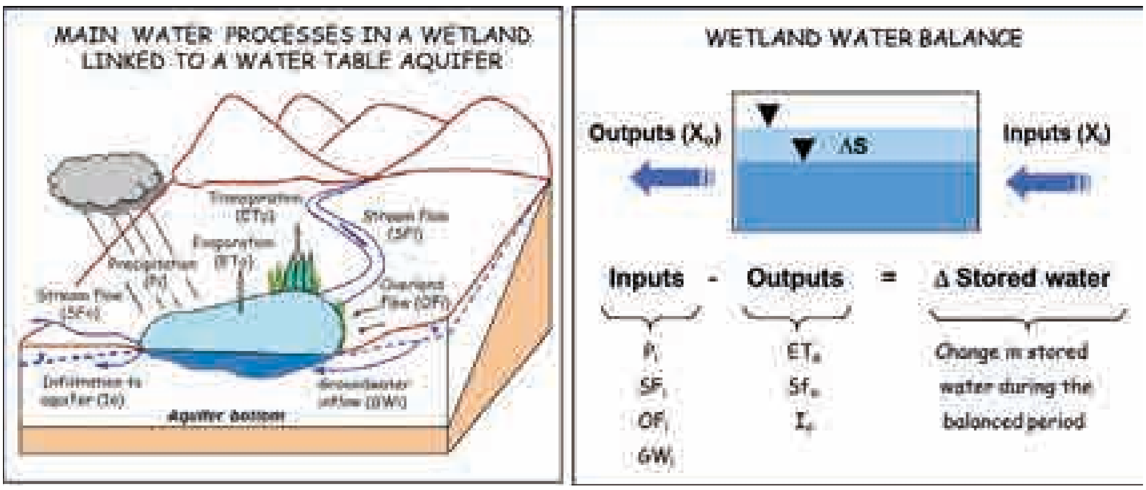


Figure 1.2.2 Left: Main water exchange processes in a wetland linked to a water table aquifer. Right: Components of the wetland water budget. Source: M. Manzano



1.2.4 Monitoring groundwater-related wetlands

Hydrological monitoring of groundwater-related wetlands can be oriented to two main purposes:

1. assessing the degree of hydrogeological and ecological linkage between the wetland and adjacent or underlying aquifers or groundwater bodies;

2. observing temporal changes in wetland water quantity, chemical composition and quality which could be derived from changes in the groundwater entering the wetland.

In all cases, monitoring of groundwater-related wetlands must be accompanied by monitoring of the surrounding aquifers or groundwater bodies. Only the comparison of regional data from the aquifer(s) and the wetland, and of time series data in both water bodies, can provide the understanding of the wetland-groundwater relationships necessary for efficient conservation of the wetland and its services.

1.2.4.1 Monitoring hydrogeological relationships of wetlands and groundwater

The starting point to assess the type of relationship between a particular wetland and the surrounding groundwater bodies is to identify all the water transfer processes that supply to and extract water and solutes from the wetland basin and to ascertain which are the most relevant. The relative importance depends not only on the presence of an aquifer but also on the nature of the soils and rocks in contact with the wetland and on the chemical composition of both groundwater and wetland water. If the wetland and the aquifer are in direct contact, the exchange of water is very probable, but if low permeability materials – clay, peat, organic matter layers – are under the wetland, the possibility of exchange may be very low. A clear review of water transfer mechanisms between a wetland and the adjacent aquifers can be seen in Ramsar (2010b), and a full review of conceptual models of groundwater-surface water relationships can be seen in Sophocleous (2002).

Figure 1.2.2 shows the water transfer mechanisms present in a wetland linked to a water table aquifer, which is a common type of groundwater-related coastal wetland, and the components of the water budget. Water budgets are expressed as water mass balance equations in which the different elements are the flow components. All quantities must be total amounts of water measured or calculated over a fixed period of time, usually several years (though they are usually expressed as average annual rates), and for the defined wetland volume. Both domains must be established following the calculation objectives and the later use of the results. The change in water storage is negative if stored water decreases.

For ecological and management purposes, in addition to the water budget it is important to describe the pattern of the wetland regimen, also called hydropattern (US EPA, 2008) or, most frequently, hydroperiod. This term refers to the inundation frequency, permanence, aerial extent and timing. In some wetlands, it may be necessary to quantify other locally relevant water components of the budget, such as those derived from perched groundwater bodies, from deep aquifers whose regional discharge occurs in the wetland location, or from the sea.

Once all the water transfer mechanisms existing in a particular wetland are identified, they must be monitored in order to be quantified and to know the possible existence of temporal and spatial variability patterns. The main hydrological variables to be monitored to quantify the wetland water budget components and to understand their degree of relationship with groundwater are precipitation, evaporation, water level variations of open water and of groundwater in the wetland, and water flows entering and leaving the wetland basin. Adequate elaboration of these data permits a knowledge of the hydroperiod, the surface water storage, and the water and solute residence times, and ultimately allows the components of a wetland's water balance and the relationship between the wetland and groundwater to be quantified. For many wetlands, the water budget terms can be roughly estimated after the conceptual model of wetland functioning is set. This can be done by using simple methods and already available data, but accurate estimations require field instrumentation and detailed measuring during a period of at least 2 or 3 years.

The main methods available to quantity the water budget variables are described synthetically:

- Precipitation and evaporation can be readily measured using rain gauges and evaporation pans, respectively. These are relatively inexpensive devices and provide reliable estimates of daily atmospheric water exchange. Evaporation can also be calculated by mass balance of water if other meteorological variables are available.

- To monitor water levels in a wetland with the water table above the ground surface, staff gauges (scales) are inexpensive tools that are easy to maintain and operate, while automatic sensors equipped with data loggers and telemetry units are most convenient for unattended continuous measurement in remote areas, if economic resources are available. If water levels are below the ground surface then small, nested or separated piezometers with different depths should be used to determine the piezometric levels at different depths and to identify the possible existence of vertical flows, as well as to monitor space and time changes. The soil saturation degree can be measured by time domain reflectometry (TDR).

- Measuring concentrated, small surface water flows entering and leaving a wetland can be performed using different portable devices such as weirs, flumes and culverts. To measure larger, open channel flows, stream discharge can be obtained manually by measuring the stream velocity across a given section or automatically in control structures which have to be constructed and maintained. Control structures exist in a number of shapes and their morphology makes them more or less adequate for different types of flow conditions. In places where control structures are not present and in-stream measurements are not possible, Manning's formula (Walkowiak, 2006) is commonly employed to measure the water velocity indirectly.

- In coastal wetlands subject to tidal exchange, sea water contributes to wetland water quantity, quality and ecology, and to their variability. Even if the tidal range in the Mediterranean coast is small, generally less than 1 m and often a few decimetres for coastal wetlands connected to the sea the marine water contribution may control the type of vegetation and biota, the hydraulic gradient (and the sense of the water exchange) between the wetland and the surrounding groundwater bodies, and many of the services that the wetland provides. The tidal inputs to a coastal wetland can be observed and measured by means of level recording. In coastal wetlands with small tidal exchange, distinguishing tidal water from fresh surface and groundwater inputs can be achieved using geochemical information. The marine water can be clearly distinguished by its high concentration of sodium and chloride and by specific ionic ratios such as Cl/HCO_3 or Cl/Br, while the continental water will have lower electrical conductivity and will probably have ion contents and ratios distinct from sea water. If carbonate materials are present, calcium will probably be the most abundant cation.

- Calculating subterranean water exchanges between a wetland and adjacent groundwater bodies is not straightforward. The empirical data needed are the hydraulic gradient between the wetland and the underground water bodies, and the hydraulic conductivity of the terrain around the wetland and of the sediment layer at the wetland bottom. To establish hydraulic gradients, the groundwater levels must be measured in piezometers drilled to attain different depths within and around the wetland. Piezometers with different depths, in separated boreholes or nested, should be placed at given locations, as they are necessary to know the existence and magnitude of vertical flows, especially in the case of heterogeneous sediments. Groundwater levels can be measured manually, using inexpensive downhole tapes or more costly electric sounding tapes, or automatically using unattended sensors either equipped with local read-out data loggers or with the most modern – and, at present, cheap – Global System for Mobile Communications (GSM) devices. These use mobile radio networks for data transmission (via e-mail, ftp or SMS) to a PC or a mobile phone. The hydraulic conductivity can be estimated though aquifer tests or, in the case of scarce economic resources, a rough estimation can be obtained from standard tables of values (Fetter, 2001).

- Groundwater inputs to coastal wetlands may also occur as localized discharges, such as concentrated and seepage springs. Concentrated springs form when an underlying confining layer for a confined, artesian aquifer is breached, or when the existence of a fault allows water from a confined aquifer to ascend to the soil or wetland surface. Spring discharge should be measured just at the discharge point. For concentrated subaerial springs this can usually be done easily either by manual or automatic methods. In the case of very rough landscape locations the spring flow may be dispersed and has to be concentrated by artificial works in order to be measured. Underwater springs in wetlands are not commonly measured in monitoring activities (only in research activities) and they are usually inferred from the results of wetlands water balance calculations and regional groundwater flow calculations, usually supported by groundwater flow modelling. Seepage occurs when shallow groundwater oozes or "seeps" from the ground over a large area and has no defined discharge point. This type of springflow usually occurs when a layer of low permeability sediments redirects groundwater to the surface after a shallow water table aquifer is recharged by heavy rainfall, or at the low-elevation, regional discharge area of large groundwater flow systems. Seepage flows are difficult to measure directly. Some work can be performed to concentrate and allow measuring of part of the outflow, but the complete discharge can only be approximated by remote sensing.

- Water chemistry sampling can be used to determine the source of water within wetlands. For example, if two groundwater sources supply water to a wetland, the geochemical signature of each source can be used to evaluate the relative magnitude of each inflow relative to the total (US EPA 2008). Selected chemical (mostly specific for each aquifer) and natural isotopic tracers (such as ^{18}O, ^{2}H, ^{13}C, ^{14}C, ^{34}S and ^{222}Rn) are successful tools for the identification of the groundwater input with respect to other water sources for a wetland.

1.2.4.2 Monitoring the ecological relationships of wetlands and groundwater

The role of groundwater in the ecological characteristics of a wetland can be assessed mostly by monitoring a set of chemical components and physicochemical variables both in the wetland and in the surrounding groundwater bodies. The main variables to be measured are pH, temperature (T), alkalinity, electrical conductivity (EC), dissolved oxygen (O_2), redox potential (Eh), turbidity, salinity and its space and temporal variations, dominant dissolved inorganic cations and anions, and nutrients such as nitrate and phosphate. In particular wetlands, other chemical components may be of interest. Some environmental isotopes such as ^{13}C, ^{34}S and ^{15}N are useful tools to assess the influence of groundwater chemistry in wetland water chemistry and ecology. However, their analyses are expensive, sampling some of them is complicated, and the interpretation of the results requires expertize in geochemistry; so they should not be analysed unless favourable conditions are met.

The concentration of some solutes and the value of some physicochemical parameters may change with temperature and/or aeration changes. Thus, they must be accurately measured in the field with caution to avoid significant changes with respect to the site conditions. This is the case for pH, T, alkalinity, O_2, Eh and the chemical species in which some nutrients are present. For example, nitrite may oxidize to nitrate or reduce to nitrogen gas and be lost to the atmosphere. The EC is not so prone to change, but changes may happen if, for example, calcite precipitates in the sample bottle before the laboratory analyses are performed. This may happen if the groundwater or surface water sample is oversaturated in calcite, resulting in a small decrease in EC.

The conventional equipment for water sampling (bailers and small pumps) can be obtained with a relatively limited budget. Field measurements of pH, EC, T, alkalinity, O_2 and Eh require a good economic inversion, but the equipment can be used reliably for years if adequately maintained.

Sampling for wetland water and groundwater physicochemical determinations must be performed only after a sampling plan has been set. The sampling plan must include the following aspets:

- a monitoring network;
- sampling and samples management protocols;
- a list of the instruments;
- the complementary material needed to take the samples (sampling devices such as bailers or pumps), to identify and adequately preserve them until the analysis (e.g. bottles of adequate volume and material, portable coolers, waterproof markers, stickers); to measure some parameters in the field; and to record the work performed (field notes, pictures, geographical location of the sampling sites).

The sampling plan must also include agreements and, later, contacts with the different laboratories previously selected to perform the water analysis.

A good understanding of wetland and aquifer hydrobiochemical and hydrogeochemical processes is necessary to interpret chemical data with the aim of understanding the ecological relationship between wetlands and groundwater.

Very good manuals on wetlands hydrology are available on the Internet: for example US EPA (2002a, 2002b, 2008); UK ES (2003); US ACE (2005). It is highly advisable to use them to assess the measurement of surface and groundwater levels, the design of boreholes inside and around a wetland, the use of water data to construct hydrographs and groundwater contour lines, the measurement of water fluxes, the acquisition of water samples for chemical and isotopic analyses, etc.

1.2.4.3 Observing temporal changes in wetland water quantity, chemical composition and quality derived from changes in the groundwater entering the wetland

The first objective of monitoring programmes is the observation of temporal variations in wetland water quantity and quality derived from changes in their relationships with groundwater. This involves the collection of a significant amount of information for statistical analyses with relatively minimal effort. The sampling design of a monitoring programme will depend on the management question being asked. Sampling efforts should be designed to collect information that will answer management questions in a way that allows robust statistical analysis. In addition, site selection and identification of appropriate monitoring periods and frequencies are all of particular concern when selecting an appropriate sampling design. Careful selection of the sampling design will allow the best use of financial resources and result in the collection of high-quality data for evaluation of the wetland resources (US EPA, 2002).

The best monitoring programmes are designed to assess wetland condition with statistical rigour while maximizing available management resources. At the broadest level, monitoring should include the following aspects (EPA, 2002):

- detecting and characterizing the ambient condition of existing wetlands;
- describing whether wetland condition is improving, degrading or staying the same;
- defining seasonal patterns in wetland conditions;
- identifying thresholds for system stressors: how much the system can be disturbed without causing unacceptable changes in wetland system quality or degradation of beneficial use.

As mentioned above, monitoring of groundwater-related wetlands must be accompanied by monitoring of the surrounding aquifer or groundwater bodies. After a preliminary characterization of the groundwater-wetland relationship, further monitoring of the groundwater systems should provide information about the aquifer dynamics, such as seasonal variations, evolution of aquifer recharge and discharge, the possible occurrence of seawater intrusion and the effects of anthropogenic actions, including groundwater abstraction, agriculture, and artificial or induced recharge.

Groundwater monitoring also requires previous design of monitoring programmes. Following EUWI (2007), the initial monitoring design must contain the following steps:

- definition of management tasks and objectives;
- specification of information needs;
- specification of technical objectives;
- specification of data to be collected.

Groundwater monitoring plans must also include the analyses to be performed and the names of the laboratories involved. It is also desirable to include the data management techniques or methods that will be used to elaborate the raw data in order to provide the information needed for water and environmental managers.

1.2.5 Wetlands classification methodologies

The methodologies for wetland classification are of great importance in the framework of environmental management. They are a management tool to use within a territory to define areas with different features, based on predefined criteria. A wide range of different wetland classifications is in use around the world. An annotated summary of some of these is given below, listed in order of their date of publication (Ramsar, 2010a).

Worldwide, the analysis of available wetlands classifications allows the differentiation of two large classification systems: genetic classifications and non-genetic classifications (DGOH, 1995). Genetic classifications pay attention to those genetic factors considered most important to explain the ecological variability of wetlands. The non-genetic classifications emphasize the standardization of current factors that create diversity in the water landscape.

The lack of an international ecological classification of wetlands makes it difficult to develop standardized transboundary programmes such as CORINE (a European Union programme for coordination on the environment) or NATURA 2000 (a European Union network of nature protection areas) and therefore to set out and use legal conservation tools, to exchange scientific information and to compare management results. It is also important that a classification system includes groundwater as an essential component of wetlands classification.

Wetlands classifications are frequently associated with wetlands inventories, because the latter collect basic information that is organized by a classification system. In practice, every classification system includes a definition of a wetland as its starting point, and so not all wetland types are included in all inventories. The wetland definition adopted, and the classification system selected, are essential to the tasks of creating an inventory, management, conservation and comparison.

Worldwide, the number of genetic classifications available is low. Among them may be quoted those of Hutchinson and Edmondson (1957), which has a morpho-genetic point of view; Novitzki (1979), which considers the origin and mechanisms of water supply to the Wisconsin wetlands; Gilvear and others (1989), which make a genetic classification of the wetlands in East Anglia, UK; Winter and Woo (1990), which proposes a genetic classification applied to USA wetlands; and the hydro-morphological classification developed by the DGOH (1995) for Spanish wetlands.

The non-genetic classifications may be divided into two groups: those that consider the use of internal characteristics (hydrology, hydrochemistry, etc.) and those that consider external characteristics (vegetation, morphology, turbidity, etc.). Classifications based on external characteristics may be divided further between those looking at biotic elements and those looking at abiotic elements. Among the non-genetic, external, biotic classifications (which use the vegetation as definition element) can be included the Golet and Larson (1974) classification, which distinguishes among 18 wetlands types based on pond vegetation; and Gore (1983) classification, which uses the same approach applied to European peatlands. Among the non-genetic, non-abiotic classifications can be included those based on analysis of the wetlands beds, for example Hakanson and Jansson (1983) and Wetzel (1983); or those based on the use of classes defined by the hydrology, bed morphology and their effects on the pond vegetation, such as the classification of Stewart and Kantrund (1971).

The non-genetic classifications, based on internal characteristics of the wetlands, are rarely used in the inventory of systems because they are based on attributes that are difficult to apply (hydro-period, hydrochemistry, organic matter decomposition, etc.). Among them are Gosselink and Turner (1978), based on gradients of hydrochemical energy; Odum (1974) for coastal wetlands; Brinson (1993) which considers the geomorphological setting of the wetlands and hydrology; and Semeniuk and Semeniuk (1995) which is based on the combination of variables between geomorphological settings and hydro-periods of the wetlands.

In Spain, the pioneering classification comes from MOPU (1991) and DGOH (1995) and was performed by researchers in ecology and hydrology for the first Spanish National Wetland Inventory (SNWI). The SNWI uses a genetic-functional classification system of wetlands which pays attention to the genetic processes involved in the wetland basin formation and to the hydrological processes involved in wetland hydrology (the dominant origin of water supply, the main water output mechanism and the dominant hydrochemical facies). It is a hierarchical classification system that allows improving the classification details of a wetland as the knowledge available increases. The SNWI methodology was improved in the Andalusian Wetlands Plan (2004). Durán and others (2003) applied the SNWI methodology to all Ramsar wetlands in Spain. The classification is based on three main factors:

1. geological setting and 'genetic' location of the wetland;
2. salinity of water and dominant ions;
3. hydro-period and degree of dependence on groundwater.

This classification can be represented graphically in a pie chart in which the upper semicircle corresponds to the genetic-geological factor, the right lower quadrant indicates the degree of salinity and dominant hydrochemical facies and the left lower quadrant the hydroperiod and degree of dependence on groundwater.

In recent years, international recognition of groundwater-dependent ecosystems (GDE) has improved. A review of some of the main characterization methods for GDE from Europe, USA, Australia and Canada is provided. It is not intended to be exhaustive, just illustrative of the wide variety of existing classifications.

Foster and others (2006) establish five types of groundwater-related ecosystems based on two criteria: the geomorphological setting (aquatic, terrestrial, etc.) and the associated groundwater flow mechanism (deep or shallow). These types of GDE are:

1. wetland ecosystems in arid ecosystems;
2. wetland ecosystems in humid regions;
3. aquatic stream-bed ecosystems in humid regions;
4. coastal lagoons ecosystems;
5. terrestrial ecosystems in arid regions.

In Australia, Eamus and Froend (2006) discuss the foundations for the characterization of groundwater-dependent ecosystems. Nevill and others (2010) discuss the connections between three types of groundwater-dependent ecosystems that include:

1. ecosystems dependent on the subsurface expression of groundwater (phreatophytic vegetation);
2. the surface expression of the groundwater-dependent ecosystems where wetlands are found, together with the base river flow and springs);
3. the actual underground ecosystems (caves and aquifers).

In the USA, Clairain (2002) identifies the mechanisms of contribution of water to wetlands, and Springer and Stevens (2009) develop a classification of springs where physical and chemical variables are used to identify 12 spring types including cave, exposure, fountain, geyser, gushette, hanging garden, helocrene, hillslope, hypocrene, limnocrene, mound-form and rheocrene.

In Canada, Warner and Rubec (1997) discuss the groundwater mechanisms that supply wetlands. More recently, Bertrand and others (2012) propose a classification system with a more eco-hydrogeological approach, based on three key processes:

- at the scale of aquifer, identifying the hydro-period and chemical type;
- at the scale of upwelling, identifying the geomorphological characteristics of the wetland;
- the biocenosis associated to ecosystem, identifying the phytosociology, characteristic species and the biogeographical area.

The USA National Wetland Classification is hierarchical, with five levels that describe the components of a wetland, namely: vegetation, substrate composition and texture, water regime, water chemistry and soil. It considers vegetated and non-vegetated habitats (Cowardin and others, 1979; Cowardin and Golet, 1995).

The Australian hydrogeomorphic Wetlands Classification is based on landforms and water regimes with further subdivisions based on areal size, shape, water quality and vegetation features. A binary format for describing wetland habitats is provided (Semeniuk, 1987; Semeniuk and Semeniuk, 1997).

The EUNIS Habitats Classification (2002) (European Nature Information System, http://eunis.eea.eu.int/index.jsp) is the European standard for hierarchical description of natural or semi-natural areas, including wetland habitats, which are identified by their facies and flora. This classification integrates earlier classifications (CORINE Biotopes, European Communities Commission, 1991; Classification of Palearctic Habitats, Council of Europe, 1996) and establishes links with other Classification types (CORINE-Land-Cover typology, Habitats Directive Annex I; Nordic classification system; and other national systems) (European Communities 1991; Council of Europe 1996; Davies and Moss 2002).

The Ramsar Classification System for Wetland Type is a hierarchical listing of wetland habitats loosely based on the USA National Wetland Classification. It has been modified on several occasions since its introduction in 1989 to accommodate further habitats of interest to the Contracting Parties to the Ramsar Convention (Scott and Jones, 1995).

The MedWet Mediterranean Wetland Classification is a hierarchical listing of wetland habitats loosely based on the USA National Wetland Classification with modifications made to reflect the range of wetland habitats around the Mediterranean. The software that accompanies the methodology enables other classifications commonly used in the region to be generated from the database (Hecker and others, 1996).

The South Africa Wetland Classification is an adaptation of the "Cowardin" wetland classification developed in the USA. Its adaptations reflect the functional aspects of wetlands based on geomorphic and hydrologic features; it is hierarchical and able to accommodate all wetland types in the region (Dini and Cowan, 2000).

The Asian Wetlands Inventory and Classification is based on landforms and water regimes. Classification can be derived from the core data fields and augmented with information on vegetation, areal size and water quality (Finlayson and others, 2002a, 2002b).

The Spanish classification is based on wetland basin origin and hydrodynamics (MOPU, 1991; DGOH, 1995). The Andalusian Wetland Plan (PAH, 2004) develops and improves the national classification.

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1.3 ASSESSMENT AND VALUATION OF WETLANDS SERVICES FOR THEIR CONSIDERATION INTO DECISION-MAKING

Antonio Camacho, Daniela Russi, Emilio Custodio and Marisol Manzano

1.3.1 Aim and scope

The aim of this chapter is to provide guidelines for the assessment and valuation of wetlands services to the experts of the MedPartnership countries participating in this project.

1.3.2 What are ecosystem services?

As defined by the Millennium Ecosystem Assessment (2005a), ecosystem services are:

> The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating and supporting services such as regulation of floods, drought, land degradation, and diseases, soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious, and other nonmaterial benefits

These three categories can also be subdivided into other subgroups.

Under the perspective of human well-being, ecosystems can be considered as "natural capital", which provide an interest to humans as ecosystem services. The ecological integrity of ecosystems consists in the maintenance of their functional features and structures, as well as of their capacity to recover from perturbations (ecological resilience). In a healthy ecosystem, ecological processes support its capacity to provide ecosystem services, which are used by humans to increase our well-being. Human activities, however, are the main cause of alterations in ecosystem health, thus affecting the capacity of ecosystems to provide services. These anthropogenic disturbances are the so-called "drivers of change" (Figure 1.3.1).

1.3.3 Wetlands, groundwater and ecosystem services: UNESCO-IHP and MedPartnership evaluation of coastal wetlands services

The global extent of wetlands is estimated to be more than 1.2 million km^2. Coastal wetlands, in common with other coastal ecosystems, are among the most productive yet most highly threatened systems in the world; and many of them depend, totally or partly, on groundwater for their hydrological balance.

Many wetlands can retain water because they overlie low-permeability substrates and therefore they present delayed, little or no interaction with regional groundwater. However, many wetlands are groundwater-fed (Figure 1.3.2) and, while some wetlands may produce limited groundwater recharge, in other cases (such as floodplains overlying sandy soils) recharge of the aquifer mostly occurs during flooding (Millennium Ecosystem Assessment, 2005b; Fan et al., 2013). The direction of water movement between the wetland and the ground may change in the same wetland, depending on season and local hydrological conditions, and also on subtle topographic changes (e.g. Figure 1.3.3).

Wetlands deliver a wide range of ecosystem services that contribute to human well-being. Provisioning services from wetlands are essential for human well-being, whereas regulating and supporting services are critical to sustaining crucial ecosystem functions that offer many benefits to people. Additionally, wetlands have significant cultural – aesthetic, educational and spiritual – values, and provide invaluable opportunities for recreation and tourism (Millennium Ecosystem Assessment, 2005b). The Ramsar Convention has edited a number of fact sheets on Wetland Ecosystem Services that describe the most important services provided by wetlands (Ramsar, 2011). They are available in Arabic, English, French and Spanish and can be used to obtain further explanations of these services.

Even though other subdivisions can be established, for the purposes of the evaluation of the ecosystem services provided by groundwater-related wetlands within the framework of UNESCO IHP MedPartnership, the following groups and subgroups of ecosystem services will be considered here:

- Provisioning services:
  - Food: fish and seafood, including aquaculture, livestock, wild game, plant and algal crops, grains, fruits, fodder and others.
  - Fuel and energy production: peat, fuel wood, tidal and wind power, and others.
  - Freshwater: supply of water for human use in different activities, such as drinking water production, agriculture and industry.
  - Fibres and construction materials: timber, willow.
  - Biochemical: medicines, cosmetics, etc.
  - Genetic pool and biotechnology: genes of interest for biotechnological purposes.
  - Minerals: salt, clay
- Regulating (and supporting) services:
  - Hydrological regimes: physical buffering of floods, sea-level rise and storm effects on coastal protection (e.g. coastal wetlands – such as coastal river floodplains – play an important role in reducing the impacts of floodwaters produced by coastal storm events), drought regulation, groundwater recharge/discharge.
  - Water purification: retention, transformation and removal of pollutants, improvement of water quality.

Figure 1.3.1 Scheme showing the relationship between ecosystems, services, human well-being and the drivers of change. Source: Martín-López et al. (2009).

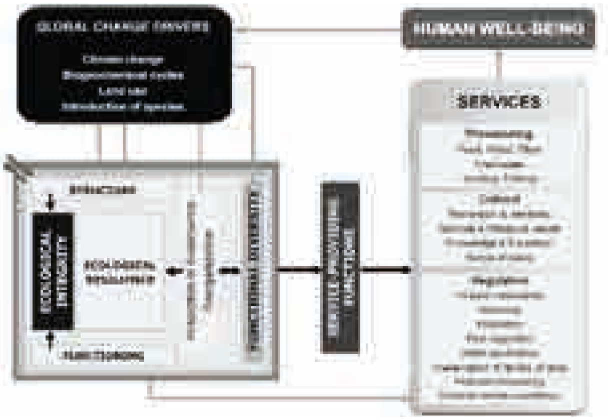


Figure 1.3.2 Main origin of water sources feeding coastal wetlands in the Júcar River Basin (eastern Spain). Source:A. Camacho.

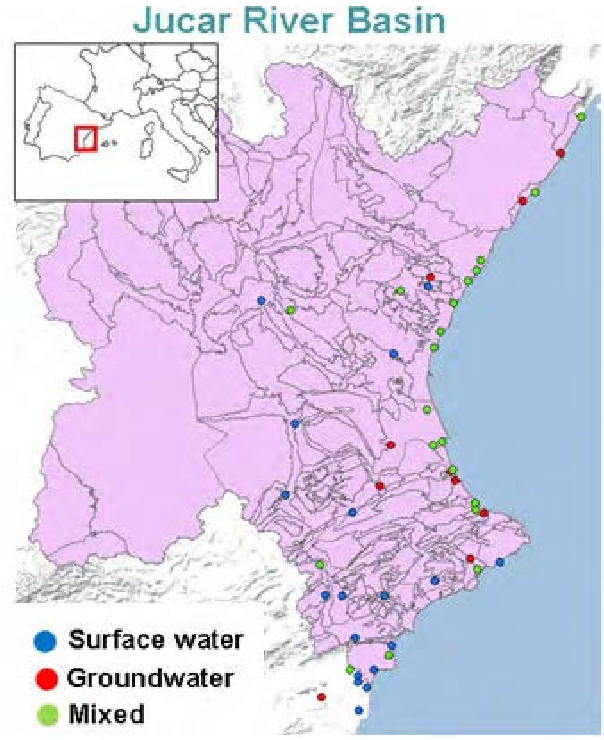
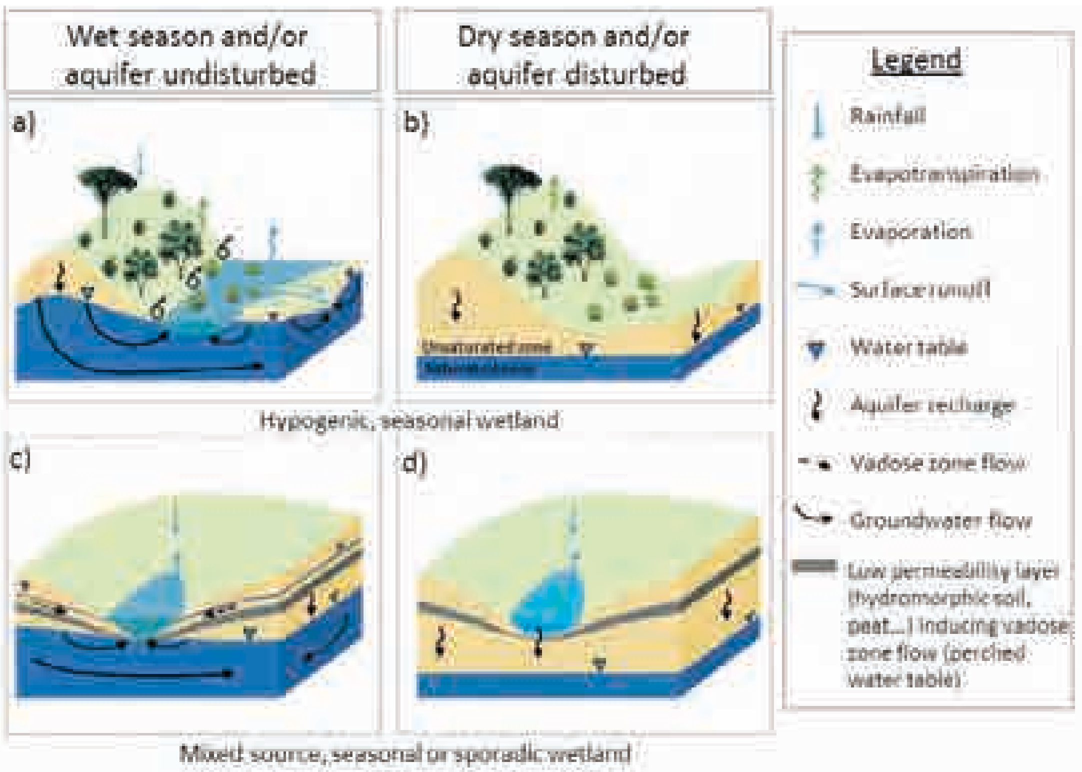


Figure 1.3.3 Illustration of the changing relationships between some wetlands and the aquifer which are common along the Mediterranean coast. a) Dune slack wetland during wet season, or with aquifer under natural flow conditions: the main water source is groundwater discharge from the surrounding aquifer. b) Same wetland during dry season, or with regional water table lowered by groundwater pumping. c) Wetland in small erosive depression and with layers of low-permeability materials underneath, during wet season, or with aquifer under natural flow conditions: main water source is permanent groundwater discharge from a regional aquifer, but also temporal discharge from ephemeral perched water table formed after significant rainfall. d) Same wetland during dry season, or with regional water table lowered by groundwater pumping: the wetland may get water from direct precipitation during heavy summer rainfall, but flooding is temporal and wetland dries because of evapotranspiration and ground infiltration. Source: modified from Manzano and others (2002).



- Morpho-sedimentary regulation: retention and export of soil and sediments
- Biological control: habitat for resident or transient species (e.g. Figure 1.3.4), preservation of ecological interactions (e.g. pollination, trophic linkages) and biological diversity, resistance to species invasions and others
- C sink and global regulation: sequestering and release of carbon
- Biogeochemical cycles: nutrient retention and transformation, accumulation of organic matter, detoxification of pollutants (e.g. reduction of nitrate concentrations by enhanced denitrification in wetland sediments)
- Air quality regulation: oxygen generation, chemical composition of the atmosphere, retention of greenhouse gases
- Local climate regulation: influence on local temperature, precipitation and other meteorological features

• Cultural services:
  - Tourism: knowledge of nature, leisure and recreational activities
  - Educational and scientific knowledge: tools for education and training, source of information for the advancement of science
  - Local knowledge and good practices: maintenance of traditional knowledge allowing sustainable exploitation of natural resources
  - Landscape and aesthetic: relaxation, personal emotions, sense of beauty, appreciation of natural features
  - Cultural identity and sense of belonging: identity by perceiving wetlands as a local heritage
  - Religious and spiritual: source of inspiration, sacredness, seat of spiritual values

In groundwater and mixed-fed wetlands, such as those evaluated at the UNESCO-IHP MedPartnership, groundwater supply is essential for the delivering of all these services, since wetlands functioning and ecosystem features depend on it. Consequently, the ecological integrity and thus the capacity of a particular groundwater-fed wetland to offer ecological services is strongly linked to its dependence of groundwater. Therefore, the ecosystem services that will be evaluated here for groundwater-related coastal wetlands can easily be attributed to the groundwater-feeding character of such wetlands. The relative importance of groundwater in the provision of these services is proportional to the relative contribution of groundwater to the hydrological balance of the wetland.

Evaluation of ecosystem services, and of their status and trends, is essential for the valuation of wetlands, as decision makers at many levels are unaware of the connection between wetland condition and the provision of wetland services and the consequent benefits for people. Preserving wetland integrity and health can result in conserving or even improving the benefits humans obtain from wetlands. "When both the marketed and non-marketed economic benefits of wetlands are included, the total economic value of unconverted wetlands is often greater than that of converted wetlands" (Millennium Ecosystem Assessment, 2005b). However many wetlands around the world have been degraded or destroyed and their capacity for offering ecosystem services diminished. The main drivers of these changes will be addressed in section 1.3.4.

Within the framework of MedPartnership–UNESCO-IHP activity the methodological approach used for the Millennium Assessment will be used to evaluate the status and trends of ecosystem services provided by groundwater-related wetlands and the drivers of change. The above-mentioned groups and subgroups of services will be evaluated for each particular wetland selected for each country report. The result of the evaluation will include the current status of the service, using a code of colours to fill the cell and the future trends under the most probable scenario, using a code of arrows as shown in Figure 1.3.5. This figure is an example of a hypothetical evaluation of a particular wetland.

Figure 1.3.4 Estimated number of species specifically inhabiting wetland ecosystems and number of endangered species within the Mediterranean area. Source: IUCN Red List of Threatened Species database (http://www.iucnredlist.org/).

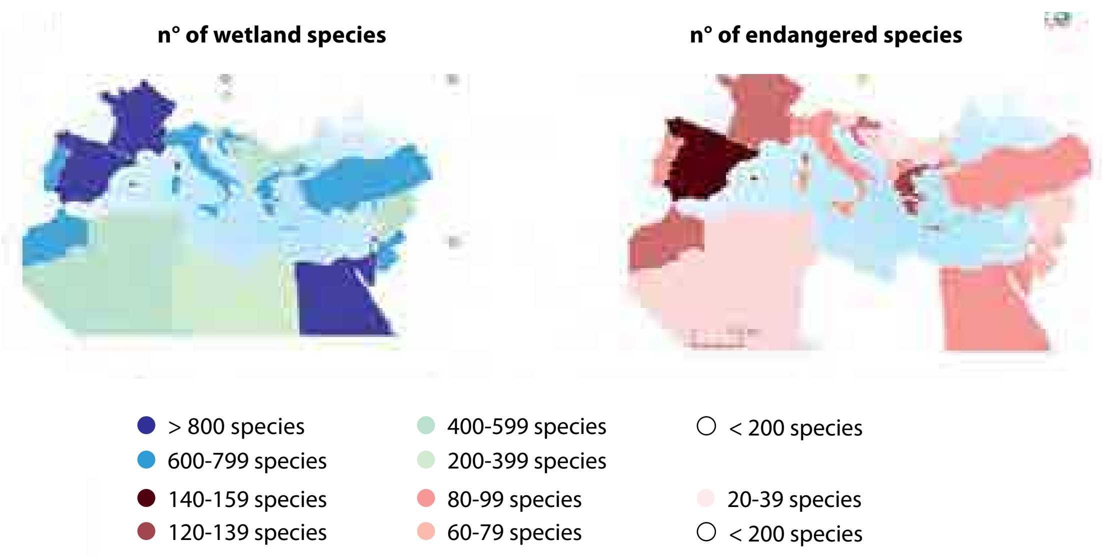
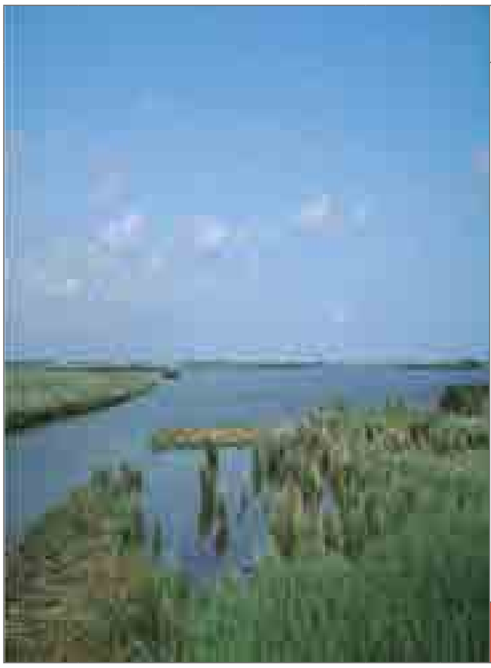


Figure 1.3.5 Example of the evaluation of the current status (colours in cells) and future trends (arrows) of ecosystem services in a hypothetical wetland. Source: A. Camacho.

SERVICE'S STATUS	SERVICE'S TRENDS
High	↑ Very rapidly increasing
Moderate	↗ Moderately increasing
Low	→ Continuing
Non-existent	↘ Moderately decreasing
Unknown	↓ Very rapidly decreasing

Inventory number	Names of wetland, Country	Type	PROVISIONING														
			Natural production of food						Artificial production of food								
			Cropping	Livestock	Fishing	Fruits collection	Huning	Other	Aquaculture	Agriculture	Other	Supply of good quality water	Water supply for diferent uses	Production of biological source materials	Production of mineral source materials	Genetic pool and biotechnology	Energy production
1	Hypothetic wetland, hypothetic country	XXXX	↑	→	→	→	→	→		→		→	→	→	→		



REGULATING								CULTURAL					
Natural species of medicinal interest	Hydrological regimes (floods, drought	Water purification	Morpho-sedimentary regulation	Biological control	C sink and global regulation	Air quality regulation	Local climate regulation	Tourism	Educational and scientific knowledge	Local knowledge and good practices	Landscape and aesthetic	Cultural identity and sense of belonging	Religious and spiritual
→	↘	→	→	→		→	↗	↗	↗	↗	→	→	

1.3.4 Drivers of change

The so-called drivers of change are the causes of shifts in the ecological status of the ecosystems and their capacity for producing services. Many ecosystems around the world are now being degraded and thus their capacity for sustaining human well-being through ecosystem services is reduced. The degradation and loss of wetlands is more rapid than that of other ecosystems. Similarly, the status of both freshwater and coastal wetland species is deteriorating faster than the status of species in other ecosystems. Direct and indirect drivers of this degradation are mostly associated with human activities. Direct drivers directly affect the ecosystem concerned, and in the case of wetlands these mainly include infrastructure development, land conversion, water withdrawal, eutrophication, pollution, overharvesting and overexploitation, and the introduction of invasive alien species (Millennium Ecosystem Assessment, 2005b). Indirect drivers are those that, from a wider extension, affect ecosystems through their consequences, such as population growth and increasing economic development (Box 1.3.2).

Box 1.3.2 Some considerations given by the Millennium Ecosystem Assessment (2005b) on the drivers of changes affecting coastal wetlands

The primary direct driver of the loss and degradation of coastal wetlands has been conversion to other land uses.

Other direct drivers affecting coastal wetlands include diversion of freshwater flows, nitrogen loading, overharvesting, siltation, changes in water temperature and species invasions.

The primary indirect drivers of change have been the growth of human populations in coastal areas, coupled with growing economic activity. Nearly half of the world's major cities are located within 50 km of the coast, and coastal population densities are 2.6 times larger than those of inland areas. This population pressure leads to conversion of coastal wetlands as a result of urban and suburban expansion and increasing agricultural demand. Given the extensive changes in land use and cover that have occurred in many coastal areas, it is unlikely that many of the observed changes in habitat and species loss will be readily reversed.

Global climate change is expected to exacerbate the loss and degradation of many wetlands, and the loss or decline of their species, and to increase the incidence of vector-borne and waterborne diseases in many regions.

The projected continued loss and degradation of wetlands will reduce the capacity of wetlands to mitigate impacts and result in further reductions in human well-being.

As an example, in the Millennium Ecosystem Assessment performed in Spain (www.ecomilenio.es) the assessment process showed that two thirds (15 of 22) of the ecosystem services provided by wetlands that were evaluated were degraded or being used unsustainably. Most affected were regulating services, mainly water, climate and soil regulation, which are also the least visible to society, along with some other traditional provisioning services such as food production, supply of water and biotics, or gene pool protection. Conversely, most cultural services were increasing, mainly those demanded by urban populations as recreational activities (e.g. bird watching), or scientific knowledge.

Wetlands are very sensitive to the effects of direct drivers such as changes in traditional land uses. The change from traditional agriculture to fully mechanized development has caused high rates of erosion, circulation of large volumes of sediment, and increased pollution by pesticides, fertilizers, etc. Other major drivers of changes were unbalanced biogeochemical cycles and, with a horizon in the short/medium term, those related to climate change (Borja and others, 2010). Despite significant legislation in recent decades at all levels (continental, national, regional and local) and a specific international convention (Ramsar), the process of alteration in wetlands has not stopped. It is critical that an integrated management strategy is devised for wetland basins, especially for those dependent on groundwater for their hydrological regimes (Borja and others, 2010). To evaluate the drivers of change in groundwater-related wetlands within the framework of UNESCO-IHP MedPartnership, the following categories and subgroups will be used:

- Resource exploitation (refers to the degree of sustainability. This is the maintenance (or not) of the ecological integrity of the wetland as a result of this exploitation)
  - Water abstraction (from the wetland, from tributaries, from groundwater next to the wetland, from groundwater in the basin)
  - Biological exploitation (Crops, forest, fishing, others)
  - Mineral exploitation (fuel, salts, rocks, others)

- Changes in land use (altering the capacity to maintain ecological health or causing ecosystem loss)
  - Deforestation
  - Reforestation
  - Forest management
  - Replacement of species
  - Extensive agriculture
  - Extensive cattle raising
  - Urbanization
  - Roads
  - Others

- Modification of the hydrological cycle (causing hydrological alterations compared to the natural regime in terms of amount of water)
  - Drainage
  - Input of excess irrigation water
  - Storage usage
  - Artificial recharge
  - Input of urban wastewater
  - Others

- Pollution (causing changes in the physical, chemical and/or biological quality of wetland water, sediments and/or biota)
  - Agricultural diffuse pollution
  - Atmospheric diffuse pollution
  - Urban/industrial point source pollution
  - Alteration of biological community structure and ecosystem functioning (causing changes in the provision of any kind of ecosystem services)
  - Invasive exotic species

- Native species extinction
  - Alteration of biogeochemical cycles
  - Fragmentation

- Effects associated with changes (occurrence of these effects resulting from the existence of other drivers)
  - Changes in chemical water quality
  - Changes in biological water quality
  - Oxidation (by lowering the water table)
  - Increased erosion
  - Soil destruction

- Global and climate changes (changes in patterns)
  - Rainfall
  - Temperature
  - Sea level rise.

As for the evaluation of ecosystem services, a code based on colours and arrows will be used, with colours referring to the effects (impact) of changes promoted by a particular driver on wetland ecological integrity and arrows showing a prognosis of the future impact of this driver of change in the most probable future scenario, as in Figure 1.3.6. This figure shows an example of a hypothetical evaluation of a model wetland.

Figure 1.3.6 Example of the evaluation of the effects (impacts, colours in cells) and predicted trends (arrows) in these effects of the main drivers of changes affecting a hypothetical wetland. Source: A. Camacho.

DRIVER'S IMPACT		DRIVER'S TRENDS	
(red)	High	↑	Very rapidly increasing
(yellow)	Moderate	↗	Moderately increasing
(green)	Low	→	Continuing
	Non-existent	↘	Moderately decreasing
(grey)	Unknown	↓	Very rapidly decreasing

Inventory number	Names of wetland, Country	Type	RESOURCE EXPLOITATION														Changes in land use									
			Water abstraction				Biological exploitation					Mineral exploitation														
			From wetland	From tributaries	Groundwater next to the wetland	Groundwater basin	Crops	Forest	Cattle raising	Fishing	Others	Fuel	Satts	Coils	Rocks	Others	Deforestation	Reforestation	Forest management	Replacement of species	Extensive agriculture	Extensive cattle raising	Urbanization	Roads	Others
	Hypothetic wetland, hypothetic country		→ Moderate	→ Moderate	↗ High	↗ High		→ Low								→ High				→ Low	↗ High	→ Low	→ High	→ Low	

MODIFICATION HYDROLOGICAL CYCLE						POLLUTION			ALTERATION OF BIOLOGICAL COMMUNITY STRUCTURES AND ECOSYSTEM FUNCTIONNING				EFFECTS ASSOCIATED WITH CHANGES					GLOBAL AND CLIMATE CHANGES		
Drainage	Input of excess irrigation	Storage usage	Artificial recharge	Input of urban wastewater	Others	Agriculture diffuse pollution	Atmospheric diffuse pollution	Urban/industrial point source pollution	Invasive exotic species	Native species extinction	Alteration of biogeochemical cycles	Fragmentation	Chemical water quality	Biological water quality	Oxidation by lowering water table	Increased erosion	Soil destruction	Rainfall	Temperature	Sea level rise
→ Moderate	↗ High	↗ High		→ Low		↗ High	Unknown	Unknown					↗ High	Unknown	Unknown	Unknown	Unknown	↘ Moderate	↗ Moderate	↗ Moderate

Table 1.3.1 Some examples of linked relationships between ecosystem services affected by different management options in a particular wetland and its basin. Source: A. Camacho.

DECISION	GOAL	WINNERS	ECOSYSTEM SERVICE DECREASE	LOSERS
Wetland drainage for agricultural use	Increasing food- providing service	Farmers, consumers	Regulation services, cultural services	Natural capital, biodiversity, local population
Urban development of the coast	Increase in GDP, jobs, income per capita	Businessmen, local economy	Regulation services, food production, fisheries, control of sea erosion, etc.	Habitat loss, local population, farmers, fishermen
Over-exploitation of aquifers feeding wetlands	Water for irrigation and drinking water production	Farmers, consumers	Regulation services, cultural services	Natural capital, biodiversity, local population

1.3.5 Winners and losers: consequences of management options on delivery of ecosystem services

Any management option directly or indirectly affecting a wetland would also affect its capacity to deliver ecosystem services. This means that minor and major policies adopted at different decision levels are likely to affect them. Thus, the different options should also be considered by addressing the changes in the provision of all types of ecosystem services and elucidating which are the beneficiaries and which are the losers in this trade-off. Some examples of these trade-offs are those between agricultural production and water quality, land use and biodiversity, and the different options for water use in a particular wetland and its basin (Millennium Ecosystem Assessment, 2005b). Table 1.3.1 shows particular examples of these issues.

1.3.6 Sources of information for the evaluation of services and trends

Although each country has its own information systems mostly managed by national governments (which should be the primary sources of information), to evaluate groundwater-related wetlands within the framework of UNESCO-IHP MedPartnership some regional sources are of special interest. The Euro-Mediterranean Information System on know-how in the Water Sector (EMWIS, www.emwis.net), a programme of the Union for the Mediterranean, is probably the most useful pan-Mediterranean source of information for information at this regional level. Other sources, such as the Mediterranean Wetland Observatory (MWO, http://www.medwetlands-obs.org/), can also supply information for evaluating the ecological status of Mediterranean wetlands. Recently, sound scientific papers on subjects including ecology, hydrology, hydrogeology and agronomy have also been found useful in evaluating the status of services and the probable evolution of trends, and for the identification of the drivers of changes acting in a particular wetland area, and their effects.

1.3.7 Monetary valuation of ecosystem services

Three categories of methodologies have been developed by environmental economists to attribute a price to environmental resources that are not exchanged in the market (see Pearce and Turner, 1990; White and others, 2011; Pascual and others, 2010):

1. Methodologies based on costs, which use market prices to indirectly estimate the monetary value of ecosystem services. The most common are:
   - methodologies based on the avoided costs, e.g. the economic damage from storms avoided by managing coastal wetlands in a sustainable way;
   - methodologies based on the replacement costs, such as the cost of mechanical purification of water, which is needed to replace natural water purification provided by healthy ecosystems;
   - methodologies based on the restoration costs, which calculate the cost of restoring a degraded ecosystem.

2. Methodologies based on revealed preferences to estimate values based on the preferences of individuals, as shown by their behaviour:
   - the Travel Cost Method, which can be used to estimate the value of a protected area through the amount of time and money people spend in order to visit it;
   - the Hedonic Pricing Method, which uses the changes in the market value of a good that is directly related to the ecosystem services to be valued. For example, differences in property prices can be used as indicators of the cultural ecosystem services provided by a landscape.

3. Methodologies based on stated preferences, such as contingent valuation, which are based on the preferences directly stated by people through surveys. When investigating relevant stakeholders, they examine their:
   - willingness to pay for improved environmental conditions
   - willingness to accept compensation for a reduction in environmental quality.

Also, since monetary valuation studies are time- and resource-intensive, in many cases monetary values already calculated elsewhere for similar ecosystems are used. This procedure is called "value" (or "benefit") transfer and needs to be carried out very cautiously because the provision of ecosystem services is often location-specific.

In general, if different methodologies are used for monetary valuation (such as has been done in the UK National Ecosystem Assessment[2]), the outcome values of different ecosystem services should – arguably – not be aggregated, as they are not fully comparable. On the other hand, if only one methodology is used, many key ecosystem services may be left out of the analysis because some ecosystem services are more easily assessed with one specific category of methodologies (e.g. cultural ecosystem services are generally valued using methodologies based on subjective preferences, whereas regulating ecosystem services tend to be valued using methodologies based on costs (see Brouwer and others, 2013).

It is important to stress that monetary valuation can only reflect part of the values embedded in the ecosystem services (Martínez-Alier and others, 1997) and should be used to complement the biophysical indicators rather than to replace them. In addition, it should not be forgotten that monetary valuation intrinsically entails considerable methodological difficulties and data gaps, due to the complexity of the ecosystems' functions and their links to human welfare. Finally, the results of monetary valuation based on subjective perceptions (i.e. those using stated or revealed preferences) should be designed carefully and viewed with caution because people are not always fully aware of the benefits they obtain from ecosystems.

Monetary valuation is criticized by some categories of experts and stakeholders as leading to commoditisation of nature (e.g. see McCauley, 2006). Also, monetary valuation is anthropocentric in nature, and ignores the ecosystems that do not provide direct benefits to people and the economy – such as the concept of ecosystem services, and intangible values – which may be socially relevant.

However, monetary valuation can be a useful policy tool to promote conservation in the eye of the categories of stakeholders who are not interested in environmental protection per se. It can have an educational role by making visible ecosystem services that in too many instances are not given enough importance because they are provided by nature for free. In certain circumstances, therefore, it can play a role in counterbalancing the multiple pressures leading to environmental degradation, which are generally economic in nature. Even though monetary evaluation will not be performed within the framework of UNESCO-IHP MedPartnership, this paragraph can serve to illustrate the possibilities of such economic valuation.

2 http://uknea.unep-wcmc.org/

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1.4 POLICY OBJECTIVES AND REGULATION REQUIREMENTS FOR THE MEDITERRANEAN COUNTRIES: REGIONAL AND INTERNATIONAL REQUIREMENTS FOR COASTAL WETLANDS (AVAILABLE INSTRUMENTS)

Raya Marina Stephan, Marko Prem, Dave Pritchard, Gareth Farr, Mark Whiteman and Antonio Camacho

1.4.1 Aim and scope

The aim of this subsection is to examine the requirements under the provisions of the regional instruments in the Mediterranean and under international instruments dealing with wetlands. A summary of key policy objectives and regulations from these instruments is provided and their application to coastal wetlands dependent on groundwater in the countries participating to the MedPartnership project is considered.

The countries of the Mediterranean basin have adopted the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean, or Barcelona Convention. The Barcelona Convention applies to the coastal areas as defined by each Party. Under the Barcelona Convention, the Protocol on Integrated Coastal Zone Management (ICZM) is a specific instrument covering the management of coastal zones. Since the wetlands under consideration in this Report are part of the coastal zone they fall, therefore, under the scope of the ICZM Protocol.

At the global level the Ramsar Convention is an international instrument completely devoted to wetlands. Other instruments such as the EU Water Framework Directive (WFD), the Groundwater Directive (GWD) and the Habitats Directive are also of relevance, even if non-binding. The south-east European countries have adopted all these Directives in their national legislations. The influence of the EU WFD is important in the Mediterranean basin, given the geographic proximity, the EU Med initiative and other neighbourhood policies.

Other instruments, such as the Protocol concerning Specially Protected Areas and Biological diversity in the Mediterranean (SPA-BIO) under the Barcelona Convention, the Convention on Biological Diversity, the Convention on the Protection and Use of Transboundary Watercourses and International Lakes, and the EU Nature Directives, will be also mentioned.

1.4.2 ICZM Protocol

Although the ICZM Protocol for the Mediterranean in the framework of the Barcelona Convention is not solely related to the management of water resources, it still provides a solid legal frame for the sustainable use of aquifers and groundwater. Signed in Madrid on 21 January 2008, the ICZM Protocol entered into force on 24 March 2011. Its transposition to national legislation and implementation is a major challenge in Mediterranean countries at present. Nine of the twenty-two Contracting Parties to the Barcelona Convention have already ratified the Protocol, including the EU. On the occasion of the Conference of the Parties 17 (Paris, 8-10 February 2012), the Action Plan for the implementation of the Protocol 2012-2019 was adopted; this sorted out the priorities for the Parties. These priorities are structured around three objectives:

- effective implementation of the Protocol at regional, national and local levels;
- strengthening the capacities of contracting parties (CPs) to implement the Protocol and use ICZM policies, instruments, tools and processes in an effective manner;
- promotion of the Protocol and its implementation within the region and globally by developing synergies with other conventions and agreements.

The Parties are convinced that this Protocol represents a crucial milestone for the Mediterranean region. It will allow the countries to better manage their coastal zones, as well as to deal with the emerging coastal environmental and development challenges.

The ICZM Protocol refers to aquifers and water resources in general in several articles. It is important to mention the definition of the coastal zone in article 2, where it is stated that coastal zone:

> means the geomorphologic area either side of the seashore in which the interaction between the marine and land parts occurs in the form of complex ecological and resource systems made up of biotic and abiotic components coexisting and interacting with human communities and relevant socioeconomic activities.

Also, according to the same article 2, integrated coastal zone management:

> means a dynamic process for the sustainable management and use of coastal zones, taking into account at the same time the fragility of coastal ecosystems and landscapes, the diversity of activities and uses, their interactions, the maritime orientation of certain activities and uses and their impact on both the marine and land parts.

A more specific reference to water resources is included in article 5 Objectives of ICZM in paragraph (c) where it is required to "ensure the sustainable use of natural resources, particularly with regard to water use". The objectives specified in article 5 provide guidance for the management of coastal areas. Many other articles refer to them, such as article 9, which regulates economic activities. A specific mention of coastal aquifers is made in article 9§2 (e) concerning the utilization of natural resources (sub-paragraph (iii)). Parties are required:

> to monitor coastal aquifers and dynamic areas of contact or interface between fresh and salt water, which may be adversely affected by the extraction of underground water or by discharges into the natural environment.

Wetlands are specifically mentioned in article 10§1. The Parties are required to create protected areas with a view to preventing the disappearance of wetlands. They are also required to:

- take into account the environmental, economic and social function of wetlands in national coastal strategies, coastal plans and programmes, and when issuing authorizations;
- take the necessary measures to regulate or, if necessary, prohibit activities that may have adverse effects on wetlands;
- undertake, to the extent possible, the restoration of degraded coastal wetlands with a view to reactivating their positive role in coastal environmental processes.

Water resources, including groundwater, have to be considered equally with other environmental and development issues when preparing various instruments for ICZM, such as those related to monitoring, environmental assessments, land and economic instruments, but particularly within the Mediterranean Strategy for ICZM (article 17) and in National Coastal Strategies, Plans and Programmes (article 18). The Parties shall, therefore, define a common regional framework for ICZM in the Mediterranean to be implemented by means of appropriate regional action plans and other operational instruments, as well as through their national strategies. When coastal aquifers are transboundary, the Parties are requested to cooperate under article 28, which regulates transboundary cooperation when preparing "their national coastal strategies, plans and programmes related to contiguous coastal zones".

The ICZM Protocol provides a good legal framework for regulating water resources, including the aquifers within the coastal zone and giving an important level of guarantee for the preservation and sustainable use of aquifers.

1.4.3 Experience of the EU Water Framework Directive (WFD) and Habitats Directive

A short overview of the application of the WFD (2000/60/EC) and the GWD (2006/118/EC) to groundwater-dependent wetlands in the UK is provided, as an example of how these two instruments can be useful in other regions of the world. For simplicity, in this chapter both instruments will be referred to as the WFD. Additionally, a short overview of the development of the WFD in Spain for lakes and wetlands is also given. This includes the links established between the WFD and the Habitats Directive with respect to the Habitats of Community Importance (HCI) of group 31 (standing waters) included in Annex 1 of the Habitats Directive, since Natura 2000 sites – and specifically their wetland ecosystems – are included as protected areas in article 6 and Annex IV of the WFD. Sharing knowledge and experience of the WFD in the UK and European countries from the Mediterranean region can help support future WFD work undertaken by the MedPartnership.

1.4.3.1 Objectives of the Water Framework Directive (WFD)

The WFD supports the management of water on a river basin scale and includes qualitative, quantitative and ecological assessments. With respect to groundwater, its main aim is to prevent and limit groundwater pollution and, more widely, to improve and maintain the status of controlled waters within EU Member States. This is done by first identifying baselines and trends and then by acting to reduce or reverse unfavourable trends (e.g. increasing nitrate levels or falling groundwater levels). This could mean reducing impacts on designated wetlands from a groundwater abstraction or improving land management to reduce nutrients entering surface waters, groundwaters or associated wetland ecosystems. With respect to protected areas, such as those included in the Natura 2000 European Network, the WFD establishes that the goals marked by the specific figure of protection, in this case the achievement of the "favourable conservation status" requested by the Habitats Directive, must be accomplished.

The Water Framework Directive (WFD) UK Technical Advisory Groups

The UK comprises England, Wales, Scotland and Northern Ireland, and much like the MedPartnership collaboration between different regions and countries, it is vital to achieve shared goals for the WFD. The Water Framework Directive UK Technical Advisory Group, or WFD UKTAG, (http://www.wfduk.org/) is a partnership of the UK environment and conservation agencies and invited technical specialists. Its aim is to provide technical advice and guidance on the implementation and application of the WFD. The WFD UKTAG consists of nine separate groups. The "Wetlands Task Team" and "Groundwater Task Team" have both provided support and guidance on the application of the WFD within the UK (e.g. UKTAG, 2004, 2007a, 2007b, 2011, 2012a, 2012b). The WFD UKTAGs provide a useful platform for knowledge sharing between countries and between various organizations with the objective of having a consistent approach to the implementation of the WFD.

The Water Framework Directive (WFD) classification process and the "wetlands test"

Groundwater bodies were delineated for the UK and a series of six tests applied to each (UKTAG, 2007b). One of these, the 'Groundwater Dependent Terrestrial Ecosystems Test' uses a combination of factors, including groundwater quantitative and resources assessments to assess significant damage (e.g. Whiteman and others, 2010). The classification process, first undertaken in 2008, resulted in the failure of several groundwater bodies due to pressures at a groundwater-dependent ecosystem. Once poor status has been assigned to a groundwater body the WFD requires that an investigation is undertaken to find out the causes and to propose ways to reverse any negative trends. This may include assessment of groundwater abstractions near a wetland or land management actions to reduce nutrient deposition.

'Poor Status' triggers investigations and data collection at wetlands

During the first classification process (2008) there was limited information (e.g. site-specific water quality or water levels) for many of the wetlands. When a wetland was classified as 'at risk' or where a wetland had resulted in a 'poor status' classification for the associated groundwater body, investigations were undertaken (e.g. SWS, 2010) and ecohydrological guidelines (e.g. Davey and others, 2010) produced. Water quality and level data were collected as a direct result of the first classification process and resulting investigations. Conceptual models of sites were improved by undertaking subsurface investigation, such as drilling and by improving ecological mapping of designated sites. Using the chemical data the UKTAG was able to assign nitrate 'threshold values' to a range of wetland types (UKTAG, 2012b) and these values were used to improve the second classification process in 2012.

Lessons from the UK experience so far

Although the UK has experienced two cycles of WFD classification, the available data for many individual wetlands are limited (although improving). Knowledge gaps should be filled by the collection and sharing of data between various organizations. The need for long-term data is evident. Without a minimum of 5 years' data, the trends, weather patterns and effects of a changing climate – or the benefits of land management actions aimed to reverse trends – cannot be measured properly.

Wetlands in the WFD and the Habitats Directive: the case of Spain

Since wetlands are water-dependent ecosystems, water management is closely linked to the good ecological status of these ecosystems. Because the WFD is the legal framework for water management in the EU, conservation of the ecological health of aquatic ecosystems is strongly dependent on development of the WFD and on consequent water management. This was recognized by the WFD when the so-called "protected areas" were included in this framework.

Although most wetlands in Spain are small, especially those in the inner parts of the Iberian Peninsula, they are quite important ecologically. For this reason, the Spanish Government did not use the general size criterion of >0.5 km2 when declaring lakes and wetlands to be water bodies, but stated that sites of lower sizes could be defined to be such when their ecologic relevance is high (CEDEX, 2008). Spain holds most of the HCI wetland habitat types included in Annex 1 of the Habitats Directive, and accounts for almost 25% of the total surface of the Natura 2000 Network of the EU.

To make possible and search for synergisms in the application of both Directives to lake and wetland ecosystems, a compatible classification system was developed for such ecosystems (CEDEX, 2008; Camacho and others, 2009), and a compatible system for evaluation of the goals based on biological and abiotic variables was also developed (Camacho and others, 2009; CEDEX 2010). These supply a powerful tool to managers of either water resources (guided by the WFD) or biodiversity resources (guided by the Habitats Directive) enabling them to speak a "common language"; they also allow the joint addressing of the conservation problems of wetlands, which compromise their capacity to provide ecological services such as good-quality water or regulation of the hydrological cycle. This is especially important when administrative competences are unshared, as in Spain, where most responsibility for biodiversity conservation falls on regional governments, whereas responsibility for water management is mainly executed by the national government in a large part of the territory. Two lessons to be learned from previous Spanish experience are:

- that links between the different levels of the administration holding competences related to either nature conservation or water management must be strengthened;

- that development of tools providing for cooperative collaboration of members of the different authorities (such as those described above) must be enhanced, to avoid excessive compartmentalization of competences, resulting in inefficient management and so to wetland degradation.

1.4.4 Ramsar Convention

The Convention on Wetlands, known as the "Ramsar Convention" after the town in Iran where it was agreed in 1971, was the first of the modern conservation treaties, and the only global treaty to focus on a particular ecosystem. It was innovative in aiming to combine conservation with sustainable use of natural resources.

Under the Convention, the term "Wetlands" covers a broader range of systems than is commonly understood, and includes groundwaters, coral reefs, rivers, peat forests, temporary wetlands and human-made systems

At the beginning of the Ramsar process there was an emphasis on waterbirds, but the text has also always referred to the ecological functions of wetlands as regulators of water regimes. Now the Ramsar Convention deals with everything from groundwater modelling to sustainable fisheries, the wetland-related aspects of climate change, poverty reduction and many other issues.

The CPs (168 in 2014) accept three main obligations:
- international cooperation, which includes various transboundary and regional arrangements;
- conservation of sites designated for the Ramsar List;
- the wise (or sustainable) use of all wetlands, which includes integrated management of water catchments and the entire hydrological cycle.

"International importance" of a wetland is the agreed standard of relative value according to which sites are admitted to the Ramsar List. CPs must each designate at least one such qualifying site.

"Ecological character" is a separate concept in the Convention which defines the target state and the baseline condition of wetlands, as a basis for setting management objectives and detecting and responding to change. If the ecological character of a listed site changes, or is likely to change, there is a strict obligation to notify the Convention Secretariat, and this can then act as a trigger for consultations and solution-finding measures. De-listing a site or reducing its area is not permitted unless a test of "urgent national interest" is satisfied and adequate compensatory provisions are made.

The requirement to promote the "wise use" of all wetlands also rests on the maintenance of their ecological character, to be achieved through the implementation of ecosystem approaches, in a context of sustainable development.

For all of these obligations, a large body of formal guidance, technical standards and case experience has evolved over the decades, and is contained in conference decisions and other publications available from www.ramsar.org. A forum of 27 countries and specialized organizations collaborate in the Mediterranean Wetlands Initiative (http://medwet.org) to support coordinated implementation in this region.

1.4.5 Other possible instruments

Under the Barcelona Convention, the Protocol concerning Specially Protected Areas (SPA) and Biological diversity (adopted in 1995, in force in 1999) applies to terrestrial coastal areas, including wetlands (article 2). Under the Protocol each Party commits to protect, preserve and manage, in a sustainable and environmentally sound way, areas of natural or cultural special value, by the establishment of SPA.

At the EU level, the Birds Directive on the conservation of wild birds (30 November 2009) imposes a responsibility on Member States to take the requisite measures to preserve, maintain or re-establish a sufficient diversity and area of habitats for all species of naturally occurring birds in the wild state in the territory of the EU. The aim of the Habitats Directive on the conservation of natural habitats and of wild fauna and flora (21 May 1992) is to contribute towards ensuring bio-diversity through the conservation of natural habitats and of wild fauna and flora in the European territory of the Member States to which the Treaty applies. Measures taken pursuant to this Directive shall be designed to maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest, taking into account economic, social and cultural requirements, and regional and local characteristics. These two Directives apply to wetlands when they form the natural habitats of wild fauna (including birds) and flora.

At the global scale, the Convention on Biological Diversity (CBD) is a comprehensive, binding agreement covering the use and conservation of biodiversity, which was adopted in 1992 and entered into force in 1993. As of 2014 there were 193 Parties to the Convention (192 countries and the EU). The CBD requires countries to develop and implement strategies for sustainable use and protection of biodiversity and provides a forum for continuing international dialogue on biodiversity-related issues through the annual Conferences of the Parties (COPs). Wetlands are often home to a very rich biodiversity (Myers, 2000; Mittermeier et al., 2005) and therefore fall under the provisions of the CBD.

In the case of transboundary waters, the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (adopted in 1992, in force in 1996 and amended in 2013) applies to all transboundary waters (surface and groundwater) and mentions ecosystems, which there is a general obligation to protect. Originally this Convention was regional and limited to the countries of the UN Economic Commission for Europe. In 2013 it was opened to all UN Member States. "The Parties to the Convention shall take all appropriate measures to ensure conservation and, where necessary, restoration of ecosystems" (articles 2 § 2d). The UN Convention on the Law of Non-navigational Uses of International Watercourses (adopted in 1997 and not yet in force) imposes the obligation to protect and preserve ecosystems within an international watercourse (a watercourse covers both surface and groundwater when they are related and share the same terminus). The same obligation is included in the draft articles on the Law of Transboundary Aquifers (annexed to UN General Assembly Resolutions 63/124 and 68/118). Therefore, under these instruments applicable to transboundary waters, the protection of ecosystems (including wetlands) is an important requirement.

1.4.6 Conclusion

The available legal framework for the management of coastal wetlands dependent on groundwater in the countries of the MedPartnership project is quite wide and comprehensive. It includes very specific instruments for the Mediterranean region, such as the ICZM Protocol or the SPA-BIO Protocol, and specific instruments for wetlands such as the Ramsar Convention. Under the ICZM Protocol, coastal wetlands are recognized as a component of the coastal zone, as well as the aquifers which sustain them, and have to be included in national strategies prepared and adopted by the Parties. Other instruments related to water, such as the EU WFD and the GWD, also provide a detailed framework for wetlands and their sustainable management. As shown in the example of the UK, the WFD has driven assessment and data collection at many groundwater-dependent wetlands, encouraging both ecologists and hydrogeologists to work together to achieve shared goals.

Initially, wetland investigations in the UK focused on permitted regulatory activities including water abstractions (groundwater quantity) and point source pollution impacts. This work was directly relevant to the achievement of the Protected Area objectives of the WFD through implementation of the EU Habitats Directive. More recently, some further wetland investigations have been triggered by the groundwater status tests for WFD, especially the "dependent terrestrial ecosystem" test or "wetland" test. These have been mainly focused on groundwater quality/chemical status (e.g. diffuse groundwater pollution issues).

In many cases, there have also been other reasons for the failure of a groundwater body, such as failure of the general chemical test or the groundwater balance test. Currently, economic appraisal is being used to determine which bundles of measures are most cost-effective in restoring groundwater bodies to good status. Any measures involving wetlands will be ranked against all the other required measures in the river basin plans.

The UKTAG and the "Wetlands Task Team" are similar to aspects of the MedPartnership in that they bring together various organizations and countries to support the implementation of the WFD. Working in this way is beneficial to achieving shared goals and should continue to be supported. This can even be improved when both the WFD and the Habitats Directive are simultaneously approached in the case of wetlands, as shown by the case of Spain. Under the Ramsar Convention, any negative change or deterioration in the ecological character of a listed site creates the obligation to consult between the Party and the Secretariat, with the objective of finding solutions. The Parties have a duty to manage their sites properly in order to avoid any loss or deterioration and at the same time they have access to assistance to reverse the situation. Parties also undertake to promote the wise use of wetlands in general. Cooperation mechanisms at regional level include the Mediterranean Wetlands Initiative (MedWet).

Under these various instruments, the requirements for the proper management of coastal wetlands dependent on groundwater seem to be well defined; however, they need to be translated into national legislation and correctly implemented.

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1.5 MAPPING TECHNIQUES USEFUL FOR MEDITERRANEAN GROUNDWATER-RELATED WETLANDS

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1.5.1 Aim and scope

The chapter aims to introduce, in a synthetic way, the available and most commonly used techniques for mapping groundwater-related wetlands.

1.5.2 Terrestrial geophysical techniques

Geophysical methods can be used both on the ground (TerraDat, 2009a, b) or from the air (Beamish and Farr, 2013) to help characterize the near and subsurface geology of a wetland. The information can be used to improve the conceptual understanding of the hydrogeology of a wetland using information gained on the structure, moisture content and contrast between various geological units of contrasting properties. Airborne methods can be useful for landscape-scale characterization or to guide further ground investigations (Beamish and Farr, 2013). However, the resolution is far less (often 200 m spacings) than on-site geophysical investigation methods that will form the major part of this discussion. The following methods were used during a ground investigation at two wetlands (Newbald Becksies and Wybunbury Moss) in the UK (TerraDat, 2009a, b). The geophysics data can be viewed in 2D or incorporated into a 3D visual model, where several different methods can be displayed together:

- Ground-penetrating radar uses reflected electromagnetic signals to image boundaries and structures within the near subsurface (Figure 1.5.1). The data can be collected easily using a portable system that is pushed or pulled along the area of interest. This method is suitable for dune systems and could be of use in many coastal wetlands in the MedPartnership area

- Electrical resistivity tomography can provide 2D cross-sectional profiles through the sub-surface that can inform on the distribution and thicknesses of the geological formations present (Figure 1.5.2). For instance, a chalk or sandstone may produce a high resistivity while a mudstone or clay would produce a low resistivity. Using electrical resistivity tomography it may also be possible to deduce the presence of structures if they produce a contrast with rocks in the surrounding country. Variations in moisture content may also produce anomalous areas of resistivity, and moisture content will modify the signal such that a saturated gravel, for example, will produce a lower resistivity than an unsaturated gravel

- Electromagnetic ground conductivity surveying changes in ground conductivity which might reveal areas of bedrock, and the distribution of areas of disturbed or made ground structures, and areas of anomalous moisture content (Figure 1.5.3). High ground conductivity values can indicate the presence of higher clay content or moisture content, with low conductivity responses indicating clay-poor lithologies such as sands and gravels, limestone or dry materials

- Combination of data from different geophysical techniques is possible (Figure 1.5.4), along with interpretation on the geological and hydrogeological properties of the wetland and surrounding area.

Geophysical methods offer an interesting option for wetland characterization. The benefits include the ability to assess large sites or even landscapes from airborne data sets, in relatively short periods. Geophysical data can also be used to help apply targeted on-site investigations, such as the location and drilling of boreholes. As with all geophysical data, the interpretation may be inconclusive and may also require confirmation by the collection of on-site data.

Figure 1.5.1 Example of ground-penetrating radar at a parabolic. Source: http://www.terradat.co.uk/

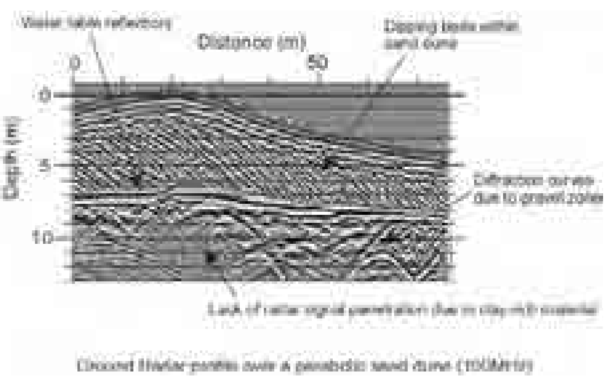


Figure 1.5.2 Example of electrical resistivity tomography from a case study at Wybunbury Moss, a wetland in England, UK. Source: TerraDat (2009b)

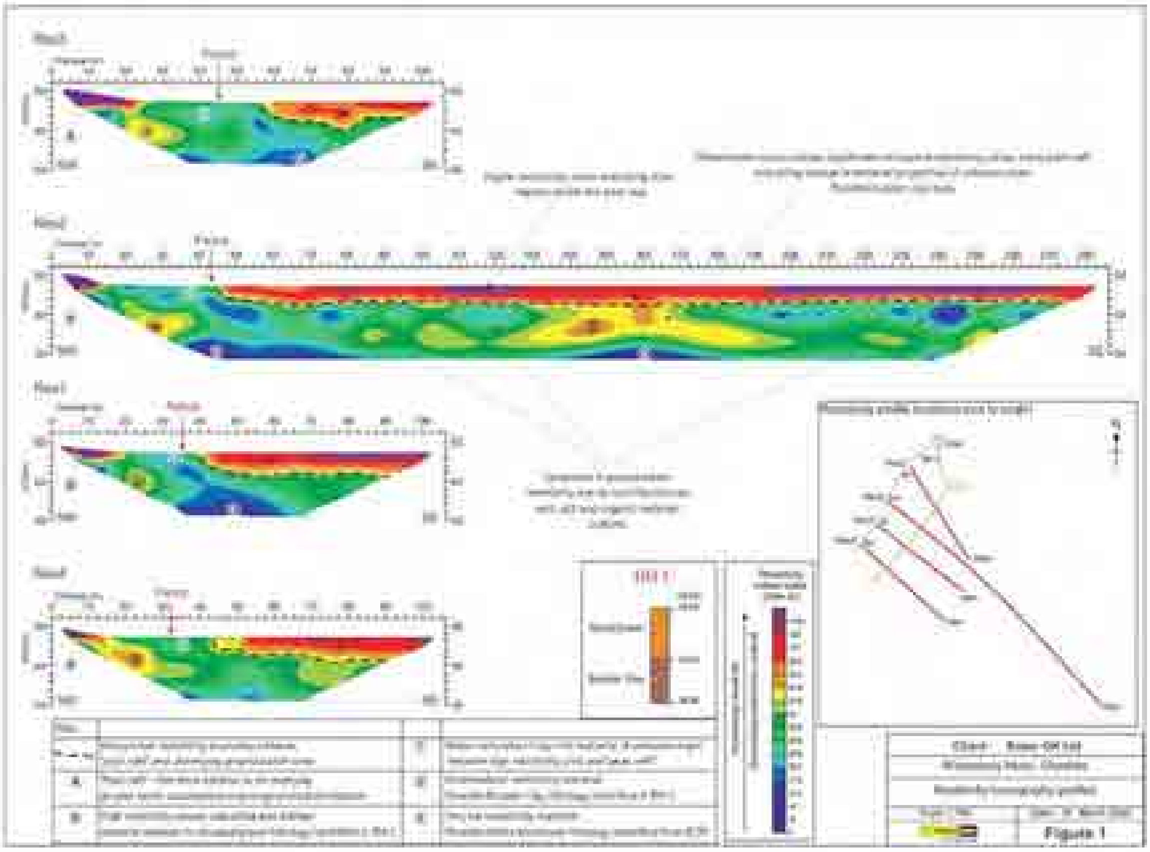


Figure 1.5.3 Example of an electromagnetic ground conductivity survey from a case study at Newbald Becksies, a wetland in England. Source: TterraDat (2009a). SSSI, Site of Special Scientific Interest.

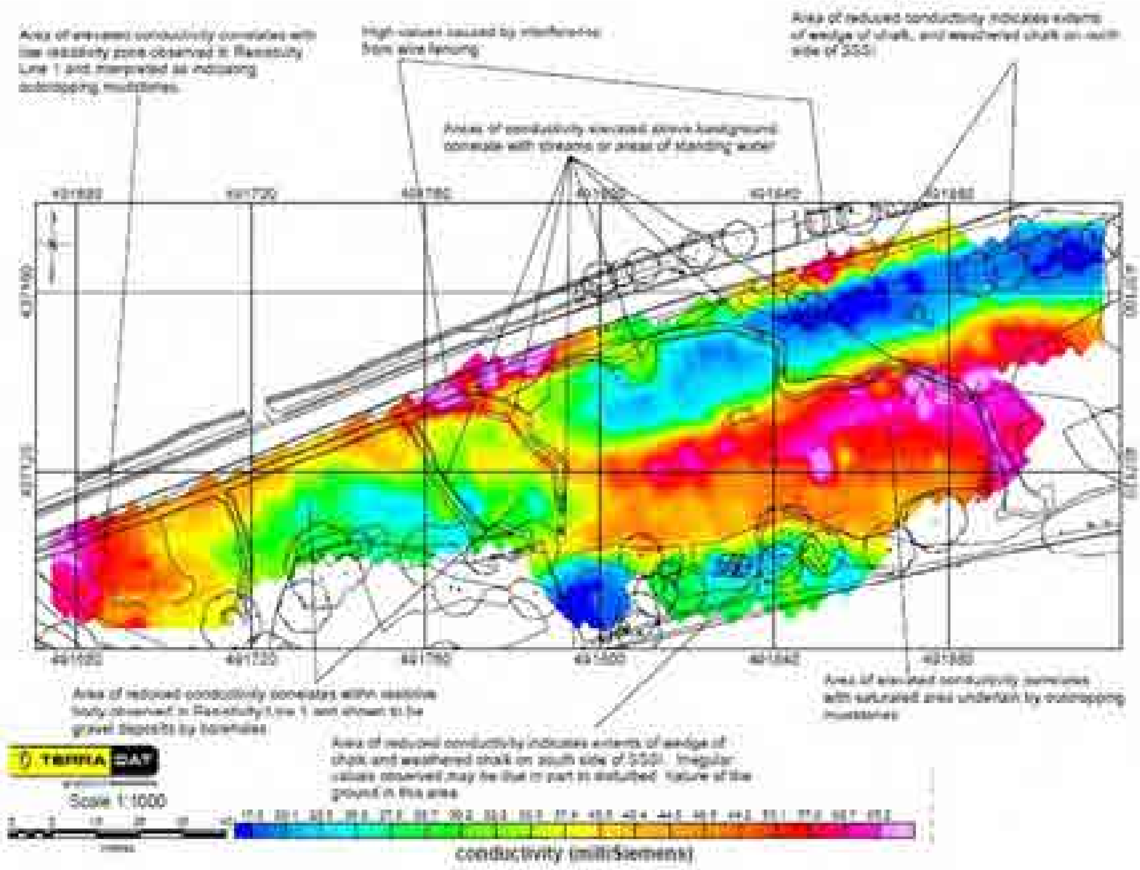
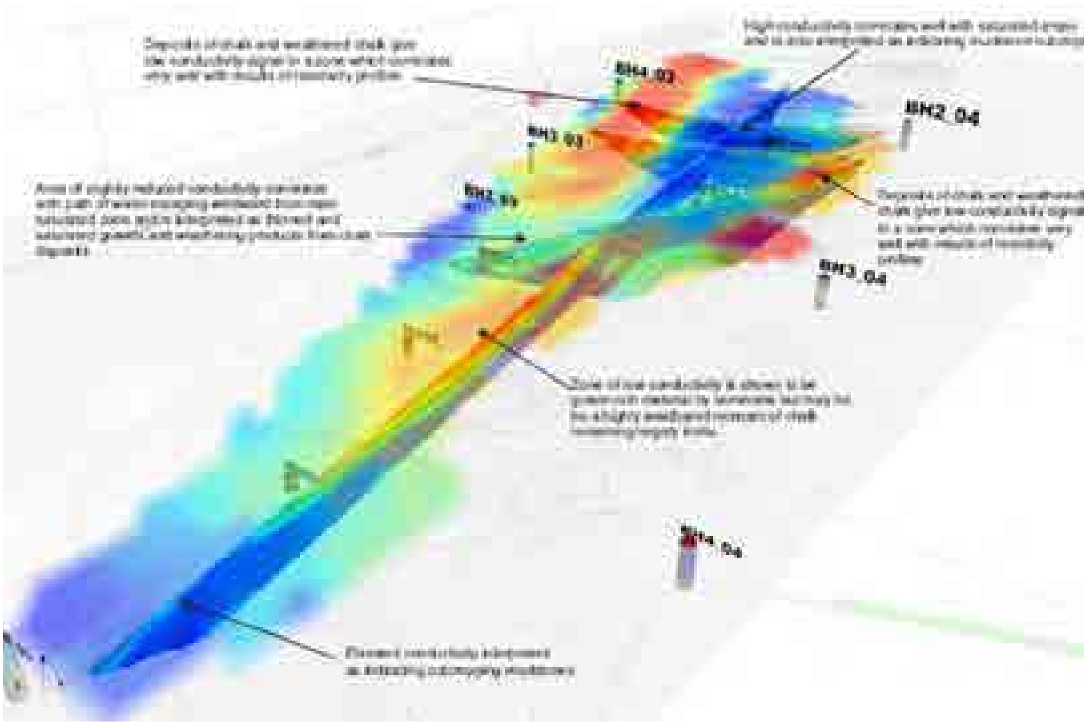


Figure 1.5.4 Example of electromagnetic ground conductivity profiles overlain on top of electrical resistivity tomography, from a case study at Newbald Becksies, a wetland in England, UK. Source: TterraDat (2009a)



1.5.3 Remote sensing

1.5.3.1 Fundamentals of remote sensing

Remote sensing consists of the acquisition and analysis of images of the Earth's surface, acquired by sensors installed on-board airborne vehicles or satellites. Each image pixel corresponds to a ground segment whose size (e.g. 30 m × 30 m) is referred to as the sensor's spatial resolution. For each pixel, the remote sensor takes a series of measurements, typically of electromagnetic radiation, which is related to the physical characteristics of the corresponding ground segment. By using remote sensing techniques, ground data can be retrieved from the pixels' records, and the images can be transformed into thematic or quantitative maps. A sound introduction to environmental remote sensing can be found in Campbell and Wynne (2011).

The benefits of using remote sensing data for the observation and assessment of the environment include:

- Synoptic visualization of large areas
- Observation of difficult-to-access sites
- Consistency with respect to the observation system
- Data acquisition in different bands of the electromagnetic spectrum
- Competitive cost of the data per unit area.

In the case of spaceborne remote sensing, the following benefits can be added to the previous list:

- Periodicity of the observations
- Retrospective information: most satellite sensors systematically acquire images of the Earth which are routinely archived. This information can be retrieved as early as for the 1970s, when the first Earth-observing satellite, Landsat 1, was launched.

With respect to the source of the measured electromagnetic radiation, remote sensing systems can be broadly classified as passive or active.

1.5.3.1.1 Passive sensors

Passive sensors measure, in units of radiance (W/m2/sterad), the electromagnetic energy reflected and emitted by the Earth in different spectral bands or wavelength ranges. Due to their good atmospheric transmission, the wavelengths mostly used for Earth observation are: the visible and near infrared band, used by optical sensors; the thermal infrared band, exploited by thermal sensors; and the microwave band, used by radiometers. A few satellite passive sensors also take gravity measurements.

The amount of radiation reflected by a target depends on the illumination conditions, but the ratio between the incident and reflected power, known as reflectance, is a specific property of the reflecting surface. The curve showing the reflectance of a material as a function of wavelength is known as the material's spectrum or spectral signature. Optical images of the Earth surface can be calibrated to reflectance, so the pixels' spectral signatures can be compared among them, to those in different images, and to existing spectral libraries. Using remote sensing techniques, pixels can be classified and specific magnitudes (e.g. biomass) can be quantified in them, thus yielding a cover map.

Spectral resolution refers to the number and width of the electromagnetic bands measured by a passive instrument. The selection of the remote sensing imagery to be used depends on the spectral and spatial resolutions, as well on the temporal observation frequency required by the application. Mapping of Mediterranean coastal wetlands often demands moderate to high spatial resolutions; that is, pixels no larger than a few tens of metres. Web-based comprehensive catalogues of Earth observation sensors are provided in the References. These catalogues include relevant information to aid the sensor selection, such as spatial resolution, spectral bands, repeat cycle, period in orbit and operating agency.

Airborne sensors can achieve better spatial and spectral resolutions than those provided by satellite sensors, though normally at the expense of a smaller imaged area. The cost of undertaking airborne campaigns has long been prohibitory for many applications. However, in the last few years, this cost has been greatly reduced by mounting lightweight sensors on board unmanned airborne vehicles (known as UAVs or drones), which are becoming usual tools for environmental monitoring and mapping (Colomina and Molina, 2014; Jensen and others, 2011).

1.5.3.1.2 Active sensors

Active sensors emit pulses of electromagnetic radiation and measure the signal backscattered by the target. The active sensors mostly used for wetland mapping are the Synthetic Aperture Radars (SARs) and the Light Detection and Ranging (LIDAR) systems.

LIDAR data are typically used to produce accurate digital terrain and vegetation elevation models. SAR sensors send out pulses of radiation at an angle to the vertical direction, referred to as the incidence angle. The frequencies used by SAR systems correspond to the microwave region of the electromagnetic spectrum, which is subdivided into narrower bands named with letters such as K, X, C, L and P. These systems can image the Earth at any time, since they provide their own source of illumination. Thanks to their relatively long wavelengths, microwaves are capable of penetrating clouds and, in most cases, rainfall. Hence, SAR images can also be acquired under almost any weather conditions.

Most SAR sensors emit and receive microwaves whose electric fields oscillate in a single plain, typically in the vertical (V) or horizontal (H) plains. These waves are referred to as vertically and horizontally polarized, respectively. The differential behaviour of the polarizations is used to characterize the target (Lee and Pottier, 2009).

In natural environments, the radar backscatter is largely controlled by the target's surface roughness, moisture content and vegetation structure (Ulaby and others, 1986). In general, the higher the soil moisture, the brighter the target appears on a SAR image. Backscatter from open water and bare soil areas of similar moisture content depends basically on their surface roughness in relation to the radar wavelength and incidence angle. If the acquisition parameters are fixed, the microwave backscattering increases with the surface roughness. The polarization state of the backscattered signal usually provides information about the vegetation canopy structure. Vertically polarized radiation, for example, interacts to a larger extent with vertically oriented elements such as trunks or stalks, while the cross-polarized signal is often indicative of multiple reflections within the vegetation volume and is related to its biomass.

1.5.3.2 Mapping Mediterranean groundwater-related coastal wetlands with remote sensing tools

Attributes of Mediterranean groundwater-related coastal wetlands to which remote sensing imagery is sensitive include: the presence of surface water, the existence of phreatophytes, and the seasonal variability in water regime, soil moisture and plant phenology.

Clear water is much less reflective than emerged land at the near and middle infrared frequencies. Thus, these bands provide good discrimination capacity between open water and land. However, the flooded areas of coastal wetlands are generally shallow and likely to hold high concentrations of chlorophyll and suspended sediments. Additionally, vegetation might partially cover the inundated zones. These circumstances may significantly increase the open water reflectance in the visible and near infrared bands. For these reasons some authors found simple thresholding of middle infrared bands (e.g. LandsatTM, ETM+ and Landsat 8's band 5) to be the best method for delineating shallow coastal flooded areas (Díaz-Delgado and others, 2010; Lee and others, 2001; Johnston and Barson, 1993).

Smooth open water induces specular reflection of the radar beam and consequently shows low backscatter (i.e. appears dark) on SAR images. However, wind-induced surface roughness can significantly increase the open water backscattering on SAR images acquired at low incidence angles or using small wavelengths relative to the roughness magnitude (Ulaby and others, 1986).

The radar signal is capable of penetrating the vegetation canopy. This capacity, which is larger for small incidence angles and long wavelengths, enables the detection of flooded and wet areas under vegetation cover. When partially flooded, the plant stems induce a double bounce reflection, yielding characteristic high backscattering values on the SAR images (Henderson and Lewis, 2008). Radar data also show sensitivity to the vegetation volume and geometry, which is related to the biomass and plant species (Grings and others, 2005). Nevertheless, the detail mapping of phreatophyte communities normally requires high spatial and spectral resolution data.

Given the dynamic nature of most coastal wetlands, multi-seasonal imagery becomes crucial to monitor the flood and vegetation temporal trends (Martí-Cardona and others, 2010). The inherent temporal variability of these ecosystems makes change detection techniques applicable for mapping their cover types.

Remote sensing gravity measurements have been used to estimate ground water storage changes at a regional scale (Pereira and Pacino, 2012). These changes help predict possible evolution trends in the wetland sites of the corresponding basin, when it is a large one.

1.5.4 Geographic Information Systems

1.5.4.1 Fundamentals of geographic information systems

Geographic Information Systems (GIS) are computer applications designed to store, visualize, overlay, combine and analyse spatial data. Spatial data refers to information that is linked to geographic coordinates which, therefore, can be represented on a map. The spatial information managed by GIS is classified into two basic types: vector and raster data. Vector spatial data are points, lines and polygons. They are used to represent point locations such as mountains, wells or airports; and spatial features with discrete boundaries such as roads by means of lines, or country borders, with polygons. A GIS can store diverse attributes associated to each spatial features, such as area or population of the country polygon, which can typically be accessed in the form of an attribute table and can be graphically represented on a map.

In a raster format, a given surface is subdivided into a regular grid of cells and a single value is stored at each cell. Raster models are useful for representing data that vary continuously over an area, such as the elevation of the terrain (digital terrain model or DTM), the biomass over a forest or the water surface temperature over a lake. Remote sensing images are examples of raster data.

GIS applications are now essential tools for performing spatial analyses and integrate data from different disciplines. Spatial data corresponding to the same geographic area can be overlaid and combined to determine spatial patterns or temporal trends. Of special interest for coastal wetland mapping is to combine remote sensing imagery and derived maps, DTMs, existing hydrogeological or vegetation cartography, the location of springs and water courses, and administrative boundaries.

1.5.4.2 Sources of spatial information

- Worldwide spatial data:
  - http://www.un.org/Depts/Cartographic/english/htmain.htm
  - http://libguides.onu.edu/content.php?pid=154318&sid=1308147
  - http://freegisdata.rtwilson.com/
  - Hydrological data:
  - http://hydrosheds.cr.usgs.gov/dataavail.php
  - http://www.fao.org/geonetwork/srv/en/metadata.show?id=30914
  - http://www.fws.gov/wetlands/Data/mapper.html

- Land cover:
  - http://landcover.usgs.gov/landcoverdata.php

- World DEM:
  - http://gdem.ersdac.jspacesystems.or.jp/
  - Administrative borders:
  - http://www.gadm.org/
  - http://global.mapit.mysociety.org

- Coordinate systems:
  - http://epsg.io/
  - http://spatialreference.org/

- Global climate data:
  - http://www.worldclim.org/
  - http://srtm.csi.cgiar.org/

- Raster and vector data sets:
  - http://earthdata.nasa.gov/gibs
  - http://www.naturalearthdata.com/downloads/

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Ulaby, F.T., R.K. Moore and A.K. Fung (1986). *Microwave Remote Sensing: Active and Passive III. From Theory to Applications* Norwood, Massachusetts, USA: Artech House.

- Web-based catalogues of Earth observation sensors:
  - http://www.itc.nl/research/products/sensordb/searchsat.aspx
  - http://gdsc.nlr.nl/FlexCatalog/catalog.html

Part 2.

Existing knowledge of groundwater-related wetlands on the Mediterranean coast

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2.1 MEDPARTNERSHIP COUNTRY REPORTS

This section compiles the country report forms provided by national experts about selected groundwater-related coastal wetlands in their countries. A synthesis of the information contained in the forms is enclosed in Annex 1 in three table-charts, one devoted to general data about the wetlands, a second one devoted to the services provided by each wetland, their reported status of performance and evolution trends, and a third one devoted to the drivers of change identified for each wetland, their reported degree of impact and evolution trends.

2.1.1 COUNTRY REPORTS LEGEND CHART

Superscripted numbers(x) in the country reports refer to the numbers in this legend.

2.1.1.1 Groundwater-related wetland general data

(1) Name of wetland

(2) Wetland type
(combine at least one number and one letter)

1 Isolated wetland
2 Wetland complex
3 Isolated within a wetland complex
A Fresh/brackish water coastal lagoon/lake
B Salt lake
C Salt pan
D Natural, concentrated spring or outflow ("eye")
E Freshwater marsh
F Brackish marsh
G Salt marsh
H Flood plain pool/lagoon
I Deltaic lagoon/pool
J Estuary
K Riparian forest
L Erosive depression
M Tectonic depression
N Water course
O Dune slacks
P Spring
Q Seepage from shallow water table
R Saline (artificial)
S Reservoir (artificial)
T Other

(3) Morphometry

Wetland surface (km^2)
Elevation, average (m a.s.l.)
Depth, average (m)
Length, average (m)
Width, average (m)

(4) Aquifer type

Water table
Semi-confined
Confined

(5) Local climate, average (or variability range, two values)

Mean rainfall (mm/year)
Mean temperature (°C)
Mean evapotranspiration (mm/year)

(6) Underlying lithology

Siliceous sediments
Carbonated sediments
Carbonate rocks
Evaporite rocks
Metamorphic rocks
Volcanic rocks
Intrusive rocks

(7) Wetland genesis

Tectonic
Erosive
Dissolution
Volcanic
Floodplain
Delta/estuary
Dune morphology
Coastal sedimentation
Artificial

(8) Wetland sediments

Sandy
Silty
Clayey
Organic-rich
Peat

(9) Water source

Rainfall on the wetland
Runoff in the basin
Deep groundwater
Shallow groundwater
Sea (tidal/wave influence)
Fluvial inundation
Artificial

(10) Groundwater flow type

Flow through
Recharge area
Discharge area, open
Discharge area, closed saline
Discharge area, closed fresh
Crypto-wetland
Variable

Brief explanation of the groundwater flow types

- Flow through: wetland is connected to a shallow aquifer and the water-table slope induces groundwater discharge in the upstream part of the wetland and aquifer recharge in the downstream part of it.
- Recharge area: water level in the wetland is higher than water-table in the aquifer (wetland may even be perched). Wetland water sources may be precipitation, overland flow, rivers, sea water or artificial supply, but the dominant outflow mechanism is infiltration by lateral or by downward flows, producing shallow or deep aquifer recharge.
- Discharge area, open: wetland receives groundwater discharge and the dominant natural mechanism of wetland evacuation is surface water outflow.
- Discharge area, closed, saline: wetland receives groundwater discharge and the dominant natural mechanism of wetland evacuation is evapotranspiration. Wetland water and sediments become increasingly saline.
- Discharge area, closed, non-saline: wetland receives groundwater discharge and the dominant natural mechanism of wetland evacuation is evapotranspiration, but surface water outflow occurs sporadically, avoiding wetland salinization.
- Crypto-wetland/hidden wetland: water table is very shallow under and around the wetland, which does not stand water but has permanent/semi-permanent characteristic phreatophyte vegetation masses. Examples: salt pans, salt and brackish marshes, dune slacks.
- Variable: The groundwater-wetland relationship pattern changes over time.

(11) Groundwater dependence

Dominant
Shared
Secondary

(12) Hydroperiod

Permanent
Seasonal
Variable

(13) Hydrochemistry

Electrical conductivity (mS/cm) average or variability range (two values):
Dominant (>50%) anion or two anions (symbols)
Dominant (>50%) cation or two cations (symbols)

(14) Dominant vegetation

Forest
Shrubs, bushes
Prairie
Halophytic vegetation
Phreatophyte vegetation

(15) Trophic state

Oligotrophic
Mesotrophic
Eutrophic
Hypereutrophic

(16) Functionality

Almost unaltered
Moderately altered
Highly altered
Artificial

(17) State of knowledge

Validated hydrogeological conceptual model
Numerical model
Chemical/isotopic information
Biological information
Socioeconomic information
Water level monitoring
Groundwater level monitoring
Water quality monitoring
Groundwater quality monitoring
Hydrogeological studies
Wetland evolution studies
Climate change impact studies
Global change impact studies
Information on wetland's uses

(18) Management status

Ramsar site
Man and Biosphere Programme (MAB), UNESCO
Nature Reserve/Other
Unprotected
Protection regulation
Management authority
Users' involvement

2.1.1.2 Main direct drivers of change in the groundwater-related wetland

(19) Resource exploitation
Water abstraction
Biological exploitation
Mineral exploitation

(20) Changes in land use
Deforestation
Reforestation
Forest management
Replacement of species
Extensive agriculture
Extensive cattle raising
Urbanization
Roads
Others (indicate which type/s of change/s)

(21) Modification of hydrological cycle
Drainage
Input of excess irrigation
Storage usage
Artificial recharge
Input of urban wastewater
Others (indicate which type/s of modification/s)

(22) Pollution
Agricultural diffuse pollution
Atmospheric diffuse pollution
Urban/industrial point source pollution

(23) Alteration of biological community structures and ecosystem
Invasive exotic species
Native species extinction
Alteration of biogeochemical cycles
Fragmentation

(24) Effects associated with changes
Chemical water quality
Biological water quality
Oxidation by lowering water table
Increased erosion
Soil destruction

(25) Global and climate changes
Rainfall
Temperature
Sea level rise

The degree of impact of the different drivers of change affecting a particular wetland and the observed or forecasted evolution trend of this impact have been assessed using the following criteria. The results of this assessment are shown in the Drivers' table-chart of Annex 1.

Evaluation of drivers' impact	Evaluation of drivers' trend
High: The impact of the driver on the wetland is high	Very rapidly increasing
Moderate: The impact of the driver is moderate	Moderately increasing
Low: The impact of the driver is low	Continuing
Non-existent: The driver does not exists	Moderately decreasing
Unknown: Unknown situation	Very rapidly decreasing Unknown trend

2.1.1.3 Wetland services global assessment of status and trends

(26) Provisioning services

Natural production of food:
Cropping
Livestock
Fishing
Fruit collection
Hunting
Other (specify)
Artificial production of food:
Aquaculture
Agriculture
Other
Supply of good-quality water
Water supply for different uses
Production of biological source materials
Production of mineral source materials
Genetic pool and biotechnology
Energy production

(27) Regulating services

Natural species of medicinal interest
Hydrological regimes (floods, drought)
Water purification
Morpho-sedimentary regulation
Biological control
Carbon sink and global regulation
Air quality regulation
Local climate regulation

(28) Cultural services

Tourism
Educational and scientific knowledge
Local knowledge and good practices
Landscape and aesthetic
Cultural identity and sense of belonging
Religious and spiritual

The status of performance of the ecosystem services identified for a particular wetland and the observed or forecasted evolution trend of this status have been assessed using the following criteria. The results of this assessment are shown in the Services' table-chart of Annex 1.

Evaluation of services' status	Evaluation of services' trend
High: The service is performed at a high level	Very rapidly increasing
Moderate: The service is performed at a moderate level	Moderately increasing
Low: The service is performed at a low level	Continuing
Non-existent: The service is not performed	Moderately decreasing
Unknown: Unknown situation	Very rapidly decreasing Unknown trend

2.1.2 ALBANIA WETLANDS COUNTRY REPORT

Emanuela Kiri

GROUNDWATER-RELATED WETLAND GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland**(1): Butrinti Lake — **Wetland general type**(2): 2H
2. **Municipality, Country**: Albania — **Coordinates (geographical)**: 39°46'14" N; 20°02'51" E
3. **Wetland surface**(3): 16.3 km^2 — **Elevation (m) maximum-average**: 1 - ?
   Average depth/length/width (m)(3): 0.7/7100/3200
4. **Contributing surface area (km^2)**: Unknown
5. **Contributing aquifer area**: 258 km^2 — **Aquifer type**(4): Semi-confined
6. **Mean rainfall**(5): 1500 mm/y — **Mean T**(5): 18.5°C — **Mean ET**(5): 1200 mm/y
7. **Underlying lithology**(6): Carbonated rocks
8. **Wetland genesis**(7): Tectonic
9. **Wetland sediments**(8): Sandy
10. **Water source**(9): Rainfall on the wetland; Sea (tidal/wave influence)
11. **Groundwater flow type**(10): Discharge area, open — **Groundwater dependence**(11): Secondary
12. **Hydroperiod**(12): Permanent
13. **Hydrochemistry**(13): **EC: 20-40 mS/cm. Dominant anion/s:** Cl; dominant cation/s: Na
14. **Dominant vegetation**(14): Shrubs, bushes
15. **Trophic state**(15): Eutrophic
16. **Funtionality**(16): Moderately altered
17. **State of knowledge**(17): Water level monitoring; Groundwater level monitoring; Water quality monitoring; Information on wetland's uses
18. **Management status**(18): Ramsar site; Management authority

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation drivers**(19): Water from tributaries; Groundwater basin; Fishing; Salts
20. **Changes in land use**(20)**:** Urbanization; Roads
21. **Modification of hydrological cycle**(21): Direction of Bistrica River artificially changed
22. **Pollution**(22): Urban/industrial point source pollution; Agricultural diffuse pollution
23. **Alteration of biological communities structures and ecosystems functioning**(23): Native species extinction
24. **Effects associated with changes**(24): Chemical water quality
25. **Global and climate changes**(25): Rainfall; Temperature

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services**(26) **(Status; Trend)**:
    26a. Natural production of food: Livestock (Moderate; Continuing); Fishing (High; Continuing)
    26b. Artificial production of food: Aquaculture (Moderate; Continuing)
    26c. Others: Supply of good-quality water (Low; Continuing); Water supply for different uses (Low; Continuing)
27. **Regulating services**(27) **(Status; Trend)**: Hydrological regimes (Low; Continuing); Biological control (Low; Continuing)
28. **Cultural services**(28) **(Status; Trend)**: Tourism (High; Continuing); Cultural identity and sense of belonging (High; Continuing)

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2.1.3 ALGERIA WETLANDS COUNTRY REPORT

Larbi Djabri

GROUNDWATER-RELATED WETLAND GENERAL DATA

(x) Refers to the numbers in the legend chart provided.

1. **Name of wetland(1)**: Guerbes — **Wetland general type(2)**: 2HKN
2. **Municipality, Country**: Guerbes, Algeria — **Coordinates (geographical):** 7°8'-7°25' E; 36°46'-37° N
3. **Wetland surface (km²)(3)**: 421 — **Elevation (m) maximum-average:** <1
   Average depth/length/width (m)(3): <1 to 20
4. **Contributing surface area (km²)**: 300
5. **Contributing aquifer area (km²)**: 150 — **Aquifer type(4)**: Two layers: unconfined and deep
6. **Mean rainfall (mm/y)(5)**: 700 — **Mean T (°C)(5)**: 18.5 — **Mean ET (mm/y)(5)**: 430
7. **Underlying lithology(6)**: Siliceous sediments; Evaporite rocks
8. **Wetland genesis(7)**: Erosive; Dune morphology
9. **Wetland sediments(8)**: Sandy; Silty
10. **Water source(9)**: Rainfall on the wetland; Runoff in the basin and sea (tidal/wave influence)
11. **Groundwater flow type(10)**: Flow through; Recharge area — **Groundwater dependence(11)**: Dominant
12. **Hydroperiod(12)**: Permanent; Seasonal
13. **Hydrochemistry(13)**: 500-11560 µS/cm; dominant anion/s: HCO_3, Cl; dominant cation/s: Ca, Na
14. **Dominant vegetation(14)**: Forest; Prairie; Halophytic vegetation
15. **Trophic state(15)**: Unknown
16. **Functionality(16)**: Moderately to highly altered
17. **State of knowledge(17)**: Validated hydogeological conceptual model; Chemical information; Groundwater levels monitoring; Surface water and Groundwater quality monitoring; Hydrogeological studies; Wetland evolution studies
18. **Management status(18)**: Ramsar site; Nature Reserve

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Groundwater from the basin and next to the wetland (the two layers are exploited); also from small dams built in the tributaries
20. **Changes in land use(20)**: Increasing intensive agriculture; Urbanization; Roads; Cattle raising; Replacement of species
21. **Modification of hydrological cycle(21)**: Input of excess irrigation; Storage usage; Drainage; Input of urban wastewater
22. **Pollution(22)**: Agricultural diffuse pollution; Urban point source pollution (wastewater discharges); Industrial point source pollution generated by a cement quarry
23. **Alteration of biological communities' structures and ecosystems functioning(23):** Illegal removal of sand will promote sediment transport and consequently reduce storage capacity in lakes
24. **Effects associated with changes(24)**: Chemical water quality
25. **Global and climate changes(25)**: Impacts of decrease in rainfall, and of rising temperatures and sea level, will increase.

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:
    26a. Natural production of food: Cropping (Moderate; Moderately increasing); Livestock (Moderate; Continuing); Fishing (Low; Continuing); Hunting (Low; Unknown)
    26b. Artificial production of food: Agriculture (Moderate; Continuing)
    26c. Others: Supply of good-quality water and Supply of water for different uses (Low; Continuing); Provision of biological and mineral source materials (Low; Continuing); Natural species of medicinal interest (Moderate; Continuing)
27. **Regulating services(27) (Status; Trend)**: Hydrological regimes (Low; Moderately decreasing); Water purification (Moderate; Continuing); Morpho-sedimentary regulation (Low, Continuing);
28. **Cultural services(28) (Status; Trend)**: Tourism, Educational and scientific knowledge, Local knowledge and good practices and Landscape and aesthetic (Low; Continuing); Cultural identity and sense of belonging (Moderate; Continuing)

ADDITIONAL INFORMATION/COMMENTS

Figure 2.1.3.1. Images of some main drivers of change in the Guerbes wetland area. Source: L. Djabri.

Guerbes wetland, Algeria.

- Left: Rock extraction.
- Right: Hadjar South cement plant.
- Reduction in the wetland surface

2.1.4 BOSNIA AND HERZEGOVINA WETLANDS COUNTRY REPORT

Zoran Mateljak

GROUNDWATER-RELATED WETLAND GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Hutovo Blato — **Wetland general type(2):** Wetland complex
2. **Municipality, Country**: Capljina, Bosnia and Herzegovina — **Coordinates (geographical):** 43°03'32" N 17°47'05" E
3. **Wetland surface (km^2)(3)**: 79.72 — **Elevation (m) maximum-average**: ?-1

   Average depth/length/width (m)(3): 2.5/10,500/7500
4. **Contributing surface area (km^2)**: 4000
5. **Contributing aquifer area (km^2)**: 1000 — **Aquifer type(4)**: Water table
6. **Mean rainfall (mm/y)(5)**: 1160 — **Mean T (°C)(5):** 14.7 — **Mean ET (mm/y)(5)**: 855
7. **Underlying lithology(6)**: Carbonated sediments
8. **Wetland genesis(7)**: Tectonic
9. **Wetland sediments(8)**: Peat
10. **Water source(9)**: Shallow groundwater
11. **Groundwater flow type(10)**: Discharge area, open — **Groundwater dependence(11)**: Dominant
12. **Hydroperiod(12)**: Permanent
13. **Hydrochemistry(13)**: EC (mS/cm): 0.5-40; dominant anion/s: HCO_3; dominant cation/s: Ca-Mg
14. **Dominant vegetation(14)**: Halophytic vegetation
15. **Trophic state(15)**: Mesotrophic
16. **Funtionality(16)**: Highly altered
17. **State of knowledge(17)**: Water level monitoring
18. **Management status(18)**: Ramsar site

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

9. **Resource exploitation(19)**: Water abstraction
20. **Changes in land use(20)**: Replacement of species
21. **Modification of hydrological cycle(21)**: Storage usage
22. **Pollution(22)**: Agricultural diffuse pollution
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Native species extinction; Alteration of biogeochemical cycles; Fragmentation
24. **Effects associated with changes(24)**: Chemical water quality; Biological water quality; Oxidation by lowering water table; Increased erosion
25. **Global and climate changes(25)**: Sea level rise

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:

    26a. Natural production of food: Cropping and Livestock (Low; Continuing); Fishing (Moderate; Moderately increasing); Hunting (High; Moderately increasing)

    26b. Artificial production of food: Agriculture (Low; Continuing)

    26c. Others: Supply of good quality water, Water supply for different uses, Production of biological source materiales and Natural species of medicinal interest (Low; Continuing); Energy production (High; Very rapidly increasing)
27. **Regulating services(27) (Status; Trend)**: Hydrological regimes (floods, drought) and Morpho-sedimentary regulation (High; Very rapidly increasing); Carbon sink and global regulation (High; Moderately decreasing); Water purification and Local climate regulation (Moderate; Moderately decreasing); Biological control (Low; Continuing); Air quality regulation (Low; Moderately decreasing)
28. **Cultural services(28) (Status; Trend)**: Landscape and aestetic and Cultural indentity and sense of belonging (High; Moderaetly decreasing); Tourism and Educational and scientific knowledge (Moderate; Moderately decreasing); Local knwoledge and good practices (Modearte; Continuing)

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2.1.5 CROATIA WETLANDS COUNTRY REPORT

Ognjen Bonacci

GROUNDWATER-RELATED WETLAND GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland**(1): Neretva delta — **Wetland general type**(2): Wetland complex (A,H,J)
2. **Municipality, Country:** Dubrovnik-Neretva County, Croatia — **Coordinates (geographical):** 43°01'40" N; 17°34'25" E.
3. **Wetland surface (km^2)**(3): 127.42 — **Elevation (m) maximum-average**: 20-0.5

   Average depth/length/width (m)(3): 0.5/20,000/3000
4. **Contributing surface area (km^2)**: 3000 (?)
5. **Contributing aquifer area (km^2)**: 500 (?) — **Aquifer type**(4): Water table
6. **Mean rainfall (mm/y)**(5): 1250 — **Mean T (°C)**(5): 15.7 **Mean ET (mm/y)**(5): 880
7. **Underlying lithology** (6): Carbonate rocks; Carbonated sediments
8. **Wetland genesis**(7): Delta/estuary; Floodplain
9. **Wetland sediments**(8): Sandy; Organic-rich
10. **Water source**(9): Rainfall on the wetland; Fluvial inundation; Shallow groundwater
11. **Groundwater flow type** (10): Flow through; Discharge area closed, non-saline — **Groundwater dependence** (11): Shared
12. **Hydroperiod**(12): Seasonal; Variable
13. **Hydrochemistry**(13): Electrical conductivity (mS/cm): 0.5-40; dominant (>50 %) anion or two anions: Cl, SO_4; dominant (>50 %) cation or two cations: Na, Ca
14. **Dominant vegetation**(14): Halophytic vegetation
15. **Trophic state**(15): Eutrophic vegetation
16. **Functionality**(16): Partly moderately altered (30%); partly highly altered (70%)
17. **State of knowledge**(17): Water quality monitoring; Biological information
18. **Management status**(18): Ramsar site

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation**(19): Water abstraction
20. **Changes in land use**(20): Extensive agriculture; Urbanization; Roads
21. **Modification of hydrological cycle**(21): Drainage; Input of excess irrigation
22. **Pollution**(22): Agricultural diffuse pollution; Urban/industrial point source pollution
23. **Alteration of biological communities structures and ecosystems functioning**(23): Agricultural diffuse pollution; Urban/industrial point source pollution
24. **Effects associated with changes**(24): Chemical water quality; Biological water quality
25. **Global and climate changes**(25): Temperature

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services**(26) **(Status; Trend)**:

    26a. Natural production of food: Fruits collection (High; Moderately increasing); Cropping (High; Continuing); Fishing (Moderate; Continuing); Hunting (Low; Continuing)

    26b. Artificial production of food: Agriculture (High; Moderately increasing)

    26c. Others: Supply of good quality water, Water supply for different uses and Production of biological source materials (Low; Continuing)
27. **Regulating services**(27) **(Status; Trend)**: Hydrological regimes (floods, drought) (Moderate; Moderately increasing); Water purification, Morpho-sedimentary regulation and Biological ocontrol (Moderate; Moderately decreasing)
28. **Cultural services**(28) **(Status; Trend)**: Tourism and Educational and scientific knowledge (High; Moderately increasing); Local knowledge and good practices, Cultural identity and sense of belonging and Religious and spiritual (Modearte; Moderately increasing)

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2.1.6 EGYPT WETLAND COUNTRY REPORT

Amr Fadl

GROUNDWATER-RELATED WETLAND GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Lake Mariut — **Wetland general type(2)**: 1A
2. **Municipality, country**: Alexandria, Egypt — **Coordinates (geographical):** 31°03'03"-31°10'22" N; 29° 51'07"-29°56'35" E.
3. **Wetland surface(3)**: 62.89 million m² — **Elevation**: 13 m. Water level is about 3.8 m below sea level

   Average depth/length/width (m)(3): 0.83 m/cannot determine as its shape is irregular
4. **Contributing surface area (km²)**: The following link leads to a topographic map. However, the area is not specified: http://www.lib.utexas.edu/maps/ams/north_africa/txu-oclc-6949452-nh35-4.jpg
5. **Contributing aquifer area (km²)**: Not determined — **Aquifer type(4):** Unconfined
6. **Mean rainfall (mm/y)(5)**: The average precipitation for 2007, 0.66 mm/day, was calculated from the precipitation record (see table below) presented in the Lake Mariout data acquisition report (NIOF, 2008). The average yearly precipitation is recorded in numerous publications (e.g. Zahran and Willis, 2008) and it ranges between 182 and 208 mm.

Monthly precipitation 2007 (mm/day)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AV.
1.77	0.95	0.42	0.14	0.05	trace	trace	0.01	0.03	0.30	1.10	1.79	0.66

Mean T (°C)(5): Monthly Temperature (°C)

MONTH	MAXIMUM	MINIMUM	AVERAGE
January	19	9.5	14
February	19.5	10	15
March	21.5	11.5	17.5
April	24	14	19
May	26.5	16.5	21.5
June	29.5	21	25.5
July	30	22.5	26.5
August	30.5	23	27
September	30	21.5	26
October	27.5	18	23
November	25	15.5	20.5
December	20.5	11.5	16
Annual	25.5	17.5	21

Mean ET (mm/y)(5): For the studied period (2000-2009), the average annual ET was 3.8 mm/day.

7. **Underlying lithology(6)**: Studies on the geology and geomorphology of the north-western Mediterranean coastal region of Egypt were reviewed by Helmy (2005). According to these studies, the entire northern region of the Egyptian western desert is covered by sedimentary formations, which range in age from lower Miocene to Holocene.

   The Holocene formation is formed of beach deposits, sand dune accumulations, wadi fillings, loamy deposits, lagoonal deposits and limestone crusts. The beach deposits are composed of loose calcareous oolitic sand with some quartz grains and shell fragments.

The sand dune accumulations are in the form of either coastal or inland dunes. The coastal dunes are composed of snow-white, coarse calcareous oolitic sand, while the inland dunes are of reddish colour and finer sand. The wadi fill comprises lime gravel and fine alluvia. The loamy deposits are fine sandy loam intermixed with gravels. Lagoonal deposits are present in the depressions between ridges and are composed of gypsum intermixed with sand and alluvium. The limestone crusts are developed on the exposed limestone surfaces.

The Pleistocene formation is formed of white and pink limestones. The white limestones are in the form of exposed ridges stretching parallel to the coast. They are composed of white calcareous oolitic sandy limestones, yielding Pleistocene microfossils, echinoid spines, calcareous algae and shell fragments. The pink limestones are composed of pinkish white oolitic sand, yielding Pleistocene micro-fauna.

The Pliocene formation is represented by creamy limestones which are marly and sandy in subsurface. They are partly exposed in some localities. The Miocene formation includes two divisions. These are collectively known as the "Marmarica Limestone". The Lower Miocene type is formed of sandy limestones, shales and marles and is known as the "Moghrs Formation". The Middle Miocene type is represented by limestones and dolostones with intercalations of clays, sandstones and siltstones.

Limestone Region of the Northwestern Delta
The deltaic coast west of Abu Qir Bay is characterized by a morphologic structure different from that to the east. This part of the coast is formed from successive chains of oolitic limestone; between them are low valleys. The limestone chains themselves appear as ridges about 120 ft. above sea level. The region has five subdivisions:

i) The coastal range is comprised of white sand dunes mainly consisting of limestone particles. There are several ideas on how the dunes were formed. Some people consider them to be coastal dunes formed at a time when the Egyptian coast was completely dry. Others attribute to them a marine origin. The width of the coastal range is about 400 m^2.

ii) Wadi Mariout extends to the south of the coastal range at five meters above sea level or less. The wadi is covered by a thick limestone soil (derived from the bordering ranges) sometimes more than five meters deep. There are different theories about how the wadi was formed: whether from crustal movements or an old lake.

iii) The Al- Max-Abu Suwayr range falls to the south of Wadi Mariout. It has a width of between 200 and 400 m. and its height is 36 m. The range slopes abruptly toward Wadi Mariout in the north and toward the Mallahat Mariout Depression in the south. The formation of this range is attributed in part to the influence of the wind. It was originally formed from remnants of sea shells and calcined sand particles fused by rain and evaporation. During the rainy season, rains loaded with diluted carbonic acid dissolve the calcium carbonate so it becomes bicarbonate; in the dry season this settles between the sand particles and solidifies.

iv) Some geologists think that the western tip of the Max-Suwayr range was subjected to limited folding which uplifted the bottom of the Mallahat Mariout. Depression and separated from it the far western sector. Evidence of this is the gypsum formations (called Wadi Al-Gibs, i.e., gypsum) which are mounds of saline deposits six meters above sea level. These forms to the period between 12,000 and 10,000 B.C., when sea level was lower and aridity prevailed. The depression of Mallahat Mariout lies between the central and southern ranges. It was previously an extension of Lake Mariout.

v) The range of Gabal Mariout (also called Al-Batn and Al-Qarn) forms the southern boundary of the depression; it is 35 m above sea level, and in the northeast reaches 51 m, although it is only 30 m height in the north-west. The width of the range is between 300 and 400 m to the south of the range, the raised plains of Mariout extend as far as the Miocene plateau.

Sandford and Arkell have summarized their opinions concerning these ranges: "The remarkable ridges of lime sand oolitic limestone west of Alexandria, separated by parallel valleys, afford a perplexing geological problem, but on the whole there is much to support the view that they were formed by wind action along a receding shore line; a new dune area is forming between the ridge nearest the sea and the present storm beach".

It is possible that the shape of Lake Mariout (broad in the east with an arm extending to the west) is attributable to its location at the convergence of deltaic formations with the region of oolitic limestone chains. The influence of the delta is apparent in the eastern lake, which is broad and shallow, while the western part is clearly influenced by the morphology of the western coast.

Sand Dunes and the Northern Coast of the Delta
Sand dunes are the main geomorphic feature in the greatest part of the deltaic coast east of Abu Qir Bay. Most of the sand dunes along the coast are low and narrow. They do not exceed a few meters above sea level, and their widths range between 500 and 1500 m. Three parallel lines of dunes stretch from the sea towards the interior. The outer line is about 50 m wide and consists of sand and silt mixed with some marine formations brought by seawater during high tide.

Lake Mariout
Lake Mariout is different from the other Northern lakes in that it is a closed lake. It is also in a unique region characterized by the presence of limestone barriers. The lake is impounded between one of those barriers and the delta. (Arab Repulic of Egypt, 2009)

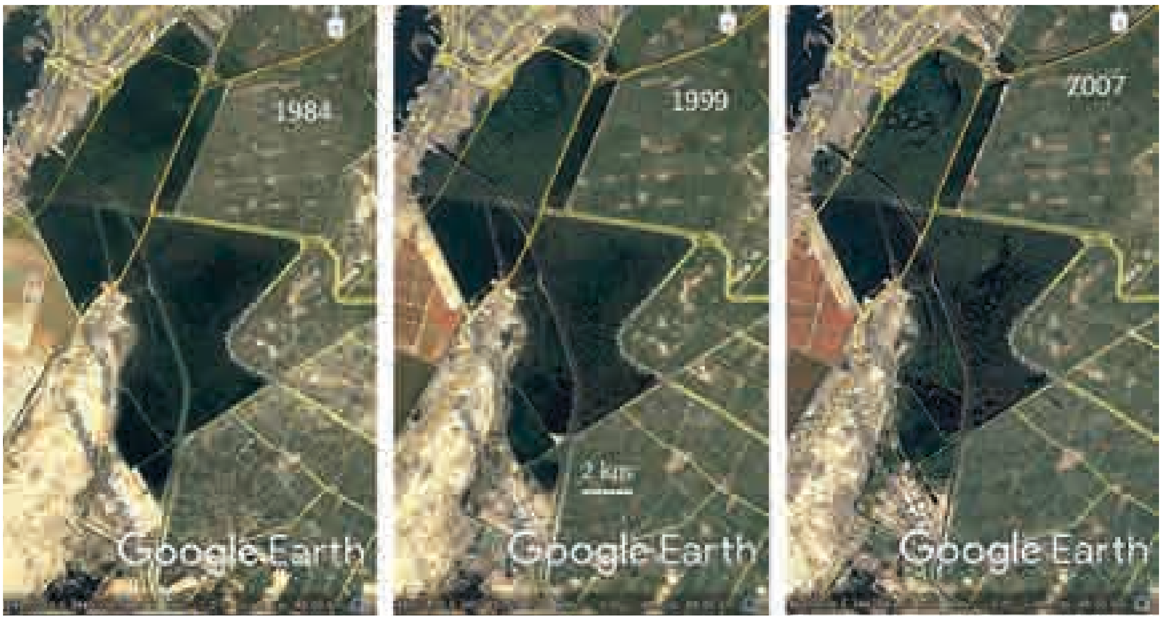
8. Wetland genesis[(7)]: The lake was formed at least 6000 years ago. The present lake represents the remnant of a huge prehistoric Lake Mareotis, which covered an area of approximately 700 km^2. Over the years the lake has undergone many changes and in several years it dried up. Warnings have been raised about the increasing negative impact of human activities on Mariut Lake.

Lake Mareotis was formed solely by the Nile, which fed the lake through a network of canals that branched off the river's defunct Canopic Branch, and approached the lake from the south and the east. Moreover, it was connected to the sea at Alexandria though a navigable canal that debouched at the city's western harbour. Accordingly, besides being a fresh water lake, Mareotis also gave access to the Nile and hence to the whole of Egypt. Therefore, it is believed that the location and characteristics of Lake Mareotis, gave the city of Alexandria one of its major advantages.

Historical, archaeological and geomorphological evidence indicate that Lake Mareotis consisted of two interlinked parts; the main basin of the lake, which extended for 40-50km south of Alexandria, and a narrow arm which was about 3km wide and extends west of Alexandria for about 40km. However, it is evident that Lake Mareotis has undergone dramatic changes during the past two millennia, which significantly affected its size and nature. During the 5th century AD, the Canopic Branch started silting up and it became defunct by the 12th century AD. Accordingly, Lake Mareotis lost its connection to the Nile, and the once navigable freshwater lake became a closed lagoon with no constant supply of water. Due to increasing evaporation, the size of the lagoon decreased significantly and by the end of the 18th century Mareotis was almost dry, except in the rainy seasons. (Khalil, 1997)

At present, the remainder of the lake is made up of several basins, dissected by roads and embankments. It has no direct connection with the Mediterranean, and its water is pumped to that sea through the El-Max pumping station. As Mariut Lake is a shallow water basin, it has more potential for high zone aquatic plant productivity. The higher aquatic plant density leads to a rapid sedimentation process and also to a decrease in the water depth.

Figure 2.1.6.1. Satellite images showing the wetland extent in different years.



9. **Wetland sediments[8]**: A collaborative programme between the Egyptian Environmental Affairs Agency (EEAA) and National Institute of Oceanography and Fisheries (NIOF) was initiated between July 2009 and June 2011. The main objectives of this programme are to evaluate the present status of the environmental, ecological and geological conditions for each of the northern lakes. During the summer of 2012 and winter of 2013 surficial sediment samples were collected from ten stations using an Ekman grab sampler from Lake Mariut and three samples from the three drains (Nubaria, Umum and Qalaa).

   Grain size distribution: The sediments of Lake Mariut varied in sand fraction from a maximum value of 23.1% and a minimum value of 6.46% with an average of 12.02%, during August 2012, while in February 2013 the maximum value was 41.81% and the minimum value was 4.26%, with an average of 14.7%. The maximum value of mud (silt and clay %) was 93.54% and the minimum value 76.9%, with an average of 87.98% during August 2012. In February 2013 the maximum value was 95.64% and the minimum value was 58.19%, with an average of 85.30%.

   Water content (%): The absolute water content in the analysed sediment samples ranged between a maximum value of 50% and a minimum value of 34.23%, with an annual average of 42.23%.

10. **Water source[9]**: During the late 19th century, the irrigation system for the north-western Nile Delta was modernized, and Mariut Lake was used as a reservoir for agricultural drainage water. Industrial and drainage wastes, as well as domestic waste water, now discharge to the lake. The main water sources are the El-Kalaa, El-Omom and El-Nobaria Drains. This discharge with its high organic matter settles on the lake bed, and consequently the depth decreases

11. **Groundwater flow type[10]**: Discharge area; Closed; Saline

    Groundwater dependence[11]: Dominant; however, as it stands, significant wastewater is being discharged making the proper category for groundwater dependence, for the time being, "shared"

12. **Hydroperiod[12]**: Permanent

13. **Hydrochemistry[13]**: The collaborative programme referred to in item 9 above ('Wetland sediments') provided the physico-chemical characteristics shown in the table below.

	TEMP (°C)	TRANS. (cm)	SALINITY (g/L)	pH	DO (mg/L)	BOD (mg/L)	COD (mg/L)	H_2S (mg/L)
Min.	14	0	1.65	7.46	0	2.94	42.67	6.25
Max.	30.5	250	6.86	8.75	14.22	729	512	216.48
Average	24	64.75	3.68	8.24	5.82	52.18	151.3	45.65

14. **Dominant vegetation[14]**: The vegetation associated with Mariut Lake comprises communities of both aquatic and terrestrial habitats (Tadros and Atta, 1958a). In the aquatic habitat Phragmites australis grows luxuriantly and densely in the shallow water (30-50 cm depth). Inwards, in deeper water, an almost pure population of Eichhornia crassipes is present, and in still deeper parts there are submerged communities of Potamogeton pectinatus associated with Ceratophyllum demersum and Lemna gibba.

    Towards the shore of the lake, the soil is saline and halophytic vegetation prevails. The vegetation of this terrestrial habitat can be distinguished into distinct zones. In the submerged soil is a community dominated by Scirpus tuberosus associated with S. litoralis and Typha domingensis. T. domingensis dominates a zone close to that of Phragmites australis and passes gradually into a S. tuberosus community which merges, as the level of the ground increases so that it become less liable to flooding, into a community dominated by either Salicornia herbacea or by Juncus rigidus. S. herbaceagradually diminishes and is replaced by Salicornia fruticosa which passes gradually to a typical Salicornia fruticosa-Limoniastrum monopetalum zone. The Juncus rigidus community, on the other hand, is replaced by a community codominated by Salicornia fruticosa-Suaeda salsa, which passes gradually to a typical S. fruticosa-Limoniastrum monopetalum type. In both situations the ground becomes very dry and saline and a Halocnemum strobilaceum community replaces that of Salicornia-Limoniastrum. On the elevated border of the dry saline beds of the western extension of Lake Mariout is a community dominated by Salsola tetrandra associated with Atriplex halimus, Frankenia revoluta, Limoniastrum monopetalum, Limonium pruinosum and Sphenopus divaricatus.

    In the less saline stands of this community Pituranthos tortuosus, Thymelaea hirsuta, Trigonella maritime and other non-halophytic species may grow. This community has also certain affinities with the non-halophytic communities. The Salsola tetrandra zone gradually gives way to a community whose principal constituents are Limoniastrum monopetalum and Lycium europaeum. Associate species include Asphodelus microcarpus, Bassia muricata, Carthamus glaucus, Cutandia dichotoma, Echinops spinosissimus, Filago spathulata, Helianthemum lippii, Ifloga spicata, Launaea nudicaulis, Noaea mucronata, Picris radicata, Plantag albicans, Reaumuria hirtella, Salvia lanigera and Suaeda pruinosa.

15. **Trophic state[15]**: Severely eutrophic.

16. **Functionality[16]**: Recent studies showed that the water quality and the biodiversity in the lake has been considerably deteriorated due to the discharged of domestic (partially treated or untreated) and industrial waste water directly and indirectly to the lake. This has

resulted in severe eutrophication to the lake, especially the main basin. Even if secondary treatment were applied, none of the treatment scenarios are expected to significantly alter the nutrients or metal concentration entering the lake from sources other than sewage. The large amounts of raw wastewater from squatters along the contributing drains, the excessive concentration of metals currently in the industrial wastes accompanied with wastewater, and the relatively low removal rates for metals and nutrients achieved by primary or even secondary treatment of any of the wastewater management scenarios are not expected to be changed significantly from the existing situation with respect to water and sediment or eutrophication.

17. **State of knowledge**[(17)]: Water quality monitoring. Wetland evolution studies

18. **Management status**[(18)]: Responsibilities for environmental protection in Egypt are dispersed among a number of Ministries and Governorates and can be classified in the following three categories:

    (a) the national environmental organization represented by the MSEA, the EEAA and its eight Regional Branch Offices (RBOs) which are charged with overall monitoring and regulatory coordination;

    (b) institutions with specific operational functions which are performed by environment units in line ministries, and by Environmental Management Units in the Governorates; and

    (c) institutions with environment support role (mostly universities and research institutes).

    One of the functions of the EEAA Alexandria RBO is to monitor wastes from inland Nile fleets and coastal waters. Water quality legislation in Egypt is governed by two main Laws: Law No. 48/1982 for protection of the river Nile and waterways from pollution; and Law 4/1994 on Environmental Protection. The Law No. 48/1982 regulates the discharge of wastewater into the River Nile and other waterways whereas the Law No. 4 of 1994 on the protection of the environment constitutes the main legislative body in the field of environment to formulate the general policy and prepare the necessary plans for the protection and promotion of the environment. The Law No. 4 of 1994 provides for the use of environmental management mechanisms, which include command and control measures such as the setting of appropriate standards, the application of the polluter pays principle (through the implementation of penalties and fines) and the use of environmental impact assessments.

    Although EEAA is responsible for the environment countrywide, Law 4/1994 retained most of the enforcing authority for inland waters with the Ministry of Water Resources and Irrigation (MWRI) and the Ministry of Interior. As EEAA is responsible for inspections regarding compliance with environmental and occupational health and safety regulations, it has to manage water quality in coordination with the MWRI and the Ministry of Health and Population.

    On a more local level, MWRI is responsible for controlling the water level in the lake Mariout through a balancing of the El-Mex pumping station with the influents to the lake. On the other hand, the General Authority for Fish Resources Development, under the Ministry of Agriculture and Land Reclamation, is responsible for the management of fish resources in the lake including aquaculture

    EEAA through its General Department for Coastal Zone Management has initiated the coordination of the ICZM planning, in which the first step was to establish the National Committee for Integrated Coastal Zone Management (NCICZM). A Ministerial Decree establishing the NCICZM was issued in 1994 with subsequent amendments. The function of the Committee is not only to draw up a consistent policy and strategy for future development, but also to resolve conflicts between different users. The National Committee includes top rank representatives of all concerned ministries, NGOs and major stakeholders.

    On a local level, in conformity with Law no. 124 of 1983, the General Authority for Fish Resources Development established the Lake Mariout Development Committee. The tasks of the Committee are to plan, supervise and implement development programmes for the Lake and to make field visits to the Lake to detect any violation. Due to its limited mandate, membership and representation, its role has been limited to regulate fish catch, develop fish production and protect the interests of the fishermen community. It includes members from Universities, NGOs, research centers, Alexandria governorate local council, General Organization for Sanitary Drainage, EEAA and fishermen association. (Arab Repulic of Egypt, 2009)

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. Resource exploitation[19]: Fish production

YEAR	PRODUCTION (Tn)	YEAR	PRODUCTION (Tn)
1986	8,800	1996	3,976
1987	8,100	1997	4,489
1988	7,770	1998	4,521
1989	3,500	1999	5,235
1990	1,900	2000	6,378
1991	2,200	2001	6,200
1992	3,500	2002	5,303
1993	3,990	2003	4,861
1994	3,516	2004	5,100
1995	3,466		

Source: General Authority for Fish Resources Development Statistics (2004).

20. Changes in land use[20]: Mariut Lake is bordered by fish farms, villages and agricultural lands. The Lake is made up of four ecological basins, dissected by roads and embankments:

- Basin (1), Aquaculture Basin, is bordered by fish farms in north, and agricultural lands in east.
- Basin (2), Main Basin, is bordered by International Coastal Road and human settlements in north and west.
- Basin (3), Western Basin, is bordered by Petroleum Companies in west.
- Basin (4), Southern Basin, is bordered by agricultural lands in the east, and Petroleum Companies and human settlements at the west.

21. Modification of hydrological cycle[21]: Drainages

22. Pollution[22]: Industrial, agricultural and domnestic discharges

23. Alteration of biological communities structures and ecosystems functioning[23]: Unknown

24. Effects associated with changes[24]: Chemical water quality. Biological water quality.

25. Global and climate changes[25]: According to a report produced for the Organization for Economic Development by Agrawala and others (2004), the Nile Delta is already subsiding at a rate of 3-5 mm per year. Just a.25-meter rise in sea level would devastate the populous cities that drive Egypt's economy. Forty percent of Egyptian industry is located in Alexandria alone; a.25-meter rise in sea level would put 60% of Alexandria's population of 4 million below sea level, as well as 56.1% of Alexandria's industrial sector. A rise of.5 meters would be even more disastrous, placing 67% of the population, 65.9% of the industrial sector, and 75.9% of the service sector below sea level. Thirty percent of the city's area would be destroyed, 1.5 million people would have to be evacuated, and over 195,000 jobs would be lost.

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. Provisioning services[26] (Status; Trends):

26a. Natural production of food: Fishing (Moderate; Moderately decreasing)

26b. Artificial production of food: Aquaculture (High; Continuing)

26c. Others:

27. Regulating services[27] (Status; Trends): Morpho-sedimentary regulation (High; Continuing); Hydrological regimes (Moderate; Moderately decreasing); Others (Unknown)

28. Cultural services[28] (Status; Trends): Cultural identity and sense of belonging and Landscape and aestetic (Low; Continuing).

This section describes the existing socioeconomic conditions of fishermen communities in the area. Three main social groups are identified, namely: fishermen, poorer communities and scattered land divisions. The fishermen community as a whole forms the poorest and most disadvantaged group in the target area. The fishermen communities are mainly located in inaccessible areas from land, as the infrastructure is limited or non-existent. The problems in reaching these communities with services and interventions have developmental, economic and social impacts. Fishing cannot be carried out throughout the year, and in the idle periods they lack alternative employment opportunities. Their socioeconomic development is limited. Also, they have some common characteristics (Arab Republic of Egypt, 2009):

- High illiteracy rates (especially that of females).
- Poor health services and high mortality rates.
- High crime rates Tendency to marry young and have large families, as stated.

ADDITIONAL INFORMATION/COMMENTS

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2.1.7 LEBANON WETLANDS COUNTRY REPORT

Amin Shaban

GROUNDWATER-RELATED WETLAND GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Tyre Beach Nature Reserve — **Wetland general type(2)**: 3Q
2. **Municipality, Country**: Lebanon — **Coordinates (geographical):** 33°13'30"; 35°13'00"
3. **Wetland surface (km²)(3)**: 3.8 — **Elevation (m) maximum-average**: 20-1
   Average depth/length/width (m)(3): 2-5/4025/950
4. **Contributing surface area (km²)**: Undefined
5. **Contributing aquifer area (km²)**: Undefined — **Aquifer type(4)**: Water table
6. **Mean rainfall (mm/y)(5)**: 730 — **Mean T (°C)(5)**: 20.2 — **Mean ET (mm/y)(5)**: 395
7. **Underlying lithology(6)**: Carbonate rocks
8. **Wetland genesis(7)**: Tectonic; Coastal sedimentation
9. **Wetland sediments(8)**: Clayey
10. **Water source(9)**: Shallow groundwater; Fluvial inundation
11. **Groundwater flow type(10)**: Discharge area, open — **Groundwater dependence(11)**: Dominant
12. **Hydroperiod(12)**: Permanent
13. **Hydrochemistry(13)**: No data available
14. **Dominant vegetation(14)**: Prairie
15. **Trophic state(15)**: Eutrophic
16. **Functionality(16)**: Moderately altered
17. **State of knowledge(17)**: Biological information; Partial hydrogeological studies
18. **Management status(18)**: Ramsar site; Nature Reserve

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Tributaries (M); Groundwater basin (H); Crops (H); Fishing (M)
20. **Changes in land use(20)**: Replacement of species (H); Extensive agriculture (H); Roads (L)
21. **Modification of hydrological cycle (21)**: Drainage (H); Input of excess irrigation (M); Storage usage (H); Input of urban wastewater (L)
22. **Pollution(22)**: Agricultural diffuse pollution (L)
23. **Alteration of biological communities' structures and ecosystems functioning(23)**: Alteration of biogeochemical cycles (M)
24. **Effects associated with changes(24)**: Chemical water quality (L); Biological water quality (L)
25. **Global and climate changes(25)**: Rainfall (M); Temperature (H); Sea level rise (M)

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:

    26a. Natural production of food: Cropping (High; Continuing); Fruit collection (High; Moderately increasing); Fishing and Hunting (Moderate; Continuing)

    26b. Artificial production of food: Aquaculture and Agriculture (High; Continuing)

    26c. Others: Supply of good-quality water, Water supply for different uses and Genetic pool and biotechnology (Moderate; Continuing)
27. **Regulating services(27) (Status; Trend)**: Hydrological regimes (Low; Continuing); Water purification and Biological control (Moderate; Continuing); Local climate regulation (Low; Continuing)
28. **Cultural services(28) (Status; Trend)**: Tourism and Educational and scientific knowledge (High; Continuing); Local knowledge and good practices and Landscape and aesthetic (Moderate; Moderately increasing); Cultural identity and sense of belonging (High; Moderately increasing)

ADDITIONAL INFORMATION/COMMENTS

Overview

Tyre Beach Nature Reserve, a Ramsar site, is one of the three identified coastal wetlands in Lebanon. It is located along the southern Lebanese coast, and represents a saturated clayey terrain where a number of springs and seeps exist.

Similar to Deir El-Nouriyeh-Cliffs of Ras Chekka wetland, there have been no specific hydrological or hydrogeological studies applied to it. Nevertheless, the springs located in the area surrounding the wetland are exploited and considered a major water source for the Tyre area.

As it is a Nature Reserve, Tyre Beach wetland has been well preserved. A number of crops have been planted and the landscape has been well conserved; notably, there are some archaeological ruins in the area.

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2.1.8 LIBYA WETLANDS COUNTRY REPORT

Omar Shalem

GROUNDWATER-RELATED WETLAND GENERAL DATA

[(x)] Refers to the numbers in the legend chart.

1. **Name of wetland[1]**: Tawurgha Spring — **Wetland general type[2]**: Spring, Sabkha (2D)
2. **Municipality, country:** Misratah, Libya — **Coordinates (geographical):** 15°07'00" E; 32°01' 00" N
3. **Wetland surface (km^2)[3]**: 80 — **Elevation (m) maximum-average**: **3**-1

   Average depth/length/width (m)[3]: 5/10,000/8000
4. **Contributing surface area (km^2)**: 600
5. **Contributing aquifer area (km^2)**: 10,0000 — **Aquifer type[4]**: Confined
6. **Mean rainfall (mm/y)[5]**: 200-250 — **Mean T (°C)[5]**: 30 — **Mean ET (mm/y)[5]**: 1800
7. **Underlying lithology[6]**: Carbonate rocks; Evaporites
8. **Wetland genesis[7]**: Tectonic
9. **Wetland sediments[8]**: Clayey, organic-rich
10. **Water source[9]**: Deep groundwater
11. **Groundwater flow type[10]**: Discharge area, open — **Groundwater dependence[11]**: Dominant
12. **Hydroperiod[12]**: Permanent
13. **Hydrochemistry[13]**: EC: 4.5 mS/cm (3.2 g/L); dominat cation/s: Na 530 mg/L; dominant anion/s: Cl 920 mg/L; SO_4 830 mg/L
14. **Dominant vegetation[14]**: Halophytic
15. **Trophic state[15]**: Eutrophic
16. **Funtionality[16]**: Moderately altered
17. **State of knowledge[17]**: Validated hydrogeological conceptual model; Water quality monitoring; Hydrogeological studies; Information on use of wetland
18. **Management status[18]**: Users' involvement

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation[19]**: From the wetland; Groundwater next to the wetland and in the basin; Crops and Cattle raising
20. **Changes in land use[20]**: Extensive agriculture; Extensive cattle raising; Urbanization; Roads
21. **Modification of hydrological cycle[21]**: Drainage; Input of excess irrigation; Storage usage; Input of urban wastewater
22. **Pollution[22]**: Agricultural diffuse pollution; Urban/industrial point source pollution
23. **Alteration of biological communities structures and ecosystems functioning[23]**: Extinction of native species; Alteration of biogeochemical cycles; Fragmentation
24. **Effects associated with changes[24]**: Chemical water quality; Biological water quality
25. **Global and climate changes[25]**: Rainfall; Temperature; Sea level rise

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services[26] (Status; Trend)**:

    26a. Natural production of food: Cropping and Fruit collection (High; Continuing); Livestock (Low; Continuing)

    26b. Artificial production of food: Agriculture (Low; Continuing)

    26c. Others: Supply of good-quality water (Low; Moderately decreasing); Supply of water for different uses (High; Moderately decreasing)
27. **Regulating services[27] (Status; Trend)**: Hydrological regimes and Biological control (Moderate; Continuing); Local climate regulation (Low; Continuing)
28. **Cultural services[28] (Status; Trend)**: Tourism and Educational and scientific knowledge (Low; Moderately increasing); Local knowledge and good practices and Cultural identity and sense of belonging (High; Moderalety increasing); Landscape and aesthetic (Moderate; Moderately increasing)

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2.1.9 MONTENEGRO WETLANDS COUNTRY REPORT

Dragan Radojevic

GROUNDWATER-RELATED WETLAND GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Skadarsko Lake **Wetland general type(2)**: 2A
2. **Municipality, country**: Podgorica, Bar, Montenegro **Coordinates (geographical):** 42°10' N; 19°16' E
3. **Wetland surface (km^2)(3)**: 395 **Elevation (m) maximum-average**: 10-4
   Average depth/length/width (m)(3): 6/14,000/40,000
4. **Contributing surface area (km^2)**: 5490
5. **Contributing aquifer area (km^2)**: Unknown **Aquifer type(4)**: Water table
6. **Mean rainfall (mm/y)(5)**: 1800 **Mean T (°C)(5)**: 15 **Mean ET (mm/y)(5)**: 1260
7. **Underlying lithology(6)**: Carbonated sediments
8. **Wetland genesis(7)**: Tectonic
9. **Wetland sediments(8)**: Sandy
10. **Water source(9)**: Runoff in the basin; Shallow groundwater
11. **Groundwater flow type(10)**: Flow through; Discharge area, open; Crypto-wetland **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: Permanent
13. **Hydrochemistry(13)**: Electrical conductivity 0.3 mS/cm; dominant anion/s: HCO_3; dominant cation/s: Ca and Mg
14. **Dominant vegetation(14)**: Shrubs, bushes
15. **Trophic state(15)**: Eutrophic
16. **Functionality(16)**: Almost unaltered
17. **State of knowledge(17)**: Validated hydrogeological conceptual model; Numerical model; Chemical/isotopic information; Biological information; Socioeconomic information; Water level monitoring; Water quality monitoring; Hydrogeological studies; Information on use of wetland
18. **Management status(18)**: Ramsar site; Nature Reserve

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Water abstraction
20. **Changes in land use(20)**: Deforestation; Replacement of species; Extensive agriculture; Urbanization
21. **Modification of hydrological cycle(21)**: Drainage; Input of excess irrigation; Storage usage; Input of urban wastewater
22. **Pollution(22)**: Agricultural diffuse pollution; Urban/industrial point source pollution
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Invasive exotic species; Native species extinction
24. **Effects associated with changes(24)**: Chemical water quality
25. **Global and climate changes(25)**: Rainfall; Temperature; Sea level rise

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:
   26a. Natural production of food: Cropping; Livestock; Fishing; Fruit collection; Hunting
   26b. Artificial production of food: Agriculture
   26c. Others: Supply of good-quality water; Water supply for different uses; Production of biological source materials; Production of mineral source materials
27. **Regulating services(27) (Status; Trend)**: Natural species of medicinal interest; Hydrological regimes (floods, drought); Water purification; Morpho-sedimentary regulation; Biological control; C sink and global regulation; Air quality regulation; Local climate regulation
28. **Cultural services(28) (Status; Trend)**: Tourism; Educational and scientific knowledge; Local knowledge and good practices; Landscape and aesthetic; Cultural identity and sense of belonging; Religious and spiritual

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GROUNDWATER-RELATED WETLAND 2 GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Tivatska solila — **Wetland general type(2)**: 1R
2. **Municipality, country:** Tivat, Montenegro — **Coordinates (geographical):** 42°23'56" N, 18°42'54" E
3. **Wetland surface (km2)(3)**: 1.5 — **Elevation (m) maximum–average**: <1

   Average depth/length/width (m)(3): ?/1600/1000
4. **Contributing surface area (km²)**: 35
5. **Contributing aquifer area (km²)**: 7 — **Aquifer type(4)**: Water table
6. **Mean rainfall (mm/y)(5)**: 1500 — **Mean T (°C)(5)**: 15 — **Mean ET (mm/y)(5)**: 1200
7. **Underlying lithology(6)**: Carbonated sediments
8. **Wetland genesis(7)**: Coastal sedimentation; Artificial
9. **Wetland sediments(8)**: Sandy
10. **Water source(9)**: Shallow groundwater
11. **Groundwater flow type(10)**: Flow through — **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12):** Permanent
13. **Hydrochemistry(13)**: EC: > 15 mS/cm. Dominant anions/cations: Cl/Na
14. **Dominant vegetation(14)**: Shrubs, bushes
15. **Trophic state(15)**: Eutrophic
16. **Functionality(16)**: Moderately altered
17. **State of knowledge(17)**: Biological information; Information on use of wetland
18. **Management status(18)**: Ramsar site, Nature Reserve

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Water abstraction; Biological exploitation; Mineral exploitation
20. **Changes in land use(20)**: Deforestation; Urbanization; Roads
21. **Modification of hydrological cycle(21)**: Drainage; Input of excess irrigation; Storage usage; Input of urban wastewater
22. **Pollution(22)**: Agricultural diffuse pollution; Urban/industrial point source pollution
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Unknown
24. **Effects associated with changes(24)**: Increased erosion; Soil destruction
25. **Global and climate changes(25)**: Rainfall; Temperature; Sea level rise

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:

    26a. Natural production of food: **Cropping, Fishing and Fruits collection (Low; Unknown);** Livestock (Moderate; Continuing); Hunting (Moderate; Moderately increasing)

    26b. Artificial production of food:

    26c. Others: Water supply for different uses (Moderate; Moderately increasing); Production of biological source materials, Supply of good quality water and Natural species of medicinal interest (Low; Continuing)
27. **Regulating services(27) (Status; Trend)**: Hydrological regimes (floods, drought), Water purification and Morpho-sedimentary regulation (Moderate; Continuing); Carbon sink and global regulation (High; Moderately decreasing); Local climate regulation (Moderate; Moderately decreasing); Air quality regulation (Low; Moderately decreasing)
28. **Cultural services(28) (Status; Trend)**: Tourism (High; Very rapidly increasing); Educational and scientific knowledge and Landscape and aesthetic (Moderate; Continuing); Local knowledge and good practices (Moderate; Moderately increasing); Cultural identity and sense of belonging (Low; Continuing)

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Figure 2.1.9.1. Some general views of Skadar lake. Source: D. Radojevic.

2.1.10 MOROCCO WETLANDS COUNTRY REPORT

Nour Eddine Laftouhi

GROUNDWATER-RELATED WETLAND GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Lagune de Bou Areg **Wetland general type(2)**: 2AL
2. **Municipality, country**: Nador, Morocco **Coordinates (geographical):** 35°10' N–2°45'-2°57' W
3. **Wetland surface (km²)(3)**: 115-140 **Elevation (m) maximum-average**: 50-0.5
   Average depth/length/width (m)(3): 8/25,000/15,000
4. **Contributing surface area (km²)**: 115
5. **Contributing aquifer area (km²)**: 250 **Aquifer type(4)**: Water table
6. **Mean rainfall (mm/y)(5)**: 350 **Mean T (°C)(5)**: 27 **Mean ET (mm/y)(5)**: 860
7. **Underlying lithology(6)**: Siliceous sediments; Carbonated sediments; Carbonate rocks; Evaporite rocks; Metamorphic rocks
8. **Wetland genesis(7)**: Erosive; Dune morphology; Coastal sedimentation
9. **Wetland sediments(8)**: Sands; Clay; Silts
10. **Water source(9)**: Rainfall on the wetland; Runoff in the basin; Shallow groundwater; Sea (tidal/wave influence)
11. **Groundwater flow type(10)**: Flow through **Groundwater dependence(11)**: Dominant
12. **Hydroperiod(12)**: Permanent/seasonal
13. **Hydrochemistry(13)**: CE: 0.5-56 mS/cm; dominant anion/s: Cl- SO_4; dominant cation/s: Na-Mg
14. **Dominant vegetation(14)**: Shrubs, bushes; Prairie; Halophytic vegetation
15. **Trophic state(15)**: Mesotrophic
16. **Funtionality(16)**: Highly altered
17. **State of knowledge(17)**: Validated hydrogeological conceptual model numerical model; Chemical/isotopic information; Biological information; Hydrogeological studies; Climate change impact studies
18. **Management status(18)**: Ramsar site; Nature Reserve; Other management authority

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: From wetland, No data; From tributaries, unknown; Groundwater next to the wetland, moderate impact/continuing trend; Groundwater basin, high impact/moderately increasing trend
20. **Changes in land use(20)**: Replacement of species, low impact and continuing trend; Extensive agriculture, low impact and continuing trend; Extensive cattle raising, No data; Urbanization, high impact/continuing trend (may be moderately increasing); Roads, moderate impact/continuing trend
21. **Modification of hydrological cycle(21)**: Drainage, moderate impact/continuing trend; Input of excess irrigation: moderate impact/continuing trend; Storage usage: high impact/moderately increasing trend; Artificial recharge: No data; Input of urban wastewater: high impact/continuing trend
22. **Pollution (22)**: Agricultural diffuse pollution: high impact/moderately increasing trend; Atmospheric diffuse pollution: unknown; Urban/industrial point source pollution: high impact/moderately increasing trend
23. **Alteration of biological communities' structures and ecosystems functioning (23)**: Unknown
24. **Effects associated with changes (24)**: Chemical water quality: high impact/moderately increasing trend; Biological water quality: unknown; Oxidation by lowering water table: unknown; Increased erosion: high impact/moderately increasing trend; Soil destruction: unknown
25. **Global and climate changes (25)**: Rainfall: moderate/moderately decreasing; Temperature: moderate/moderately increasing; Sea level rise: moderate/moderately increasing

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services** [26] **(Status; Trend)**:

    26a. Natural production of food: Livestock (Moderate; Continuing); Fishing (Low; Continuing); Cropping and Fruit collection (Low; Unknown)

    26b. Artificial production of food: Agriculture (Low; Unknown)

    26c. Others: Supply of good-quality water, Water supply for different uses, Production of biological source materials and Production of mineral source materials (Low; Continuing); Natural species of medicinal interest (High; Continuing)

27. **Regulating services**[27] **(Status; Trend)**: Hydrological regimes (Moderate; Moderately decreasing); Water purification and Morpho-sedimentary regulation (Low; Continuing); Local climate regulation (Moderate; Moderately increasing)
28. **Cultural services**[28] **(Status; Trend)**: Tourism, Educational and scientific knowledge and Local knowledge and good practices (Moderate; Moderately increasing); Landscape and aesthetic and Cultural identity and sense of belonging (Low; Continuing)

ADDITIONAL INFORMATION/COMMENTS

GROUNDWATER-RELATED WETLAND 2 GENERAL DATA

[x] Refers to the numbers in the legend chart.

1. **Name of wetland**[1]: Estuaire Oued Laou — **Wetland general type**[2]: 2HKN
2. **Municipality, Country**: Martil, Morocco — **Coordinates (geographical)**: 35°36'12.8"N;**5°16'24.4"** W
3. **Wetland surface (km^2)**[3]: 18 — **Elevation (m) maximum–average:** 20-2

   Average depth/length/width (m)[3]**:** 6/70,000/200-500
4. **Contributing surface area (km^2)**: 18
5. **Contributing aquifer area (km^2)**: 18 — **Aquifer type**[4]: Water table
6. **Mean rainfall (mm/y)**[5]: 630 — **Mean T (°C)**[5]**:** 18.3 — **Mean ET (mm/y)**[5]: 1022
7. **Underlying lithology**[6]: Siliceous sediments; Carbonate sediments
8. **Wetland genesis**[7]: Tectonic; Erosive; Flood plain; Delta/Estuarial deposits; Coastal sedimentation
9. **Wetland sediments**[8]: Sandy; Silty; Clayey
10. **Water source**[9]: Rainfall on the wetland; Runoff in the basin; Shallow groundwater; Fluvial inundation; Sea (tidal/wave influence)
11. **Groundwater flow type**[10]: Flow through; Discharge area; Closed saline — **Groundwater dependence**[11]: Shared
12. **Hydroperiod**[12]: Permanent/Seasonal
13. **Hydrochemistry**[13]: CE: 3.6 mS/cm; dominant anion/s: HCO_3; dominant cation/s: Ca-Mg
14. **Dominant vegetation**[14]: Bushes; Prairie; Halophytic vegetation
15. **Trophic state**[15]: Mesotrophic
16. **Funtionality**[16]: Highly altered
17. **State of knowledge**[17]: Chemical/isotopic information; Biological information; Water level Monitoring; Hydrogeological studies
18. **Management status**[18]: Ramsar site; Nature Reserve; Other management authority

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation**[19]: From wetland, No Data; From tributaries, high impact and moderately increasing trend; Groundwater next to the wetland, high impact/moderately increasing trend; Groundwater basin, high impact/moderately increasing trend; Crops: high impact/continuing trend
20. **Changes in land use**[20]: Replacement of species, No data; Extensive agriculture, moderate impact/continuing trend; Extensive cattle raising, moderate impact/continuing trend; Urbanization, high impact/continuing trend (may be moderately increasing); Roads, moderate impact/continuing trend
21. **Modification of hydrological cycle**[21]: Drainage, high impact and continuing trend; Input of excess irrigation: low impact and continuing trend; Storage usage: high impact, unknown trend; Artificial recharge: moderate impact/continuing Trend; Input of urban wastewater: moderate impact/continuing Trend
22. **Pollution** [22]: Agricultural diffuse pollution: moderate impact/moderately decreasing trend; Atmospheric diffuse pollution: unknown; Urban/industrial point source pollution: high impact/moderately increasing trend
23. **Alteration of biological communities' structures and ecosystems functioning** [23]:

24. **Effects associated with changes** (24): Chemical water quality: unknown; Biological water quality: high impact/moderately increasing trend; Oxidation by lowering water table: moderate impact/continuing trend; Increased erosion: low impact/continuing trend; Soil destruction: low impact/continuing trend
25. **Global and climate changes** (25): Rainfall: high impact/moderately increasing trend; Temperature: high impact/moderately increasing trend; Sea level rise: high impact/moderately increasing trend

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services** (26) **(Status; Trend)**:

    26a. Natural production of food: Fishing (Low; Moderately decreasing); Cropping and Fruits collection (Low; Unknown)

    26b. Artificial production of food: Agriculture (Low; Continuing)

    26c. Others: Water supply for different uses (Low; Continuing);
27. **Regulating services**(27) **(Status; Trend)**: Hydrological regimes (Moderate; Moderately decreasing); Local climate regulation (High; Continuing)
28. **Cultural services**(28) **(Status; Trend)**: Tourism (High; Continuing); Educational and scientific knowledge and Local knowledge and good practices (Moderate; Continuing); Landscape and aesthetic (Low; Continuing)

ADDITIONAL INFORMATION/COMMENTS

GROUNDWATER-RELATED WETLAND 3 GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland**(1): Estuaire Oued Moulouya **Wetland general type**(2): 2HKN
2. **Municipality, Country**: Berkane, Morocco **Coordinates (geographical)**: 35° 06’50.8” N; 2°20’45.5” W
3. **Wetland surface (km²)**(3): 27 **Elevation (m) maximum-average**: 20-0.6

   Average depth/length/width (m)(3): 6/300/40-100
4. **Contributing surface area (km²)**: 27
5. **Contributing aquifer area (km²)**: diffuse **Aquifer type**(4): Water table
6. **Mean rainfall (mm/y)**(5): 550 **Mean T (°C)**(5): 18.6 **Mean ET (mm/y)**(5): 1200
7. **Underlying lithology**(6): Siliceous sediments; Silts; Clays
8. **Wetland genesis**(7): Erosive; Flood plain; Delta/Estuarial deposits; Coastal sedimentation
9. **Wetland sediments**(8): Sands; Clay; Silts
10. **Water source**(9): Rainfall on the wetland; Runoff in the basin; Shallow groundwater; Sea (tidal/wave influence)
11. **Groundwater flow type**(10): Flow through; Discharge area, closed saline **Groundwater dependence**(11): Shared
12. **Hydroperiod**(12): Permanent/Seasonal
13. **Hydrochemistry**(13): CE: 2.5-3 mS/cm; dominant anion/s: HCO_3; dominant cation/s: Ca-Mg
14. **Dominant vegetation**(14): Bushes; Prairie; Halophytic vegetation
15. **Trophic state**(15): Mesotrophic
16. **Funtionality**(16): Highly altered
17. **State of knowledge**(17): Chemical/isotopic information; Biological information; Water level monitoring; Hydrogeological studies
18. **Management status**(18): Ramsar site; Nature Reserve; Other management authority

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation**(19): From wetland, No Data; From tributaries, high impact /moderately increasing trend; Groundwater next to the wetland, high impact/moderately increasing trend; Groundwater basin, high impact/moderately increasing trend; Crops: high impact/continuing trend
20. **Changes in land use**(20): Replacement of species, No data; Extensive agriculture, moderate impact/continuing trend; Extensive cattle raising, moderate impact/continuing trend; Urbanization, high impact/continuing trend (may be moderately increasing); Roads, moderate impact/continuing trend
21. **Modification of hydrological cycle**(21): Drainage, high impact/continuing trend; Input of excess irrigation: low impact/continuing trend; Storage usage: high impact and unknown trend; Artificial recharge: moderate impact/continuing Trend; Input of urban wastewater: moderate impact/continuing Trend

22. Pollution [22]: Agricultural diffuse pollution: moderate impact/moderately decreasing trend; Atmospheric diffuse pollution: unknown; Urban/industrial point source pollution: high impact/moderately increasing trend

23. Alteration of biological communities' structures and ecosystems functioning [23]: Non-existent

24. Effects associated with changes [24]: Chemical water quality: unknown; Biological water quality: high impact/moderately increasing trend; Oxidation by lowering water table: moderate impact/continuing trend; Increased erosion: low impact/ continuing trend; Soil destruction: low impact/continuing trend

25. Global and climate changes [25]: Rainfall: high impact/moderately increasing trend; Temperature: high impact/moderately increasing trend; Sea level rise: high impact/moderately increasing trend

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. Provisioning services [26]:

26a. Natural production of food: Fishing (Low; Moderately decreasing); Livestock (Moderate; Continuing); Cropping and Fruits collection (Low; Unknown)

26b. Artificial production of food: Agriculture (Low; Continuing)

26c. Others: Water supply for different uses (Low; Continuing); Natural species of medicinal interest (High; Continuing)

27. Regulating services[27] **(Status; Trend)**: Hydrological regimes (Moderate; Moderately decreasing); Local climate regulation (High; Continuing)

28. Cultural services[28] **(Status; Trend)**: Tourism (High; Continuing); Educational and scientific knowledge (Moderate; Continuing); Local knowledge and good practices (Moderate; Moderately increasing); Landscape and aesthetic (Low; Continuing)

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2.1.11 PALESTINE WETLANDS COUNTRY REPORT

Khalid Qahman

GROUNDWATER-RELATED WETLAND GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Wetland of Wadi Gaza — **Wetland general type(2)**: 2AHJ
2. **Municipality, Country**: Gaza, Palestine — **Coordinates (geographical):** 31°26'33"-31° 27' 32" N; 34°22'37"-34°24'35" E
3. **Wetland surface (km^2)(3)**: 0.25 — **Elevation (m) maximum-average**: <1
   Average depth/length/width (m)(3): 1.0/1000/100
4. **Contributing surface area (km^2)**: 3600
5. **Contributing aquifer area (km^2)**: 365 — **Aquifer type(4)**: Water table
6. **Mean rainfall (mm/y)(5)**: 335 — **Mean T (°C)(5)**: 20 — **Mean ET (mm/y)(5)**: 1582
7. **Underlying lithology(6)**: Carbonated sediments
8. **Wetland genesis(7)**: Estuary; Flood plain
9. **Wetland sediments(8)**: Sandy; Clayey
10. **Water source(9)**: Rainfall on the wetland; Runoff in the basin; Shallow groundwater
11. **Groundwater flow type(10)**: Recharge — **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: Variable
13. **Hydrochemistry(13)**: EC (mS/cm) 1.5-3.3; dominant anion/s: HCO_3; dominant cation/s: Na
14. **Dominant vegetation(14)**: Shrubs, bushes; Halophytic vegetation; Phreatophyte vegetation
15. **Trophic state(15)**: Eutrophic
16. **Funtionality(16)**: Highly altered
17. **State of knowledge(17)**: Chemical/isotopic information; Biological information; Socioeconomic information; Water level monitoring; Groundwater level monitoring; Water quality monitoring, Groundwater quality monitoring; Hydrogeological studies
18. **Management status(18)**: Nature Reserve; Other

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Wadi Gaza wetland area is located in the south-west of the Wadi at the Wadi's mouth. It covers a small area (about 25 ha) compared to other wetlands in the world. The water table of the aquifer in the wetland intersects with the topography and emerges at the surface. Another source of fresh water supplying the wetland ecosystem is storm water that accumulates during the rainy season. Untreated wastewater is discharged from the adjacent residential properties into Wadi Gaza and hence its wetland, yet it is very rich in biodiversity and of great significance to migrating birds from Europe to Africa in autumn. Information gathered from meetings with local people and an archaeologist working at the site of Wadi Gaza suggests that the wetland site of Wadi Gaza is old as the wadi itself. Interviews with the local community confirm that until the late 1960s the wetland site was much larger than it is now. Local people say that the wetland site was permanently flooded and that it was like a jungle, describing the water seeping out from it in those days as "very sweet". The pressure put on land and groundwater after the second Palestinian migration in 1948 (due to the concentration of large numbers of people in the small area of the Gaza Strip and Israeli activities upstream) was the main cause of the deterioration of Wadi Gaza and the wetland.

    Figure 2.1.11.1 shows the number of agricultural wells in the neighbourhood of Wadi Gaza between 1970 and 2005. In 1970, the agricultural abstraction from groundwater was very low, and remained at about this rate until 1973. In this year, the abstraction rate increased suddenly, because of the increase in citrus cultivation.

    The Israelis built reservoirs and dams along the upstream branches of the Wadi to use the water for irrigation and other uses. Examples of such reservoirs are shown in Figure 2.1.11.2. One of the reservoirs is constructed on the Wadi Al Sharia and the other on the Wadi Al Shallala (Rabah, 2010).

Figure 2.1.11.1 Historical construction of agricultural wells in the Wadi Gaza area. Source: K. Qahman.

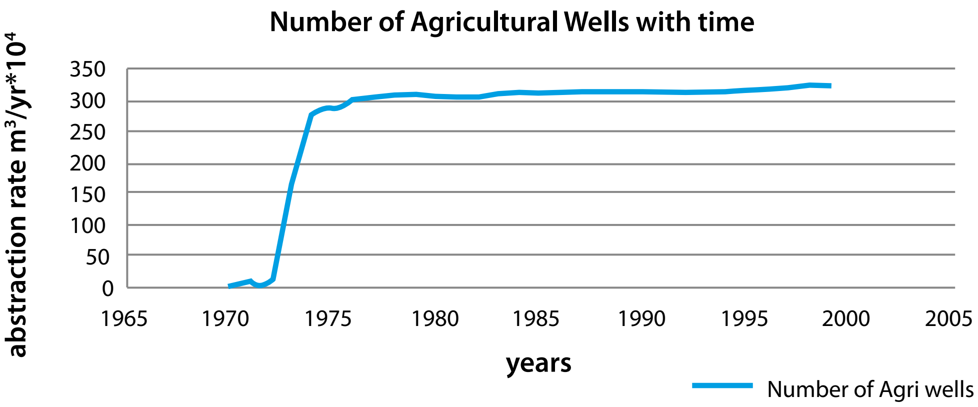
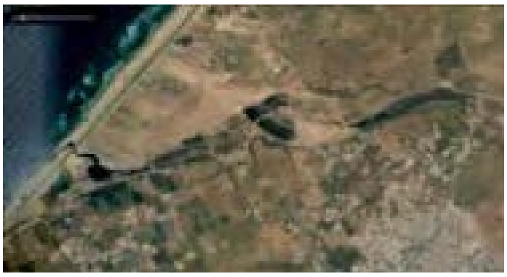


Figure 2.1.11.2 Examples of reservoirs constructed on the upstream branches of Wadi Gaza

Figure 2.1.11.3 Historical development in the vicinity of Wadi Gaza wetland. Source: K. Qahman.


December 2004


May 2005


June 2007


August 2011

20. Changes in land use[20]: Before the 1990s, Wadi Gaza and the lake at the mouth of the Wadi were considered to be natural areas. Agricultural lands and biological diversity characterized the surroundings. The agricultural land along the Wadi was very productive, with grapes in the west, citrus and olives in the centre and rain-fed crops in the east. This period was followed by huge, random and mostly unplanned developments, as people found incomes had increased following job opportunities and they started to expand horizontally in order to improve living conditions. This development and changes in regulation in the area along the Wadi has reduced the agricultural land (Figure 2.1.11.3). Large-scale infrastructure projects also featured in this period. Wadi Gaza bridge was built on the coastal road and other activities followed; a dam beside the bridge was piled to prevent the flow of water from the Wadi to the sea; and the construction of a power plant was started in 2001 just beside the Wadi to the south. The power plant area was previously used as agricultural land.

The period after 2005 featured unplanned development of both large-scale and small-scale projects. In the south, a temporary wastewater treatment plant has been built in the lake at the mouth of the Wadi and is expected to start operating in few months (Figure 2.1.11.4). It is intended to serve the middle area of the Gaza Strip (central area communities) for a temporary period until the construction of Central Gaza wastewater treatment plant. The design flow of the temporary treatment plant is 18,000 m^3/d and it comprises: inlet works (bar screen); one anaerobic pond; one aerated lagoon; and a settling and maturation lagoon. The treated effluent is discharged to the sea by a gravity line. This treatment plant will be taken out of service when the Central Gaza wastewater treatment plant is ready for operation.

In addition, there has been a change in the use of the land to the north of the lake from agricultural grape cultivation to residential or recreational.

Large, privately owned agricultural units were divided into small parcels and people started to develop these for many purposes (Figure 2.1.11.5). The main construction activities are for recreation; 10-15% of the parcel is built upon and the rest used for gardens. The boundaries of private parcels are moving closer to the lake boundaries, and in some cases are less than 20 m from the lake. As a result of land divisions a new small road network has appeared, leading to the lake.

Land uses in the catchment area can be classified into urban, agricultural and Wadi bed. Urban areas include residential, services and large-scale projects; agriculture includes rain-fed crops, olives, horticulture, greenhouses and natural areas; and the Wadi bed and wetlands include dry lands and wetlands.

21. Modification of hydrological cycle[21]:

1. Hydrology of Wadi Gaza: Wadi Gaza is a seasonal surface water stream that runs during the winter after rain events, due to surface runoff of storm water. The watershed (catchment area) originates in the Hebron Mountains and Northern Negev and ends at the Mediterranean Sea; it has a total (approximate) area of 3500 km^2 and a total length of 105 km (Figure 2.1.11.6). The main tributaries of Wadi Gaza are Wadi Al Sharia (starting in the Hebron Mountains) and Wadi Al Shallala (starting in the heights of the northern Negev). The two tributaries join at a point approximately 2 km east of the Gaza Strip border to form the so-called Wadi Gaza (MEDWET, 2001).

The catchment area of the Wadi within the Gaza Strip extends over a distance of 9 km, which is very small compared to the 105 km total length of the Wadi, and has an area of 60 km^2 out of the total catchment of 3500 km^2. This illustrates the fact that the source of Wadi Gaza runoff during rainstorms is from the outside of Gaza and under the control of the Israelis. The catchment area within the Gaza Strip is composed of six sub-catchments (C11-C17) (MEDWET, 2002).

2. Hydrological data of Wadi Gaza site: As a result of the upstream control structures (reservoirs and dams on the Israeli side) the natural hydrology of Wadi Gaza has been changed. An example of this change is that Wadi Gaza became almost dry and runs only once or twice a year at times when the Israeli reservoirs are full or under maintenance. A second example of the hydrological changes is the extreme increase of the peak flow in the Wadi following sudden opening of the control structures at the Israeli side during serious storm events. Such peak flows have caused destructive floods in Wadi Gaza over the last three decades since the construction of the above-mentioned structures (Figure 2.1.11.7).

Figure 2.1.11.4 Layout of existing and planned pipelines to Wadi Gaza temporary wastewater treatment plant. Source: K. Qahman.

Figure 2.1.11.5 Urban development on a former agricultural area to the north of the lake. Source: K. Qahman.

Figure 2.1.11.6 Watershed (catchment area) of Wadi Gaza. Source: K. Qahman.

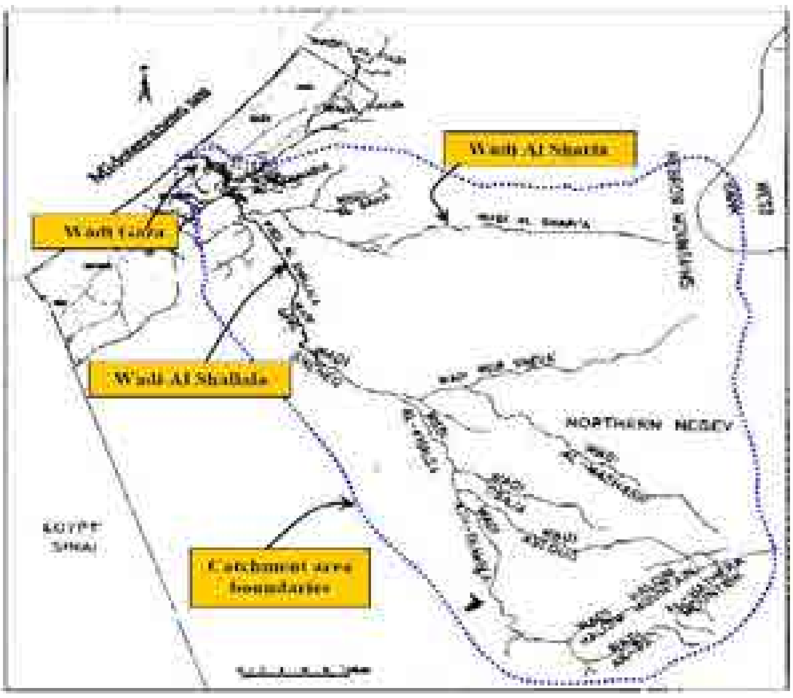
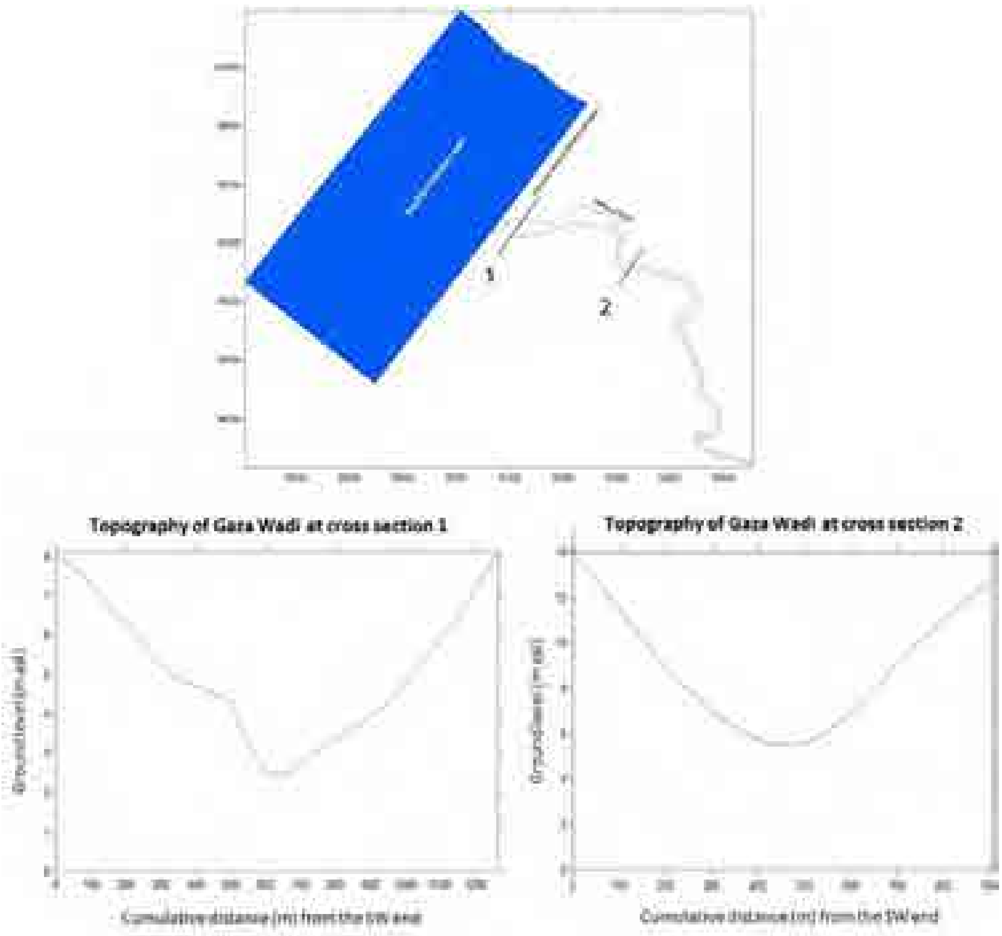


Figure 2.1.11.7 Selected photos showing flash floods in Wadi Gaza. Source: K. Qahman.

▲ Wadi Gaza flash flood January 2010

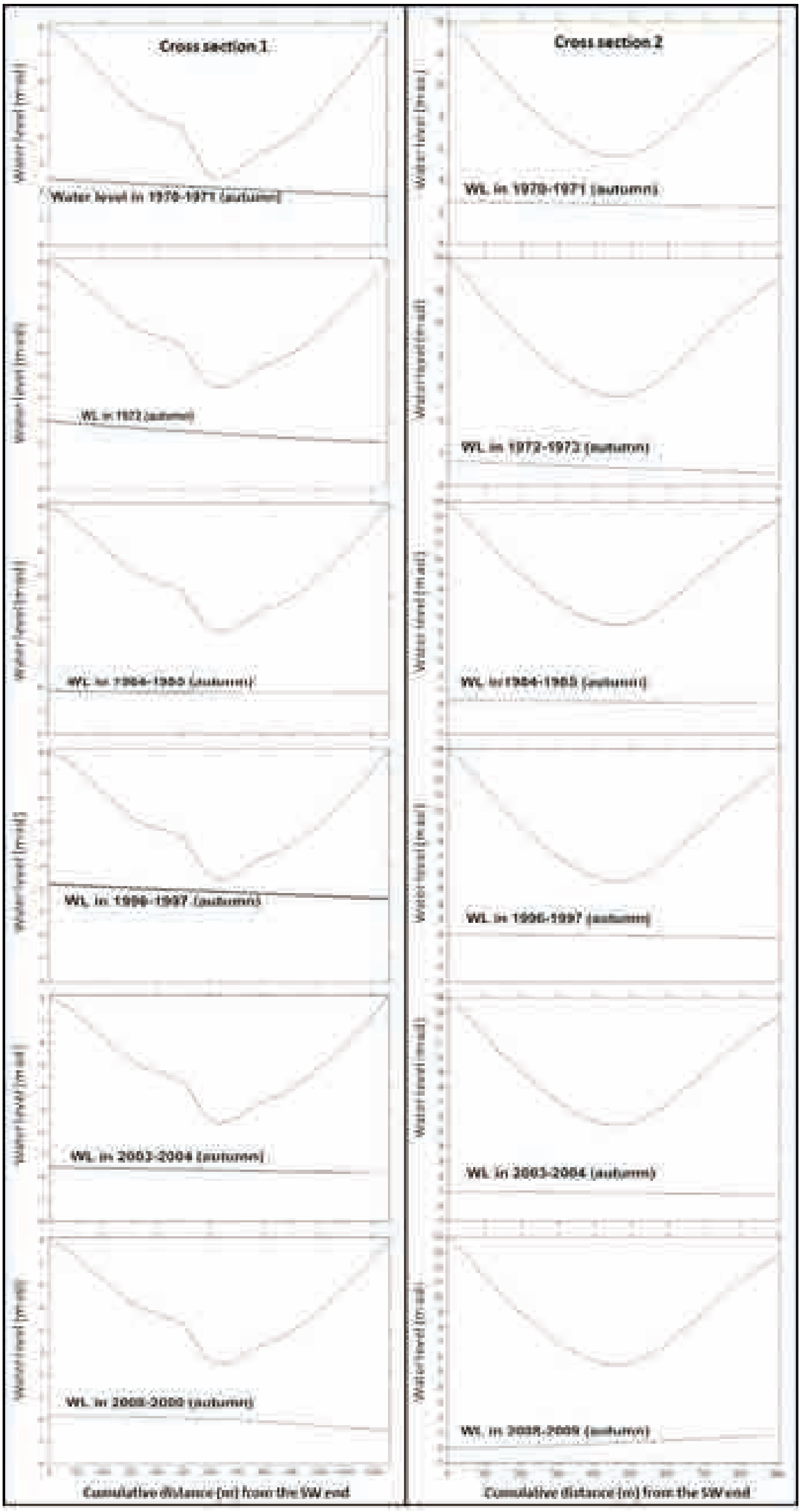
▼ Wadi Gaza flash flood, December 2013

Figure 2.1.11.8 Up: Location of the cross sections studied in Wadi Gaza. Source: K. Qahman.



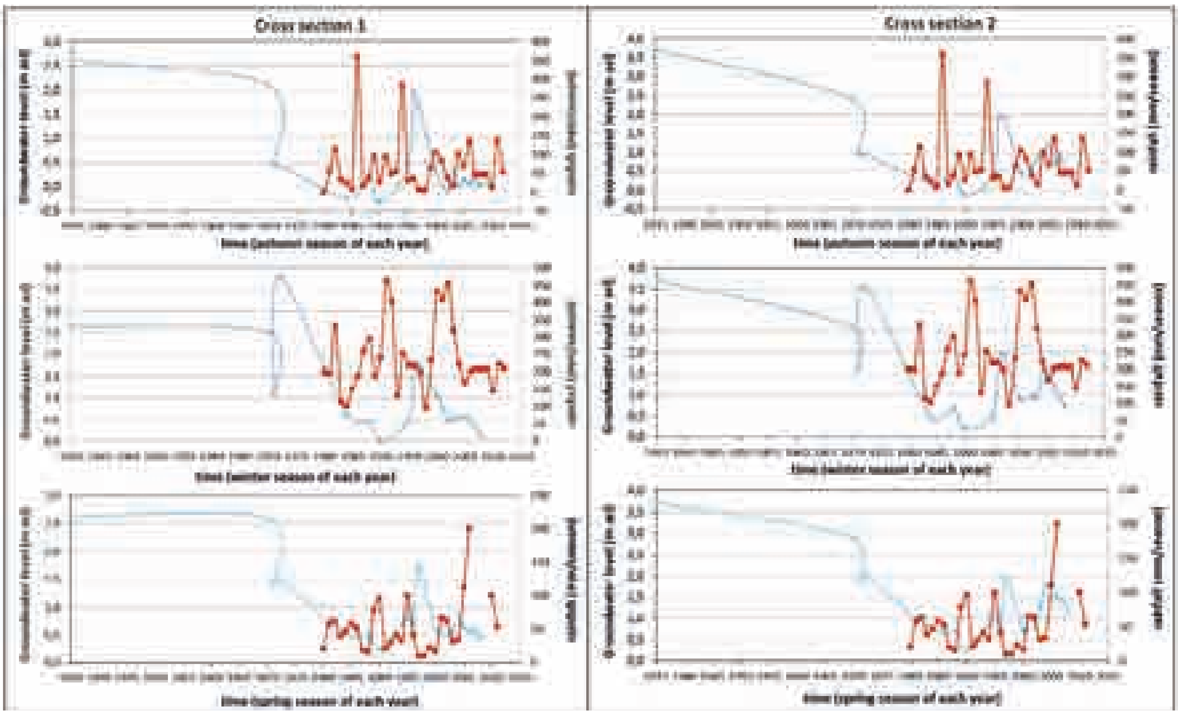
▲ Topography of Wadi Gaza at cross sections 1 and 2. The cumulative distances increase from SW to NE

Figure 2.1.11.9 Evolution of groundwater level (WL) in the autumn seasons of years 1970 to 2009 (surveys performed between September 15 and November 30) at cross sections 1 (left) and 2 (right). Source: K. Qahman.



The cumulative distances increase from SW to NE

Figure 2.1.11.10 Total rainfall amounts and groundwater level for the autumn seasons of several years at sections 1 and 2.
Source: K. Qahman.



Surface water and groundwater interaction

The only exact hydrological data available for the Wadi Gaza site are rainfall data and groundwater level, and analysis of these two data in the region of Wadi Gaza was carried out in order to identify interaction between the wetland and the aquifer in Wadi Gaza.

Study has focused on two cross sections for Wadi Gaza to examine the two main factors that affect the situation in its wetland. The first cross section is approximately 100 m from the mouth of Wadi Gaza, and the second is approximately 550 m away, as shown in Figure 2.1.11.8. The first cross section has a width of 1200 m and the second cross section 900 m. They were located to observe the groundwater–wetland interaction. Figure 2.1.11.8 also shows the variation in topography with distance at cross sections (1) and (2). The variation of groundwater level at cross sections 1 and 2 are shown for the period 1970 to 2009 as autumn season data (Figure 2.1.11.9) and winter season data (Figure 2.1.11.10). The variation in water level with the amount of precipitation in each season for the same hydrological years was also analysed, to identify the effects of rainfall on water levels and wetland (Figure 2.1.11.10).

As mentioned above, the precipitation data and observed water level data for many hydrological years were used to observe the interaction between aquifer and wetland in Wadi Gaza. Figure 2.1.11.9 shows the variation in groundwater levels through cross sections (1) and (2) in the autumn of different hydrological seasons.

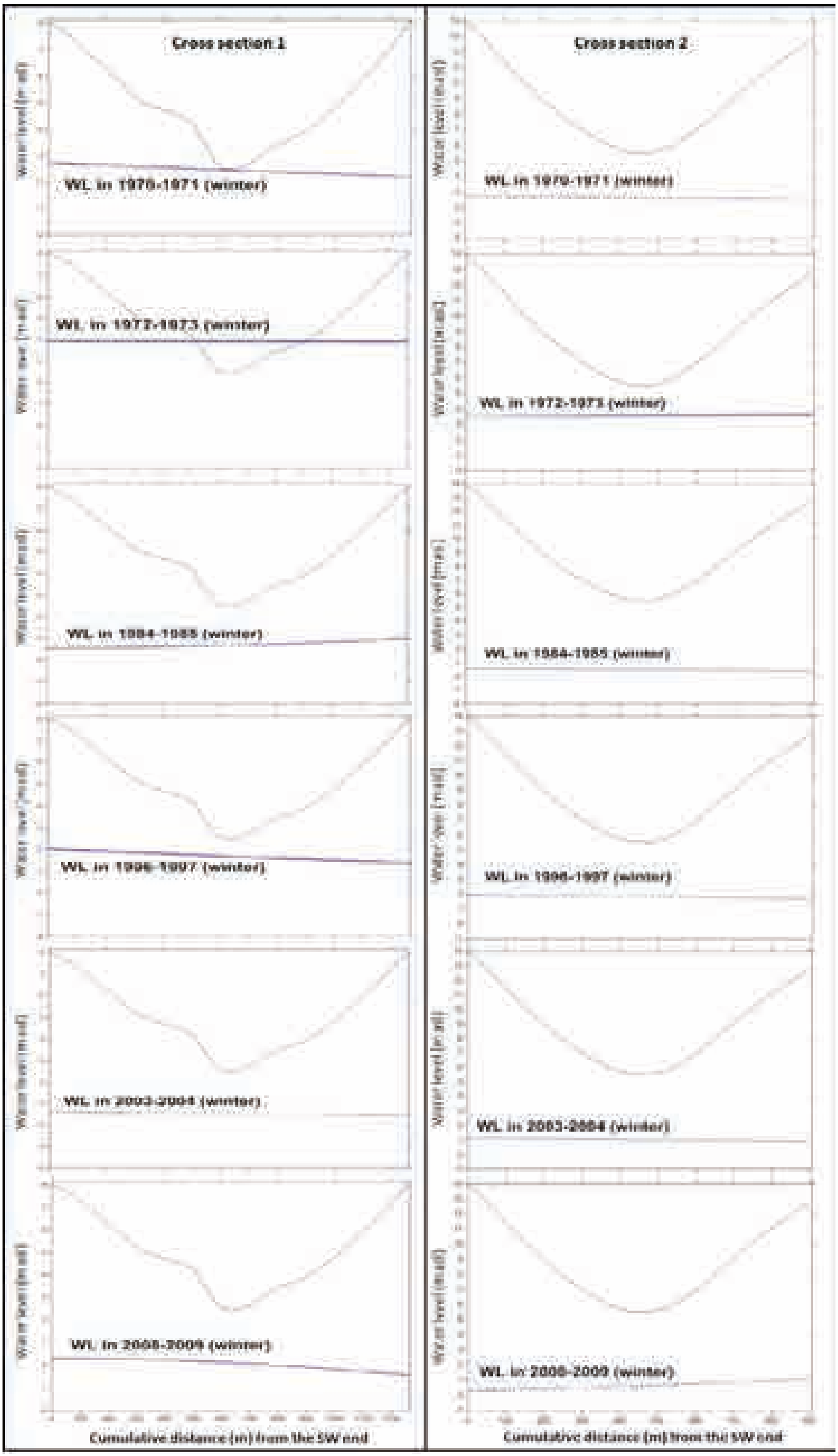
Figure 2.1.11.10 shows the variation in groundwater level and the amount of rainfall in the autumn of the years 1935-2012 at cross sections (1) and (2). It is clear that, in 1935, the groundwater level was around 2.6 m and 3.6 m at cross sections 1 and 2, respectively. From this time, the groundwater level gradually decreased to about 0.7 m in 1985; the level then fluctuated and rose suddenly to around 2 m in 1992, and decreased again to around 0.5 m in 2000, remaining in the same range until 2008.

The rainfall data show a fluctuation from about zero to around 350 mm in autumn; the highest levels of rainfall were in 1986 and 1995.

By observing the patterns of groundwater level with rainfall versus time, we can infer that higher rainfall in any year is followed by a higher groundwater level in the next year or period, and that lower rainfall in any year is followed by a lower groundwater level in the next year or period. This observation takes no account of the effect of abstraction, a factor which we will review later.

Next, groundwater levels and rainfall data in winter and their effects on the wetland were reviewed. Figure 2.1.11.11 makes it clear that the water levels in the early 1970s were high with respect to the ground level of Wadi Gaza, at about 2.8-4 m and 2.8-3.5 m at cross sections (1) and (2), respectively. After that period, from the late 1970s to the early 1980s, groundwater levels declined significantly to a level of about 0.5 m at the two cross sections mentioned above. Finally, from the early 1980s to the present day there are fluctuations in groundwater levels within a range of 0 m to 1.5 m.

Figure 2.1.11.11 Evolution of groundwater level (WL) in the winter seasons of years 1970-1971 to 2008-2009 (surveys performed between December 15 and February 28) at cross sections 1 (left) and 2 (right). Source: K. Qahman.



The cumulative distances increase from SW to NE

Figure 2.1.11.12 Wastewater and solid waste dumping in Wadi Gaza, March 2014. Source: K. Qahman.

22. Pollution[22]: The wetland ecosystem of Wadi Gaza is a major source of mosquitoes (Diptera: Culicidae) in the Gaza Strip due to its water content that comes from different sources including wastewater. Local inhabitants frequently complain of mosquito proliferation and ask the responsible parties for urgent solutions. Solid waste dumping and eutrophication are the main pollution threats in the Wadi Gaza wetland area (Figure 2.1.11.12). The latter generally occurs whenever either fresh or saline waters receive excessive sewage or farm fertilizer runoff.

At present Wadi Gaza receives about 12000 m^3 of untreated wastewater daily, a figure expected to reach 18,000 m^3 by the beginning of 2020. This causes the large blooms of algae clogging waterways and preventing sunlight from penetrating into the water. When the algae die and begin to rot the process uses vast amounts of dissolved oxygen contained in the water. The warmth of summer in the Wadi Gaza encourages the speed at which the algae grow.

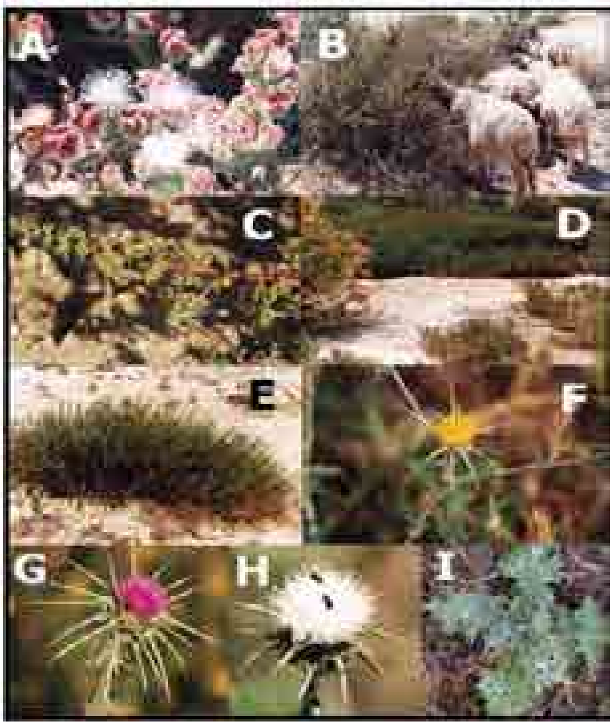
23. Alteration of biological communities structures and ecosystems functioning[23]: Wadi Gaza is an indispensable part of the natural heritage in Palestine and has a rich biodiversity in terms of fauna and flora (Figure 2.1.11.13). As many as 70 plant species belonging to 32 families and 24 orders were identified during the spring of 2004. The aster or daisy family (Compositae) was the largest family and comprised 14 plant species (20%) of the recorded species (Abd Rabou and others, 2008a).

The vegetation in the Wadi is dominated by tamarisk growing on the dunes and sand deposits in and around the Wadi bed. The wetter areas have stands of *Typha* spp. which also fringe the water body near the outlet to the sea. Around 125 ha of saltmarshes recorded in the Gaza Environmental Profile of 1994 have disappeared following construction of the sea bridge at the mouth of the Wadi Gaza in 1996. This has disrupted the outlet, affected windblown sand deposition, improved access to the public and generally modified the whole of the ecology and geomorphology of the Wadi Gaza estuary. The bridge foundations have also blocked the course of the river and therefore raised the level of water in the wetland. While this may be the case, it is evident that sand accumulation, either brought down by Wadi Gaza in recent floods, or deposited during sea storm events, is the other proximate cause of the blockage. During westerly storms, seawater may be pushed over the sand barrier into the Wadi, maintaining brackish conditions in the downstream part of the system.

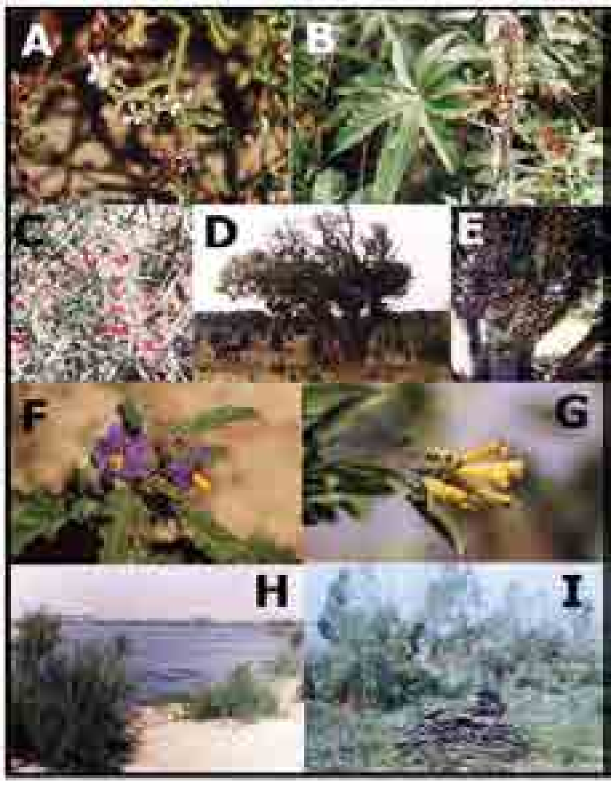
Birds are considered good indicators of the degree of human disturbance to various ecosystems, and so a 2-year field survey of the birds of Wadi Gaza Nature Reserve and its environs was made from October 2002 to September 2004. Two different sites were addressed for carrying out this survey. Site I is almost hydric and represents a unique wetland ecosystem; site II is almost dry except for some storm water ponds occurring during the rainy season. A total of 118 avifaunistic species belonging to 38 families and 11 orders was determined and listed. Aquatic birds comprised 49 (41.5%) of the species counted, while terrestrial birds comprised 69 (58.5%) species. The Passeriformes was the biggest order and comprised 41 (34.7%) of the recorded species. Non-passerines comprised 77 species (65.3%), of which Charadriiformes formed the biggest order and comprised 27 species. Eighty-five (72.0%) of the bird species were migratory and the others were resident. The House Sparrow was the most common bird species in Wadi Gaza Nature Reserve. Other common species were the Cattle Egret, Chukar, Moorhen, Coot, Spur-winged Plover, Rock Dove, Laughing Dove, Barn Swallow, Yellow-vented Bulbul, White Wagtail, Palestine Sunbird and Hooded Crow (Figure 2.1.11.14). The major potential threats to avifauna included overpopulation, urbanization, residential and agricultural encroachment on the expense of natural areas, habitat destruction and fragmentation, hunting and poaching, intensive pesticide use and human disturbance at nest sites. The Israeli Occupation is still adversely affecting bird ecology in the area by the uprooting and demolishing of vast vegetated areas. To rehabilitate Wadi Gaza Nature Reserve and its environs we recommend that cooperation between the different parties should be improved; that public awareness should be enhanced; and that environmental laws and legislation should be implemented to protect wildlife and to ensure sustainability of the system for both humans and biota (Abd Rabu and others, 2007a).

Figure 2.1.11.13 Flora of Wadi Gaza. Source: modified from Abd Rabou and others (2008a)

▲ (A) Evergreen cypress, **Cupressus sempervirens**; (B-C) Dense monospecific stands of the common reed, **Phragmites australis**, and its harvest by local people; (D) The harvest of the giant reed, **Arundo donax**; (E) Sea daffodil, **Pancratium maritimum**; (F) Date palm, **Phoenix dactylifera**; (G) Hottentot fig, **Carpobrotus edulis**



▲ (A) Common (crystalline) ice-plant, **Mesembryanthemum crystallinum**; (B) Sheep graze on the shrubby saltbush (sea orache) **Atriplex halimus**; (C) Russian thistle, **Salsola kali**; (D) Shrubby swamp-fire (glasswort), **Arthrocnemum fruticosum**, grows in the saline depressions (the soil appears white due to salt accumulation); (E) Sagebrush (sand wormwood), **Artemisia monosperma**; (F) Knapweed (cornflower or pale star thistle), **Centaurea pallescens**; (G-I) The purple and white flowers and the white mottled leaf of the blessed milk-thistle (marian thistle), **Silybum marianum**



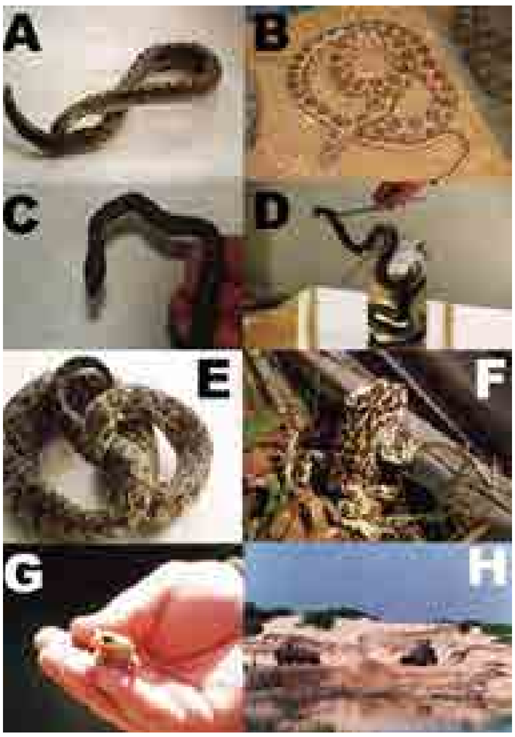
◀ (A) Sea rocket, **Cakile maritima**; (B) Castor-oil plant or palma Christi, **Ricinus communis**; (C) Camel-thorn, **Alhagi maurorum**; (D-E) The horizontal growth and fruits of an old sycamore fig, **Ficus sycamorus**; (F) Silver-leaf nightshade, **Solanum elaeagnifolium**; (G) The flower of the tree tobacco, **Nicotiana glauca**; (H-I) The shrubs of the Nile tamarisk, **Tamarix nilotica**, are usually overexploited for their timber which is used as grapevine supports

Figure 2.1.11.14 Birds of Wadi Gaza. Source: modified from Abd Rabou and others (2007a)

▲ (A) Little Bittern, **Ixobrychus minutus**; (B) Cattle Egret, **Bubulcus ibis**; (C) Black Kite **Milvus migrans**; (D) Marsh Harrier **Circus aeruginosus**; (E) Long-legged Buzzard, **Buteo rufinus**; (F) Lesser Kestrel, **Falco naummani**; (G) Common Kestrel, **Falco tinnunculus**

▲ (A) Chukar, **Alectoris Chukar**; (B) Common Quail, **Coturnix coturnix**; (C) Coot, **Fulica atra**; (D) Stone Curlew, **Burhinus oedicnemus**; (EF) Spur-winged Plover, **Hoplopterus spinosus** and its ground nest; (G) Turtle Dove, **Streptopelia turtur**; (H) Laughing Dove, **Streptopelia senegalensis**, juvenile

Figure 2.1.11.15 Herpetofauna of Wadi Gaza. Source: modified from Abd Rabou and others (2007b)



◀ (A) Sand Boa, **Eryx jaculus**; (B) Coined Snake, **Coluber nummifer**; (C) Red Whip Snake, **Coluber rubriceps**; (D) Syrian Black Snake, **Coluber jugularis asianus**; (E) Palestine Viper, **Vipera palaestinae**; (F) Common Toad, **Bufo viridis**; (G) Tree Frog, **Hyla savignyi**; (H) Habitat destruction and modification in Wadi Gaza

The reptiles and amphibians of the Gaza Strip and Wadi Gaza were also surveyed between 2002 and 2004. A total of 21 herpetofaunistic species (2 turtles, 8 lizards, 8 snakes and 3 anurans) belonging to 3 orders and 15 families was encountered. The species described were all resident and were mostly found throughout the year. The diversity of terrestrial and aquatic ecosystems in the study area encouraged the occurrence of the species. However, the ever-increasing human impact on the existing natural resources in the Gaza Strip has threatened the ecology of wildlife, where the populations of frogs and many reptilian species are declining in an alarming fashion. The results reinforce the need for long-term inventories in order to understand the ecology and dynamics of herpetofauna and other wildlife communities in the study area (Abd Rabu et al 2007b) (Figure 2.1.11.15).

24. **Effects associated with changes[(24)]**: Wadi Gaza is a Palestinian surface freshwater resource. In ancient times, many civilizations were established on its banks and in the neighbouring areas. At the time of the Palestine Nakbah (exodus) in 1948, Wadi Gaza was a place of running fresh water, fertile soil, abundant natural plants, wildlife and many natural resources. After the Israeli Occupation of the Gaza Strip in 1967, the situation changed. The resources have become depleted and the total environment has undergone serious deterioration.

Deterioration of the environment of Wadi Gaza started after the 1970s and the establishment of upstream dams and reservoirs by the Israeli Occupation, which prevented running water from reaching the lower portion lying in the Gaza Strip. Wadi Gaza is suffering now from many problems including the drainage of untreated wastewater, solid waste disposal, destruction of natural habitats, cultural heritage and landscapes, hunting and poaching of wildlife, over-cutting of natural vegetation, over-grazing and the proliferation of mosquitoes. It is concluded that the current environmental situation of Wadi Gaza is not promising and that deterioration will continue unless efforts are put in place to rehabilitate and conserve the ecosystem in a sustainable fashion.

Seasonal variations of chemical composition of water and bottom sediments (Shomar and others, 2005)

Water and sediment samples were collected from 18 sampling stations in Wadi Gaza in 2001 and 2002 to: (1) establish a baseline condition of the geochemistry of surface water and sediments; (2) assess the impact of seasonal variation on distribution of heavy metals and major ions; and (3) identify possible natural and anthropogenic sources of pollution. The heavy metal concentrations in the sediments of the lake (downstream) were higher than those of the eight eastern stations (upstream) where the water was shallower. Shallower areas showed greater temporal variation than deeper areas. Several elements (P, Fe, Mn and As) showed the greatest temporal variability. For example, in the winter rainy season these elements decreased 2-10 times compared to their values in summer. Moreover, Ca, Na, Cl, PO_4 and NO_3 decreased 3, 3, 5, 2 and 4 times, respectively. Some of the trace metals were more abundant in these waters compared to the domestic wastewaters of the study area. The averages of Cd and Co were 6 and 43 *µg/l, respectively*, and these were 50 times higher than the domestic wastewater results. The discharge of olive oil mill wastewater was recorded in the Ca, Na, Mg, K and P concentrations in sediments of one of the sampling stations (Shomar and others, 2005).

Health problems are usually associated with wetlands and neglected areas rich in wastes including, primarily, liquid wastes. In case of Wadi Gaza Nature Reserve, the problem of mosquitoes and other annoying insects continues to worsen. This was clear from the verbal and nonverbal responses of the people interviewed. The study showed that stagnant wastewater was ranked by most participants (85.0%) as the main cause of the proliferation of mosquitoes and the emission of offensive odours which affect the life of Wadi Gaza residents. Other causes were ranked by participants, but with low scores, such as solid wastes (2.5%), trees and shrubs surrounding the wetland ecosystem of Wadi Gaza (2.5%) and the lack of sanitation and personal hygiene (1.7%). However, 8.3% of participants provided multiple answers and selected many factors contributing to mosquito proliferation in Wadi Gaza; 72.5% linked the proliferation of mosquitoes to many of the prevailing diseases in the area, including fever, skin rashes, inflammation and itching. Although malaria is absent in the Gaza Strip, five participants claimed that mosquitoes transmit malaria to Wadi Gaza inhabitants (Abd Rabu et al, 2008b).

25. **Global and climate changes[(25)]**: According to Dentoni (2012), the main outcomes from analysis of future projected variables from 1981-2010, from four different Global Circulation–Regional Circulation (GCM–RCM) models are:

- Precipitation rates will increase in the next 30 years, and then decrease in the following 30 years
- Extreme precipitation events (daily precipitation >10 mm/d) will increase in the next 30 years, and then decrease in the following 30 years
- Very extreme precipitation events (daily precipitation >20 mm/d) will increase in the next 30 years and then decrease in the following 30 years
- Temperatures will rise up to 2°C in the next 60 years

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. Provisioning services[(26)]: The wetland ecosystem of Wadi Gaza is a refuge for wildlife, including many threatened species, and hence wildlife hunting is practised using different hunting tools. Tree cutting and collection of food, and herbs for medicinal uses, were found to be customary among Bedouins inhabiting Wadi Gaza and other localities of the Gaza Strip. They also graze their livestock on natural vegetation, though all such activities may deteriorate the fragile ecosystems prevailing there. The production of baskets, carpets, kites, food dishes, chairs and huts, along with wood and timber exploitation, are direct uses of reeds and woody plants in Wadi Gaza. The system has a storage potential of more than 100,000 m^3 surface water that could be considered as a convenient water resource for agricultural uses. It has the potential to partially treat large quantities of wastewater. It reduces the impacts of flood to neighbouring agricultural lands and human dwellings. It could act as a recreational facility. It represents a natural laboratory enhancing scientific research in different disciplines. Small-scale extraction of sand, stone and gravel from the Wadi bed has been documented.

26a. Natural production of food: The natural flora of Wadi Gaza has commonly been used in different ways as a food source, herbal medicine, fodder for grazing animals and timber and fuel production (Abd Rabou and others, 2007c). Other direct human uses for specific floristic species has also been recognized (Figures 2.1.11.16 and 2.1.11.17). Many wildlife species were found to make numerous uses of the wild vegetation as well.

Many ecological values have been attributed to reeds that grow extensively in Wadi Gaza. They provide primary productivity that constitutes the base of the food chain in the wetland and pond ecosystems, and grazing material (especially the young shoots and leaves) for goats and livestock. This is especially important given the lack of or unavailability of ranges or pastures in the Gaza Strip in general and Wadi Gaza in particular.

Some bird species such as Coots, Ducks and Moorhens also graze or feed in reed areas. The decomposition of leaves and stems supports detrital food chains for many invertebrate species.

Figure 2.1.11.16 Reeds and tamarisk are major plants in Wadi Gaza harvested for multiple uses. Source: K. Qahman.

Figure 2.1.11.17 Direct uses of natural products of Wadi Gaza. Source: K. Qahman.

Figure 2.1.11.18 Wildlife hunting is common around the wetland ecosystem of Wadi Gaza. Source: K. Qahman.

Figure 2.1.11.19 Sheep grazing in the Wadi Gaza, March 2014. Source: K. Qahman.

Hunting
In Wadi Gaza, and due to absence of environmental laws and legislation, a large range of bird species is hunted using different tools including nets for domestic, commercial and game purposes (Figure 2.1.11.18). Although the wetland ecosystem is polluted, aquatic birds including water fowl are hunted and sometimes used as food material, and other species killed as predators or pests. Many reptiles, particularly snakes, are considered by local people as a threat and are consequently killed.

Fishing
Fishing is carried out in the estuary lake and the wetland. The upstream levee constructions by the Israeli authorities, which prevent rainwater from flowing to the lower reaches, reduce the amounts of open water; and the current pollution of the wetland reduces fish populations and the fish themselves are unfit for consumption. Since the inception of the Palestinian Authority in 1994, security forces have enforced the prohibition against fishing activities in Wadi Gaza. If rehabilitation occurs and water flows permanently in its course then Wadi Gaza, along with its wetland ecosystem, will have the potential to be a promising fishery as it was in the past.

Grazing
Because of the absence of real ranges and forests in the Gaza Strip, some Bedouin families graze their livestock on the natural vegetation of Wadi Gaza, especially around its wetland ecosystem (Figure 2.1.11.19). Such grazing activities could threaten the ecological integrity of the system as it may destroy birds' nests, uproot seedings and impede or delay the normal growth of many plant species. The removal of plant cover subjects wildlife species to predation, hunting and poaching.

To avoid such human activities, some wildlife may leave to find other safe habitats. Overgrazing can lead to the dispersion of unpalatable plants and to land erosion. It is the responsibility of the authorities to manage land uses such as grazing and logging to protect the residual tamarisk and reed forests which characterize wetlands and marshes, and support wildlife.

Herbal medicine
In the Wadi Gaza area local people, mainly Bedouin families, use many floristic species medicinally to treat numerous diseases and disorders including diabetes, stomach ulcers and pains, intestinal troubles, wounds, skin diseases, fevers and headaches, arthritis, urinary system illness and kidney stones, parasites, sexual weakness, heart and blood diseases, anaemia and even cancers, according to many inhabitants. Many studies carried out in Palestine have confirmed these uses of many plants and herbs.

Water use
Most of the Wadi Gaza wetland bodies are polluted by sewage, solid waste and other chemicals and, as a result, are expected to contaminate water wells. However, the wetland Wadi Gaza ecosystem serves as an important surface water storage reservoir, having the potential to store more than 100,000 m^3 of surface water. Many people stated that, in the past, the water was used for drinking. Due to its poor quality the use of water from the wetland is now restricted to irrigation of neighbouring agricultural fields and thus provides a cheap and convenient water resource. Plastic tubes or pipes are sometimes seen near wetlands and are used for pumping water to agricultural fields and farms using electric motors.

Figure 2.1.11.20 Sand and gravel extraction from Wadi Gaza. Source: K. Qahman.

Figure 2.1.11.21 Wadi Gaza and (inset) a sign in Arabic marking its designation as a Nature Reserve in 2000. Source: K. Qahman.

Gravel and sand extraction

Sand, stone and gravel were extracted on a large scale from the Wadi bed for construction purposes during 1948-1964. They are still extracted for the same purposes but on a smaller scale. These extraction activities leave 1-m deep pits in the Wadi bed, which in turn cause deterioration to the landscape and geomorphology of Wadi Gaza (Figure 2.1.11.20).

26b. Artificial production of food. According to the Palestinian strategy, in the future the wadi will be changing (Dorsch, 2014) to:

- a small creek or sometimes to a large river with permanent water flow; although most parts of the large wadi area will of course remain dry during the year and show only scattered vegetation
- continuous water flow in the wadi based on high-quality treated effluent from the WWTP and additional treatment in constructed wetlands (reed beds or similar)
- unpolluted, high-quality surface water of bathing water quality.

As mentioned above, improvements to the abiotic environmental sectors will provide better living conditions for flora and fauna. Solution of the solid waste problem, continuous water flow within the wadi, public awareness, law enforcement, maintenance and control within the Wadi Gaza Regional Park and the protected areas would guarantee a restoration of natural habitats and wildlife.

High-quality surface water would provide a basis for new habitats for aquatic fauna, waterfowl and other animals. The delta area in particular would continue to improve, migrating birds would return and the number of species would increase. Hunting and poaching should be strictly forbidden.

River-bank vegetation would be established as a result of continuous water flow. The diversity of habitats and species would increase significantly, and in the long term the potential natural flora and fauna could be revived and preserved - but only with full awareness and support from the people living in the area and those visiting it.

26c. Others: In recognition of its importance as a natural area and as the only coastal wetland in Palestine, Wadi Gaza was declared a Nature Reserve in June 2000 (Figure 2.1.11.21). Wadi Gaza is historically rich in biodiversity and still important as a stopover point for birds on the Africa-Eurasia migratory route. It is one of the most important bird areas in Palestine, attracting avifauna because of its aquatic and semi-aquatic nature, and thus providing ecotourism and recreation to interested parties.

In spite of the current attention given by local, regional and international parties to Wadi Gaza, its environment and ecology are deteriorating daily at an alarming rate. Recent research has indicated that Wadi Gaza and its wetland ecosystem have a relatively high diversity of vertebrate fauna and flora, with birds being the most conspicuous vertebrate fauna. The need to conserve the wetland ecosystem of Wadi Gaza is urgent because of the escalating threats it faces.

27. Regulating services[(27)]:

Flood control

Floods are an irregular feature of Wadi Gaza and are restricted to few days a year. The wetland reduces the impacts of flood to the agricultural land and houses on both banks, because wetlands function as natural sponges that trap and slow release surface water, rain and flood waters (Figure 2.1.11.22). Trees, shrubs and other vegetation also slow the speed of flood waters and distribute them more slow over the floodplain, and this in turn reduces erosion. The holding capacity of the wetland helps control floods and prevents waterlogging of crops. However, in many years such floods have been destructive and a risk to human life and property. Floods cut off roads and telephone communications, and kill livestock and many people.

Solid waste land filing

The use of open land, wadis and wetlands as random solid waste and wastewater disposal sites is common in Palestine. Construction debris and domestic waste are frequently dumped in Wadi Gaza and its wetland ecosystem, especially when the Israeli army closed the route to the main Gaza Strip landfills. Wadi Gaza is also a site for dumping dead animals and agricultural waste.

Sewage discharge and partial treatment

The system acts as a natural treatment facility for the large quantities of untreated wastewater currently discharged (12,000 m^3/day) to the Wadi Gaza water course. This sewage water comes mainly from the three refugee camps of Bureij, Maghazy and Nuseirat. Many goats and sheep have been seen drinking from sewage pools in Wadi Gaza (Figure 2.1.11.23).

28. Cultural services[(28)]: Cultural heritage

The cultural heritage of Wadi Gaza Nature Reserve is still suffering from destruction and negligence. The assessment showed its importance as a natural area harbouring a unique wetland ecosystem rich in biodiversity in coastal Palestine, and representing a pathway for migratory birds. It also encompasses archaeological sites of ancient civilizations represented by Tal as-Sakan, Tal es-Sanum, Tal al-Ajjul, Tal or Tour Ikhbina and Tal Umm-Amer, which are facing many anthropological threats. The study indicated that the current situation of Wadi Gaza Nature Reserve is not promising for people, wildlife or the cultural heritage.

Scientific and educational values

Being a unique coastal wetland ecosystem, it can be a natural laboratory enhancing scientific research in different disciplines. Many research activities have been carried out to study various scientific aspects of Wadi Gaza.

Recreational values

The Mediterranean coast is the most important tourist and recreational destination in the Gaza Strip. In addition, the wetland ecosystem of Wadi Gaza can provide an important recreational facility if well-managed. For decades, many visitors to the wetland found it to be a source of inspiration for the creative arts such as writing, painting or photography. Other people come simply to enjoy the beauty of the landscape and the natural habitat.

Figure 2.1.11.22 The wetland of Wadi Gaza can serve in regulating flood water. Source: K. Qahman.

Figure 2.1.11.23 Wastewater discharged into Wadi Gaza imposes environmental and health risks to humans and biota. Source: K. Qahman.

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2.1.12 SYRIA WETLANDS COUNTRY REPORT

Abdulah Droubi

GROUNDWATER-RELATED WETLAND GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Akkar - plain **Wetland general type(2)**: Extended wetland
2. **Municipality, country**: Tartous, Syria **Coordinates (geographical):** 34°40'00" N; 36°01'00" E
3. **Wetland surface (km²)(3)**: **25** **Elevation (m)**:< 50 m - ?
   Average depth/length/width (m)(3): <0.5/5000/5000
4. **Contributing surface area (km²)**: **60**
5. **Contributing aquifer area (km²)**: **6** **Aquifer type(4)**: Water table
6. **Mean rainfall (mm/y)(5)**: 854 **Mean T (°C)(5)**: 22 **Mean ET (mm/y)(5)**: 550
7. **Underlying lithology(6)**: Siliceous sediments
8. **Wetland genesis(7)**: Flood plain
9. **Wetland sediments(8)**: Clayey; Sandy; Silty
10. **Water source(9)**: Rainfall; Runoff ; Shallow groundwater; Tidal near the sea; Fluvial inundation
11. **Groundwater flow type(10)**: Recharge area **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: **Seasonal**
13. **Hydrochemistry(13)**: Electrical conductivity (mS/cm): 70-100; dominant anion/s: HCO_3; dominant cation/s: Ca
14. **Dominant vegetation(14)**: Prairie
15. **Trophic state(15)**: Unknown
16. **Functionality(16)**: Highly altered
17. **State of knowledge(17)**: Validated hydrogeological conceptual model; Numerical modelling; Water level monitoring; Groundwater level monitoring; Hydrogeological studies; Water quality monitoring
18. **Management status(18)**: Unprotected

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Water abstraction from tributaries and groundwater; Crops; Aquaculture
20. **Changes in land use(20):** Extensive agriculture; Urbanization; Roads
21. **Modification of hydrological cycle(21)**: Drainage; Storage usage; Input of excess irrigation water
22. **Pollution(22)**: Agriculture diffuse; Urban/industrial point source pollution
23. **Alteration of biological communities structures and ecosystems functioning(23):** Alteration of biochemical cycles; Native species extinction
24. **Effects associated with changes(24)**: Chemical water quality; Biological water quality; Soil destruction
25. **Global and climate changes(25)**: Rainfall ; Temperature; Sea level rise

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:
   26a. Natural production of food: Cropping and Fruits collection (High; Very rapidly increasing); Livestock (Moderate; Moderately increasing); Other: Fodder (Low; Unknown)
   26b. Artificial production of food: Agriculture (High; Very rapidly increasing); Aquaculture (Moderate; Continuing)
   26c. Others: Water supply for different uses; Supply of good-quality water
28. **Regulating services(27) (Status; Trend)**: Hydrological regimes (Moderate; Moderately decreasing); Water purification and Morpho-sedimentary regulation (Low; Continuing)
29. **Cultural services(28) (Status; Trend):** Tourism and Educational and scientific knowledge (Low; Continuing); Local knowledge and good practices (Moderate; Continuing)

ADDITIONAL INFORMATION/COMMENTS

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2.1.13 TUNISIA WETLANDS COUNTRY REPORT

Noureddine Gaaloul and Kamel Zouari

GROUNDWATER-RELATED WETLAND GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Korba (Cap Bon) **Wetland general type(2)**: Isolated wetland
2. **Municipality, Country**: Korba, Tunisia **Coordinates (geographical):** 36°33' N; 10°51 'E
3. **Wetland surface (km^2)(3)**: 5 **Elevation (m) maximum-average**: <1

   Average depth/length/width (m)(3): 0.5/8500/350
4. **Contributing surface area (km^2)**: 3
5. **Contributing aquifer area (km^2)**: 2 **Aquifer type(4)**: Water table
6. **Mean rainfall (mm/y)(5)**: 480 **Mean T (°C)(5)**: 20 **Mean ET (mm/y)(5)**: 630
7. **Underlying lithology(6)**: Carbonated sediments
8. **Wetland genesis(7)**: Dune morphology
9. **Wetland sediments(8)**: 80% Sandy and Clayey
10. **Water source(9)**: Rainfall on the wetland; Runoff in the basin; Shallow groundwater
11. **Groundwater flow type(10)**: Recharge area; Discharge area, open **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: Seasonal
13. **Hydrochemistry(13)**: Electrical conductivity (mS/cm) (20-80); dominant anion/s: Cl; dominant cation/s: Na
14. **Dominant vegetation(14)**: Halophytic vegetation
15. **Trophic state(15)**: Phreatophyte vegetation
16. **Functionality(16)**: Highly altered
17. **State of knowledge(17)**: Validated hydrogeological conceptual model; Numerical model; Chemical/isotopic information; Water level monitoring; Groundwater level monitoring; Water quality monitoring; Groundwater quality monitoring; Hydrogeological studies; Wetland evolution studies
18. **Management status(18)**: Ramsar site; Nature Reserve/Other

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Groundwater next to the wetland
20. **Changes in land use(20)**: Extensive agriculture; Extensive cattle raising; Urbanization; Roads
21. **Modification of hydrological cycle(21)**: Drainage; Artificial recharge; Input of urban wastewater
22. **Pollution(22)**: Agricultural diffuse pollution; Urban/industrial point source pollution
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Native species extinction and Alteration of biogeochemical cycles have a high impact, which Is increasing rapidly.
24. **Effects associated with changes(24)**: Chemical water quality; Increased erosion; Soil destruction

26. **Global and climate changes(25)**: Rainfall; Temperature; Sea level rise

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26):**

    26a. Natural production of food: Livestock (Moderate; Continuing); Fishing (Low; Continuing); Cropping, Fruits collection and Hunting (Low; Unknown)

    26b. Artificial production of food: Agriculture (Low; Continuing)

    26c. Others: Supply of good-quality water, Water supply for different uses, Production of biological source materials and Production of mineral source materials (Low; Continuing); Natural species of medicinal interest (Moderate; Continuing)
27. **Regulating services(27)**:; Hydrological regimes (floods, drought) (Moderate; Moderately decreasing); Water purification and Morpho-sedimentary regulation (Low; Continuing); Local climate regulation (Moderate; Moderately increasing)
28. **Cultural services(28)**: Tourism, Educational and scientific knowledge and Local knowledge and good practices (Moderate; Moderately increasing); Landscape and aesthetic and Cultural identity and sense of belonging (Low, Continuing)

ADDITIONAL INFORMATION/COMMENTS

1. Description of the study area (Korba Wetland aquifer)

The Korba coastal plain is located in the east of the Cap-Bon peninsula in north-eastern Tunisia, extends from Nabeul in the south to the city of Kélibia, and it is bounded by the Mediterranean Sea in the east and the Djebel Sidi Abderrahmen anticline in the west. The climate of the study area is semi-arid with an average annual precipitation of 420 mm. The annual average temperature ranges between 17 and 19 °C and the relative humidity, at the level of Korba station, varies between 71 and 81%.

Freshwater resources are essentially constituted by the river of Chiba and Lebna in the central sector of the plain and by the groundwater' which is affected by salinization. The exploitation of the Korba aquifer has increased linearly from 270 wells pumping 4 Mm^3 in 1962 (Ennabli, 1980) to more than 9239 wells pumping 54 Mm^3 in 2004 (CRDA, 2005). Hence, the interest is to understand the geometric configuration of this aquifer.

The Korba aquifer of Cap-Bon peninsula (North-east of Tunisia), which extends over 40 km and occupies an area of 438 km^2, is of great economic importance. Its location in an often narrow plain with intense human activity (agriculture, industry, tourism…) makes it particularly vulnerable from both a qualitative and quantitative alteration.

The eastern section of Cap Bon contains over some fifty kilometres a string of wetlands extending of 10 to 15 km in length and occupying the low-lying sections of the littoral plain whose width does not exceed 1 km. They are isolated from the sea by two dunal formation of low elevation separated by lowlands, which are flooded by the sea during the winter storms. The lagoons dry up almost entirely in the summer except for the Korba wetland. The dunal ridges and the wetlands proper are part of the Public Maritime Territory; the land section between the wetland and the national highway to the east are private property.

The Korba wetland is one of the most important humid environment in the eastern region of the Cap-Bon peninsula. It is considered as an ecological site and a traditional relay for the major migratory birds. The Korba wetland is located at the north-east of Tunisia, it's separated from the sea by a sandy bar (Figure 2.1.13.1a).

The Korba wetland, the only one with a permanent inlet from the sea, hydrological problems are linked to the gradual filling of the inlet and accumulation of sediment impinging on water flow.

2. Geological and hydrogeological setting

The Korba-Mida aquifer is made up mainly of marine sediments deposited in the Dakhla syncline north of Korba city (Abbes and Polak, 1981) (Figure 2.1.13.1a). The study area is bounded to the north by Wadi Lebna, to the south by Wadi Sidi Othmen, to the west by the elevated mountains consisting of Mio-Pliocene sequences, and to the east by the Mediterranean Sea. The aquifer system is constituted by the superficial and shallow Plio-Quaternary formations and by the deeper Miocene units. The Miocene base is constituted by impermeable marls and contains brackish water with a salinity of 3–4 g/L (Rekaya, 1989). The younger upper Miocene is actively pumped at 150–500 m depth upstream of the study site and is tapped for drinking-water supply well in Taffeloun. The deep Miocene aquifer is captive and feeds the upstream Plio-Quaternary; its natural outlet is the sea (Gaaloul et al., 2008; 2012)

The relationship between both deep Miocene and Plio-Quaternary aquifers is known but not clear. With no distinction in hydraulic terms, the Pliocene and Quaternary deposits form the Plio-Quaternary aquifer. According to electric sections, the Pliocene part contains a succession of saturated freshwater and brackish-water levels with, in the bottom, layers saturated with variably salty water (Kouzana et al., 2009). It is locally semi-confined due to less permeable deposits (Kerrou et al., 2010) and is, the most productive aquifer of the area. Its recharge is provided by direct infiltration of rainwater and stream water. It is severely affected by salinization from seawater intrusion. The Quaternary part is vertically compartmentalized in places. Its recharge occurs principally through incised glacis and outcrops and is favored by the topographic relief formed by Quaternary Tyrrhenian fossil dunes. The main coastal sabkhas are no longer the natural outlets of the Tyrrhenian, due to a reversal of the hydraulic gradient

Numerous works have been examined the geological framework of Korba aquifer (e.g. Ennabli, 1980; Ben Salem, 1992) from borehole lithology and water wells. It is underlain mainly by Pliocene formations and Quaternary marine platforms. To the authors' knowledge, the origin of such fresh groundwater in this very limited area is not clear but could be linked to the presence of faults affecting Miocene formations and favoring mixing (Figure 2.1.13. 1b).

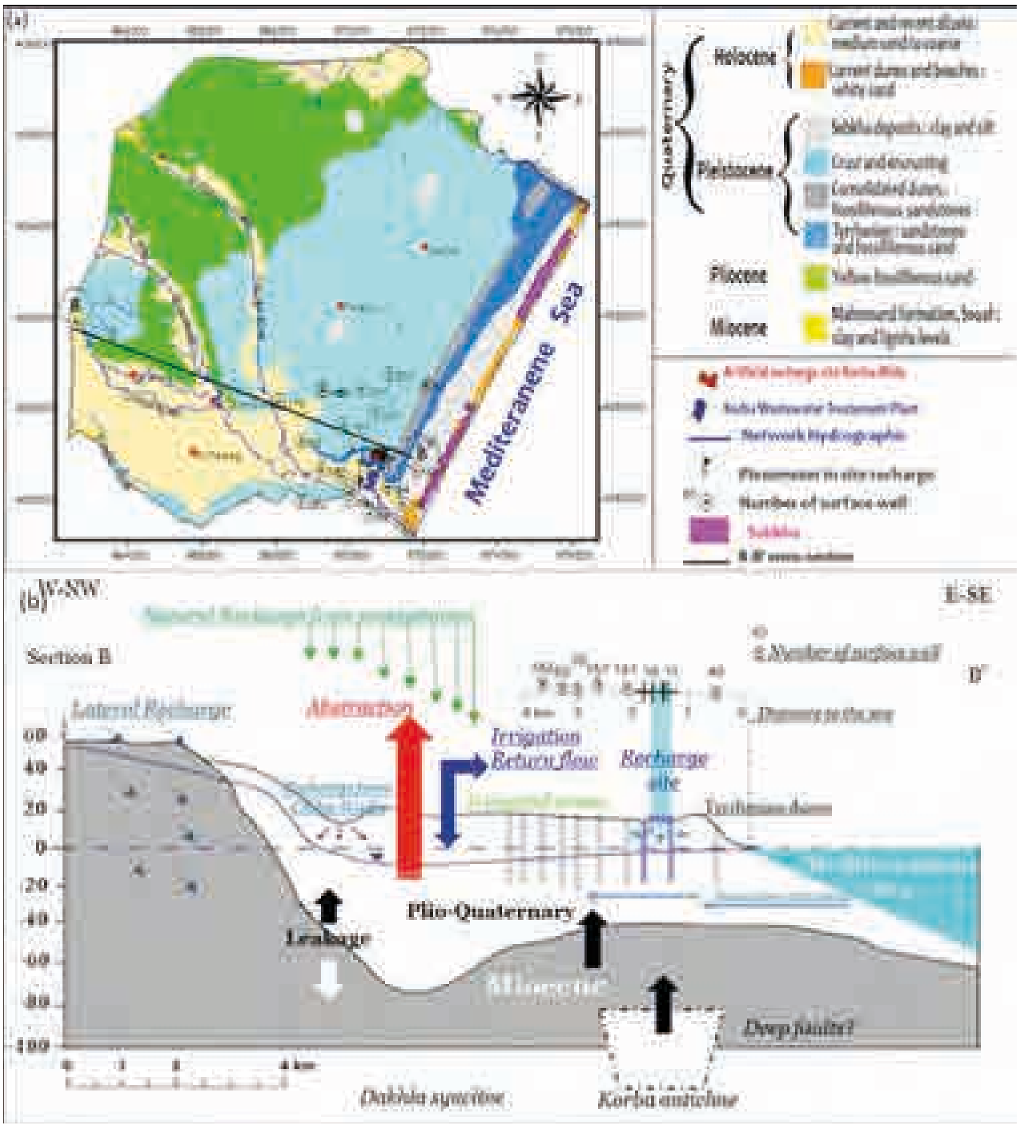
Three main geological formations constitute the aquifer system (Figure 2.1.13.1a):

(i) The Middle Miocene is the base of the system and is not exposed except some relics north-west of the study area. It is 2700 m thick and is made up of detrital deposits mainly from deltaic bodies. The upper part is composed of lenticular sandstones and marls with lignite levels and clay in the study area (Figure 2.1.13.1a) truncated by riverine systems (Abbes and Polak, 1981) with a thickness of 500 m.

(ii) Marine Pliocene sediments transgress unconformably over the Miocene (Figure 2a) and outcrop NW of Taffeloun. These are composed mainly of interbedded sandstone-sand-marl topped with variably clayey sandstone with a thickness varying between 15 and 160 m (Ben Salem,1992).

(iii) Quaternary deposits in the study site contain upper Pleistocene and Holocene deposits. It can reach 150 m in the Taffeloun area. At the base, the upper Pleistocene deposits with a thickness of 30 m, also called the Tyrrhenian deposits of the last marine transgression, are made up with fossiliferous carbonate sandstones and covered by old consolidate dunes with fossiliferous limestone (Figure 2.1.13.1a). The further Pleistocene deposits, described as three marine platforms, show mixed carbonate, bioclastic and siliciclastic sediments (Temani et al., 2008; Elmejdoub and Jedoui, 2009). This facies is truncated by a carbonate sequence and aeolian oolitic deposits. The uppermost continental Pleistocene is represented by continental red deposits and a centimeter- to meter-thick calcrete extending over large areas (Chakroun et al., 2005; Elmejdoub and Jedoui, 2009; Ben Hamouda et al., 2011). At Taffeloun, the calcrete outcrops and its thickness is 15 m (Figure 2.1.13.1a).

Figure 2.1.13.1: (a) Geological setting of the Korba-Mida basin showing piezometric network and farm-well sampling points; (b) Schematic geological cross-section (BB') through the study area showing the locations of the artificial recharge site, studied wells and piezometers. Source: modified after Cary et al. (2013).



The comprehension of the geometry of the aquifer and its lithology are very important to understand the functioning of groundwater modelling. Water table in this unit has an average depth of about 35 m and low transmissivity comparing to the northern part. Both Somâa and Pliocene formations are discordant on the Miocene marl which constitutes the basement of this system. At the same time, this Miocene marl series may contain sandstone bars with different thickness and lateral variation constituting a third reservoir of Miocene with considerable water resources. The relationship between both systems exists but is not very clear. The groundwater recharge of the uppermost aquifer derives from rainfall (420 mm/year).

The integration of this value over the area of interest (400 km^2) yields 17 Mm^3/year (Gaaloul et al., 2012). Additional recharge from rivers and topographic depressions is also contributed in recharge. Therefore, no perennial rivers are present in the region. Nevertheless, during the rainy season, three main rivers arise: Lebna, Chiba and Lahjar, the first two hold the name to two dams as well. These rivers flow across the plain mainly from north-east to south-west.

The water balance is as follows: rainwater infiltration and irrigation recharge are estimated at around 18 Mm^3/y (Kerrou et al., 2010), direct infiltration from wadis and dams reaches nearly 8 Mm^3/y. Pumped abstraction of the groundwater by 2008 was estimated at 50 Mm^3, (Ennabli, 1980; Paniconi et al., 2001; Kerrou et al., 2010) which is twice the total recharge. Overexploitation induces piezometric depletion and seawater intrusion leading to salinization of groundwater.

The high salinization in some parts of the study area has been attributed to seawater intrusion process, because of the high and increasing contents of chloride ions and electric conductivity value distribution. However, recent studies of this aquifer have shown that the chemical characteristics of groundwaters are the result of different components: intruding seawater, direct cation exchange linked to seawater intrusion, dissolution processes associated with cations exchange and solute recycling through irrigation return flow (Gaaloul et al, 2010; 2013).

3. Geochemical and seawater investigation

The mainly cause of salinization is the mixing between freshwater and saltwater under seawater intrusion process. It was clearly observed from the EC profile in the area investigated. All samples show a rapid increase of EC at depths of 5 m below sea-level. These depths represent the interface between freshwater and saltwater. Furthermore, brackish water has been found in the upper aquifer. This finding has been interpreted as being due to the recycling of irrigation water where the uses of fertilizers contribute to the high EC values. Seawater fractions varied from 0.24% to 54.68%. Seawater seems to contribute to the composition of groundwater. The mixing of seawater with fresh-brachich water was confirmed, using Piper diagram. Nevertheless, mixing freshwater-seawater was not conservative and accompanied by other geochemical processes. Plotted in a Piper diagram, the majority of samples are Na-Ca-Cl type.

A number of wells plot on are in the Theoretical Mixing Line indicating that mixing processes are taking place as a result of their higher SO_4 and Ca content. The most likely source of this Sulphate is from dissolution of the small amounts of Gypsum scattered through the aquifer, present in the catchment area or the evaporation of the irrigation water excess (Kouzana et al., 2009) and of the Calcium is also from the dissolution and precipitation of the Calcite. These observations suggest that dissolution of gypsum would be a potential source of both Ca and SO_4. Gypsum source are mainly fertilizers or precipitation by evaporation at the topsoil. The hydrogeological and hydrochemical investigations seem to be a useful tool to better understand the Korba unconfined aquifer of Cap-Bon where saltwater intrusion will eventually spread, particularly during dry periods. Consequently, both groundwater monitoring and management and groundwater conservation are essential for efficient surveillance of the saltwater intrusion.

The electrical conductivity values range from 2 to 3 mS/cm and the Ca–HCO_3 groundwater type dominates. However, high EC value (between 9 and 30 mS/cm) appear in the central part of the plain specially in Korba, Diar El Hojjej and Tafelloun areas which are relatively marked by the presence of shallow depth piezometric level and the Na-Ca-Cl groundwater type dominates. Since the Cl- ions are considered as chemical inert, the increase of Cl- concentration along a flow line could be attributed to seawater intrusion and mixing with the fresh water of the aquifer (Gaaloul et al., 2013).

Seawater phenomena are confirmed in areas present values more than 25% of seawater. In the central area of the plain between Korba, Tafelloun and Menzel Horr, the seawater intrusion has advanced far inland (approximately a distance of 3 km) and the Cl iso-contours indicate a relatively narrow transition zone between the seawater and the freshwater. The others cause of saltwater intrusion in this area are the small saturated aquifer thickness and intensive agriculture. Always, pumping wells used for irrigation in the entire area are not abandoned until the electrical conductivities exceed 5–8 mS/cm (Bulletin Copeau, 2008). Indeed, hundreds of wells close to the coast were salinized and then abandoned despite the action of the government forbidding new wells in the area and distributing surface water.

In Korba aquifer, seawater intrusion probably is one of the main causes of water salinization, but also water-rock interaction, anthropogenic activity and rainfall may be causes of other kinds of contamination of water which will be investigate by geochemical investigations (Gaaloul et al., 2008; Gaaloul, 2008).

The geochemical data, whether concentration or B isotopic composition, exhibit a large variability over the 3 years; it is generally more pronounced for piezometer than for wells samples. The B isotopic compositions significantly shifted back and-forth due to mixing with end-members of various origin. Under the variable contribution of meteoric recharge, the Plio-Quaternary groundwater ($\delta^{11}B$ of 35–40.6 ‰, a mean B concentration of 30 mmol/L, no carbamazepine, n = 7) was subject to seawater intrusion that induced a high $\delta^{11}B$ level ($\delta^{11}B$ of 41.5–48.0 ‰, a mean B concentration of 36 µmol/L, and n = 8). Fresh groundwater ($\delta^{11}B$ of 19.89 ‰, B concentration of 2.8 µmol/L, no carbamazepine) was detected close to the recharge site and may represent the deep Miocene pole which feeds the upper Plio-Quaternary aquifer. The managed recharge water ($\delta^{11}B$ of 10.67–13.8 ‰, n = 3) was brackish and of poor quality with a carbamazepine content showing a large short term variability with an average daily level of 328 ± 61 ng/L. A few piezometers in the vicinity of the recharge site gradually acquired a B isotopic composition close to the wastewater signature and showed an increasing carbamazepine content (from 20 to 910 ng/L). The combination of B isotopic signatures with B and carbamazepine contents is a useful tool to assess sources and mixing of treated wastewaters in groundwater (Cary et al., 2013).

Generally, the major element concentrations illustrate a strong variability of water quality in samples collected for this study in temporal and spatial terms. In wells, conductivity varied between 5200 and 10,000 µS/cm. The groundwater was generally enriched in Ca, SO_4 and HCO_3, compared with simple mixing with seawater. All the wells and some of the piezometers showed a Na deficiency most commonly combined with a K deficiency Strontium plotted in excess versus Cl and Na + K.

The B isotopic compositions significantly shifted back-and-forth. The $\delta^{11}B$ shifts with time in the piezometers (2, 11, 15) under the influence of the treated wastewater recharge helps demonstrate the high system reactivity, especially through equilibrium processes such as sorption reactions. These major variations between fresh and brackish facies are interpreted as due to the spatial displacement and temporal mixing of Plio-Quaternary groundwater with fresh groundwater and recharge water under various hydrodynamic constraints such as the infiltrated recharge volume, withdrawals, and meteoric recharge. The increasing salinization of the groundwater combined with agricultural practices is gradually impacting the groundwater quality. The superimposition of a 'recharge front' due to the new 'treated wastewater' component modified the previous transitional states away from equilibrium by adding a new constraint, i.e. the development of reducting conditions with the intrusion of high amounts of organic matter and the entry of a new B and CBZ source. Although the natural amounts of metals in the aquifer is not known, pollutant metals issued from human activities were injected into the aquifer and the oxidizing-reducing conditions enhanced their mobility. The well-documented salinity front, which is not geographically homogeneous due to the geological and hydrodynamic conditions, generates mixing with groundwater of the order of less than 20% of the seawater fraction, which is coherent with the previously cited studies.

The notable evolution of the B isotopic signature in the wells between 2009 and 2011 was probably due to the irregular progression of seawater intrusion affected by natural recharge, withdrawals, and irrigation and mixing with Miocene groundwaters. Salinity at the recharge site generally decreased from 10 g/L in 2004 to 2–3 g/L in 2011; here attention must be paid to the role of the fresh groundwater body whose refreshing effect must not be confounded with that of the recharge waters. (Cary et al., 2013).

4. Geochemical characterization of Korba wetland (Cap Bon-Tunisia)

During the recent past, the Korba wetland was a container of domestic, agricultural, and industrial waste water. It was, also, a waste disposal site. This area of the coastline is potentially favorable as a nesting site for the sea turtle *Caretta caretta* and could serve as a migration refuge for *Numenius tenuirostris*, an endangered species which has already been observed there (APAL, 2005; Baccar et al., 2001; Bachali and El Asmi, 1996; Bouden et al., 2004; 2006; 2009; IUCN, 1965; IUCN, 1984; MedWetCoast, 2003).

The pressures on this zone are many due to the expansion of urban areas with backfilling of the wetlands, tourism development projects and illegal urban development. Added to this are various forms of pollution due to the disposal of liquid and solid waste from household or industrial origin (canning) in the lagoons where fresh water inputs and sediments are reduced as a result of the construction of several dams in the hills (Jaballah, 2003). This is further aggravated by excessive withdrawals and salinification of ground water. Coastal erosion is severe and the pressures caused by hunting are heavy. (Romdhane et al., 2001; Pearce et al., 1994; Hughes et al., 1996)

The Korba wetland catchment area is consisted of the Tertiary and Quaternary grounds. The continental and marine contributions of water of the lagoon are occasional (flood and storms). In spite its proximity to sea, the Korba wetland is characterized by a semi-arid climate. The sedimentary deposition is mainly detrital. Sands, rich in carbonates, dominate the eastern part is until an average depth of 1 meter. The clayey fraction, which dominates the lower levels, is rich in carbonates, and the western edge of the wetland, is poor in carbonates. The carbonates are predominant at the base and miner the top. They are in relation to the accumulation of the shells. This study allowed us to distinguish at the bottom a facies predominantly coastal, characterizing an open environment, and at the top a facies is typically lagoonal, indicating a relatively confined environment. (Oueslati, 1983; Hecker et al., 1996).

From a sedimentological point of view, the Korba wetland is mainly characterized by sediments of continental origin. Clays are the dominant feature of the western border (land-side) while sands are the ones of the eastern border (sea-side).

A preliminary organic geochemical study shows (Bouden et al., 2004) that the superficial sediments contain high Carbone Organique Total (COT) contents (0.48 up to 5.21 %) (Qninba, 2001, RAMSAR). Nonetheless, the TOC values increase from North to South. The analyses indicate that the organic matter have mainly a continental origin. Cadmium and copper contents, highly influenced by domestic and industrial activities especially in the South, show an increase from North to South. Whereas the N-S manganese and chromium rising contents can be attributed to the Chiba river supplies. The high concentrations of Zn and Ni are observed in sediments of the lagoon inner borders. Copper, chromium and manganese contents of the analyzed sediments are lower than those already measured in clays, while Cd, Pb, Sr and Zn show common increase, resulting from the anthropic activities around the study area. However, most of the metals traces register higher amounts in the accumulation zone rather than the amounts usually observed in soils and sediments.The chemical speciation of Cr, Ni, Zn and Pb, averaging 50 %, 53 %, 42 % and 36 % respectively, indicates that these metals are mainly associated to the residual fraction. By contrast, 41 % of the total Cu is mainly associated to the organic and sulfide phase. Manganese is concentrated in the oxides and hydroxides (50 %), whereas Cd (45 %) is attributed to the carbonate fraction. The chemical split of trace metal in the samples registering the highest amounts, has led to better understanding of the distribution of metals traces among the organic and the inorganic phases. In particular, this fractionation allowed to observe a preferential concentration of some metals traces in one (eg.: Cu, Cd, Zn, Pb) two (eg.: Ni) or more phases (eg.: Cr), thus depending on their mutual affinity (Slama, 2003).

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2.1.14 TURKEY WETLANDS COUNTRY REPORT

Serdar Bayari

GROUNDWATER-RELATED WETLAND 1 GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Yumurtalık Lagoon — **Wetland general type(2)**: 1AHI
2. **Municipality, Country**: Adana, Turkey — **Coordinates (geographical):** 36°39.501' N; 35° 33.824' E
3. **Wetland surface (km^2)(3)**: 179.7 — **Elevation (m) maximum-average**: 1 - 0.5
   Average depth/length/width (m)(3): 1/17,000/6000
4. **Contributing surface area (km^2)**: 5000 (est.)
5. **Contributing aquifer area (km^2)**: 5000 (est.) — **Aquifer type(4)**: Semi-confined
6. **Mean rainfall (mm/y)(5)**: 770 — **Mean T (°C)(5)**: 18.7 — **Mean ET (mm/y)(5)**: 890
7. **Underlying lithology(6)**: Siliceous sediments; Carbonated sediments
8. **Wetland genesis(7)**: Floodplain; Delta/estuary; Dune morphology; Coastal sedimentation
9. **Wetland sediments(8)**: Sandy; Silty; Clayey
10. **Water source(9)**: Rainfall on the wetland; Deep groundwater; Shallow groundwater; Sea (tidal/wave influence)
11. **Groundwater flow type(10)**: Flow through; Discharge area, open — **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: Permanent
13. **Hydrochemistry(13)**: EC: 58.7 mS/cm; dominant anion/s: Cl; dominant cation/s: Na
14. **Dominant vegetation(14)**: Shrubs, bushes; Prairie; Halophytic vegetation
15. **Trophic state(15)**: Mesotrophic
16. **Funtionality(16)**: Moderately altered
17. **State of knowledge(17)**: Biological information; Socioeconomic information; Water quality monitoring; Groundwater quality monitoring; Hydrogeological studies; Wetland evolution studies; Climate change impact studies; Information on wetland's uses
18. **Management status(18)**: Ramsar site; Nature Reserve/Other; Protection regulation; Management authority

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Water abstraction from the wetland is continuing/low. Water abstraction from tributaries is moderately decreasing/low. Groundwater basin is moderately increasing/low. Crops are moderately increasing. Forest is moderately decreasing/low. Cattle raising and Fishing are continuing/low. Salt mineral exploitation is continuing/low. Overexploitation from fuel, soils and rocks are unknown
20. **Changes in land use(20)**: Extensive agriculture and Extensive cattle raising are continuing/moderate
21. **Modification of hydrological cycle(21)**: Input of urban wastewater is continuing/low
22. **Pollution(22)**: Agricultural diffuse pollution is continuing/low. Atmospheric diffuse pollution is unknown
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Invasive exotic species and native species extinction are unknown
24. **Effects associated with changes(24)**: Increased erosion is moderately increasing/high
25. **Global and climate changes(25)**: Non-existent

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:

    26a. Natural production of food: Cropping (Moderate; Moderately increasing); Livestock, Fishing, Fruit collection and Hunting (Low; Continuing)

    26b. Artificial production of food: Aquaculture (Moderate; Continuing); Agriculture (Moderate; Increasing)

    26c. Others: Supply of good-quality water and Supply of water for different uses (Low; Moderately decreasing); Production of biological source materials, Production of mineral source materials, Genetic pool and biotechnology, Energy production and Natural species of medicinal interest (Low; Very rapidly decreasing)
27. **Regulating services(27) (Status; Trend)**: Hydrological regimes (floods, drought) (Moderate; Continuing); Water purification and Biological control (Moderate; Moderately increasing); Air quality regulation and Local climate regulation (Low; Continuing)
28. **Cultural services(28) (Status; Trend)**: Tourism, Cultural identity and sense of belonging, and Religious and spiritual (Low; Continuing); Educational and scientific knowledge, Local knowledge and good practices, Landscape and aesthetic (Moderate; Moderately increasing)

ADDITIONAL INFORMATION/COMMENTS

GROUNDWATER-RELATED WETLAND 2 GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Akyatan Lagoon **Wetland general type(2)**: 1AHI
2. **Municipality, Country**: Adana, Turkey **Coordinates (geographical):** 36° 40.79' N, 35° 16.74' E
3. **Wetland surface (km²)(3)**: 131 **Elevation (m) maximum-average**:1 - 0.5
   Average depth/length/width (m)(3): 1/18300/6500
4. **Contributing surface area (km²)**: 14,560 (est.)
5. **Contributing aquifer area (km²)**: 5000 (est.) **Aquifer type(4)**: Semi-confined
6. **Mean rainfall (mm/y)(5)**: 770 **Mean T (°C)(5)**: 18.7 **Mean ET (mm/y)(5)**: 890
7. **Underlying lithology(6)**: Siliceous sediments; Carbonated sediments
8. **Wetland genesis(7)**: Floodplain; Delta/estuary; Dune morphology; Coastal sedimentation
9. **Wetland sediments(8)**: Sandy; Silty; Clayey
10. **Water source(9)**: Rainfall on the wetland; Runoff in the basin; Deep groundwater; Shallow groundwater; Sea (tidal/wave influence)
11. **Groundwater flow type(10)**: Flow through; Discharge area, open **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: Permanent
13. **Hydrochemistry(13)**: 62.2 mS/cm, Cl, Na
14. **Dominant vegetation(14)**: Shrubs, bushes; Halophytic vegetation
15. **Trophic state(15)**: Mesotrophic
16. **Funtionality(16)**: Moderately altered
17. **State of knowledge(17)**: Biological information; Socioeconomic information; Water quality monitoring; Groundwater quality monitoring; Hydrogeological studies; Wetland evolution studies; Climate change impact studies; Information on wetland's uses
18. **Management status(18)**: Ramsar site; Nature Reserve/Other; Protection regulation; Management authority

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Water abstraction from wetland is continuing/low. Water abstraction from tributaries is moderately decreasing/low. Groundwater basin is moderately increasing/low. Crops are moderately increasing. Forest is continuing/moderate. Cattle raising and Fishing are continuing/low. Overexploitation from fuel, soils and rocks are unknown
20. **Changes in land use(20)**: Forest management is continuing/low. Extensive agriculture and Extensive cattle raising are continuing/moderate
21. **Modification of hydrological cycle(21)**: Input of urban wastewater is continuing/low
22. **Pollution(22)**: Agricultural diffuse pollution is continuing/low. Atmospheric diffuse pollution is unknown
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Invasive exotic species and native species extinction are unknown
24. **Effects associated with changes(24)**: Increased erosion is moderately increasing/low
25. **Global and climate changes(25)**: Non-existent

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status/Trend)**:

    26a. Natural production of food: Cropping (Moderate; Moderately increasing); Livestock, Fishing, Fruit collection and Hunting (Low; Continuing)

    26b. Artificial production of food: Aquaculture (Moderate; Continuing); Agriculture (Moderate; Moderately increasing)

    26c. Others: Supply of good-quality water an Water supply for differebt uses (Low; Moderately decreasing); Production of biological source materials, Production of mineral source materials, Genetic pool and biotechnology, Energy production and Natural species of medicinal interest (Low; Very rapidly decreasing)
27. **Regulating services(27) (Status/Trend)**: Hydrological regimes (floods, drought) (Moderate; Continuing); Water purification and Biological control (Moderate; Moderately increasing), Air quality regulation and Local climate regulation (Low; Continuing)
28. **Cultural services(28) (Status/Trend)**: Tourism, Cultural identity and sense of belonging, and Religious and spiritual (Low; Continuing), Educational and scientific knowledge, Local knowledge and good practices are continuing/low, and Landscape and aesthetic (Moderate; Moderately increasing)

ADDITIONAL INFORMATION/COMMENTS

GROUNDWATER-RELATED WETLAND 3 GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland**(1): Tuzla Lagoon — **Wetland general type**(2): 1AHI
2. **Municipality, Country**: Adana, Turkey — **Coordinates (geographical)**: 36°42.76' N; 35°3.63' E
3. **Wetland surface (km²)**(3): 21 — **Elevation (m) maximum-average**: 1 - 0.5
   Average depth/length/width (m)(3): 1/9900/2300
4. **Contributing surface area (km²)**: 14,560 (est.)
5. **Contributing aquifer area (km²)**: 5000 (est.) — **Aquifer type**(4): Semi-confined
6. **Mean rainfall (mm/y)**(5): 770 — **Mean T (°C)**(5): 18.7 — **Mean ET (mm/y)**(5): 890
7. **Underlying lithology**(6): Siliceous sediments; Carbonated sediments
8. **Wetland genesis**(7): Floodplain; Delta/estuary; Dune morphology; Coastal sedimentation
9. **Wetland sediments**(8): Sandy; Silty; Clayey
10. **Water source**(9): Rainfall on the wetland; Runoff in the basin; Deep groundwater; Shallow groundwater; Sea (tidal/wave influence)
11. **Groundwater flow type**(10): Flow through; Discharge area, open — **Groundwater dependence**(11): Shared
12. **Hydroperiod**(12): Permanent
13. **Hydrochemistry**(13): 76.4 mS/cm, dominant anion/s: Cl; dominant cation/s: Na
14. **Dominant vegetation**(14): Shrubs, bushes; Halophytic vegetation
15. **Trophic state**(15): Mesotrophic
16. **Funtionality**(16): Moderately altered
17. **State of knowledge**(17): Biological information; Socioeconomic information; Water quality monitoring; Groundwater quality monitoring; Hydrogeological studies
18. **Management status**(18): Nature Reserve/Other; Protection regulation; Management authority

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation**(19): Water abstraction from wetland is continuing/low. Water abstraction from tributaries is moderately decreasing/low. Groundwater basin is moderately increasing/low. Crops are moderately increasing. Forest is moderately decreasing/low. Cattle raising is continuing/low and Fishing continuing/high. Overexploitation from fuel, soils and rocks is unknown
20. **Changes in land use**(20): Forest management is continuing/low. Extensive agriculture and Extensive cattle raising are continuing/moderate
21. **Modification of hydrological cycle**(21): Input of urban wastewater is continuing/low
22. **Pollution**(22): Agricultural diffuse pollution is continuing/low. Atmospheric diffuse pollution is unknown
23. **Alteration of biological communities structures and ecosystems functioning**(23): Invasive exotic species and native species extinction are unknown
24. **Effects associated with changes**(24): Increased erosion is moderately increasing/low
25. **Global and climate changes**(25): Non-existent

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services**(26) **(Status; Trend)**:

    26a. Natural production of food: Cropping (Moderate; Moderately increasing); Livestock, Fishing and Fruit collection (Low; Continuing); Hunting (High; Continuing)

    26b. Artificial production of food: Aquaculture (Low; Continuing); Agriculture (Moderate; Moderately increasing)

    26c. Others: Supply of good-quality water and Supply of water for different uses (Low; Continuing); Production of biological source materials, Production of mineral source materials, Genetic pool and biotechnology, Energy production and Natural species of medicinal interest (Low; Very rapidly decreasing)
27. **Regulating services**(27) **(Status; Trend)**: Hydrological regimes (floods, drought) (Moderate; Continuing); Water purification (Moderate; Moderately increasing); Biological control, Air quality regulation and Local climate regulation (Low; Continuing)
28. **Cultural services**(28) **(Status; Trend)**: Tourism, Cultural identity and sense of belonging, Religious and spiritual, Educational and scientific knowledge, Local knowledge and good practices, and religious and spiritual (Low; Continuing); Landscape and aesthetic (Moderate; Moderately increasing)

ADDITIONAL INFORMATION/COMMENTS

GROUNDWATER-RELATED WETLAND 4 GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Dipsiz Wetland — **Wetland general type(2)**: 1B
2. **Municipality, Country**: Mersin, Turkey — **Coordinates: (geographical)** 36°44.64' N; 34°54.85' E
3. **Wetland surface (km²)(3)**: 10.7 — **Elevation (m) maximum-average**: 1 - 0.5
   Average depth/length/width (m)(3): 1/1500/1000
4. **Contributing surface area (km²)**: 14560 (est.)
5. **Contributing aquifer area (km²)**: 5000 (est.) — **Aquifer type(4)**: Semi-confined
6. **Mean rainfall (mm/y)(5)**: 675 — **Mean T (°C)(5)**: 19.0 — **Mean ET (mm/y)(5)**: 890
7. **Underlying lithology(6)**: Siliceous sediments; Carbonated sediments
8. **Wetland genesis(7)**: Floodplain; Delta/estuary; Coastal sedimentation
9. **Wetland sediments(8)**: Sandy; Silty; Clayey
10. **Water source(9)**: Rainfall on the wetland; Runoff in the basin; Deep groundwater; Shallow groundwater; Sea (tidal/wave influence)
11. **Groundwater flow type(10)**: Flow through; Discharge area; Closed, saline **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: Permanent
13. **Hydrochemistry(13)**: 13.7 mS/cm; dominant anion/s: Cl; dominant cation/s: Na
14. **Dominant vegetation(14)**: Shrubs, bushes; Halophytic vegetation
15. **Trophic state(15)**: Mesotrophic
16. **Funtionality(16)**: Moderately altered
17. **State of knowledge(17)**: Chemical/isotopic information; Biological information; Socioeconomic information; Water quality monitoring; Groundwater quality monitoring
18. **Management status(18)**: Nature Reserve/Other; Protection regulation; Management authority

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Water abstraction from wetland is continuing/low. Water abstraction from tributaries is moderately decreasing /low. Groundwater basin is moderately increasing/low. Crops are continuing/moderate. Forest is moderately decreasing/low. Cattle raising and Fishing are continuing/low. Salt mineral exploitation is continuing/moderate. Overexploitation from fuel, soils and rocks are unknown
20. **Changes in land use(20)**: Extensive agriculture and Extensive cattle raising are continuing/moderate
21. **Modification of hydrological cycle(21)**: Input of urban wastewater is continuing/low
22. **Pollution(22)**: Agricultural diffuse pollution is continuing/low. Atmospheric diffuse pollution is unknown
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Invasive exotic species and native species extinction are unknown
24. **Effects associated with changes(24)**: Increased erosion is moderately increasing/low
25. **Global and climate changes(25)**: Non-existent

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:
    26a. Natural production of food: Cropping (Moderate; Contnuing); Livestock, Fishing and Hunting (Low; Continuing)
    26b. Artificial production of food: Aquaculture and Agriculture (Low; Continuing)
    26c. Others: Supply of good-quality water and Supply of water for diferent uses (High; Continuing); Production of biological source materials, Production of mineral source materials, Genetic pool and biotechnology, Energy production and Natural species of medicinal interest (Low; Very rapidly decreasing)
27. **Regulating services(27) (Status; Trend)**: Hydrological regimes (floods, drought) (Moderate; Continuing); Water purification (Modearte; Moderately increasing); Biological control, Air quality regulation and Local climate regulation (Low; Continuing)
28. **Cultural services(28) (Status; Trend)**: Tourism, Cultural identity and sense of belonging, Religious and spiritual, Educational and scientific knowledge, Local knowledge and good practices (Low; Continuing); Landscape and aesthetic (Moderate; Moderately increasing)

ADDITIONAL INFORMATION/COMMENTS

GROUNDWATER-RELATED WETLAND 5 GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Göksu Delta **Wetland general type(2)**: 2AIP
2. **Municipality, Country**: Mersin, Turkey **Coordinates (geographical)**: 36° 17.74' N, 33° 59.08' E
3. **Wetland surface (km²)(3)**: 150 **Elevation (m) maximum-average**: 2 - 0.5
   Average depth/length/width (m)(3): 1/4000/4000
4. **Contributing surface area (km²)**: 10100 (est.)
5. **Contributing aquifer area (km²)**: 225 (est.) **Aquifer type(4)**: Semi-confined
6. **Mean rainfall (mm/y)(5)**: 603 **Mean T (°C)(5)**: 18.5 **Mean ET (mm/y)(5)**: 1027
7. **Underlying lithology(6)**: Siliceous sediments; Carbonated sediments
8. **Wetland genesis(7)**: Floodplain; Delta/estuary; Coastal sedimentation
9. **Wetland sediments(8)**: Sandy; Silty; Clayey
10. **Water source(9)**: Rainfall on the wetland; Runoff in the basin; Deep groundwater; Shallow groundwater; Sea (tidal wave influence)
11. **Groundwater flow type(10)**: Flow through; Discharge area, open **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: Permanent
13. **Hydrochemistry(13)**: **EC:** 32.1 mS/cm: dominant anion/s: Cl/HCO_3; dominant cation/s: Na/Ca
14. **Dominant vegetation(14)**: Prairie
15. **Trophic state(15)**: Mesotrophic
16. **Funtionality(16)**: moderately altered
17. **State of knowledge(17)**: Validated hydrogeological conceptual model; Numerical model; Chemical/isotopic information; Biological information; Socioeconomic information; Water quality monitoring; Groundwater quality monitoring; Hydrogeological studies; Wetland evolution studies; Climate change impact studies; Information on wetland's uses
18. **Management status(18)**: Ramsar site; Nature Reserve/Other; Protection regulation; Management authorit

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Water abstraction from wetland is continuing/low. Water abstraction from tributaries is moderately decreasing/low. Groundwater basin is moderately increasing/low. Crops are continuing/low. Forest is moderately decreasing/low. Cattle raising and Fishing are continuing/low. Overexploitation from fuel, soils and rocks are unknown
20. **Changes in land use(20)**: Extensive agriculture and Extensive cattle raising are continuing/low
21. **Modification of hydrological cycle(21)**: Input of urban wastewater is continuing/low
22. **Pollution(22)**: Agricultural diffuse pollution is continuing/low. Atmospheric diffuse pollution is unknown
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Invasive exotic species and native species extinction are unknown
24. **Effects associated with changes(24)**: Increased erosion is moderately increasing/high
25. **Global and climate changes(25)**: Non-existent

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:

    26a. Natural production of food: Cropping, Livestock, Fishing, Fruit collection and Hunting (Low; Continuing)

    26b. Artificial production of food: Aquaculture and Agriculture (Low; Continuing)

    26c. Others: Supply of good-quality water and Supply of water for different uses (Moderate; Moderately decreasing); Production of biological source materials, Production of mineral source materials, Genetic pool and biotechnology, Energy production and Natural species of medicinal interest (Low; Very rapidly decreasing)
27. **Regulating services(27) (Status; Trend)**: Hydrological regimes (floods, drought) and Water purification (Moderate; Continuing); Biological control (High; Moderately increasing); Air quality regulation and Local climate regulation (Low; Continuing)
28. **Cultural services(28) (Status; Trend)**: Tourism, Cultural identity and sense of belonging, and Religious and spiritual (Low; Continuing/low); Educational and scientific knowledge (High; Moderately increasing); Local knowledge and good practices, and Landscape and aesthetic (Moderate; Moderately increasing)

ADDITIONAL INFORMATION/COMMENTS

GROUNDWATER-RELATED WETLAND 6 GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Dalaman Wetlands — **Wetland general type(2)**: 1AIP
2. **Municipality, Country**: Muğla, Turkey — **Coordinates (geographical):** 36°41.64' N; 28°49.37' E
3. **Wetland surface (km^2)(3)**: 284 — **Elevation (m) maximum-average**: 4 - 0.5

   Average depth/length/width (m)(3): 1/2800/1500
4. **Contributing surface area (km^2)**: 3400 (est.)
5. **Contributing aquifer area (km^2)**: 80 (est.) — **Aquifer type(4)**: Water table; Semi-confined
6. **Mean rainfall (mm/y)(5)**: 1044 — **Mean T (°C)(5)**: 18.9 — **Mean ET (mm/y)(5)**: 1209
7. **Underlying lithology(6)**: Siliceous sediments; Carbonated sediments; Carbonate rocks; Metamorphic rocks
8. **Wetland genesis(7)**: Tectonic; Floodplain; Delta/estuary; Dune morphology; Coastal sedimentation
9. **Wetland sediments(8)**: Sandy; Silty; Clayey
10. **Water source(9)**: Rainfall on the wetland; Runoff in the basin; Deep groundwater; Shallow groundwater
11. **Groundwater flow type(10)**: Flow through; Discharge area, open — **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: Permanent
13. **Hydrochemistry(13)**: **CE:** 8.5 mS/cm; dominant anion/s: Cl/HCO_3; dominant cation/s: Na/Ca
14. **Dominant vegetation(14)**: Shrubs, bushes; Prairie; Halophytic vegetation
15. **Trophic state(15)**: Mesotrophic
16. **Funtionality(16)**: Moderately altered
17. **State of knowledge(17)**: Chemical/isotopic information; Biological information; Socioeconomic information; Water quality monitoring; Hydrogeological studies; Wetland evolution studies
18. **Management status(18)**: Nature Reserve/Other; Protection regulation; Management authority; Users' involvement

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Water abstraction from wetland is continuing/low. Water abstraction from tributaries is moderately decreasing /low. Groundwater basin is moderately increasing/low. Crops are continuing/low. Forest is moderately decreasing/ low. Cattle raising and Fishing are continuing/low. Overexploitation from fuel, soils and rocks are unknown
20. **Changes in land use(20)**: Extensive agriculture and Extensive cattle raising are continuing/low. Urbanization is moderately increasing/low
21. **Modification of hydrological cycle(21)**: Input of urban wastewater is continuing/low
22. **Pollution(22)**: Agricultural diffuse pollution is continuing/low. Atmospheric diffuse pollution is unknown
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Invasive exotic species and native species extinction are unknown
24. **Effects associated with changes(24)**: Increased erosion is moderately decreasing/low
25. **Global and climate changes(25)**: Non-existent

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:

    26a. Natural production of food: Cropping (Low; Moderately increasing); Livestock and Fishing (Low; Moderately decreasing); Fruit collection and Hunting (Low; Continuing)

    26b. Artificial production of food: Aquaculture and Agriculture (Low; Continuing)

    26c. Others: Supply of good-quality water and Water supply for different uses (Low; Continuing); Production of biological source materials, Production of mineral source materials, Genetic pool and biotechnology, Energy production and Natural species of medicinal interest (Low; Very rapidly decreasing)
27. **Regulating services(27) (Status; Trend)**: Hydrological regimes (floods, drought), Air quality regulation and Local climate regulation (Low; Continuing); Water purification (Low; Moderately increasing); Biological control (Moderate; Moderately increasing)
28. **Cultural services(28) (Status; Trend)**: Tourism (Low; Moderately increasing); Cultural identity and sense of belonging, Religious and spiritual, Educational and scientific knowledge and Local knowledge and good practices (Low; Continuing); Landscape and aesthetic (High; Moderately increasing)

ADDITIONAL INFORMATION/COMMENTS

GROUNDWATER-RELATED WETLAND 6 GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Dalyan Wetlands — **Wetland general type(2)**: 1AIP
2. **Municipality, Country**: Muğla, Turkey — **Coordinates (geographical)**: 36°48.09' N; 28°37.48' E
3. **Wetland surface (km^2)(3)**: 15 — **Elevation (m) maximum-average**: 2 - 0.5

   Average depth/length/width (m)(3): 1/6000/1700
4. **Contributing surface area (km^2)**: 650 (est.)
5. **Contributing aquifer area (km^2)**: 15 (est.) — **Aquifer type(4)**: Water table
6. **Mean rainfall (mm/y)(5)**: 1064 — **Mean T (°C)(5)**: 18.3 — **Mean ET (mm/y)(5)**: 1415
7. **Underlying lithology(6)**: Carbonate rocks
8. **Wetland genesis(7)**: Tectonic; Floodplain; Delta/Estuary; Dune morphology; Coastal sedimentation
9. **Wetland sediments(8)**: Sandy; Silty
10. **Water source(9)**: Rainfall on the wetland; Runoff in the basin; Deep groundwater; Shallow groundwater
11. **Groundwater flow type(10)**: Flow through; Discharge area, open — **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: Permanent
13. **Hydrochemistry(13)**: **EC:** 37.3 mS/cm; dominant anion/s: Cl-HCO_3; dominant cation/s: Na-Ca
14. **Dominant vegetation(14)**: Shrubs, bushes; Halophytic vegetation; Phreatophyte vegetation
15. **Trophic state(15)**: Mesotrophic
16. **Funtionality(16)**: Moderately unaltered
17. **State of knowledge(17)**: Chemical/isotopic information; Biological information; Socioeconomic information; Water quality monitoring; Hydrogeological studies; Wetland evolution studies; Information on wetland's uses
18. **Management status(18)**: Nature Reserve/Other; Protection regulation; Users' involvement

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Water abstraction from wetland is continuing/low. Water abstraction from tributaries is moderately decreasing/low. Groundwater basin is moderately increasing/low. Crops are continuing/low. Forest is moderately decreasing / low. Cattle raising and Fishing are continuing/low. Overexploitation from fuel, soils and rocks are unknown
20. **Changes in land use(20)**: Extensive agriculture and Extensive cattle raising are continuing/low.
21. **Modification of hydrological cycle(21)**: Input of urban wastewater is continuing/low
22. **Pollution(22)**: Agricultural diffuse pollution is continuing/low. Atmospheric diffuse pollution is unknown
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Invasive exotic species and native species extinction are unknown
24. **Effects associated with changes(24)**: Increased erosion is moderately decreasing/low
25. **Global and climate changes(25)**: Non-existent

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:

    26a. Natural production of food: Cropping, Fruit collection and Hunting (Low; Continuing); Livestock (Low; Moderately decreasing); Fishing (Low; Moderately increasing)

    26b. Artificial production of food: Aquaculture (High; Moderately increasing); Agriculture (Low; Continuing)

    26c. Others: Supply of good-quality water and Water supply for different uses (Low; Continuing); Production of biological source materials, Production of mineral source materials, Genetic pool and biotechnology, Energy production and Natural species of medicinal interest (Low; Very rapidly decreasing); Water purification (Low; Very rapidly increasing)
27. **Regulating services(27) (Status; Trend)**: Hydrological regimes (floods, drought) (Low; Continuing); Water purification (Low; Moderately increasing); Biological control (Moderate; Moderately increasing); Air quality regulation and Local climate regulation (Low; Continuing)
28. **Cultural services(28) (Status; Trend)**: Tourism (Low; Moderately increasing); Cultural identity and sense of belonging, Religious and spiritual, Educational and scientific knowledge, and Local knowledge and good practices (Low; Continuing); Landscape and aesthetic (High; Continuing)

ADDITIONAL INFORMATION/COMMENTS

GROUNDWATER-RELATED WETLAND 6 GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Büyük Menderes Delta **Wetland general type(2)**: 2AHI
2. **Municipality, Country**: Aydın, Turkey **Coordinates (geographical)**: 37°35.49' N; 27°13.85' E
3. **Wetland surface (km²)(3)**: 91 **Elevation (m) maximum-average**: 5 - 0.5
   Average depth/length/width (m)(3): 1/18400/4700
4. **Contributing surface area (km²)**: 25000 (est.)
5. **Contributing aquifer area (km²)**: 350 (est.) **Aquifer type(4)**: Semi-confined
6. **Mean rainfall (mm/y)(5)**: 601 **Mean T (°C)(5)**: 21.7 **Mean ET (mm/y)(5)**: 1200
7. **Underlying lithology(6)**: Siliceous sediments; Carbonated sediments
8. **Wetland genesis(7)**: Tectonic; Floodplain; Delta/Estuary; Coastal sedimentation
9. **Wetland sediments(8)**: Sandy; Silty; Clayey
10. **Water source(9)**: Rainfall on the wetland; Runoff in the basin; Deep groundwater; Shallow groundwater
11. **Groundwater flow type(10)**: Flow through; Discharge area, open **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: Permanent
13. **Hydrochemistry(13)**: **EC:** 25.3 mS/cm; dominant anion/s: Cl; dominant cation/s: Na
14. **Dominant vegetation(14)**: Shrubs, bushes; Prairie; Halophytic vegetation
15. **Trophic state(15)**: Mesotrophic
16. **Funtionality(16)**: Moderately unaltered
17. **State of knowledge(17)**: Chemical/isotopic information; Biological information; Socioeconomic information; Water quality monitoring; Groundwater quality monitoring; Hydrogeological studies; Wetland evolution studies; Information on wetland's uses
18. **Management status(18)**: Nature Reserve/Other; Protection regulation

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Water abstraction from wetland is continuing/low. Water abstraction from tributaries is moderately decreasing/low. Groundwater basin is moderately increasing/low. Crops are continuing/low. Forest is moderately decreasing/low. Cattle raising and Fishing are continuing/low. Overexploitation from fuel, soils and rocks are unknown
20. **Changes in land use(20)**: Extensive agriculture and Extensive cattle raising are continuing/low
21. **Modification of hydrological cycle(21)**: Input of urban wastewater is continuing/low
22. **Pollution(22)**: Agricultural diffuse pollution is continuing/high. Atmospheric diffuse pollution is unknown
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Invasive exotic species and native species extinction are unknown
24. **Effects associated with changes(24)**: Increased erosion is moderately increasing/low
25. **Global and climate changes(25)**: Non-existent

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:

    26a. Natural production of food: Cropping (Moderate; Continuing); Livestock (Moderate; Moderately decreasing); Fishing, Fruit collection and Hunting (Low; Continuing)

    26b. Artificial production of food: Aquaculture and Agriculture (Low; Moderately increasing)

    26c. Others: Supply of good-quality water and Water supply for different uses (Low; Moderately decreasing); Production of biological source materials, Production of mineral source materials, Genetic pool and biotechnology, Energy production and Natural species of medicinal interest (Low; Very rapidly decreasing)
27. **Regulating services(27) (Status; Trend)**: Hydrological regimes (floods, drought) (Low; Continuing); Water purification (Moderate; Continuing); Biological control (Moderate; Moderately increasing); Air quality regulation and Local climate regulation (Low; Continuing)
28. **Cultural services(28) (Status; Trend)**: Tourism, Cultural identity and sense of belonging, Religious and spiritual and Local knowledge and good practices (Low; Continuing); Educational and scientific knowledge and Landscape and aesthetic (Moderate; Moderately increasing)

ADDITIONAL INFORMATION/COMMENTS

GROUNDWATER-RELATED WETLAND 9 GENERAL DATA

x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Küçük Menderes Delta **Wetland general type(2)**: 1AIP
2. **Municipality, Country**: Aydın, Turkey **Coordinates (geographical)**: 37°59.23' N; 27°18.36' E
3. **Wetland surface (km²)(3)**: 326 **Elevation (m) maximum-average**: 5 - 0.5
   Average depth/length/width (m)(3): 1/1500/700
4. **Contributing surface area (km²)**: 3500 (est.)
5. **Contributing aquifer area (km²)**: 25 (est.) **Aquifer type(4)**: Semi-confined
6. **Mean rainfall (mm/y)(5)**: 637 **Mean T (ºC)(5)**: 16.6 **Mean ET (mm/y)(5)**: 820
7. **Underlying lithology(6)**: Siliceous sediments; Carbonated sediments; Carbonate rocks; Volcanic rocks
8. **Wetland genesis(7)**: Tectonic; Volcanic; Delta/Estuary; Artificial
9. **Wetland sediments(8)**: Sandy; Silty
10. **Water source(9)**: Rainfall on the wetland; Runoff in the basin; Deep groundwater; Shallow groundwater
11. **Groundwater flow type(10)**: Flow through; Discharge area, open **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: Permanent
13. **Hydrochemistry(13)**: **EC:** 3-11 mS/cm; dominant anion/s: Cl; dominant cation/s: Na
14. **Dominant vegetation(14)**: Shrubs, bushes
15. **Trophic state(15)**: Mesotrophic
16. **Funtionality(16)**: Moderately unaltered
17. **State of knowledge(17)**: Chemical/isotopic information; Biological information; Socioeconomic information; Water quality monitoring; Groundwater quality monitoring; Hydrogeological studies; Wetland evolution studies; Information on wetland's uses
18. **Management status(18)**: Nature Reserve/Other; Protection regulation; Management authority

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Water abstraction from wetland is continuing/low. Water abstraction from tributaries is moderately decreasing/low. Groundwater basin is moderately increasing/low. Crops are continuing/low. Forest is moderately decreasing/low. Cattle raising and Fishing are continuing/low. Overexploitation from fuel, soils and rocks are unknown
20. **Changes in land use(20)**: Extensive agriculture and Extensive cattle raising are continuing/low
21. **Modification of hydrological cycle(21)**: Input of urban wastewater is continuing/low
22. **Pollution(22)**: Agricultural diffuse pollution is continuing/high. Atmospheric diffuse pollution is unknown
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Invasive exotic species and native species extinction are unknown
24. **Effects associated with changes(24)**: Increased erosion is continuing/moderate
25. **Global and climate changes(25)**: Non-existent

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

27. **Provisioning services(26) (Status; Trend)**:

    26a. Natural production of food: Cropping (Moderate; Continuing); Livestock (Low; Moderately decreasing); Fishing, Fruit collection and Hunting (Low; Continuing)

    26b. Artificial production of food: Aquaculture (Low; Continuing); Agriculture (Low; Moderately increasing)

    26c. Others: Supply of good-quality water and water supply for different uses (Low; Moderately decreasing); Production of biological source materials, Production of mineral source materials, Genetic pool and biotechnology, Energy production and Natural species of medicinal interest (Low; Very rapidly decreasing)

27. **Regulating services(27) (Status; Trend)**: Hydrological regimes (floods, drought) (Low; Continuing); Water purification (Low; Moderately decreasing); Biological control (Moderate; Moderately increasing); Air quality regulation and Local climate regulation (Low; Continuing)
28. **Cultural services(28) (Status; Trend)**: Tourism, Cultural identity and sense of belonging, Religious and spiritual and Educational and scientific knowledge (Low; Continuing); Local knowledge and good practices (Low; Moderately decreasing); Landscape and aesthetic (Moderate; Moderately increasing)

ADDITIONAL INFORMATION/COMMENTS

GROUNDWATER-RELATED WETLAND 10 GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Gediz Delta **Wetland general type(2)**: 2AIP
2. **Municipality, Country**: İzmir, Turkey **Coordinates (geographical)**: 38°32.69' N; 26°54.11' E
3. **Wetland surface (km²)(3)**: 908 **Elevation (m) maximum-average**: 5 - 0.5
   Average depth/length/width (m)(3): 1/21500/6900
4. **Contributing surface area (km²)**: 17500 (est.)
5. **Contributing aquifer area (km²)**: 1000 (est.) **Aquifer type(4)**: Semi-confined
6. **Mean rainfall (mm/y)(5)**: 646 **Mean T (°C)(5)**: 17.9 **Mean ET (mm/y)(5)**: 851
7. **Underlying lithology(6)**: Siliceous sediments; Carbonated sediments
8. **Wetland genesis(7)**: Tectonic; Volcanic; Floodplain; Delta/Estuary; Artificial
9. **Wetland sediments(8)**: Sandy; Silty
10. **Water source(9)**: Rainfall on the wetland; Runoff in the basin; Deep groundwater; Shallow groundwater
11. **Groundwater flow type(10)**: Flow through; Discharge area, Open **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: Permanent
13. **Hydrochemistry(13)**: **EC:** 1.09 mS/cm; dominant anion/s: HCO_3; dominant cation/s: Na
14. **Dominant vegetation(14)**: Shrubs, bushes; Prairie
15. **Trophic state(15)**: Mesotrophic
16. **Funtionality(16)**: Moderately unaltered
17. **State of knowledge(17)**: Chemical/isotopic information; Biological information; Socioeconomic information; Water quality monitoring; Groundwater quality monitoring; Hydrogeological studies; Information on wetland's uses
18. **Management status(18)**: Ramsar site; Nature Reserve/Other; Protection regulation; Management authority

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Water abstraction from wetland is continuing/low. Water abstraction from tributaries is moderately decreasing/low. Groundwater basin is moderately moderate/low. Crops are continuing/low. Forest is moderately decreasing/low. Cattle raising and Fishing are continuing/low. Salt mineral exploitation is continuing/high. Overexploitation from fuel, soils and rocks are unknown
20. **Changes in land use(20)**: Extensive agriculture and Extensive cattle raising are continuing/low. Urbanization is moderately increasing/low
21. **Modification of hydrological cycle(21)**: Input of urban wastewater is continuing/low
22. **Pollution(22)**: Agricultural diffuse pollution is continuing/low. Atmospheric diffuse pollution is unknown
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Invasive exotic species and native species extinction are unknown
25. **Effects associated with changes(24)**: Increased erosion is moderately decreasing/low
26. **Global and climate changes(25)**: Non-existent

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:

    26a. Natural production of food: Cropping (Modearte; Continuing); Livestock (Low; Moderately decreasing); Fishing, Fruit collection and Hunting (Low; Continuing)

    26b. Artificial production of food: Aquaculture (Low; Continuing); Agriculture (Low; Moderately increasing)

    26c. Others: Supply of good-quality water and Water supply for different uses (Low; Moderately decreasing); Production of biological source materials, Production of mineral source materials, Genetic pool and biotechnology, Energy production and Natural species of medicinal interest (Low; Very rapidly decreasing)
27. **Regulating services(27) (Status; Trend)**: Hydrological regimes (floods, drought) (Low; Continuing); Water purification (Low; Moderately decreasing); Biological control (Moderate; Moderately increasing); Air quality regulation and Local climate regulation (Low; Continuing)
28. **Cultural services(28) (Status; Trend)**: Tourism (Low; Moderately increasing); Educational and scientific knowledge and Landscape and aesthetic (Moderate; Moderately increasing); Local knowledge and good practices (High; Moderately increasing); Cultural identity and sense of belonging and Religious and spiritual (Low; Continuing)

ADDITIONAL INFORMATION/COMMENTS

GROUNDWATER-RELATED WETLAND 11 GENERAL DATA

(x) Refers to the numbers in the legend chart.

1. **Name of wetland(1)**: Gökçeada Lagoon — **Wetland general type(2)**: 1AHI
2. **Municipality, country**: Çanakkale, Turkey — **Coordinates (geographical):** 40°8.36′ N; 25°57.36′ E
3. **Wetland surface (km²)(3)**: 31.5 — **Elevation (m) maximum-average**: 2 - 0.5
   Average depth/length/width (m)(3): 1/1300/800
4. **Contributing surface area (km²)**: 20 (est.)
5. **Contributing aquifer area (km²)**: 20 (est.) — **Aquifer type(4)**: Water table
6. **Mean rainfall (mm/y)(5)**: 735 — **Mean T (°C)(5)**: 15.2 — **Mean ET (mm/y)(5)**: 1021
7. **Underlying lithology(6)**: Siliceous sediments
8. **Wetland genesis(7)**: Erosive; Coastal sedimentation
9. **Wetland sediments(8)**: Sandy; Silty
10. **Water source(9)**: Rainfall on the wetland; Shallow groundwater
11. **Groundwater flow type(10)**: Discharge area, closed saline — **Groundwater dependence(11)**: Shared
12. **Hydroperiod(12)**: Permanent
13. **Hydrochemistry(13)**: **EC:** 0.5-129 mS/cm; dominant anion/s: Cl; dominant cation/s: Na
14. **Dominant vegetation(14)**: Shrubs, bushes; Halophytic vegetation
15. **Trophic state(15)**: Mesotrophic
16. **Funtionality(16)**: Almost unaltered
17. **State of knowledge(17)**: Chemical/isotopic information; Biological information; Socioeconomic information; Water quality monitoring; Groundwater quality monitoring; Wetland evolution studies
18. **Management status(18)**: Nature Reserve/Other; Protection regulation; Management authority

MAIN DIRECT DRIVERS OF CHANGE IN THE GROUNDWATER-RELATED WETLAND

19. **Resource exploitation(19)**: Water abstraction from wetland is continuing/low. Water abstraction from tributaries is moderately decreasing/low. Groundwater basin is moderately increasing. Crops are continuing/low. Forest is moderately decreasing/low. Cattle raising and Fishing are continuing/low. Overexploitation from fuel, soils and rocks are unknown
20. **Changes in land use(20)**: Non-existent
21. **Modification of hydrological cycle(21)**: Input of urban waste water is low and continuing
22. **Pollution(22)**: Agricultural diffuse pollution is continuing/low. Atmospheric diffuse pollution is unknown
23. **Alteration of biological communities structures and ecosystems functioning(23)**: Invasive exotic species and native species extinction are unknown
24. **Effects associated with changes(24)**: Increased erosion is continuing/low
25. **Global and climate changes(25)**: Non-existent

WETLAND SERVICES GLOBAL ASSESSMENT OF STATUS AND TRENDS

26. **Provisioning services(26) (Status; Trend)**:

    26a. Natural production of food: Cropping, Fruits collection and Hynting (Low; Continuing); Livestock (Low; Moderately decreasing)

    26b. Artificial production of food: Agriculture (Low; Continuing)

    26c. Others: Supply of good-quality water and Water supply for different uses (High; Continuing); Production of biological source materials, Production of mineral source materials, Genetic pool and biotechnology, Energy production and Natural species of medicinal interest (Low; Very rapidly decreasing)
27. **Regulating services(27) (Status; Trend)**: Hydrological regimes (floods, drought), Water purification, Biological control, Air quality regulation and Local climate regulation (Low; Continuing)
28. **Cultural services(28) (Status; Trend)**: Tourism and Landscape and aesthetic (Moderate; Continuing); Educational and scientific knowledge, Cultural identity and sense of belonging and Religious and spiritual (Low; Continuing); Local knowledge and good practices (Low; Moderately increasing).

2.2 CASE STUDIES

2.2.1 IMPACTS OF PHYSICAL AND ANTHROPOGENIC STRESSES ON TYRE BEACH WETLAND, LEBANON

Amin Shaban

Lebanon has been known for its many surface and sub-surface water resources. Recently, this has changed due to a number of physical and anthropogenic factors. For example, over the past few decades the discharge in rivers and springs has decreased by about 50-60% (Shaban and others, 2014), while the water table in groundwater reservoirs has deepened to several tens of metres (Shaban, 2011). In addition the area of snow cover, as the main source of water in Lebanon, has been also reduced by about 25% (Shaban, 2014). This status is reflected in the per capita income, which has also declined by 50% in the last three decades (Shaban, 2014).

Water stress in Lebanon is concentrated mainly in the coastal zone, which is occupied by more than 70% of the Lebanese population. Thus, water demand/supply became a crucial geo-environmental issue, and conserving water resources has been raised as an urgent water management tool.

As major sources of water, wetlands in Lebanon are considered to be non-conventional. They are mainly used for domestic and agricultural uses, as well as representing unique landforms for diverse flora and fauna. Unfortunately, the Lebanese wetlands are witnessing severe changes due to the decrease in the amount of feeding water resulting from changing climatic conditions and over-exploitation.

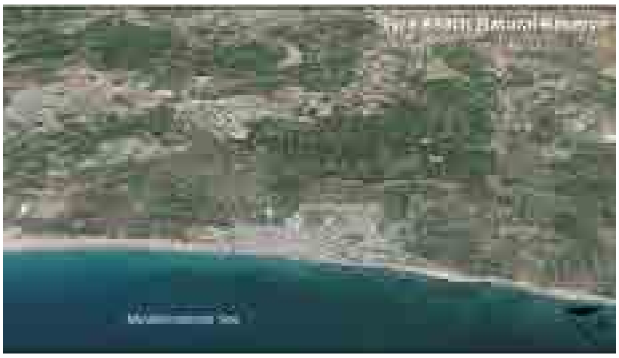
The Ramsar-identified coastal wetland of Tyre Beach along the southern Lebanese coast is an example of the stresses influencing Lebanese wetlands. Tyre Beach, which has a number of springs forming lakes and ponds, as well as saturated terrain, has been subjected to relevant changes in its hydrologic regime which substantially affected its water feeding mechanism.

The preliminary field investigations showed that the water-feeding mechanism of Tyre Beach wetland is mainly controlled by fault systems. These transport groundwater from the recharge areas several kilometres from the outlets, and then feed the coastal springs forming the lakes and ponds as well as the saturated terrain.

The abstraction of groundwater from the aquifer recharge areas has lately been exacerbated and the number of wells dug has doubled, resulting in intensive pumping of groundwater (Shaban, 2014). These impacts in turn affect the volume of water discharged from the springs forming the Tyre Beach wetland. The inhabitants estimated that the actual discharge was roughly half of the regular amount. The components of the wetland have been correspondingly influenced, and the decreased amount of feeding water creates a negative impact on the existing flora and fauna. The local population, as well as changing climatic conditions, has also had an impact (Case Study Figure 1).

This is a typical example of one of the Lebanese wetlands which are changing under rapid physical and anthropogenic stresses. These stresses must be addressed and management approaches to conserve these wetlands must be applied through in-depth investigation and assessment.

Figure 2.2.1.1 Intensive cultivation and dense human settlements surrounding the Tyre Beach Ramsar site. Source: A. Shaban.



Shaban, A. (2011). Analyzing climatic and hydrologic trends in Lebanon. *Journal of Environmental Science and Engineering*, vol. 5, No. 3, pp. 483-492.

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Shaban, A., and others (2014). Assessment of climate change impact on water, agriculture and energy in Lebanon. Presentation at International conference on The Water-Food-Energy-Climate Nexus in Global Drylands, 12-13 June 2014. Rabat, Morocco.

2.2.2 IMPACTS OF INTENSIVE LAND USE ON THE WADI GAZA WETLAND, PALESTINE

Khalid Qahman

Wadi Gaza Nature Reserve (and wetland) is situated on the Middle East Mediterranean coast in the middle of the Gaza Strip, Palestine. The watershed of Wadi Gaza covers more than 3500 km^2 of the Northern Negev Desert, the Hebron Mountains and the small catchment in the Gaza Strip. The Wadi's length from origin to mouth is about 105 km, the last 9 km of which is in the Gaza Strip. The Wadi discharges to the Mediterranean Sea. The Wadi Gaza wetland area is located at the Wadi's mouth, to the south-west of the Wadi. It covers a small area compared to other wetlands worldwide, about 25 ha. The water table of the aquifer in the wetland intersects with the topography and emerges at the surface. Another source of fresh water supplying the wetland ecosystem is storm water that accumulates during the rainy season. Untreated wastewater is discharged in Wadi Gaza, and hence its wetland, from the adjacent residential masses; yet it is very rich in biodiversity and of great significance to migrating birds from Europe to Africa in the autumn (MedWetCoast, 2001).

Several threats are causing deterioration to Wadi Gaza wetland performance and services:

- Resource exploitation. Local people say that the wetland site was permanently flooded and that it was like a jungle, describing the water seeping out from it in those days as "very sweet". The pressure put on land and groundwater after the second Palestinian migration in 1948 (from the concentration of large numbers of people in the small area of the Gaza Strip and the Israeli activities upstream) were the main causes of the deterioration of Wadi Gaza and its wetland. In 1970, groundwater abstraction for agricultural uses was very low. It remained at this level until 1973, when the abstraction rate increased suddenly due to the increase in citrus cultivation in neighbouring area of Wadi Gaza. In addition, reservoirs and dams were constructed along the upstream branches of the Wadi, outside Palestine, for irrigation and other uses.

- Changes in land use. After 2005, unplanned development led to the construction of large-scale projects and small-scale development. A temporary wastewater treatment plant has been constructed within the lake, at the mouth of the Wadi, and is expected to start operating in few months. This wastewater plant was constructed to serve the middle area of the Gaza Strip (for central area communities) for a temporary period until the construction of a Central Gaza wastewater treatment plant (Case Study Figure 2). The design flow of the temporary treatment plant is 18,000 m^3/d, and it is proposed to discharge the treated effluent to the sea by a gravity line. This treatment plant will be taken out of service when the Central Gaza wastewater plant is ready for operation (TECC, 2014).

- Surface water and groundwater interaction. The Wadi Gaza wetland is linked to the coastal aquifer. In 1935 the groundwater level was around 3 m a.s.l. After this time, the water table gradually decreased to about 0.7 m in 1985, and then fluctuated until it rose suddenly to approximately 2 m in 1992, decreasing again to around 0.5 m in 2000, and finally remaining in the same range until 2008. The rainfall data show a fluctuation from about 0 mm to around 350 mm in the autumn, with the highest historic rainfall in 1986 and 1995. By observing the patterns of groundwater level with rainfall versus time, we can infer that higher rainfall in any year is followed by a higher groundwater level in the next year or period, and that lower rainfall in any year is followed by a lower groundwater level in the next year or period. This does not taken into account the effect of abstraction.

It can be concluded that the volume of water in the wetland basin changes throughout the year, and from year to year, depending on the amount of rain that year and the artificial activities (such as canalizing) carried out by people to the watercourse of the Wadi. The wetland of Wadi Gaza is mainly deprived of its water both by of construction of upstream dams and by the excessive pumping of groundwater in the whole of the Gaza Strip. The result is some loss in overall water supply to the wetland and, equally important, an interruption to the natural, seasonal cycle of high and low flows that is essential to the life cycles of plants, fish, birds and other wildlife.

In recognition of its importance as a natural area and as the only wetland in Palestine, Wadi Gaza was declared a Nature Reserve in June 2000. The Ministry of Environmental Affairs requested that municipalities should revise their land use plans to ensure that the Wadi bed be respected as a protected area. Wadi Gaza is characterized by its unique water system where fresh and saline water can be found, as well as both terrestrial and freshwater-to-saline water birds such as flamingos. On 2 April 2014 the Permanent Delegation of Palestine to UNESCO submitted an application to include the Wadi Gaza in the World Heritage list.

Figure 2.2.2.1 Wadi Gaza wetland (lower end of the Wadi) and temporary wastewater plant in the left of the photograph.

2.2.3 THE NEED FOR SHARED INTERNATIONAL REGULATIONS IN TRANSBOUNDARY WETLANDS: THE HUTOVO BLATO-NERETVA DELTA CASE, BOSNIA-HERZEGOVINA AND CROATIA

Ognjen Bonacci and Zoran Mateljak

The Lower Neretva valley represents an ecologically unique area. It stretches along the final 30 km of the Neretva River, from the Hutovo Blato Nature Park in Bosnia and Herzegovina (B&H) to the river's mouth, branching into a wide delta (Case Study Figure 3). The Lower Neretva valley covers some 20,000 ha, out of which 8000 ha belong to the Hutovo Blato and about 12,000 to the Neretva River Delta. The Ramsar sites of Hutovo Blato and the Neretva River Delta should be evaluated as one integral transboundary site. The same birds use both sites during migration, wintering and even breeding. Some species breed in the Hutovo Blato and feed in the Neretva River Delta. It is difficult to evaluate two sites according to Ramsar criteria separately when it comes to numbers of birds that are regularly present. It would be more appropriate to evaluate both Ramsar sites together and treat them as one transboundary site.

In the surrounding area especially problematic issues are those related to transboundary water management and numerous water regulations in the catchment area of the Neretva and Trebišnjica Rivers in B&H. The watersheds of these two rivers are connected underground, through karst. Redirection of waters from the so-called the "upper horizons" of the Trebišnjica River into the area of the "lower horizons" where the hydropower plants are located results in loss of water in the Lower Neretva area, lower summer water level, drying out of water springs and strengthening of influence of the seawater intrusion. There are even plans to increase these activities and to take most of the available water for additional use by hydropower plants in Eastern Herzegovina. Currently, an environmental impact assessment is being prepared cooperatively by the two countries. Considerable water regime disturbance was also caused by the operation of five upstream hydropower plants on the Neretva River on the territory of B&H. Their dams retain water and sediments, thus causing frequent and rapid water level changes or water shortages, especially during the summer. The only large project being implemented (from 2008 to date) is the GEF/World Bank transboundary project "Neretva and Trebišnjica River Management Project". The project objective is to provide mechanisms for efficient and equitable water allocation among the users of the Neretva and Trebišnjica river basins at the transboundary level, and for enhancing the basin ecosystems and biodiversity through improved water resources management.

The most prominent factors in the past that adversely affected the ecological character of both sites were connected to water management, including land reclamation activities with the purpose of turning wetland into agricultural land. The greatest threats are also connected to water management for agriculture. As the consequence of water regulation activities in the surrounding area of Croatia and B&H, there is a trend of decrease in water level and quantity in the Lower Neretva that adversely affects wetland habitats and biological diversity, and also agriculture. Reduced water in Neretva and its tributaries in the delta, as well as the stronger influence of sea water intrusion into this flat area, can be expected.

In 1997 the project MedWet was initiated within the Ramsar convention. It was financed by the European Union fund LIFE and the project included Neretva's delta area in Croatia. As part of the project a seminar on the socioeconomic aspects of using the valley of the Neretva was also conducted with participation by the proper experts and the local community.

In 1999 a 2-year LIFE programme, "Third countries, preparation of the new way of managing of the Hutovo Blato" was initiated. The aim of the project was to develop methods for re-establishing the basic wetland structure with special emphasis on fish and bird communities.

During 2000 the project "Promotion of cooperation and exchange in the countries of South Eastern Europe" began, with financial help from the Swiss Agency for Development and Cooperation. The project was part of the programme "Regional Environmental Reconstruction Programme for South Eastern Europe" (REReP) and was coordinated by the Regional Environmental Centre for Central and Eastern Europe. Neretva's lower valley was one of the areas where the project took place and its aim was to develop regional cooperation for nature protection by supporting civil society institutions. Through that programme local non-governmental organizations (NGOs) ran some valuable small projects in 2001.

In a meeting on 3 May 2003, in the Ramsar site of Hutovo Blato, momentous decisions were taken to implement transboundary collaboration on the Neretva River and its wetlands. The example of the transboundary Prespa Park (Macedonia and Greece) was presented and analysed during the meeting, and it was agreed that it was a valid model to adopt. The three studies that have been carried out in relation to the Neretva (the pilot work on the Lower Neretva within the framework of the MedWet2 LIFE Third Countries project in 1996-1998; the LIFE project on Hutovo Blato; and the Ramsar Small Grants Fund (SGF) project on transboundary collaboration, the last two just completed) were discussed, as they provide very useful information and conclusions, complemented by work on orthophotography and GIS mapping of the area, funded by the Spanish government.

The following actions were agreed:

- Signature on 6 June 2003 of a memorandum of collaboration between the two countries (the Federation of Bosnia and Herzegovina and the Republic of Croatia), supported by the Principality of Monaco and Ramsar/MedWet
- Establishment of a seven-member Neretva Co-ordination Committee to implement the collaboration, consisting of three members from each side (representing the central authorities, local government and NGOs), with MedWet as an observer
- Convening of the first meeting of the Committee, as soon as its members are appointed, by MedWet
- Priority given to the preparation of a Strategic Action Plan, based on the previous studies for the area and on similar work done for Prespa Park.

Figure 2.2.3.1 Views of the Hutovo Blato Nature Reserve and the Neretva delta. Source: O. Bonacci.

2.2.4 IMPACTS OF THE EXISTENCE OF WETLAND REGULATIONS ON THE CULTURAL SERVICES OF THE WETLAND AND THE ECONOMY OF THE DALYAN AREA, TURKEY

Serdar Bayari

The Köyceğiz-Dalyan special environmental protection area (SEPA), extending to area of 461.5 km^2 (Case Study Figure 4), is a potential Ramsar site. This wetland eco-system comprises the Köyceğiz Lake, a meromictic lake fed by waters of fresh, thermal and marine origin; and an estuary, serving as a perfect nesting, breeding and wintering area for migratory and local birds, linking the lake to the 4.5 km-long İztuzu beach, a spit along the Mediterranean Sea (Case Study Figure 5). The spit, which is a 150-m wide sandy beach, is one of the world's most important breeding sites of the endangered loggerhead sea turtle, *Caretta caretta*. The wetland is located in a tectonic collapse area developed mainly in Mesozoic-aged carbonates and ophiolite rocks. Köyceğiz Lake, in the north, is thought to have developed during the early Quaternary by fluvial sediment accumulation between the main collapse area and the sea. The lake occupies an area of 55 km^2 and comprises 24-m deep northern and 32m deep southern basins, separated by a 12-m deep sill. A thermal spring on the southern shore, several perennial streams mainly pouring into the northern basin and year-round groundwater recharge are the main feeders of the lake. The lake discharges through a 6-m deep, 75-m wide and 6-km long canal into the estuary before entering the Mediterranean Sea. The thermal groundwater discharge into the lake on the southern shore causes a permanent anoxic zone below a depth of 12 m.

The Köyceğiz-Dalyan SEPA involves 4 towns and 13 villages with an estimated total population of 50,000 inhabitants. The rural economy is based mainly on greenhouse cultivation and citrus horticulture. In the towns such as Dalyan, in the centre, the economy is based almost entirely on touristic activities. The tourism season covers the period between May and November during which about one million tourists visit the area. Touristic activities involve visiting pools for mud baths along the southern shore of the lake, visiting the carved rock tombs of the ancient city of Kaunos (once a major seaport of the Carian civilization in the 6th century BC), taking tours on boats and feeding the sea turtles with blue crab in the estuary, sunbathing and swimming alongside İztuzu beach, and socializing in Dalyan.

The nature protection history of Köyceğiz-Dalyan SEPA begins in 1988 with legislative action for the protection of nature in areas of exceptional natural values, together with the socioeconomic interests that increase human pressure. The SEPAs aim to establish and maintain a mutually beneficial system between the natural assets and socioeconomic activities so that the local residents pay utmost respect to the existing ecosystem while maximizing their income. Soon after the early regulations in 1988 it was recognized that "the regulations" alone were not as effective as had been presumed, and that comprehensive and continuing education of the local people on how to balance human benefits and nature's requirements was more essential. Projects such as the National System of Marine Protected areas of Turkey (http://www.mpa.gov.tr) are of considerable help, not only in the Köyceğiz-Dalyan SEPA, but in others along the shores of the Mediterranean and Aegean Seas in Turkey. Probably the best example of the joint use of natural resources in Köyceğiz-Dalyan SEPA is the management of İztuzu Beach. The beach is visited for swimming and sunbathing by thousands of tourists brought from Dalyan town in boats owned by local residents. Part of the beach, used by sea turtles lay eggs in holes they dig in sand, is not allowed for tourism activity which is limited to certain parts of the day. Moreover, that part of the beach is closed to human activity from dawn to dusk and no artificial lights that can be seen from the beach are allowed, to help hatching baby turtles using moonlight as a guide to find the way to the sea.

While the SEPA management based on a mutual benefits approach proved to be successful, continuous scientific monitoring of the natural conditions is essential. For example, feeding the sea turtles with blue crabs as a tourist show has already been banned, since this activity seems to lead some sea turtles to stop their annual migration across the Atlantic Ocean to Florida.

Figure 2.2.4.1 Locations of sites mentioned in the text

Figure 2.2.4.2 Aerial view of İztuzu Beach and Dalyan Estuary

Part 3.

Guidelines and recommendations for the evaluation and integrated management of groundwater-related Mediterranean coastal wetlands

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3.1 GUIDELINES

Groundwater-related coastal wetlands are not only relevant features of coastal Mediterranean landscapes, but also significant local, regional and even national sources of economic and cultural resources.

To evaluate groundwater-related coastal wetlands and get the basic information needed to: (i) understand the origin of each wetland and its relationship with surrounding and/or underlying aquifers; (ii) categorize the services that each wetland provides to the human populations nearby, the status of these services and their possible deterioration trends; (iii) classify the pressures that can result in deterioration of the wetland functioning, its ecological status and services after their relative impact; and (iv) promote realistic and efficient wetland management plans, the following actions are needed:

- Identify the presence of groundwater-related coastal wetlands and delineate them
- Perform geological and hydrological assessments of these coastal wetlands, design (or select among the many existing methodologies) a classification system and apply it to the studied wetlands, even if the degree of available scientific knowledge is variable
- Conduct a hydrochemical assessment, define a baseline and identify possible deterioration trends in water quality
- Identify the services that the wetlands are performing and assess their status and trends
- Identify the pressures that can have a negative effect upon a wetland functioning, its ecological status and services, evaluate how these pressures could change with time and define the possible actions that could be used to stop or decrease the impact of the pressures
- Identify the protection/regulatory tools available at local, national and international scales to protect the wetlands
- Integrate wetlands management into water and land use planning and management.

Some recommendations are briefly provided in Section 3.2 to carry out the work involved in each of the above actions.

3.2 RECOMMENDATIONS

3.2.1 IDENTIFICATION AND DELINEATION OF MEDITERRANEAN GROUNDWATER-RELATED COASTAL WETLANDS

The coastal zone is the discharge area of groundwater recharged in the continent, which makes this area a likely location for groundwater-related wetlands. Some of the groundwater discharging at present in the dry areas of the Mediterranean coastline may derive largely from rainfall recharged in formerly wetter times, which means that such groundwater may be thousands of years old. Present-day groundwater recharge from local rainfall in the coast is also possible, taking place in dune formations and in the surrounding areas of higher elevation.

Many groundwater-related coastal wetlands occur in shallow water table areas, or where groundwater discharges to the surface, but some are linked to deep groundwater flows ascending to the land surface in the coastal zone. In a given wetland, the direction of water movement between the wetland and the ground may change, depending on season, local hydrological conditions and subtle topographic changes. As a result of regional and local groundwater processes, coastal wetlands related to groundwater display a wide range of natural typologies as springs, seepage areas, dune slacks, coastal lagoons, marshlands, abandoned stream courses, deltaic lagoons and ponds, dry ravines and gullies, peat lands, mudflats, saltpans, sebkhas, etc., which also present different balances between the surface water and groundwater feeding them. Artificial wetlands linked to groundwater are also abundant in the Mediterranean coastal zone; the main types are rice fields, excavated ponds and lagoons, current and abandoned channels, and salinas.

While the morphology and dimensions of the largest natural Mediterranean coastal wetlands and lakes are usually well known, this is not the case for small wetlands, whose characteristics are usually quite variable. Small wetlands, especially those located in the periphery of larger wetlands, usually provide highly valuable conditions for cropping, fishing and hunting, collection of natural plants, tourism, education and regulation of hydrologic variability. Furthermore, these small wetlands also help to regulate erosional, biological and chemical cycles, and they are often permanent water areas to support wildlife when the main wetland areas become dry. In other words, the smaller coastal wetlands can be important sources of provisioning, regulating and cultural services, as are large wetlands and coastal lakes. To continue taking advantage of the range of services provided by small groundwater-related coastal wetlands it is necessary to identify and delineate these wetlands in the Mediterranean coastal zone.

At present, remote sensing and satellite images can provide a low-cost approach to help identify and delineate the extent of wetlands over large areas in the Mediterranean coastal zone. These remote sensing tools are useful for landscape scale delineation and mapping. Their use reduces the economic resources needed for the optimal evaluation of large areas. However, it is also essential to undertake field surveys to gather more detailed information on the type, condition and pressures affecting individual wetlands. These field surveys are especially needed to identify the main water-feeding sources to the wetland.

3.2.2 GEOLOGICAL AND HYDROGEOLOGICAL ASSESSMENT AND CLASSIFICATION OF MEDITERRANEAN GROUNDWATER-RELATED COASTAL WETLANDS

The geological structure and lithology both under and around a coastal wetland, including the wetland bottom sediments, may explain most of its physical, chemical and hydrodynamic characteristics. They are even more relevant because both geological structure and lithology are the main factors controlling groundwater dynamics and its relationship with the wetland. For coastal wetlands located in river or deltaic flood plains, the lithology of the whole river basin may also help in explaining some of the main wetland characteristics, such as size, depth, salinity, chemical type and hydroperiod. Sediments in the wetlands bottom and their nature (organic or mineral) and texture (sandy, silty, clayey, peaty, muddy) may play a dominant role in influencing the frequency, extent and duration of flooding (known as the wetland hydroperiod). In order to understand the Mediterranean coastal wetland behaviour and its causes, a good knowledge of the geology at two scales is necessary, basin and local.

The geological assessment needed at basin scale can be accomplished by compiling and using the information usually available at national level in the geological institutes and surveys, ministerial departments and institutions (mines, public works, agriculture, land planning) and academia (universities and research institutions). In many cases, especially for particularly relevant or representative wetlands – which are usually well studied – most of the information on geological structure and lithology required at regional and local scales can be also obtained from public management and research organizations. However, many small and less-studied wetlands lack geological/hydrogeological/ecological information, or there are unknown or poorly known aspects that are relevant to understand the wetland origin and/or behaviour. When this is the case, it may be necessary to undertake targeted fieldwork to collect new geological/hydrogeological/ ecological information. Geophysical surveys, borehole drilling, lithological and mineralogical sampling and soil analysis, hydro-ecological walkover surveys and hydrochemical surveys are among the most relevant works to be performed. This information, combined with a geological map, allows building geological cross sections across the wetland area and developing geological models for each wetland basin. As the time needed for a geological aspect to change is usually very large compared to human life (0.1 Myrs at least; usually 1 Myrs or more), geological studies do not have to be repeated over time. However, traditional geological investigations often miss the crucial near-surface deposits upon which wetlands ecosystems depend, and successive works and projects have to be undertaken to approach what is needed according to evolving circumstances (Whiteman and others, 2009; Gómez-Ortiz and others, 2010).

From a quantitative point of view, the contribution of groundwater to a wetland can vary across time and space. In some wetlands, groundwater will be the dominant source of water, whereas in others groundwater may only represent a small and variable proportion of the total water supply. However, for most coastal wetlands the presence of groundwater, even if temporary and in small proportions, is a key factor for the chemical, physical and biological characteristics of the wetland. Groundwater provides fresh, unpolluted or slightly polluted water to coastal wetlands and, in dry areas, is usually the only water source for the wetland during dry seasons, dry years and droughts. Thus, groundwater quantity, quality, chemical characteristics, spatial and temporal flow pattern variability around the wetland, as well as the variability of the water fluxes and solute exchanges with the wetland, may control the ecological features of a particular wetland and how they change in time. However, as is usual around the Mediterranean coastal zone, arid and semi-arid conditions can mask the presence of groundwater and even the presence of the wetland itself. This is the case of crypto-wetlands (seepage or hidden wetlands), where there is no surface water and groundwater is at soil level or at the reach of vegetation capable of using it. A common type of crypto-wetland around the Mediterranean coast is the saltpan, which results from the evaporation of outflowing groundwater.

In order to understand the characteristics of a coastal wetland and their variability and origin, a groundwater assessment may be required. As in the case of geology, the hydrogeological information required should cover both local and basin scales. The sources of hydrogeological information are the same as the geological information. Unlike the geological setting, the hydrogeological environment is more dynamic. Piezometric levels around and under the wetland, groundwater chemistry and salinity can all change over both space and time, due to natural and anthropogenic influences. In order to characterize these changes repeated temporal surveys may be required to define baseline conditions and monitor change against these baselines.

At the present time most of this work can be performed by combining the use of remote sensing and images with in situ installed sensors supported by some detailed field surveys. It is advisable to invest some resources in designing and instrumenting a hydrological monitoring network which could be completed over a few years (see Section 1.2), although economic and human resources for operation and maintenance have to be secured. Hydrogeological assessment is also needed to design aquifer management plans that allow coastal groundwater-related wetlands to maintain their natural behaviour or to restore it.

Classifying wetlands is useful for describing and managing their natural variability (see Section 1.2). Geological and hydrogeological classification of wetlands allows standardization of plans for wetlands monitoring and management, which means increasing efficiency in the use of the available resources as well as in the impact of the scientific, technical and management actions undertaken. Classification is useful not only for the best known wetlands, but even more for the lesser known and studied wetlands. However, other features additional to the geology and hydrology of the wetland, which certainly can be related with the former, must also be used to achieve a useful ecological classification of the wetland (e.g. Camacho and others, 2009), which is essential for any well-designed management plan.

One of the most useful tools derived from wetlands classification is the possibility to select reference coastal wetlands for each hydrogeological-ecological type (established in a classification chart designed for the working area). The use of reference sites as a view of the ecological goals to be achieved for the ecosystem is widely used in environmental management and has particularly been used for the development of policy rules related to aquatic ecosystems, such as those established by the European Water Framework Directive (e.g. CIS Working Group 2.3. - REFCOND, 2005; Free and others, 2007; CEDEX, 2009). Restoration goals for degraded ecosystems are also established through comparison with reference ecosystems (Van Andel and Aronson, 2005). Designating reference wetlands has two main utilities:

1. They can be used as research sites for scientists and managers to test and apply scientifically based methods to measure and describe wetlands functioning.

2. They can be used to establish realistic conservation goals and restoration objectives for the more deteriorated wetlands.

Reference wetlands are often the best preserved in their hydrogeological type, and it is also useful that some reference wetlands represent a range of conditions existing across the wetland type and the regional area. However, to decide that a given wetland is similar to a reference one a minimum of knowledge is needed. Apparent similarities, not supported by reliable data, may cause classification errors and induce inappropriate evaluation and management actions.

Classification, behaviour, management and action related to a groundwater-related wetland can be better achieved when adequate, well-established and validated conceptual models of both the wetland and the contributing area are available, supported by the geological model and elaborated with the adequate consideration of hydrometric, hydrochemical and environmental isotope data.

3.2.3 CHEMICAL ASSESSMENT AND TRENDS IDENTIFICATION

Wetland chemistry and its variability are responsible for the water quality and determine the biological community inhabiting a particular wetland. Natural changes may induce changes in water quality that make the water non-appropriate, unusable and even deadly for many species (e.g. salinity increases, changes in ion ratios, anoxic conditions, pH shift and iron enrichment). Many natural changes are recurrent and reversible and used to follow seasonal or inter-annual patterns, as for example alternating oxic and anoxic conditions. However some changes, both natural and anthropically derived, are persistent over time and alter essential wetland features, as for example salinization.

Some chemical trends, especially those inducing water quality deterioration and salinity changes, have to be identified early in order to undertake measures to try to stop them. Baseline chemical data from a range of different, representative wetlands are vital to enable trend determination. Identification of the source/s that lead to water quality deterioration and/or salinity changes is needed to overcome the pressures. Local and regional (basin level) measures may be required to counterbalance chemical pressures on groundwater that supports coastal wetlands. In some cases, such as atmospheric deposition, regional or even global sources may need to be considered to understand the pressures affecting wetlands. All this involves identification of the sources of changes and attempts to eliminate or isolate them, although when the sources are geological formations the measures may involve flow, pH or redox restoration, among other measures.

Chemical assessment is needed both to know the quality of wetland water and its origin, and to identify chemical trends and their causes.

3.2.4 ECOLOGICAL ASSESSMENT

Coastal wetlands have their own unique ecosystems, many of which are internationally rare and protected through national and international legislation and agreements (e.g. Ramsar, www.ramsar.org). It is important to map the extent of these ecosystems and their condition and trends over time in order to relate changes in the ecology to the quantitative, chemical and management pressures upon the wetland.

When referring to the ecology of a particular wetland, all the previously mentioned wetland features (geology, hydrology, chemistry, etc.), as well as other key ecological factors, are included. Thus, the expression "ecological assessment" means the evaluation of the main ecological features that determine wetland structure (physical structure, biological community structure, etc.) and function (hydrology, biogeochemistry, biological interactions, etc.). Identifying these main ecological factors (which feature in any ecosystem, and particularly in wetlands) is essential in making an adequate classification and assignation of this particular wetland to any wetland type. This in turn is basic to establishing conservation and/or restoration goals that mimic the ecological features of the type reference wetland (Van Andel and Aronson, 2005; Camacho and others, 2009). Assessing the basic characteristics of the healthy ecosystem is thus the crux of the ecological assessment, and consequently ecological assessment provides the key to adequate management.

Apart from baseline mapping of the ecosystems, additional ecological surveys (designed to look for particular aspects) may be required to detect changes and relate them to specific pressures. Targeted surveys may need to be repeated every few years.

3.2.5 SERVICES IDENTIFICATION: ASSESSMENT OF STATUS, TRENDS, THREATS AND ACTIONS

Following the Millennium Ecosystem Assessment (2005a), ecosystem services can be defined as:

> The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating and supporting services such as regulation of floods, drought, land degradation, and diseases, soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious, and other nonmaterial benefits.

In groundwater-related coastal wetlands, many ecosystem services are derived from or supported by the presence of groundwater inflow and the roles it can play in supporting the hydrology and ecology of the wetland.

Evaluation of the ecosystem services, their status and trends is essential for valuing the wetlands, as decision makers at many levels are unaware of the connection between wetland condition and the provision of wetland services and the consequent benefits for people. Preserving wetland integrity and health would result in maintaining or even improving the benefits that humans obtain from wetlands. However, many wetlands around the world have been degraded or destroyed, and their capacity for offering ecosystem services has been diminished or eliminated from both anthropogenic and natural causes (Millennium Ecosystem Assessment, 2005b).

In order to obtain worldwide comparable results for the evaluation of ecosystem services provided by groundwater-related wetlands within the framework of the UNESCO-IHP component "Management of coastal aquifers and groundwater" of the MedPartnership project, an evaluation system has been designed (see Section 1.3). This shares the methodological approach established for the Millennium Ecosystem Assessment (2005a) and adapted to the case of groundwater-related coastal wetlands. It consists of grouping the services into three main types: provisioning, regulating and cultural, and in evaluating the status of a set of pre-selected ecosystem services whose results are shown using a code of colours, and the future trends of those services under the most probable scenario using a code of arrows (see Section 1.3). It is very useful to have information on the evolution of a wetland's ecology to be able to forecast its future evolution, thus allowing the identification of adequate actions and measures to be undertaken, reverting degradation trends and starting recovery towards attaining an acceptable status.

Altogether many wetlands around the world have been degraded or destroyed, and their capacity for offering ecosystem services diminished from both anthropogenic and natural causes. In the Millennium Ecosystem Assessment terminology, the factors that induce direct changes in the functioning of wetlands are the so-called "drivers of change". In the framework of the UNESCO-IHP MedPartnership the main drivers affecting coastal groundwater-related wetlands functioning have been grouped under resource exploitation (surface water and groundwater, biological and mineral resources), changes in land use, modification of the hydrological cycle, pollution, and effects associated with changes and with global and climate changes.

One of the main anthropogenic pressures impacting groundwater-related coastal wetlands is intensive groundwater exploitation. Exploitation of groundwater can result in the decrease of water levels and a reduction of groundwater discharge to wetlands. These pressures can result in vegetation changes, hydroperiod modification, alterations in water and soil salinity, drying of soil and wetlands, subsidence and collapses, pollution of surface water and groundwater, increase of coastal erosion, etc. Other relevant drivers that can have negative impacts are pollution (agricultural, urban, industrial, atmospheric), which induces a deterioration in wetlands services, global change and climate change, which can reduce groundwater recharge and discharge to wetlands, increase sea level and induce more extreme events, etc.

To undertake efficient conservation, restoration and management plans for coastal groundwater-related wetlands, it is very useful to evaluate the level of impact of a set of pre-selected drivers and the evolution trends of their impacts. In the framework of the UNESCO-IHP component of the MedPartnership project the methodology is also given (see Section 1.3).

When evaluating services and drivers, and their evolution trends, a relevant point to take into account is that all the assessments have to be supported with a reliable and easy system to locate qualitative and quantitative data. This would give confidence, and therefore utility, both to the raw data and to the conclusions. Only if empirical information is lacking it is possible to use the experience and knowledge of some professionals. The sources of information used to assess the services, and the drivers, have to be indicated in each case.

There is a huge variety of useful data, from groundwater time series, ecological mapping, wetland water level and salinity evolution, to economic results after agricultural activities have been performed in the wetland area. All these data can be obtained from both national and international public management and research institutions (see Section 1.3).

There is almost no information on the role that women play on wetlands and groundwater conservation, neither on the contribution of groundwater-related wetlands' services to women well-being. However, all around the world there are examples of the narrow relationship existing between women daily life and wetlands and water sustainable use and preservation. To improve the knowledge on this relationship and take advantage of it, both for wetlands conservation and for women empowerment and gender equality, it is imperative to include the gender dimension systematically into all type of actions addressed to increase knowledge on wetlands and groundwater and to preserve them and their services. To better understand gender roles, it is necessary to identify or design specific sex-disaggregated indicators to be used in surveys, interviews and statistical analysis. Women empowerment and gender equality will be reached by incorporating women in monitoring and management actions.

3.2.6 PROTECTION/REGULATIONS

Coastal groundwater-related wetlands are among the most productive yet highly threatened systems in the world. Some particularly important wetlands on the Mediterranean coast are protected to different extents under varied types of legal entities and institutional settings, but a great number of them, particularly the smaller ones, lack any protection.

In the countries of the MedPartnership project, the available regional, legal framework for the management of groundwater-related coastal wetlands is quite wide and comprehensive. It includes very specific instruments for the Mediterranean region such as the Protocol on Integrated Coastal Zone Management (ICZM Protocol) or the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA-BIO Protocol), and specific instruments for wetlands such as the Ramsar Convention. Under the ICZM Protocol, coastal wetlands are recognized as components of the coastal zone, as well as the aquifers which sustain them, and have to be included in national strategies prepared and adopted by the Parties.

Other related instruments are the Convention on Biological Diversity (CBD), the Convention on the Protection and Use of Transboundary Watercourses and International Lakes, and – within EU territories – the EU Nature Directive. Within the latter, the Water Framework Directive (WFD) and Groundwater Directive (GWD) are powerful law instruments related to water. The WFD provides a detailed framework regarding aquatic ecosystems and their sustainable management. Under these various instruments, the requirements for the proper management of coastal groundwater-related wetlands seem to be well defined. However, they need to be adequately transposed into the national legislation of member countries, rightly interpreted and correctly implemented.

3.2.7 CONSIDERATION OF WETLANDS IN WATER AND LAND USE PLANNING AND MANAGEMENT

Coastal wetlands are important elements of both river basins and coastal zones. Wetlands are the link between land and water resources, and coastal wetlands are the link between continental and marine ecosystems and resources. Moreover, they are closely linked to the territory, history and economy of local and regional populations through the free provision of water, food and sources of energy in the past, and through the creation of employment in activities such as agriculture, fishing, hunting and mining in recent times. Thus, the efficient management of coastal wetlands would ensure that they will continue providing services to human beings in the future.

The quality of a wetland's functioning, and consequently the quality of the services a wetland provides to the people benefiting from them, is directly linked to the ecological quality of the wetland and its surrounding environment. Thus, wetland protection programmes are most effective when coordinated with other surface and groundwater protection programmes and with other resource management programmes, such as flood control and land drainage/agriculture, water supply, protection of fish and wildlife, land use, recreation and non-point source pollution. Moreover, the behaviour of coastal wetlands is controlled by factors that occur at different scales and which maintain a hierarchical spatial organization. Higher-order factors are influenced by geographical, geological, climatic, economic and political factors that do not act or are barely noticed at the local scale.

From the point of view of water resources and aquatic ecosystems, in most cases the minimum spatial scale to be considered for management plans is the river basin. However, resource protection programmes have historically focused on a single goal or a small set of goals. These sectorial programmes have succeeded in identifying and controlling, to some degree, the larger local problems and their causes, but most of them failed to manage problems at basin and/or aquifer scale and even larger. It is, therefore, necessary to use an approach that addresses the interconnections between water resources and the land, air and water environment surrounding the wetlands at adequate spatial and temporal scales.

A watershed-based approach to wetlands protection considers the whole water system, including other resource management programmes that address land, air, water and energy. The concept and consideration of what is currently called IWRM allows the multifaceted water resources to be addressed from both the technical and the governance point of view (Martínez-Santos and others, 2014). This should consider the existence of wetlands and the services they provide by carefully managing the available water resources, both natural (surface water, groundwater, imported water from other areas, rainfall harvesting, etc.) and industrial or artificial (seawater and brackish water desalination, water reclamation), and even the consideration of virtual water (hidden flow of water if food or other commodities are traded from one place to another).

The protection and preservation of wetlands depend largely on water policy preferences. When water scarcity – a common situation in many Mediterranean areas – is addressed with offers of increased water from public and private institutions, it is hard to protect wetlands and difficult actions are needed. However, when this scarcity is solved, at least partly, through demand and use management policies (direct action, taxes, pricing, net water saving from irrigation efficiency improvement, reduction in transport and storage losses, even temporal and well-designed subsidies) there is the possibility of returning part of the saved water resources to restore the water environment and to improve wetland conditions. However, the improvement of wetland conditions does not mean introducing imported, reclaimed or/and industrially produced water into the groundwater-related wetland, since this may and probably will affect the hydroperiod and the water quality values and fluctuations. Such management actions have been carried out in some of the more significant Spanish groundwater-related wetlands, such as the Tablas de Daimiel, with results that are both positive and negative and which remain to be evaluated in depth. The European WFD favours demand management policies as the preferred means to preserve and restore the water environment. Notwithstanding, the full dimension of water – and specifically groundwater – governance is still at its early stages.

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Annex 1.

Coastal groundwater-related wetlands inventoried: synthesis charts

CHART 1. GENERAL CHARACTERISTICS OF THE INVENTORIED WETLANDS

			Local climate					Underlying lithology							Morphometry				
Inventory number	Name of wetland, Country	General type (see below)	Average rainfall (mm/year)	Average temperature (ºC)	Average evapotranspiration (mm/year)	High seasonality	Low seasonality	Siliceous sediments	Carbonated sediments	Carbonate rocks	Evaporite rocks	Metamorphic rocks	Volcanic rocks	Intrusive rocks	Surface area (km^2)	Elevation, Max - Average (m a.s.l.)	Depth, Max - Average (m)	Length, Max - Average (m)	Width, Max - Average (m)
1	Butrinti, Albania	2H	1500	18.5	1200	•				•					16	1-?	21.4 - 14	7100 -?	3200 -?
2	Guerbes, Algeria	2HKN	700	18.5	430	•		•			•				421	<1	10 - 20	1500 -?	300 -?
3	Hutovo Blato, Bosnia and Herzegovina	2ENPQS	1160	14.7	855	•			•						79.72	? - 1	14.5 - 2.5	10500 -?	7500 -?
4	Neretva Delta, Croatia	2AHJ	1250	15.7	880	•			•						127.42	20 - 0.5	1.5 - 0.5	16 -?	7.5 -?
5	Lake Mariut, Egypt	1A	195	14.8			•	•							62.9	13 - ?	2.7 - 0.83	25000 -?	10000 -?
6	Tyre Beach, Lebanon	3Q	730	20.2	395					•					3.8	20 - 1	2 - 5	4025 -?	950 -?
7	Tawurgha Spring Libya	3D	200-250	30	1800		•			•	•				80	3 - 1	5	10000 -?	8000 -?
8	Skadarsko Lake, Montenegro	2A	1800	14.5	1260				•						395	10 - 4	60 - 6	14000 -?	40000 -?
9	Tivatska Solila, Montenegro	1R	1500	15	1200				•						1.5	<1	?	? - 1600	?- 1000
10	Bou Areg Lagoon, Morocco	2AL	350	27	860	•		•	•	•	•	•			115	50 - 0.5	8	25000 -?	15000 -?
11	Moulouya Estuary, Morocco	2HKN	550	18.6	1200	•		•							27	20 - 0.6	6 - 0.5	300 - 500	40 - 100
12	Oued Laou Estuary, Morocco	2HKN	630	18.3	1022	•		•	•						18	20 - 2	6	70000 -?	200 - 500
13	Wetland of Wadi Gaza, Palestine	2AHJ	335	20	1582	•			•						0.025	<1	2.0 - 1.0	1000 -?	100 -?
14	Akkar Plain, Syria	2EHN	880	22	550	•		•					•		25	<50-?	<0.5	5000 - ?	5000 - ?
15	Korba (Cap Bon), Tunisia	1BHIQ	480	20	630	•			•						5	<1	1 - 0.5	?- 8500	?- 350
16	Yumurtalık Lagoon, Turkey	1AHI	770	18.7	890	•		•	•						180	1 - 0.5	1.5 - 1.0	21.4 - 17.0	8.4 - 6.0
17	Akyatan Lagoon, Turkey	1AHI	770	18.7	890	•		•	•						131	1 - 0.5	1.5 - 1.0	18.3 - 15.0	6.5 - 4.5
18	Tuzla Lagoon, Turkey	1AHI	770	18.7	890	•		•	•						21	1 - 0.5	1.5 - 1.0	9.9 - 5.7	2.3 - 1.3
19	Dipsiz wetland, Turkey	1B	675	19.0	890	•		•	•						10.7	1 - 0.5	1.5 - 1.0	2.7 - 0.8	1.8 - 0.6
20	Göksu Delta, Turkey	2AIP	603	18.5	1027	•		•	•						150	2 - 0.5	1.5 - 1.0	6.1 - 4.0	5.3 - 4.0
21	Dalaman Wetlands, Tukey	1AIP	1044	18.9	1209	•		•	•	•		•			284	4 - 0.5	1.5 - 1.0	2.8 - 2.8	1.5 - 1.5
22	Dalyan Wetlands, Turkey	1AIP	1064	18.3	1415	•				•					15	2 - 0.5	2.5 - 1.0	6 - 6	1.7 - 1.7
23	Büyük Menderes Delta, Turkey	2AHI	601	21.7	1200	•		•	•						91	5 - 0.5	1.5 - 1.0	18.4 - 18.4	4.7 - 4.7
24	Küçük Menderes Delta, Turkey	1AIP	637	16.6	820	•		•	•	•			•		326	5 - 0.5	1.5 - 1.0	1.5 - 1.5	0.7 - 0.7
25	Gediz Delta, Turkey	2AIP	646	17.9	851	•		•	•						908	5 - 0.5	1.5 - 1.0	21.5 - 21.5	6.9 - 6.9
26	Gökçeada Lagoon,Turkey	1AHI	735	15.2	1021	•		•							4	2 - 0.5	1.5 - 1.0	2.2 - 1.3	1.3 - 0.8

(*): Average or variability range

CHART 1 (CONTD). GENERAL CHARACTERISTICS OF THE INVENTORIED WETLANDS

Inventory number	Name of wetland, Country	Wetland genesis									Wetland sediments					Water source							Groundwater flow type (see below)							Hydro - period			Hydrochemistry		
		Tectonic	Erosive	Dissolution	Volcanic	Floodplain	Delta/estuary	Dune morphology	Coastal sedimentation	Artificial	Sandy	Silty	Clayey	Organic-rich	Peat	Rainfall on the wetland	Runoff in the basin	Deep groundwater	Shallow groundwater	Sea (tidal / wave influence)	Fluvial inundation	Artificial	Flow through	Recharge area	Discharge area, open	Discharge area, closed saline	Discharge area, closed fresh	Criptowetland	Variable	Permanent	Seasonal	Variable	Electrical conductivity (mS/cm) (*)	Dominant (> 50 %) anion/anions	Dominant (> 50 %) cation/cations
1	Butrinti, Albania	•									•					•				•					•					•			20 - 40	Cl	Na
2	Guerbes, Algeria		•					•			•	•				•	•			•			•	•						•	•		0.5 - 11.5	$Cl\text{-}HCO_3$	Na-Ca
3	Hutovo Blato, Bosnia and Herzegovina	•	•	•								•	•		•	•		•	•				•	•	•					•	•		0.5 - 40	HCO_3	Ca-Mg
4	Neretva Delta, Croatia						•		•			•	•	•	•	•	•		•	•	•	•	•	•						•	•		0.5 - 40	$Cl\text{-}SO_4$	Na-Ca
5	Lake Mariut, Egypt					•	•		•	•	•	•	•			•			•		•	•				•				•			1 - 7	Cl	Na
6	Tyre Beach, Lebanon	•							•				•						•		•				•					•					
7	Tawurgha Spring Libya	•										•	•					•							•					•			4.5	$Cl\text{-}SO_4$	Na
8	Skadarsko Lake, Montenegro	•									•								•		•		•		•			•		•			0.3	HCO_3	Ca-Mg
9	Tivatska Solila, Montenegro								•	•	•								•				•							•			>15	Cl	Na
10	Bou Areg Lagoon, Morocco		•					•	•		•	•	•			•	•		•	•			•							•	•		0.5 - 56	$Cl\text{-}SO_4$	Na-Mg
11	Moulouya Estuary, Morocco		•			•	•		•		•	•	•			•	•		•	•	•		•			•				•	•		2.5 - 3	HCO_3	Ca-Mg
12	Oued Laou Estuary, Morocco	•	•			•	•		•		•	•	•			•	•		•	•	•		•			•				•	•		3.6	HCO_3	Ca-Mg
13	Wetland of Wadi Gaza, Palestine					•	•	•	•				•	•		•	•		•					•	•							•	1.5 - 3.3	HCO_3	Na
14	Akkar Plain, Syria					•						•	•		•	•	•		•	•	•			•	•						•		0.5 - 1	HCO_3	Ca
15	Korba (Cap Bon), Tunisia							•			•		•			•	•		•	•				•							•		20 - 80	Cl	Na
16	Yumurtalık Lagoon, Turkey					•	•	•	•		•	•	•			•		•	•	•			•		•					•			58.7	Cl	Na
17	Akyatan Lagoon, Turkey					•	•	•	•		•	•	•			•	•	•	•	•			•		•					•			62.2	Cl	Na
18	Tuzla Lagoon, Turkey					•	•	•	•		•	•	•			•	•	•	•	•			•		•					•			76.4	Cl	Na
19	Dipsiz wetland, Turkey					•	•		•		•	•				•	•	•	•				•			•				•			13.07	Cl	Na
20	Göksu Delta,Turkey					•	•		•		•	•	•			•	•	•	•	•			•		•					•			32.1	$Cl\text{-}HCO_3$	Na-Ca
21	Dalaman Wetlands, Tukey	•				•	•	•	•		•	•	•			•	•	•	•				•		•					•			8.5	$Cl\text{-}HCO_3$	Na-Ca
22	Dalyan Wetlands, Turkey	•				•	•	•	•		•	•				•	•	•	•				•		•					•			37.3	$Cl\text{-}HCO_3$	Na-Ca
23	Büyük Menderes Delta, Turkey	•				•	•		•		•	•	•			•	•	•	•				•		•					•			25.3	Cl	Na
24	Küçük Menderes Delta, Turkey	•			•		•			•	•	•				•	•	•	•				•		•					•			3 - 11	Cl	Na
25	Gediz Delta, Turkey	•			•	•	•			•	•	•				•	•	•	•				•		•					•			1.09	HCO_3	Na
26	Gökçeada Lagoon,Turkey		•						•		•	•				•			•							•				•			0.5 - 129	Cl	Na

CHART 1 (CONTD). GENERAL CHARACTERISTICS OF THE INVENTORIED WETLANDS

Inventory number	Name of wetland, Country	Groundwater dependence			Dominant vegetation					Trophic state				Functionality				State of knowledge														Management status						
		Dominant	Shared	Secondary	Forest	Shrubs, bushes	Prairie	Halophytic vegetation	Phreatophyte vegetation	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic	Almost unaltered	Moderately altered	Highly altered	Artificial	Validated hydrogeological conceptual model	Numerical model	Chemical/isotopic information	Biological information	Socio-economic information	Water level monitoring	Groundwater level monitoring	Water quality monitoring	Groundwater quality monitoring	Hydrogeological studies	Wetland evolution studies	Climate change impact studies	Global change impact studies	Information on wetland's uses	Ramsar site	MAB	Natural reserve / Other	Unprotected	Protection regulation	Management Authority	User's involvement
1	Butrinti, Albania			•		•						•				•							•	•	•	•					•	•					•	
2	Guerbes, Algeria	•			•		•	•							•	•		•		•			•	•	•	•	•	•				•		•				
3	Hutovo Blato, Bosnia and Herzegovina	•	•			•		•			•	•			•	•	•			•	•	•	•		•		•	•			•	•		•		•	•	
4	Neretva Delta, Croatia		•			•		•			•	•				•	•	•			•		•				•		•	•	•	•						
5	Lake Mariut, Egypt		•			•	•	•				•				•		•		•			•	•			•				•	•		•		•	•	
6	Tyre Beach, Lebanon	•					•					•			•						•						•					•		•				
7	Tawurgha Spring Libya	•						•				•			•			•	•	•		•	•	•	•	•	•				•						•	•
8	Skadarsko Lake, Montenegro		•			•						•		•				•		•	•	•	•		•		•				•	•		•				
9	Tivatska Solila, Montenegro			•		•						•			•						•	•									•	•		•				
10	Bou Areg Lagoon, Morocco	•				•	•	•			•	•				•		•	•	•	•						•		•			•		•			•	
11	Moulouya Estuary, Morocco		•				•	•			•					•				•	•		•				•				•	•		•			•	
12	Oued Laou Estuary, Morocco		•			•	•				•					•				•	•	•	•	•	•	•	•				•	•		•			•	
13	Wetland of Wadi Gaza, Palestine		•			•		•	•			•				•				•	•	•	•	•	•	•	•							•				
14	Akkar Plain, Syria		•				•									•		•	•	•			•	•	•	•	•								•			
15	Korba (Cap Bon), Tunisia		•					•	•							•		•	•	•			•	•	•	•	•	•				•		•				
16	Yumurtalık Lagoon, Turkey		•			•	•	•			•				•						•	•			•	•	•	•	•		•	•		•		•	•	
17	Akyatan Lagoon, Turkey		•			•		•			•				•						•	•			•	•	•	•	•		•	•		•		•	•	
18	Tuzla Lagoon, Turkey		•			•	•	•			•				•						•	•			•	•	•							•		•	•	
19	Dipsiz wetland, Turkey		•			•		•			•				•					•	•	•			•	•								•		•	•	
20	Göksu Delta, Turkey		•				•				•				•			•	•	•	•	•			•		•	•	•		•	•		•		•	•	
21	Dalaman Wetlands, Tukey		•			•	•	•			•				•					•	•	•			•		•	•			•			•		•	•	•
22	Dalyan Wetlands, Turkey		•			•		•	•		•				•					•	•	•			•		•	•			•			•		•		•
23	Büyük Menderes Delta, Turkey		•			•	•	•			•				•					•	•	•			•	•	•	•			•			•		•		
24	Küçük Menderes Delta, Turkey		•			•					•				•					•	•	•			•	•	•	•			•			•		•	•	
25	Gediz Delta, Turkey		•			•	•				•				•					•	•	•			•	•	•				•	•		•		•	•	
26	Gökçeada Lagoon,Turkey		•			•		•			•			•						•	•	•			•	•		•						•		•	•	

CHART 1 (CONTD). GENERAL CHARACTERISTICS OF THE INVENTORIED WETLANDS

Key for the classification after a general type of coastal wetlands (combine at least one number and one letter):

1	Isolated wetland
2	Wetland complex
3	Isolated within a wetland complex

A	Fresh/brackish coastal lagoon/lake
B	Salt lake
C	Salt pan
D	Natural, concentrated spring or outflow
E	Fresh water marsh
F	Brackish marsh
G	Salt marsh
H	Flood plain pool/lagoon
I	Deltaic lagoon/pool
J	Estuary
K	Riparian forest
L	Erosive deptression
M	Tectonic depression
N	Water course
O	Dune slacks
P	Spring
Q	Seepage from shallow water table
R	Saline (artificial)
S	Reservoir (artificial)
T	Other

Meaning of the groundwater flow types coastal wetlands considered

Flow through: Wetland is connected to a shallow aquifer and the water-table slope induces groundwater discharge in the upstream part of the wetland and aquifer recharge in the downstream part of the wetland.

Recharge area: Wetland water elevation is higher than the aquifer water-table elevation (wetland may even be perched). Wetland water sources may be precipitation, overland flow, rivers, sea water or artificial supply, but the dominant outflow mechanism is infiltration by lateral or by downward flow, producing shallow or deep aquifer recharge.

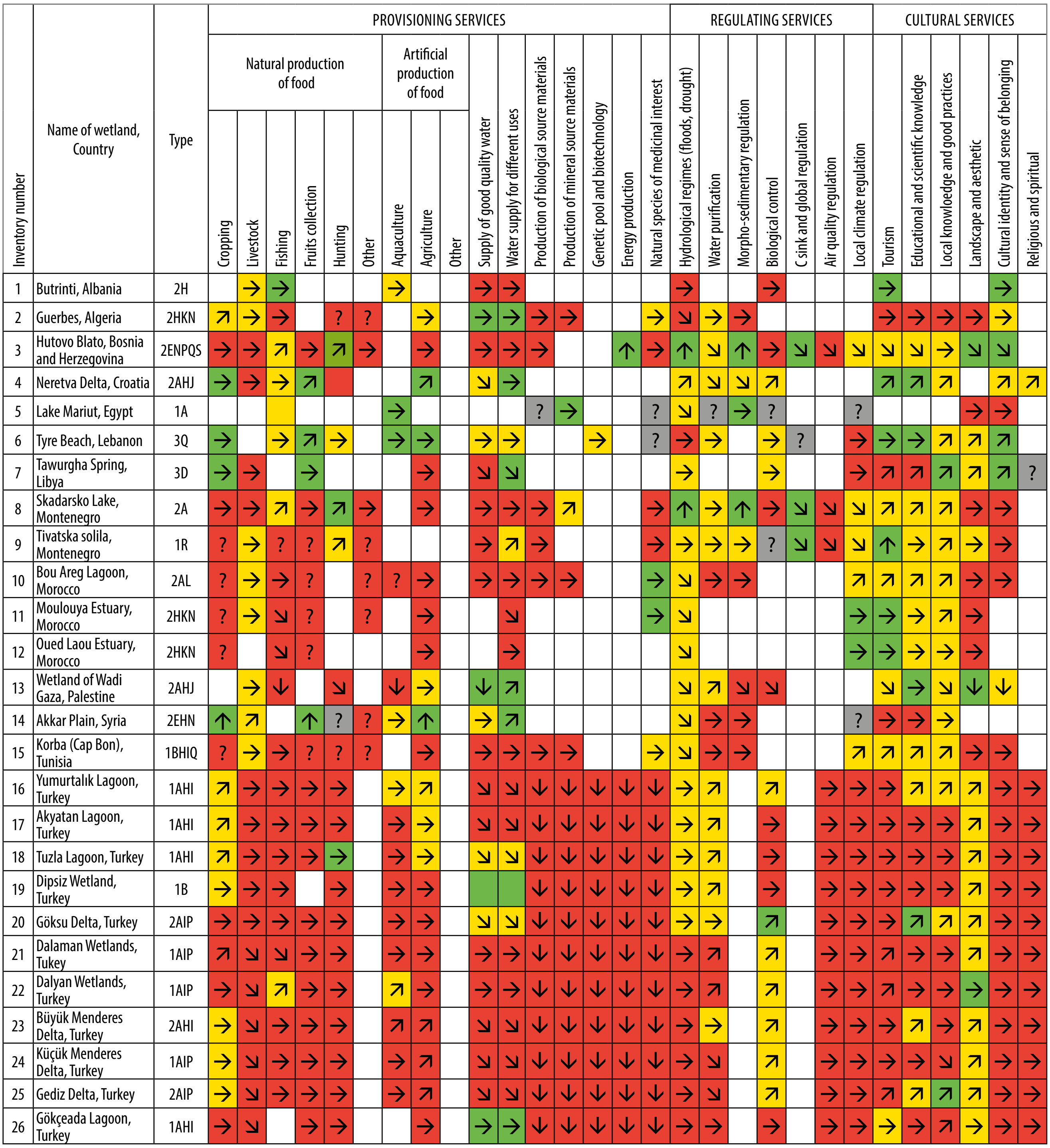
Discharge area, open: Wetland receives groundwater discharge and the dominant natural mechanism of wetland evacuation is surface water outflow.

Discharge area, closed, saline: Wetland receives groundwater discharge and the dominant natural mechanism of wetland evacuation is evapotranspiration. Wetland water and sediments are increasingly saline.

Discharge area, closed, non-saline: Wetland receives groundwater discharge and the dominant natural mechanism of wetland evacuation is evapotranspiration, but surface water outflow occurs from time to time, avoiding wetland salinization.

Crypto-wetland/hidden wetland: Water table is very shallow under and around the wetland, which does not have standing water but has permanent/semi-permanent characteristic phreatophyte vegetation masses. Examples: salt pans, salt and brackish marshes, dune slacks. Variable: The groundwater-wetlands relationship pattern changes over time.

CHART 2. GLOBAL ASSESSMENT OF SERVICES IN THE INVENTORIED WETLANDS



SERVICE'S STATUS	SERVICE'S TRENDS
High (green)	↑ Very rapidly increasing
Moderate (yellow)	↗ Moderately increasing
Low (red)	→ Continuing
Non-existent (white)	↘ Moderately decreasing
Unknown (grey)	↓ Very rapidly decreasing

CHART 3. MAIN DIRECT DRIVERS OF CHANGE IN THE INVENTORIED WETLANDS

Inventory number	Name of wetland, country	Type	RESOURCE EXPLOITATION: Water abstraction				Biological exploitation					Mineral exploitation				
			From wetland	From tributaries	Groundwater next to the wetland	Groundwater basin	Crops	Forest	Cattle raising	Fishing	Others	Fuel	Salts	Soils	Rocks	Others
1	Butrinti, Albania	2H		→ L		→ M				→ H			→ H			
2	Guerbes, Algeria	2HKN		→ M	→ M	↗ H	↗ H		→ L							→ H
3	Hutovo Blato, Bosnia and Herzegovina	2ENPQS	↑ H	↑ H	↑ H	↑ H	→ L		→ L	↗ M				→ L		
4	Neretva Delta, Croatia	2AHJ	→ L	→ M	↗ H	↗ H	↗ H		→ L	→ M						
5	Lake Mariut, Egypt	1A	→ M							→ M			→ L			
6	Tyre Beach, Lebanon	2L		↗ M		↗ H	↗ H			→ M						?
7	Tawurgha Spring Libya	Q3	→ H		↗ H	↗ H	→ M		→ M							
8	Skadarsko Lake, Montenegro	3D	↗ H	↗ H	↗ H	↗ H	↗ H		→ M	→ M						
9	Tivatska solila, Montenegro	2A	↗ M	↗ M	↗ H	↗ H	→ M		→ M					→ M		
10	Bou Areg Lagoon, Morocco	1R		?	→ M	↗ H	↗ H		→ L	→ L						
11	Moulouya Estuary, Morocco	2AL		↗ H	↗ H	↗ H	→ H		→ M	→ L						
12	Oued Laou Estuary, Morocco	2HKN		↗ H	↗ H	↗ H	→ H		→ M	→ L						
13	Wetland of Wadi Gaza, Palestine	2HKN	↘ L	↗ H	↗ H	↗ H		→ L	→ L	↓ L				↗ M	↗ M	
14	Akkar plain, Syria	2AHJ		→ M	→ M	↗ H	↗ H		→ M							
15	Korba (Cap Bon), Tunisia	2EHN		→ M	→ M	↗ H	↗ H		→ L							→ H
16	Yumurtalık Lagoon, Turkey	1BHIQ	→ L	↘ L		↗ L	↗ M	↘ L	→ L	→ L		?	→ L	?	?	
17	Akyatan Lagoon, Turkey	1AHI	→ L	↘ L		↗ L	↗ M	→ M	→ L	→ L		?		?	?	
18	Tuzla Lagoon, Turkey	1AHI	→ L			↗ L	↗ M	↘ L	→ L	→ H		?		?	?	
19	Dipsiz Wetland, Turkey	1AHI	→ L			↗ L	→ M	↘ L	→ L	→ L		?	→ M	?	?	
20	Göksu Delta,Turkey	1B	→ L	↘ L		↗ L	→ L	↘ L	→ L	→ L		?		?	?	
21	Dalaman Wetlands, Tukey	2AIP	→ L	↘ L		↗ L	↗ L	↘ L	→ L	→ L		?		?	?	
22	Dalyan Wetlands, Turkey	1AIP	→ L	↘ L		↗ L	→ L	↘ L	→ L	→ L		?		?	?	
23	Büyük Menderes Delta, Turkey	1AIP	→ L	↘ L		↗ L	→ L	↘ L	→ L	→ L		?		?	?	
24	Küçük Menderes Delta, Turkey	2AHI	→ L	↘ L		↗ L	→ L	↘ L	→ L	→ L		?		?	?	
25	Gediz Delta, Turkey	1AIP	→ L			↗ L	→ L	↘ L	→ L	→ L		?	→ H	?	?	
26	Gökçeada Lagoon,Turkey	2AIP	→ L			↗ L	→ L	↘ L	→ L	→ L		?		?	?	

Inventory number	Name of wetland, country	Type	Changes in land use									Modification of hydrological cycle					
			Deforestation	Reforestation	Forest management	Replacement of species	Extensive agriculture	Extensive cattle raising	Urbanization	Roads	Others	Drainage	Input of excess irrigation	Storage usage	Artificial recharge	Input of urban wastewater	Others
1	Butrinti, Albania	2H							↗ H	↗ M						→ M	
2	Guerbes, Algeria	2HKN				→ L	↗ H	→ L	→ H	→ L		→ M	↗ H	↗ H		→ L	
3	Hutovo Blato, Bosnia and Herzegovina	2ENPQS				↗ M	→ L	→ L	→ L	→ M		→ M	→ L	↑ H	→ H	→ L	
4	Neretva Delta, Croatia	2AHJ					↗ H		↗ M	↗ M		→ H	↗ M	→ M		↗ M	
5	Lake Mariut, Egypt	1A					↗ H			→ L	→ H	→ H	↗ H	↗ H		→ L	
6	Tyre Beach, Lebanon	2L				→ H	↗ H			→ L	?	→ H	↗ M	↗ H		→ L	
7	Tawurgha Spring Libya	Q3					↗ H	→ M	↑ H	↗ M		→ M	→ M	→ L		↗ M	
8	Skadarsko Lake, Montenegro	3D	→ M			→ M	→ M	→ L	→ H	→ L		→ M	→ M	→ M		→ H	
9	Tivatska solila, Montenegro	2A	→ M			?	→ L	→ L	↗ H	→ M		→ M	→ M	→ M		→ M	
10	Bou Areg Lagoon, Morocco	1R				→ L	→ L		→ H	→ L		→ M	→ L	↗ H		→ H	
11	Moulouya Estuary, Morocco	2AL					→ M	→ M	→ H	→ M		→ H	→ L		→ M	→ M	
12	Oued Laou Estuary, Morocco	2HKN					→ L	→ L	↗ H	→ M		→ M	→ L			→ H	
13	Wetland of Wadi Gaza, Palestine	2HKN	↗ M		↘ L		↘ L		↑ H	↗ M			→ L	↗ M	↗ M	↗ H	
14	Akkar plain, Syria	2AHJ				?	↗ H	→ L	↗ H	→ M		→ M	↗ H	↗ H		→ H	
15	Korba (Cap Bon), Tunisia	2EHN				→ L	↗ H	→ L	→ H	→ L		→ M	↗ H	↗ H	↗ H	→ L	
16	Yumurtalık Lagoon, Turkey	1BHIQ					→ M	→ M								→ L	
17	Akyatan Lagoon, Turkey	1AHI			→ L		→ M	→ M								→ L	
18	Tuzla Lagoon, Turkey	1AHI			→ L		→ M	→ M								→ L	
19	Dipsiz Wetland, Turkey	1AHI					→ M	→ M								→ L	
20	Göksu Delta,Turkey	1B					→ L	→ L								→ L	
21	Dalaman Wetlands, Tukey	2AIP					→ L		↗ L							→ L	
22	Dalyan Wetlands, Turkey	1AIP					→ L									→ L	
23	Büyük Menderes Delta, Turkey	1AIP					→ L									→ L	
24	Küçük Menderes Delta, Turkey	2AHI					→ L									→ L	
25	Gediz Delta, Turkey	1AIP					→ L		↗ L							→ L	
26	Gökçeada Lagoon,Turkey	2AIP														→ L	

Inventory number	Name of wetland, country	Type	Pollution			Alteration of biological community structures and ecosystem functioning				Effects associated with changes					Global and climate changes		
			Agricultural diffuse pollution	Atmospheric diffuse pollution	Urban/industrial point source pollution	Invasive exotic species	Native species extinction	Alteration of biogeochemical cycles	Fragmentation	Chemical water quality	Biological water quality	Oxidation by lowering water table	Increased erosion	Soil destruction	Rainfall	Temperature	Sea level rise
1	Butrinti, Albania	2H			→ M		→ M			↗ H					↘ M	↗ M	↗ M
2	Guerbes, Algeria	2HKN	↗ H	?	?					↗ H	?	?	?	?	↘ M	↗ M	↗ M
3	Hutovo Blato, Bosnia and Herzegovina	2ENPQS	→ M		↘ L	→ H	↗ H	↗ H	↗ H	↗ H	↗ H	↗ H	↗ H	→ L	→ M	↗ M	↗ M
4	Neretva Delta, Croatia	2AHJ	↗ H		↗ M		↗ M	↗ M	↗ M	↗ M	↗ M				→ M	→ M	→ M
5	Lake Mariut, Egypt	1A	↗ H	?	↗ M	↗ H				↗ H	↗ H	?	?	?	?	↗ M	↗ M
6	Tyre Beach, Lebanon	2L	→ L		?			→ M		→ L	→ L				→ M	→ H	↗ M
7	Tawurgha Spring Libya	Q3	↗ L		↗ M		↗ L	→ L	↗ L	↗ M	→ L				→ M	→ M	→ M
8	Skadarsko Lake, Montenegro	3D	↗ H	?	→ M					→ M	→ L	→ L	→ L	→ L	↘ M	↗ M	↗ M
9	Tivatska solila, Montenegro	2A	→ M	?	→ M					?	?	?	→ L	→ L	↘ M	↗ M	↗ M
10	Bou Areg Lagoon, Morocco	1R	↗ H	?	↗ H					↗ H	?	?	↗ H	?	↘ M	↗ M	↗ M
11	Moulouya Estuary, Morocco	2AL	↘ M	?	↗ H					?	↗ H	→ M	→ L	→ L	↗ H	↗ H	↗ H
12	Oued Laou Estuary, Morocco	2HKN	→ H	?	↗ H					↗ H	↗ H			→ L	↗ H	↗ H	↗ H
13	Wetland of Wadi Gaza, Palestine	2HKN	→ M	→ L	→ M	↗ M	→ M	→ L		↗ M	↗ M		↗ M	↗ M	↗ H	↗ L	↗ H
14	Akkar plain, Syria	2AHJ	↗ H	?	?		↑ H	↑ H		↗ H	↗ H	?	?	→ L	↗ H	↗ H	↗ M
15	Korba (Cap Bon), Tunisia	2EHN	↗ H	?	↗ H					↗ H	?	?	?	?	↘ M	↗ M	↗ H
16	Yumurtalık Lagoon, Turkey	1BHIQ	→ L	?		?	?						↗ H				
17	Akyatan Lagoon, Turkey	1AHI	→ L	?		?	?						↗ L				
18	Tuzla Lagoon, Turkey	1AHI	→ L	?		?	?						↗ L				
19	Dipsiz Wetland, Turkey	1AHI	→ L	?		?	?						↗ L				
20	Göksu Delta,Turkey	1B	→ L	?		?	?						↗ H				
21	Dalaman Wetlands, Tukey	2AIP	→ L	?		?	?						↘ L				
22	Dalyan Wetlands, Turkey	1AIP	→ L	?		?	?						↘ L				
23	Büyük Menderes Delta, Turkey	1AIP	→ H	?		?	?						↗ L				
24	Küçük Menderes Delta, Turkey	2AHI	→ H	?		?	?						→ M				
25	Gediz Delta, Turkey	1AIP	→ L	?		?	?						↘ L				
26	Gökçeada Lagoon,Turkey	2AIP	→ L	?		?	?						→ L				

DRIVER'S IMPACT	DRIVER'S TRENDS
High	↑ Very rapidly increasing
Moderate	↗ Moderately increasing
Low	→ Continuing
Non-existent	↘ Moderately decreasing
Unknown	↓ Very rapidly decreasing

Annex 2.

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Management and Protection of Mediterranean Groundwater-Related Coastal Wetlands and their Services

In the framework of the GEF/UNEP-MAP Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem, UNESCO-IHP executed a component on "Management of coastal aquifers and groundwater", which included an activity on "Implementation of eco-hydrogeology applications for management and protection of coastal wetlands". The aim of the activity was to reverse degradation trends in coastal aquifers and groundwater-related coastal wetlands and enhance human wellbeing, namely by providing appropriate capacities for the integration of an ecosystem services approach into groundwater and wetlands assessment and management.

To this end, UNESCO-IHP sought the cooperation of experts in order to design and carry out actions aiming to generate a new conceptual framework integrating hydrogeological, ecosystem, and management considerations in the management of Mediterranean groundwater-related coastal wetlands. Among key actions, a background document was prepared, detailing the basic aspects to be considered for an improved management of Mediterranean groundwater-related coastal wetlands through the assessment of the interlinkages between groundwater flows, wetlands services, and human wellbeing.

The present document sets forth the conceptual and empirical aspects that must be examined and followed to better understand the relationships between groundwater-related wetlands, geology, hydrology, and services to human well-being. It also presents methods for inventorying the basic information needed to characterize wetlands and aquifer functioning and to assess wetlands' contribution to human well-being. Finally, it proposes guidelines and recommendations for the evaluation and integrated management of Mediterranean groundwater-related coastal wetlands in order to preserve the sustaining role of groundwater in relation the many environmental services that wetlands provide.

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