United Nations
Educational, Scientific and
Cultural Organization

International
Hydrological
Programme

MANAGEMENT OF COASTAL AQUIFERS AND GROUNDWATER

FINAL REPORT

Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem

MedPartnership

Together for the Mediterranean Sea

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MANAGEMENT OF COASTAL AQUIFERS AND GROUNDWATER

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SC-2015/WS/22

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This is the first time – within the context of a major marine protection project – that coastal aquifers are considered an important element of the environmental continuum "River basin-coastal zone-continental shelf", and analysed in the context of an environmental diagnostic of a large marine ecosystem (LME). There are, hence, no examples to follow: on the contrary, it is hoped that the results of this endeavour will set an example of global relevance.

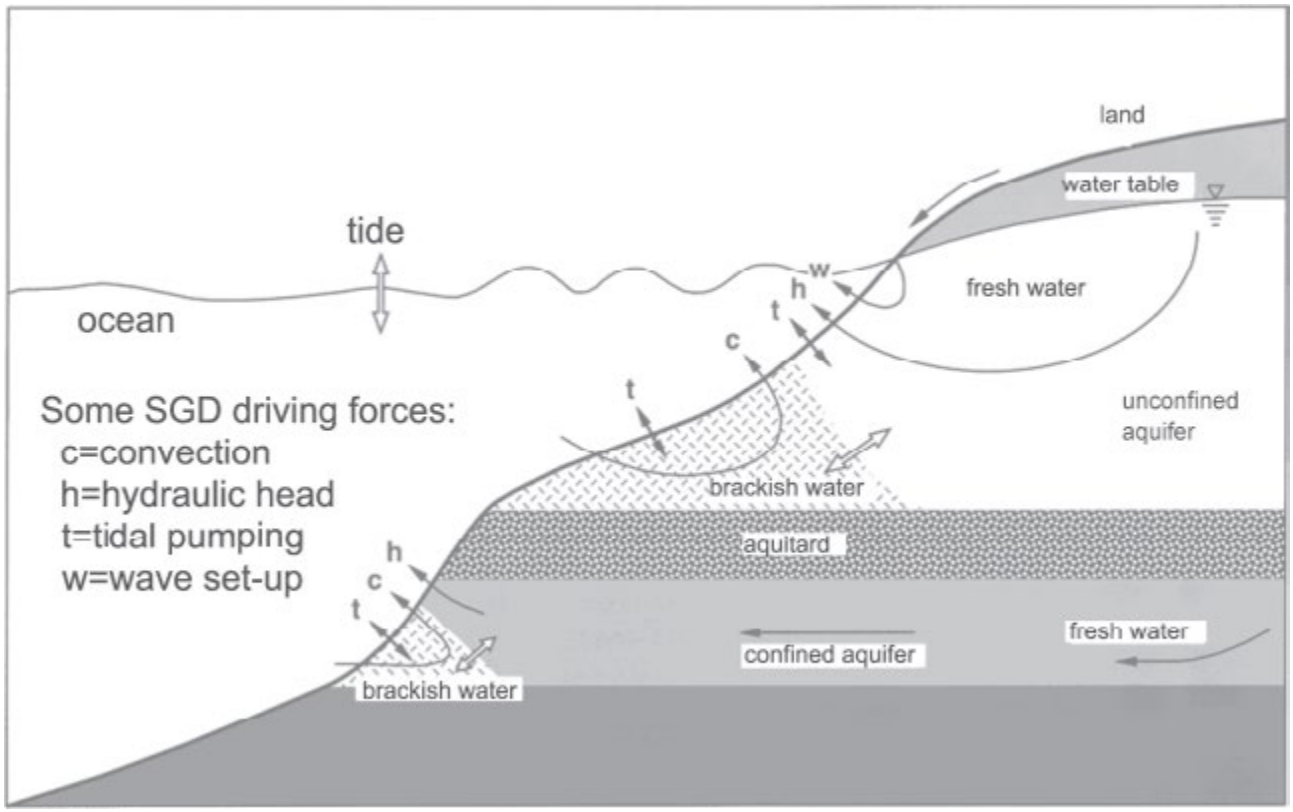
ABBREVIATIONS AND ACRONYMS

ACVM	Aquifer Comprehensive Vulnerability Mapping
BDBiH	Brčko District of Bosnia and Herzegovina
BiH	State of Bosnia and Herzegovina
DRE	Direction des Des Ressources en Eau
DSI	Directorate of State Hydraulic Works
FAO	Food and Agriculture Organization of the United Nations
FBiH	Federation of Bosnia and Herzegovina
GEF	Global Environment Facility
GWA	General Water Authority
ICZM	Integrated Coastal Zone Management
IHP	International Hydrological Programme
IMF	Integrative Methodological Framework
IWRM	Integrated Water Resources Management
KAVA	Karst Aquifers Vulnerability Assessment
LME	Large Marine Ecosystem
MAB	Man and the Biosphere
NS ICAM	National Strategy for Integrated Coastal Zone Management
PNA	Palestinian National Authority
RS	Republic of Srpska
SGD	Submarine Groundwater Discharge
SPA	Specially Protected Areas
TDA	Transboundary Diagnostic Analysis
UNESC0	United Nations Educational, Scientific and Cultural Organization
WFD	Water Framework Directive
WWTP	Waste Water Treatment Plants

1.
INTRODUCTION

Although not as obvious as river discharge, continental groundwater also discharges directly into the ocean wherever a coastal aquifer is connected to the sea. Artesian aquifers can extend for considerable distances from the shore underneath the continental shelf, with discharge to the ocean at their points of outcrop. In some cases, these deeper aquifers may have fractures or other breaches in the overlying confining layers, allowing groundwater to flow into the sea. Although submarine springs and seeps have been known for many years (written accounts exist from at least the Roman period), these features have traditionally been perceived as hydrological "curiosities" rather than as objects for serious scientific investigation. Within the last few decades, recognition has emerged that groundwater discharge into the sea may be both volumetrically and chemically important.

Figure 1.1. Submarine groundwater discharge (SGD) nomenclature of fluid exchange and schematic depiction of processes associated with submarine groundwater discharge. Not to scale. Arrows indicate fluid movement (from Burnett and others, 2003, modified from Thibodeaux and Boyle 1987).



SGD may consist of multiple components. The main one is meteoric water fallen on dry land as atmospheric precipitation, which has infiltrated soil overlying the rock, and percolated to the water table. Another important component of SGD may be re-circulated seawater that can be driven in part by hydraulic gradients on land as well as by various oceanic forces. In some cases, SGD can also contain saline connate groundwater or groundwater whose salinity has been raised by dissolution of salt within the aquifer itself.

Many factors affect rates of fresh groundwater flow into the coastal zone, either directly or indirectly. Driving force and transmissivity are the main factors that determine the flux of terrestrially derived SGD. The driving force is a function of the hydraulic gradient (influenced by topography) and the terrestrial groundwater recharge rate (affected by precipitation and evapotranspiration). The types and extent of vegetation, as well as climate, will determine evapotranspiration rates. Transmissivity may be controlled by permeability (geology) and development of river systems (geomorphology). Thus, parameters related to geology, precipitation, vegetation (land use) and topography are all contributing factors in determining rates of fresh groundwater flow to the sea. Without the benefit of measurements, one may predict that land-derived SGD fluxes would be high in areas of high permeability (karst), high relief near the coast; areas without well-developed river systems (some large oceanic islands); and regions with high groundwater recharge rates (e.g. humid tropics).

The flux of terrestrially driven groundwater through coastal sediments is becoming recognized as an important mechanism for transferring material from the land to the ocean. Flow may occur through the surficial aquifer or through breaches in deeper, semi-confined coastal aquifers. This process may affect the biogeochemistry of estuaries and the coastal ocean through the addition of nutrients, metals and carbon. During the passage of terrestrially derived fluids through the sediments, mixing of seawater with fresh groundwater and chemical reactions of the fluids with solid phases may occur. The emerging fluid is chemically distinct from the groundwater and seawater end-

members. Concentrations of nutrients, trace metals, organic carbon, methane and CO2 may be considerably higher than in surface ocean waters. Groundwater-borne nutrients can have significant effects on water quality in surface estuaries. Groundwater may have nutrient concentrations several orders of magnitude greater than surface waters either via contamination (e.g. from septic systems) or natural processes. Thus, nutrient concentrations in coastal groundwater, which are modified by man-made changes to coastal regions, may be a significant factor in the eutrophication of near-shore waters.

Increasing population density and changing agricultural practices in coastal areas have led to releases of nutrients (and other contaminants) into the coastal environment from fertilizer use, industrial practices and wastewater discharge. These increased nutrient releases have led to eutrophication in many coastal waters, which is a widespread concern. Yet, the role that groundwater-derived nutrients have played in coastal eutrophication is not well understood in many areas. The ecological and economic impacts of eutrophication have been substantial in many coastal regions, and this demands a better understanding of the contribution of groundwater-derived nutrient fluxes. Management of wastewater treatment practices in coastal regions depends critically on accurate estimates of the flux and quality of groundwater in the coastal zone. In addition, informed resource management requires an improved understanding of the geological framework of coastal aquifers, the pathways by which groundwater travels to the coastal zone, the specific locations and dimensions of submarine discharge zones and the geochemical transformations that take place prior to discharge.

It is hence evident that to understand coastal dynamics and assess the state of coastal and marine resources and ecosystems, the interactions between coastal aquifers and the marine environment must be taken into full consideration, and reflected in Integrated Coastal Zone Management (ICZM) plans and marine protection strategies.

The Transboundary Diagnostic Analysis (TDA) for the Mediterranean Sea LME (UNEP-MAP/MED POL, 2005) recognizes coastal aquifers as part of the Mediterranean marine ecosystem:

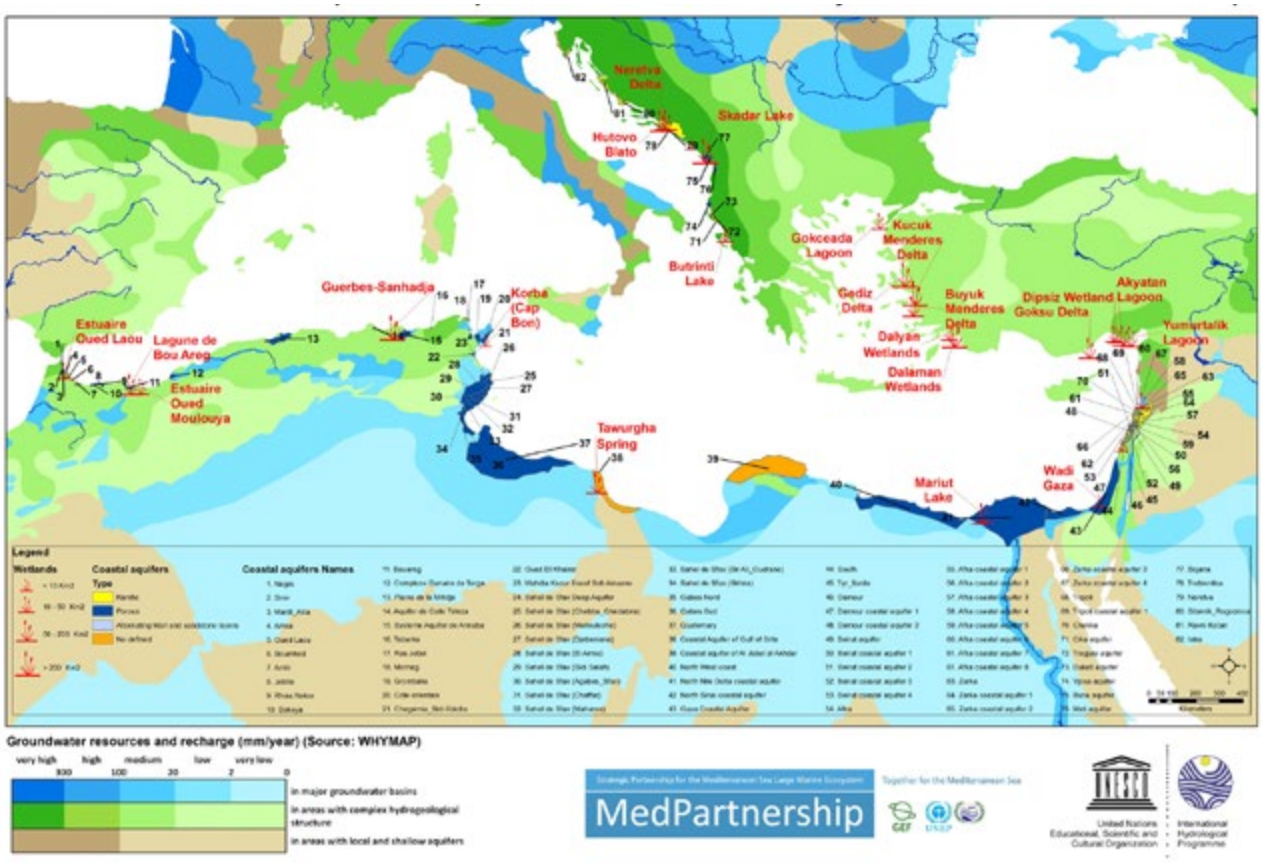
- Coastal aquifers provide another source of freshwater discharge to the Mediterranean. The seepage from the coastal aquifers, estimated at 13 billion m3/yr in the UNEP / Blue Plan study (http://www.planbleu.org/), accounts for about one quarter of the total freshwater inflow into the Mediterranean. The seepage inflows are prevalent on the eastern coast of the Adriatic, dominated by its karstic aquifer systems, as well as the eastern and southern Mediterranean coast with semi-arid and arid conditions and limited precipitation and runoff and limited surface watercourses and discharge points. The karstic coastal aquifers discharge directly into the sea without previous intervention of rivers or lakes and the functions as flows and storage in karst are directly related to the quantitative status, represented by the discharge flows and the water budgets. The karstic aquifer discharges include also substantial submarine discharges with large submarine karstic freshwater springs with flows as high as 50 m3/sec that are recharged on land. The coastal seepage and submarine discharges are critical to the water balance and seawater quality in the marine sub-basins and support wetlands and brackish water habitats with biodiversity and fishery nursery areas in the coastal zones. The coastal aquifers are threatened by over-exploitation and consequent seawater intrusion and water and land salinization, thereby adding to the deficit in recharge of the Mediterranean.

The 2005 TDA does not, however, include a more in-depth analysis of Mediterranean SGDs, nor does it draw any diagnostic conclusions. Having recognized this pitfall, and in response to the Declaration on Groundwater in the Mediterranean (Malaga-Marrakech 2006), UNEP-MAP, with the cooperation of UNESCO-IHP, has incorporated into the project: "Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem-Regional Component: Implementation of Agreed Actions for the Protection of the Environmental Resources of the Mediterranean Sea and Its Coastal Areas" (2008), a sub-component (1.1) on "Management of coastal aquifers and groundwater". The long-term objective of the Management of Coastal Aquifers and Groundwater sub-component was to reverse the trends in over-extraction and degradation in the quality of coastal aquifers. Activities focused on assessing the risks to coastal aquifers and associated uncertainties, the preparation of sub-regional action plans, demonstrations in collaboration with ICZM, Integrated Water Resources Management (IWRM) and Marine Protected Areas, improving knowledge about the role of groundwater in sustaining coastal ecosystems and the identification of the legislative, policy and institutional reforms needed.

Objectives of the Management of Coastal Aquifers and Groundwater sub-component are:

- Assessment of the hydrogeological and legal-institutional aspects related to coastal aquifers, involving an updated inventory of coastal aquifer resources and the identification of major risks and uncertainties at specific coastal aquifer systems
- Vulnerability mapping of aquifers at selected sites with the aim of transferring technology and knowledge to responsible institutions
- Integration of coastal aquifers in two case study demonstration projects in a selected river basin and a coastal zone
- Assessment of the current state of coastal groundwater-related ecosystems (wetlands and coastal lagoons)
- A coastal aquifer supplement to the Transboundary Diagnostic Analysis for the Mediterranean Sea (TDA-MED) based on the outcome of the risk and uncertainty assessment and vulnerability mapping
- Development of sub-regional action plans on coastal aquifers.

Figure 1.2. Main Mediterranean coastal aquifers and representative wetlands assessed by UNESCO-IHP for the MedPartnership



(Skoulikaris 2015)

Table 1.1. Main outputs of the coastal aquifers sub-component

Outputs
Final report, including: 1. Inventory and characterization of Mediterranean coastal aquifers 2. TDA supplement 3. Regional action plan
Pilot demonstrations: Aquifer vulnerability mapping 1. Vulnerability mapping of Novljanska Žrnovnica karstic spring catchment area (Croatia) 2. Vulnerability mapping of the Pula coastal aquifer (Croatia) 3. Vulnerability mapping of the Ghar El Melh coastal aquifer (Tunisia) Conjunctive management of surface and groundwater resources 1. Contributions to the Buna/Bojana transboundary integrated management plan: Joint ICZM and IWRM plan integrating groundwater and aquifers (Albania and Montenegro) 2. Contributions to Algeria's National ICZM Strategy and Reghaia's Coastal Plan, integrating groundwater and aquifers (Algeria) 3. An Integrative Methodological Framework (IMF) for Coastal, River Basin and Aquifer Management: Towards Converging Management Approaches for Mediterranean Coastal Zones Groundwater and coastal ecosystems 1. Study of the processes affecting groundwater quality and salinization in coastal zones: the case of the Bou Areg coastal aquifer and the Nadoor lagoon (Morocco) 2. Impact of climate change on water resources of the coastal wetlands in Lebanon
Assessment of groundwater-related ecosystems: 1. Main hydrogeological characteristics, ecosystem services and drivers of change of 26 representative Mediterranean groundwater-related coastal wetlands 2. Hydrogeological and ecosystem classification of representative Mediterranean coastal groundwater-related wetlands: map of selected wetlands in the Mediterranean area
Assessment of the main coastal aquifers in the Mediterranean: • National reports on the hydrogeological characteristics of main Mediterranean coastal aquifers: Albania, Algeria, Bosnia and Herzegovina, Croatia, Egypt, Lebanon, Libya, Montenegro, Morocco, Palestine, Tunisia and Turkey
Assessment of the legal, institutional and policy aspects of coastal aquifer management in the Mediterranean: • Regional assessment of the legal, institutional and policy aspects of coastal aquifer management • National reports on the legal, policy and institutional framework for coastal aquifer management: Albania, Algeria, Bosnia and Herzegovina, Croatia, Egypt, Lebanon, Montenegro, Morocco, Palestine and Tunisia

These documents can be accessed online at the UNESCO-IHP Groundwater Portal at http://groundwaterportal.org/project/medpartnership.

2.

INVENTORY AND CHARACTERIZATION OF MAIN MEDITERRANEAN COASTAL AQUIFERS AND GROUNDWATER-RELATED WETLANDS

All major coastal aquifers of the countries participating in the MedPartnership have been taken into consideration within the context of the sub-component, not just those that are transboundary (i.e. those extending across national boundaries). In fact the point has to be made that "all" coastal aquifers contribute to the integrity and functioning of the coastal zone and marine ecosystems, and that their degradation reflects upon, and contributes to, the major transboundary issues affecting – in this specific case – the Mediterranean Sea.

Contrary to all other water bodies, aquifers are located in the subsurface and visible only through the eyes of science, that is, hydrogeology. As a consequence, while in all countries of the world groundwater is being used intensively, in many cases this happens in the absence of a full understanding of the nature and characteristics of the resource, including of its occurrence in defined geological permeable rock formations known as "aquifers". Moreover, groundwater resource boundaries, or aquifer boundaries, are often very poorly known and so many aquifers remain unknown or only partly recognized as separate, often unconnected, entities.

This is particularly true for coastal aquifers, whose special nature and interlinkages with the marine environment are often not recognized by countries. Lack of recognition increases their vulnerability to anthropogenic pressures. Hence, the need to:

1. make coastal aquifers "visible" and recognized by the countries where they are located
2. collect, to the extent feasible within the context of MedPartnership, a set of data for each aquifer that (combined) give a first description of its present hydrogeological, environmental, socioeconomic and governance conditions, and of its interactions with adjoining water bodies and ecosystems.

2.1 METHODOLOGICAL APPROACHES

The following methodological approaches were adopted:

1. **Harmonization of information.** The methodology for identification and characterization has been designed in such a way as to provide, within a defined period of time, a harmonized and comparable synopsis of the Mediterranean coastal aquifers, reflecting the present state of knowledge and availability of information. This harmonization has been achieved by ensuring technical and scientific supervision and using predefined guidelines; methodologies; information formats and forms; and coordination of efforts at the regional and national level
2. **Country involvement.** The identification-characterization exercise has directly involved all Mediterranean littoral countries taking part in MedPartnership. Country involvement has been an essential element of the methodology, given the need to improve data availability, and to achieve visibility and recognition of the aquifers, their boundaries and characteristics
3. **Acquisition of information.** The data acquisition was a complex activity because it encompassed a large number of aquifers, spread all along the southern and eastern Mediterranean coastline. Thus conditions ranged from well-documented aquifer systems, managed by institutions that monitor all relevant aspects, to poorly explored aquifer systems that are not monitored or managed at all. The systematic use of questionnaires and national networks of experts has been identified as the main tool, feasible within the financial and time constraints of the MedPartnership. Questionnaires addressed primarily:
   - The existence and spatial distribution of coastal aquifers
   - Information on the key elements that characterize their "status", and the situation relating to governance and other "processes"
   - The identification of issues of transboundary concern
   - Interactions with other water bodies.

Note: The maps presented in this chapter were established with (i) information on the location and extent of main coastal aquifers provided to UNESCO-IHP by designated representatives of the MedPartnership countries and (ii) Esri base maps which were created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved. For more information about Esri® software, please visit www.esri.com. These maps were prepared by UNESCO Chair and Network / International Network of Water-Environment Centres for the Balkans (INWEB), Aristotle University of Thessaloniki, Greece.

2.2 COASTAL AQUIFERS OF THE ADRIATIC BASIN

The following pages contain the results of the coastal aquifer identification and characterization work. For each of the 46 coastal aquifers forming part of the inventory, a summary of relevant information is provided ("country cards"):

- Location and boundaries
- Name
- Main hydrogeological and environmental characteristics
- Key issues of concern
- Legal and institutional aspects.

2.2.1 Albania

Albanian coastal aquifers are relatively small (<300 Km^2) and are characterized by Quaternary alluvial deposits (porous) and carbonate deposits (karstic). The largest aquifers are located in the deltas of the Mati, Erzeni and Vjosa Rivers. The aquifers present in the Dukati and Pavlla river deltas are of a limited extent, but their thickness is considerable (the Dukati aquifer's mean thickness is between 40 and 150 m). Coastal aquifer recharge occurs through river water infiltration and precipitation. Groundwater has traditionally been used for drinking water and industrial activities, while surface water has typically been preferred for irrigation. The groundwater potential of Albania is estimated at 340 m3/s (70% of this from karstic aquifers). The mean annual rainfall is 1422 mm/yr, which is concentrated (about 70%) between the months of November and May. The majority of karstic coastal aquifers (about 70%) discharge through submarine springs. The Ramsar-listed Viluni Lagoon near the Buna River is recognized as a groundwater-related ecosystem.

Issues of concern

The extent of saltwater intrusion in coastal aquifers is not well studied; however, based on estimates of winter and spring recharge rates and groundwater extraction rates, it is assumed that this is most likely a serious concern. Coastal aquifers also experience significant pollution by nitrites and ammonia, including the Vjosa and Mati (northern part) aquifers and Uji Ftohte (Vlore) and Potami (Himare) springs. Additional pollution occurs in coastal aquifers located in urbanized regions that lack protected sanitary zones around groundwater extraction sites. Coastal aquifers are, furthermore, threatened by the illegal exploitation of the gravels (as raw materials) in riverbeds and also in many recharge areas of the aquifers. This lowers water tables and decreases the infiltration capacity of riverbeds from which aquifers are recharged.

Table 2.2.1.1. Main coastal aquifers in Albania

Aquifer name	Hydrogeology	Extent	Salinity	Main uses	Entity responsible for management	Recharge (Mm3/yr)	Abstraction (Mm3/yr)
Cika	Karstic	189 km^2	Localized but severe (from 0.25 to 3 g/l)	Domestic supply, irrigation and livestock	MEFWACVB	173.4	4.7
Tragjasi	Karstic	155 km^2	Localized and moderate (from 0.25 to 1.2 g/l)	Drinking water	MEFWACVB. Monitored 3-4 times per year for main anions and cations, and physical properties	164.0	39.4
Dukati	Unconfined in porous deposits	37.5 km^2	Localized and moderate (from 0.25 to 1.2 g/l)	Drinking water	MEFWACVB. Monitored 3-4 times per year for main anions and cations, physical properties and water levels	4.7	3.2
Vjosa	Confined in porous deposits	242 km^2	Localized but severe (from 0.25 to 1.5 g/l)	Drinking water	MEFWACVB. Monitored 3-4 times per year for main anions and cations, physical properties, heavy metals and water levels	41.0	37.8
Mati	Confined in porous deposits	264 km^2	Localized but severe (from 0.25 to 3 g/l)	Drinking water	MEFWACVB. Monitored 3-4 times per year for main anions and cations, physical properties, heavy metals and water levels	141.9	72.5
Buna	Confined in porous deposits	181 km^2	Localized but severe (from 0.35 to 4 g/l)	Drinking water	MEFWACVB. Monitored 3-4 times per year for main anions and cations and physical properties	10.4	4.7

MEFWACVB, Ministry of Environment, Forest and Water Administration Council of Vjosa Basin

Table 2.2.1.2 presents an overview of the results of the analysis of the aquifer questionnaires and is intended to provide a visual indication of the potential areas of concern for the aquifers studied. The analysis considered five criteria:

1. Pollution from nutrients
2. Pollution from other substances
3. Dependency on the aquifer for domestic uses
4. Links between the aquifer and ecosystems
1. Salinization.

Based on the responses provided by the national expert in the aquifer questionnaire, a score of 0-3 was assigned to each criterion, and a colour was used to indicate the relative level of concern: very low (white), low (green), medium (orange), high (red).

Table 2.2.1.2. Overview of Albania coastal aquifers analysed

Aquifer name	Nutrients	Other pollutants	Dependency for domestic uses	Links with ecosystems	Salinization
Buna aquifer					
Cika aquifer					
Dukati aquifer					
Mati aquifer					
Tragjasi aquifer					
Vjosa aquifer					

Legal matrix[1]

Albania has made efforts to transpose the fundamental principles, objectives and measures from the EU Framework Directives in order to fully integrate the EU *acquis* in the area of water resource management into national legislation. A new Water Law was adopted in December 2012 and entered into force in December 2013. The new law fully complies with the provisions of the EU Water Framework Directive.

1. The information on legal aspects shown in the Final Report is only a summary, focused on groundwater and coastal aquifers, of the very extensive assessment which can be found in UNEP/MAP, UNESCO-IHP, 2015, "Legal, institutional and policy aspects of coastal aquifer management – Regional report", Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership), Paris.

Table 2.2.1.3. Policy and legal aspects of water management

Water policies and strategies	
Main principles and objectives	National Strategy for Development and Integration 2014-2020: • Managing rivers by basin • Creating an electronic water cadaster • Integrated management of transboundary waters • Fully transposing water-related EU *acquis* into national legislation • Establishing a data collection system for marine habitants, etc.
Consideration of groundwater and of coastal aquifers	None
Legal framework (main principles and measures)	
Water ownership	Law No. 111/2012, dated 15 December 2012, "On Integrated Management of Water Resources": • All water resources are state property
Groundwater consideration	• Law No. 111/2012, dated 15 December 2012 "On Integrated Management of Water Resources", provides for protection of groundwater and implementation of plans for improving its status • Law No. 10431, dated 9 June 2011 "On Environmental Protection", provides for water protection: - ensuring the prevention of damage to surface and groundwater quality - improving the quality of surface waste waters and achieving water quality objectives - rehabilitating contaminated groundwater - improving the balance between the abstraction and the natural regeneration of groundwater - protection of aquatic flora and fauna • Law No. 8102, dated 28 March 1996 (amended by law No. 9352, dated 3 March 2005; Law No. 9584, dated 17 July 2006 and Law No. 9915, dated 12 May 2008), "On sector regulatory framework for water supply and disposal, and the treatment of wastewater": - establishes a regulatory framework for an independent regulatory authority responsible for water resources, water supply and disposal of wastewater processing, including surface and groundwater resources • Law No. 9663, dated 18 December 2006, "On Concessions" regulates the procedures for granting concessions for use of natural resources, including water resources (surface and groundwater) for hydropower, and for the production, distribution and management, collection, distribution and management of water for irrigation, drainage and cleaning of canals and dams..

2.2.2 Bosnia and Herzegovina

Bosnia and Herzegovina has one coastal aquifer, the Trebišnjica aquifer, which extends into the territory of Croatia. The Trebišnjica aquifer is primarily karstic, formed in very fractured and porous limestone. The recharge of this aquifer occurs mainly through infiltration of precipitation and from sinking rivers, with infiltration rates especially high in the spring as a result of increased river flow from melting snow. Average rainfall is approximately 1780 mm/yr, with elevated precipitation occurring in autumn and spring. Surface and groundwater regimes were altered drastically with the construction of several important dams and reservoirs during the era of the former Yugoslavia. The independent states that emerged from the former Yugoslavia are now faced with complex, transboundary water management challenges resulting from these constructed systems. These challenges have presented cooperation opportunities, as evidenced in the development of joint water monitoring programmes between countries in the region (i.e. Serbia, Montenegro and Croatia).

Issues of concern

The quality of groundwater in the Trebišnjica aquifer is generally good, but it does experience periodic problems with turbidity and bacteriological pollution (mostly solved by disinfection with chlorine). Seawater intrusion is not a concern for this aquifer, given the presence of an impermeable flysch rock layer.

In terms of groundwater quantity, it is important to note that groundwater reserves are far greater than current groundwater abstractions in this aquifer. This trend is not expected to change in the near future. However, since this is a shared aquifer, some economic activities outside of Bosnia and Herzegovina (e.g. tourism in Croatia) could trigger an increased demand for water from this aquifer and result in greater environmental concerns in the future. Furthermore, the aquifer's recharge rate could decrease as a result of changes in precipitation regimens linked to climate change (including decreased snowfall and subsequently less infiltration from snowmelt).

At the present time, the main policy concern is the disagreement surrounding the modification of a number of sub-law documents (rules), especially the "Rule on protection zone of drinking water sources".

Table 2.2.2.1. Main coastal aquifer in Bosnia and Herzegovina

Aquifer name	Hydrogeology	Extent	Salinity	Main uses	Entity responsible for management	Recharge (Mm3/yr)	Abstraction (Mm3/yr)
Trebišnjica	Karst	1,674 km^2	Local and moderate	>75% Drinking Water, ~25% Industry (mostly in Croatia)	Ministry of Agriculture, Forestry and Water Management of the Republic of Srpksa Ministry of Agriculture, Forestry and Water Management of the Federation of Bosnia and Herzegovina	Not known	10.34

Table 2.2.2.2 presents an overview of the results of the analysis of the aquifer questionnaires and is intended to provide a visual indication of the potential areas of concern for the aquifers studied. The analysis considered five criteria:

1. Pollution from nutrients
2. Pollution from other substances
3. Dependency on the aquifer for domestic uses
4. Links between the aquifer and ecosystems
2. Salinization.

Based on the responses provided by the national expert in the aquifer questionnaire, a score of 0-3 was assigned to each criterion, and a colour was used to indicate the relative level of concern: very low (white), low (green), medium (orange), high (red).

Table 2.2.2.2. Overview of the Bosnia and Herzegovina coastal aquifer analysed

Aquifer name	Nutrients	Other pollutants	Dependency for domestic uses	Links with ecosystems	Salinization
Trebišnjica					

Legal matrix[2]

The State of Bosnia and Herzegovina (BiH) consists of two entities: the Federation of Bosnia and Herzegovina (FBiH) and the Republic of Srpska (RS). The Brčko District of Bosnia and Herzegovina (BDBiH) has been created under the exclusive sovereignty of Bosnia and Herzegovina. There is no legally binding act related to water at the State level, with the exception of the Rulebook on Health Safety of Drinking Water. In BiH, water management issues are not addressed in the Constitution so they fall under the following provision: "All governmental functions and powers not expressly assigned in this Constitution to the institutions of Bosnia and Herzegovina shall be those of the Entities" (Article III, Paragraph 3 of the Constitution of BiH). Therefore water management issues are within the competence of the entities.

The Cantonal level at a glance. The Federation of BiH is subdivided into ten Cantons, which makes the water governance even more complex in this part of the State. Each Canton has its own government and adopts its own laws (in accordance and fully complying with FBiH legislation). The main functions and tasks related to water assigned to the Cantons include permitting and allocation of water resources under their competence (drainage, irrigation, water supply, hydropower and water protection).

2. The information on legal aspects shown in the Final Report is only a summary, focused on groundwater and coastal aquifers, of the very extensive assessment which can be found in UNEP/MAP, UNESCO-IHP, 2015, "Legal, institutional and policy aspects of coastal aquifer management – Regional report", Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership), Paris.

Table 2.2.2.3. Policy and legal aspects of water management

Water policies and strategies	
Main principles and objectives	Development Strategy of FBiH (2010-2020): The Strategy identifies water and groundwater as development factors • Strategic goals of the strategy: – Legal and institutional reform of the water sector – Integrating water management into the economic system – Safeguarding the good status of surface and groundwater – Harmonizing with EU acquis Water Management Strategy (FBiH) (2011) for the period 2010-2022 includes strategic objectives related to groundwater: • Strategic objective no. 1: legal reform of the water sector and alignment with EU water acquis • Strategic objective no. 8: achieving and maintaining good status of surface water and groundwater to protect aquatic flora and fauna, and needs of water users Framework Plan of Development of Water Management (2006) of RS; groundwater referred to in several objectives: • Ensuring the implementation of the EU Water Framework Directive • Defining limits of substances for surface and groundwater in protected areas • Programme establishing monitoring of nitrates in surface water and groundwater • Adopting measures to prevent water contamination and protection in case of outflow in ground and surface water – Strategy of Integral Water Management of RS for the period 2014-2024; draft version (not adopted yet; currently passing through parliament). Adopted on the basis of the Framework Plan. Special emphasis on waste water treatment plants.
Consideration of groundwater	In all strategic and planning documents
Legal framework (main principles and measures)	
Water ownership	FBiH: • Category I waters: FBiH is the owner • Category II waters: the city or the municipality is the owner unless regulated otherwise by the Cantonal regulations
Groundwater consideration	FBiH: • Water Law (2006) RS: • Water Law (2006, amended in 2009) BDBiH: • Water Law (2004, amended in 2005 and 2007)
Coastal aquifers consideration	None

BDBiH, Brčko District of Bosnia and Herzegovina; FBiH, Federation of Bosnia &Herzegovina; RS, Republic Srpska

2.2.3 Croatia

The coastal aquifers in Croatia are primarily karstic in nature, with significant discharges of fresh groundwater to the Adriatic Sea. The total average annual fresh water runoff in the Adriatic Sea is 886 m^3/s, of which a major portion is groundwater. The average annual precipitation in Croatia ranges from 650 mm in eastern Slavonia to 3500 mm or more in Gorski Kotar (Lividraga, 3800 mm). The continental part of Croatia is characterized by maximum levels of precipitation in summer and minimum in winter; the transitional area between the continental and the Mediterranean climate is characterized by maximum levels of precipitation in November and minimum levels in February; while the coastal area and the mountainous hinterland (recharge area of coastal aquifers) is characterized by maximum levels of precipitation in winter and minimum levels in summer.

In the Neretva, Ravni Kotari and Istra coastal aquifers, the most important pressure is the intensive use of water for irrigation (mainly by an unknown number of unregistered wells that are pumping water). In the proximity of the Šibenik-Rogoznica coastal aquifer, however, there are fewer suitable areas for agriculture and consequently less pressure on this aquifer from irrigation activities, compared with the other aquifers in Croatia that were studied.

Issues of concern

The greatest pressure on most coastal aquifers is the uncontrolled abstraction of groundwater for irrigation from unregistered wells, which leads to seawater intrusion in many areas. The ever-growing demand for water from the public water supply system further intensifies this problem. Most coastal aquifers are also naturally influenced by salinization to some degree, caused by changes in sea levels during the last geological period. Apart from salinization, the quality of groundwater in coastal aquifers is also negatively impacted by pollution from the intensive use of fertilizers and pesticides in agriculture, as well as the release of untreated wastewaters from numerous settlements. In the southernmost area of the Istra peninsula, in and around Pula, industry and industrial wastewater discharges also exert an important pressure on water quality in the coastal aquifer.

Table 2.2.3.1. Main coastal aquifers in Croatia

Aquifer name	Hydrogeology	Extent	Salinity	Main uses	Entity responsible for management	Recharge (Mm3/yr)	Abstraction (Mm3/yr)
Istra	Karstic	584.9 km^2	Widespread and severe salinization	Irrigation, livestock and industry. Monitored for water levels, nitrogen, salinity, heavy metals, pesticides and industrial organic compounds	Croatian Waters	Not known	Not known
Neretva	Karstic	215.8 km^2	Local and moderate salinization	Domestic supply, irrigation and livestock. Monitored for water levels and salinity	Croatian Waters	Not known	Not known
Ravni Kotari	Karstic	616.9 km^2	Local and moderate salinization	Domestic supply, irrigation, livestock and industry. Monitored for nitrogen, salinity, heavy metals, pesticides and industrial organic compounds	Croatian Waters	Not known	Not known
Šibenik-rogoznica	Karstic	523.3 km^2	Local and moderate salinization	Domestic supply, irrigation and livestock. No monitoring of groundwater levels or quality	Croatian Waters	Not known	Not known

Table 2.2.3.2 presents an overview of the results of the analysis of the aquifer questionnaires and is intended to provide a visual indication of the potential areas of concern for the aquifers studied. The analysis considered five criteria:

1. Pollution from nutrients
1. Pollution from other substances
1. Dependency on the aquifer for domestic uses
1. Links between the aquifer and ecosystems
3. Salinization.

Based on the responses provided by the national expert in the aquifer questionnaire, a score of 0-3 was assigned to each criterion, and a colour was used to indicate the relative level of concern: very low (white), low (green), medium (yellow), hig (red).

Table 2.2.3.2. Overview of Croatia coastal aquifers analysed

Aquifer name	Nutrients	Other pollutants	Dependency for domestic uses	Links with ecosystems	Salinization
Šibenik-rogoznica					
Istra					
Neretva					
Ravni Kotari					

Legal matrix[3]

Croatia has a relatively comprehensive legal framework for water management based on the EU Directives. It gives due consideration to groundwater within the river basin as per EU requirements, but without any specific mention of coastal aquifers. The institutional framework seems to be relatively clear with a national agency, Croatian Waters, in charge of water management, and the Water Management Directorate under the Ministry of Agriculture.

3. The information on legal aspects shown in the Final Report is only a summary, focused on groundwater and coastal aquifers, of the very extensive assessment which can be found in UNEP/MAP, UNESCO-IHP, 2015, "Legal, institutional and policy aspects of coastal aquifer management – Regional report", Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership), Paris.

Table 2.2.3.3. Policy and legal aspects of water management

Water policies and strategies	
Main principles and objectives	Water Management Strategy 2009-2023 - Ensures good-quality water for drinking, for various economic purposes and for water-dependent ecosystems - Defines protected areas (abstraction of drinking water, vulnerable and sensitive areas, protection of habitats and species) - "User/polluter pays" principle - Recovery of costs of water services River Basins Management Plan (2013-2015) - Analysis of characteristics of the basins - Overview of the impact of human activities on the status of surface waters, including transitional and coastal waters and groundwater - Economic analysis of water use - Overview of the water monitoring systems - Programme of measures for improving the water status - Contains the following registers and report: ii) Register of protected areas (summary) iii) Register of more detailed plans and programmes related to specific sub-basins, sectors and specific questions or types of water in the river basin district to which the plan refers, with a summary of their contents iv) Register of the water bodies with their features v) Report on public information and consultation
Consideration of groundwater and of coastal aquifers	• Intensification of the establishment of sanitary protection zones around well fields and springs • Implementation of adequate protective measures in these zones • Recording of data and economy of groundwater resources established for groundwater monitoring
Legal framework (main principles and measures)	
Water ownership	Waters are a common good and may not be the object of rights of ownership and other property rights (article 7 of the Water Act)
Groundwater consideration	The Water Act applies to groundwater
Coastal aquifers consideration	None

2.2.4 Montenegro

Montenegro has two coastal aquifers, the Bojana aquifer, which extends into the territory of Albania, and the Boka Bay aquifer. Along the coast, the Bojana aquifer is characterized by alluvial deposits, while further inland it is karstic in nature. It is primarily used for domestic activities including the supply of drinking water, though it also ensures an important supply of water for irrigation. The Boka Bay aquifer is another important coastal aquifer, supplying water to the municipalities of Kotor, Tivat, Herceg Novi and also sustaining the Tivatska solila wetland. Precipitation in Montenegro's south-western coastal zone ranges from 1500 to 2000 mm/yr, while in the north-eastern mountain ranges of Orjen, Lovćen and Rumija it is typically over 3000 mm/yr. It is estimated that coastal aquifers in Montenegro discharge approximately 2511 Mm3/yr to the Adriatic.

Issues of concern

Seawater intrusion is the major problem facing the coastal aquifer in Montenegro. While some degree of salinization is natural in origin, most elevated salinity levels are the result of seawater intrusion. This is caused by increased abstractions in the coastal area to supply water to growing coastal populations that include a significant number of tourists in summer months. Groundwater extraction rates are at their highest during these dry summer months when there is decreased aquifer recharge from precipitation, resulting in significant lowering of groundwater levels (for example in the Bojana aquifer) and consequently an increase in the occurrence of seawater intrusion.

Demands for water in the coastal zone are increasing and are estimated to reach 68 Mm3/yr by 2021, while the estimated available reserves of groundwater in the coastal zone by this date are estimated at 256 Mm3/yr. Other significant threats to the quality of coastal groundwater include the discharge of untreated domestic wastewater through submarine outfalls and unchecked urban development for the tourism industry. There is no monitoring of groundwater levels.

Priority actions for coastal aquifer management should include a detailed groundwater monitoring programme (quantity and quality) to provide sufficient data for modelling future groundwater conditions, as well as consideration of allocation of water permits to non-commercial facilities such as schools, hospitals, agricultural producers and individual wells, which are currently not monitored for water consumption.

Table 2.2.4.1. Main coastal aquifers in Montenegro

Aquifer name	Hydrogeology	Extent	Salinity	Main uses	Entity responsible for management	Recharge (Mm3/yr)	Abstraction (Mm3/yr)
Boka Bay	Unconfined, karst	900 km^2	Widespread and severe (14-84 mg/L TDS)	Domestic supply (including tourism), irrigation and industrial activities	Ministry of Agriculture, Directorate for Water, Municipalities of Kotor, Tivat, Herceg Novi	2020	8
Bojana	Unconfined in porous deposits, karst	250 km^2	Widespread and severe (natural)	Domestic supply, irrigation. No monitoring of groundwater levels or quality	Ministry of Agriculture, Directorate for Water, Municipality of Ulcinj	Not known	5.5

TDS, total dissolved solids

Table 2.2.4.2 presents an overview of the results of the analysis of the aquifer questionnaires and is intended to provide a visual indication of the potential areas of concern for the aquifers studied. The analysis considered five criteria:

1. Pollution from nutrients
2. Pollution from other substances
3. Dependency on the aquifer for domestic uses
4. Links between the aquifer and ecosystems
5. Salinization.

Based on the responses provided by the national expert in the aquifer questionnaire, a score of 0-3 was assigned to each criterion, and a colour was used to indicate the relative level of concern: very low (white), low (green), medium (yellow), high (red).

Table 2.2.4.2. Overview of Montenegro coastal aquifers analysed

Aquifer name	Nutrients	Other pollutants	Dependency for domestic uses	Links with ecosystems	Salinization
Boka bay aquifer					
Bojana					

Legal matrix[4]

In the preparation of the Water Law (Official Gazette of the Republic of Montenegro, No. 27/2007) an effort was made to harmonize its provisions with the EU Water Framework Directive 2000/60/EC (WFD). Preparation of by-laws for the implementation of the Law and for further transposition of relevant EU Directives such as those for Groundwater (2006/118/EC), Bathing Waters (2006/7/EC), Nitrates (91/676/EEC) and others are under way. The main provisions are summarized in Table 2.2.4.3.

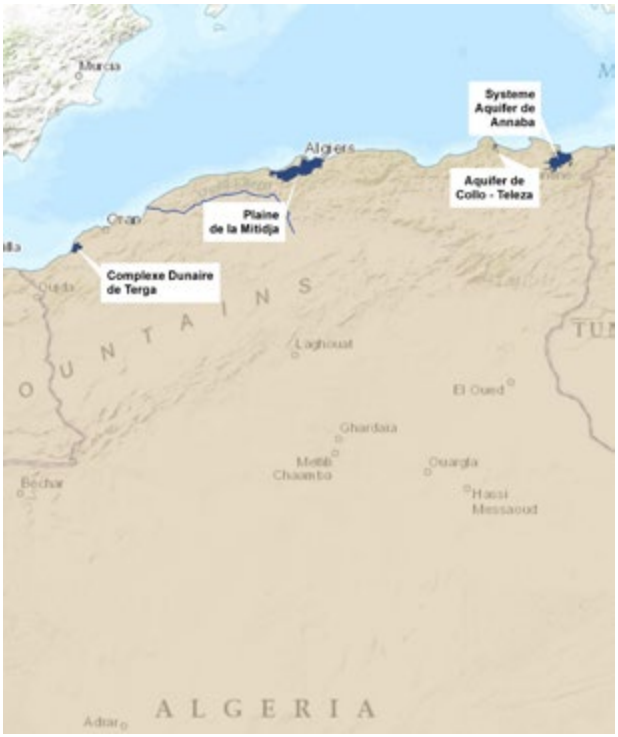
4. The information on legal aspects shown in the Final Report is only a summary, focused on groundwater and coastal aquifers, of the very extensive assessment which can be found in UNEP/MAP, UNESCO-IHP, 2015, "Legal, institutional and policy aspects of coastal aquifer management – Regional report", Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership), Paris.

Table 2.2.4.3. Policy and legal aspects of water management

Water policies and strategies	
Main principles and objectives	Water Basis (2001): describes the status of water and water management facilities according to individual areas, the conditions for maintenance and development of water resources to ensure the most advantageous and the most expedient technical, economic and environmental solutions for uniform water management, protection from adverse effects of water, protection of waters from pollution and use. National Strategy for Sustainable Development (NSSD) (2007): sets the overall framework for application of integrated approaches in managing natural resources (including water and coastal zone) and protecting the environment. The priority objective for water is ensuring sufficient quantity of good-quality drinking water and introducing integrated river basin management, with the necessary legal and institutional changes and improvements in the quality control and monitoring of waters. National Strategy for Integrated Coastal Zone Management (NS ICAM) (draft document, 2014): • contains a special part related to water, covering all waters including groundwater • identifies key issues, challenges and strategic goals for integrated coastal zone management • comprises a set of operational objectives for each goal, with measures, activities, indicators and partnerships for implementation
Consideration of groundwater and of coastal aquifers	The Water Basis describes all groundwater sources per water basin, and the capacities of individual groundwater sources, as well as their usage, pollution prevention and protection measures. Overall assessment of the state of groundwater indicates the ecological status is good. Main sources of pollution are communal waste waters, industrial waste waters, usage of fertilizers and intrusion of saline waters in coastal area
Legal framework (main principles and measures)	
Water ownership	Water is State property (article 6, Water Law)
Groundwater consideration	Groundwater is considered under the Water Law
Coastal aquifers consideration	The Law on Public Maritime Domain includes, in the Public Maritime Domain, submarine springs and wells on the shore (article 2) (Official Gazette of the Republic of Montenegro, No. 14/92)

2.3 COASTAL AQUIFERS OF THE SOUTH, CENTRAL AND LEVANTINE BASINS

2.3.1 Algeria



Algeria's 59 coastal aquifers are characterized mainly by sand, sandy clay and gritty clay formations, and in most cases they are in relation with a surface water body. In an average year, these coastal aquifers provide 914.5 Hm3/yr in exploitable water resources. Agriculture accounts for the dominant use of the coastal aquifers studied, with domestic and industrial activities as secondary uses. Coastal aquifers sustain several important ecosystems, including the El Mohken wetland (Plaine de Collo), Reghaia Lake (Plaine Alluviale de La Mitidja) and the Ramsar-listed sites Lake Tonga and Lake Oubeira (Plaine d'Annaba). Average annual rainfall ranges from 400 mm in the west to more than 1200 mm in the east, with less than 100 mm near the edge of the Sahara. Algeria is considered a water-scarce country.

Issues of concern

The coastal zone experiences intense pressure from human populations (281 inhabitants/km2) as well as industrial activities (51% of the country's industrial plants are located along the coast) and a growing tourism industry (9 million visitors in 2005). Rising sea levels have been observed, increasing the vulnerability of coastal aquifers to sea water intrusion.

Furthermore, solid waste management practices have a negative impact on the coastal zone, with 380 uncontrolled disposal sites along the coast.

Table 2.3.1.1. Main coastal aquifers in Algeria

Aquifer name	Hydrogeology	Extent	Salinity	Main uses	Responsible management entity	Recharge Mm3/yr	Abstraction Mm3/yr
Massif Dunaire de Terga	Unconfined in sand and sandstone formations	185 km^2	Local and moderate, but severe salinity in some areas. From natural origins, ranging from 1,000 to 10,000 mg/l in total mineralization.	Primarily used for agriculture, followed by domestic purposes and finally industry. Monitored for water levels and nitrogen compounds.	Agence Nationale des Ressources Hydrauliques (ANRH) Direction régionale Ouest / Agence de Bassin Oranie Chott Chergui	Not known	Not known
Plaine Alluviale de La Mitidja	Unconfined in gravel and clay formations	1,492 km^2	Local but severe, from natural origins and human activities, ranging from 574 mg/l to 4,741 mg/l	Primarily used for agriculture, with secondary uses for domestic purposes and industry. Monitored for water levels and salinity.	Ministère des Ressources en Eau, Agence de bassin hydrographique	307	315
Plaine de Collo	Unconfined in alluvial sediments	30 km^2	Local and moderate with levels between 200 and 1,100 mg/l.	Primarily used for agriculture, followed by domestic purposes and finally industry.	Direction des Ressources en Eau de la Wilaya (DRE)	Not known	Not known
Plaine d'Annaba	Semi-confined, stratified in sand and gravel deposits.	757 km^2	Local and moderate, from natural origins, ranging from 300 to 2,000 mg/l.	Primarily used for agriculture, with secondary uses for domestic purposes and industry. Monitored for water levels, nitrogen, salinity and heavy metals.	Direction des Ressources en Eau (DRE) de la Wilaya de Annaba	Not known	61

Table 2.3.1.2 presents an overview of the results of the analysis of the aquifer questionnaires and is intended to provide a visual indication of the potential areas of concern for the aquifers studied. The analysis considered five criteria:
Pollution from nutrients
1. Pollution from other substances
2. Dependency on the aquifer for domestic uses
3. Links between the aquifer and ecosystems
4. Salinization.

Based on the responses provided by the national expert in the aquifer questionnaire, a score of 0-3 was assigned to each criterion, and a colour was used to indicate the relative level of concern: very low (white), low (green), medium (yellow), high (red).

Table 2.3.1.2. Overview of Algeria coastal aquifers analysed

Aquifer name	Nutrients	Other pollutants	Dependency for domestic uses	Links with ecosystems	Salinization
Aquifère de Collo - Teleza					
Complexe Dunaire de Terga					
Plaine de la Mitidja					
Système Aquifère de Annaba					

Legal matrix[5]

The legal framework for the management of aquifers in Algeria seems relatively complete, with a water law including various provisions related to groundwater as well as implementation decrees on this issue.

In addition to the central administration, composed of the Ministry of Water Resources and other ministries also in charge in the water sector, the institutional frame is composed of many national public establishments under the umbrella of the Ministry of Water Resources. Other national agencies are also in charge of water from different perspectives. A consultative council has also been established.

5. The information on legal aspects shown in the Final Report is only a summary, focused on groundwater and coastal aquifers, of the very extensive assessment which can be found in UNEP/MAP, UNESCO-IHP, 2015, "Legal, institutional and policy aspects of coastal aquifer management – Regional report", Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership), Paris.

Table 2.3.1.3. Policy and legal aspects of water management

National policy and strategy for water	
Principles and objectives	The main principles of the water policy are: • Saving water through controlling leakage and water waste • Creating awareness in the user of the rational use of water • Protecting water from all sorts of pollution • Universality: water is the business of all users • Research and evaluation of surface and groundwater resources It aims to: • Increase mobilization of the resource • Rehabilitate and develop the infrastructures (drinking water and sanitation) • Modernize and extend the irrigated surfaces to support the strategy for food security • Ensure good water governance and improve management indicators
Consideration of groundwater and coastal aquifers	None
Legal framework (main principles and provisions)	
Water ownership	Water belongs to the public domain (Water Law no. 05-12, 4 August 2005)
Consideration of groundwater	Law no. 05-12 Executive decree no. 10-23 of 2010 on the quantitative protection of groundwater Executive decree no. 10-25 of 2010, establishing the granting modalities of a concession for establishing water pumping installations (surface and groundwater) in view of ensuring an autonomous supply of industrial zones or units Executive decree no. 10-317 of 2010 defining the conditions for the sampling and analyses of ground and surface water resources. Executive decree no. 10-318 of 2010 defining the granting modalities for concessions for using water resources from fossil or slowly renewable aquifer systems Executive decree no. 11-219 of 2011 defining the quality objectives of surface and groundwater for drinking purposes
Consideration of coastal aquifers	None

2.3.2 Egypt

Human populations in Egypt's Mediterranean coastal area rely heavily on groundwater found in three main coastal aquifer systems covering nearly 18,000 km2. These main coastal aquifers are all porous in nature, varying from oolitic limestone to sandy gravel formations, in confined and semi-confined states. One of these aquifers – the Nile Delta aquifer – contains one of the largest freshwater reservoirs in the world, with an estimated capacity of 500 billion m3. Despite this, Egypt suffers from acute water shortage. Agriculture accounts for the main use of the coastal aquifers, with important quantities of groundwater also extracted for domestic uses, including drinking water. The average rainfall in the Mediterranean coastal zone varies from 130 to 170 mm/yr. Groundwater discharges to the Mediterranean are negligible. Coastal aquifers support important ecosystems including those at Lake Burulus, Lake Bardawil, Lake Maryut, Lake Manzala and some salt flats.

Issues of concern

These include seawater intrusion following over-exploitation of groundwater for agriculture and domestic purposes (from increasing demands and also inefficient irrigation and distribution systems). Pollution concerns arise from leaching of sewage from unlined septic tanks. Waterlogging of irrigated areas is expected to exacerbate soil salinization.

Table 2.3.2.1. Main coastal aquifers in Egypt

Aquifer name	Hydrogeology	Extent	Salinity	Main uses	Entity responsible for management	Recharge	Abstraction
North-west coast	Oolitic limestone	5000 km^2	Between 870 ppm and 9500 ppm in shallow hand-dug wells and 2000-25,344 ppm in drilled wells (shallow unconfined aquifers up to 100 m in depth)	Agriculture, domestic, with limited use for drinking water and for industry. Quality (salinity) and levels monitoring network is available	Research Institute for Groundwater	100 mm/yr	8 Mm3/yr
North Delta	Sand and gravel beds, intercalated with clay lenses	24,300 km^2	Between 1500 and 5000 ppm	Mainly agriculture (75%), domestic and drinking water, with some industrial use. Monitored for water levels, nitrogen compounds, salinity and heavy metals	Research Institute for Groundwater	50 mm/yr	Not known
North Sinai	Complex fluviatile sandy gravel and shallow marine calcareous limestone	2900 km^2	Between 500 ppm and 7000 ppm	Mainly agriculture (> 70%), domestic and drinking water, with limited use for industry. Quality (salinity) and levels monitoring network is available	Research Institute for Groundwater	100 mm/yr	Not known

Table 2.3.2.2 presents an overview of the results of the analysis of the aquifer questionnaires and is intended to provide a visual indication of the potential areas of concern for the aquifers studied. The analysis considered five criteria:s

1. Pollution from nutrients
2. Pollution from other substances
3. Dependency on the aquifer for domestic uses
4. Links between the aquifer and ecosystems
5. Salinization.

Based on the responses provided by the national expert in the aquifer questionnaire, a score of 0-3 was assigned to each criterion, and a colour was used to indicate the relative level of concern: very low (white), low (green), medium (yellow), high (red).

Table 2.3.2.2. Overview of Egypt coastal aquifers analysed

Aquifer name	Nutrients	Other pollutants	Dependency for domestic uses	Links with ecosystems	Salinization
North Nile Delta coastal aquifer					
North Sinai coastal aquifer					
North-west coast					

Legal matrix[6]

The legal framework in Egypt for water management is composed of two laws (Law 12/1984 on irrigation and drainage, and Law 213/1984 modifying some items of the previous law) which address primarily irrigation, the dominant water use sector. A law for groundwater was drafted in 2010, but has not been adopted yet. At the institutional level, the water sector is dominated by the Ministry of Water Resources and Irrigation, which is composed of two major departments and four main authorities.

6. The information on legal aspects shown in the Final Report is only a summary, focused on groundwater and coastal aquifers, of the very extensive assessment which can be found in UNEP/MAP, UNESCO-IHP, 2015, "Legal, institutional and policy aspects of coastal aquifer management – Regional report", Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership), Paris.

Table 2.3.2.3. Policy and legal aspects of water management

Water policies and strategies	
Main principles and objectives	The national water policy (until 2017) rests on three major pillars: 1. Increasing water use efficiency 2. Water quality protection 3. Pollution control and water supply augmentation The National Water Resources Plan Project developed water resources management and investment plans, including for groundwater resources. Its implementation depends on: 1. development of additional water resources 2. more efficient use of the available water resources 3. improvement of water quality to protect public health and the environment Strategy of water resources development and management in Egypt until 2050 considers major issues of concern such as scarcity of water, pollution control, securing water quality and water saving, industrial and agricultural waste disposal, protection of groundwater resources and environmental problems of climate change. Groundwater management is one of the key issues in this strategy.
Consideration of groundwater and of coastal aquifers	Strategy of water resources development and management
Legal framework (main principles and measures)	
Water ownership	No information
Groundwater consideration	Groundwater is recognized in Law No. 48/1982 (Article 1-C) and its supplementary Decree 8/1983 (Article 1-11) as one of the categories of the water bodies in the country
Coastal aquifers consideration	None

2.3.3 Lebanon

Coastal aquifers in Lebanon are mainly karstic in nature and discharge significant quantities of water to the Mediterranean (about 0.4 billion m3/yr). Groundwater satisfies nearly 45% of Lebanon's total water needs. In 2005, water withdrawal by sector was distributed among agriculture (60%), domestic uses (29%) and industry (11%). This trend is generally reflected in the consumption of groundwater from coastal aquifers, although some aquifers are exploited primarily for either industry or domestic uses. At present, there are limited monitoring networks for groundwater levels but none for groundwater quality. Annual precipitation on the coastal plain ranges from 600 to 1000 mm.

Issues of concern

High coastal population density (greater than 1500 inhabitants per km2) and a heavy reliance on groundwater exert significant pressures on coastal aquifers. Seawater intrusion is the most common quality problem in coastal aquifers, and results from over-exploitation of groundwater. Agriculture is the main pressure driver for several risks associated with coastal aquifers, including salinization, nitrification and yield reduction. Industrial activities have also introduced heavy metals, organic compounds and hydrocarbons into some aquifers.

Table 2.3.3.1. Main coastal aquifers in Lebanon

Aquifer name	Hydrogeology	Extension	Salinity	Main uses	Entity responsible for management	Recharge	Abstraction
Afka	Karst	60 km^2	Not a concern	Drinking water (less than 25%), irrigation (less than 25%) and industry (less than 25%)	Ministry of Energy & Water (MOEW)	Not known	Not known
Beirut	Semi-confined, in alternating marl and sandstone formations	90 km^2	Widespread and severe	Industry (between 25 and 50%), drinking water (less than 25%) and irrigation (less than 25%)	Beirut Water Authority	Not known	Not known
Chekka	Karst	600 km^2	Local and moderate	Industry (more than 75%) and drinking water (less than 25%)	MOEW	Not known	Not known
Damour	Karst	30 km^2	Widespread and severe	Irrigation (between 50 and 75%) and drinking water (less than 25%)	Beirut Water Authority	Not known	Not known
South	Karst	1,050 km^2	Not a concern	Drinking water (around 50%) and irrigation (around 50%)	MOEW	Not known	Not known
Tripoli	Karst	103 km^2	Local and moderate	Industry (more than 75%) and drinking water (less than 25%)	MOEW	Not known	Not known
Tyr-Saida	Semi-confined, in alternating marl and sandstone formations	150 km^2	Widespread and severe	Irrigation (between 50 and 75%) and drinking water (less than 25%)	MOEW	Not known	Not known
Zarka	Karst	2,000 km^2	Not a concern	Irrigation (between 25 and 50%), industry (between 25 and 50%) and drinking water (less than 25%)	MOEW	Not known	Not known

Table 2.3.3.2 presents an overview of the results of the analysis of the aquifer questionnaires and is intended to provide a visual indication of the potential areas of concern for the aquifers studied. The analysis considered five criteria:

1. Pollution from nutrients
2. Pollution from other substances
3. Dependency on the aquifer for domestic uses
4. Links between the aquifer and ecosystems
5. Salinization.

Based on the responses provided by the national expert in the aquifer questionnaire, a score of 0-3 was assigned to each criterion, and a colour was used to indicate the relative level of concern: very low (white), low (green), medium (yellow), high (red).

Table 2.3.3.2. Overview of Lebanon coastal aquifers analysed

Aquifer name	Nutrients	Other pollutants	Dependency for domestic uses	Links with ecosystems	Salinization
Afka					
Beirut					
Chekka					
Damour					
South					
Tripoli					
Tyr-Saida					
Zarka					

Legal matrix[7]

Lebanon has undertaken a major reform of the institutional framework for its water sector with the adoption of Law no. 221/2000. From the legal aspect there is no comprehensive water law as such, but rather scatted texts, some of them dating back to the Ottoman period (provisions from the Mejelle 1875) and French mandate (1925 and 1926).

A draft Water Code was prepared but has still not been adopted due to the political unrest. The legislation is fragmented, with weak enforcement.

7. The information on legal aspects shown in the Final Report is only a summary, focused on groundwater and coastal aquifers, of the very extensive assessment which can be found in UNEP/MAP, UNESCO-IHP, 2015, "Legal, institutional and policy aspects of coastal aquifer management – Regional report", Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership), Paris.

Table 2.3.3.3. Policy and legal aspects of water management

Water policies and strategies	
Main principles and objectives	Plan (2000-2010): objective: to ensure the necessary volume of water to satisfy the needs of the population in all uses - National Water Sector Strategy (2010-2018) - Baseline for the Strategy (September 2010) - Forecasts for water supply and demand (November 2010) - Investment plan for the period 2011-2015 (December 2010), 4 pillars: 1. Institutional reforms as defined by Law no 221/2000, amended by Law no. 241 (7 August 2000) and Law no. 377 (14 December 2001) 2. Improve the financial performance of the sector: participation of the private sector, and establishment of more rational tariffs 3. Adopt the water law and develop the legal framework for the national Strategy 4. Include environmental concerns in the water sector such as protection of the water resources and of the recharge zones The implementation of the National Strategy is compromised by the political situation in Lebanon
Consideration of groundwater and of coastal aquifers	The plan recognizes the need for a global approach with elements of IWRM. Lebanon ratified the ICZM Protocol (decree No. 639 dated 18 September 2014)
Legal framework (main principles and measures)	
Water ownership	Water (including groundwater) is a public property with the exception of the acquired rights (Order no. 144/S 1925)
Groundwater consideration	Decree no. 14438 (2 May 1970), organizing the exploration and use of groundwater Ministerial order no. 118 (13 September 2010), defining the administrative procedure for the permits
Coastal aquifers consideration	ICZM Protocol ratified (Decree No. 639, 18 September 2014)

2.3.4 Libya

Groundwater supplies 95% of the water used in Libya. Forty percent of Libya's population is located in the Jeffara Plain, in an area that represents 1% of the country's surface area. The coastal aquifer system in this area is composed of a shallow unconfined aquifer with Mio-Quaternary deposits and dolomitic limestone, and a deep, confined aquifer of Miocene deposits. The shallow coastal aquifer provides most of the irrigation and domestic water in the Jeffara Plain. Other coastal aquifers include those of karst formations with appreciable discharges to the Mediterranean Sea. Agriculture accounts for the main use of these coastal aquifers, with important quantities of groundwater also extracted for domestic and some industrial uses. Rainfall is less than 100 mm per year in 93% of Libya's land surface; arable regions – such as Jabal al Akhdar zone of Cyrenaica and the Jeffara Plain – receive between 250 and 600 mm per year.

Issues of concern

Intense exploitation has led to seawater intrusion in most coastal aquifers. In the Jeffara Plain aquifer, inflow from the sea was estimated at 166 Mm3/yr. Irrigation water with increased salinity levels has led to problems with soil salinization and serious effects on the citrus crops in the coastal zone. Furthermore, the water distribution systems are experiencing problems with corrosion to metallic components (e.g. pipes and taps) from increasingly saline water, resulting in increased maintenance costs and potential health hazards from dissolved metals. Pollution problems stemming from unlined septic tanks have also been documented.

Table 2.3.4.1. Main coastal aquifers in Libya

Aquifer system name	Hydrogeology	Extent	Salinity	Main uses	Entity responsible for management	Recharge (Mm3/yr)	Abstraction (Mm3/yr)
North-west Libya (Gefara Plain)	Shallow unconfined aquifer (Mio–Plio–Quaternary) is made of sand, clay, marl, calcarenite and detrital limestone. Deep confined aquifers belong to Middle Miocene (sand, clay), Lower Miocene (sandy and dolomitic limestone), Lower Cretaceous (sandstone), Upper Triassic (sandstone), Middle Triassic (dolomitic limestone)	20,000 km^2	500-5000 ppm	90% of abstraction is used for agriculture. Domestic use is mostly supplied from sources outside the Gefara plain in addition to desalination. Domestic and industrial uses represent only 10% of groundwater abstraction at present	General Water Authority (GWA)	120-140 Mm3/yr from rainfall and runoff and 120 Mm3/yr as ground-water inflow from south. Total recharge therefore ca 250 Mm3/yr	1049 Mm3/yr in 2005; current figure is likely to be the same
Gulf of Sirte	Quaternary, Tertiary (Miocene and Palaeo-Eocene formations) and Miocene (limestone, marly limestone and marls), Palaeo-Eocene (clay, marl and gypsum), Upper Cretaceous, Lower Cretaceous and Palaeozoic	14,000 km^2 (for the coastal portion of this aquifer system)	Very high (6-10 g/l) in the Gulf of Sirte area; west of Tawurgha salinity is 1.3-2.5 g/l	Very small exploitation due to highly mineralized nature. Monitoring of groundwater levels routinely conducted. Water quality sporadically monitored	GWA	20 Mm3/yr	135 Mm3/yr in the area from Khoms to Tawurgha + 2 Mm3/yr in the Gulf of Sirte area
Jabal al Akhdar	Shallow aquifers: Quaternary and Miocene. Deep aquifers: Oligocene, Eocene, Upper Cretaceous. Main aquifers within the Tertiary formations (Eocene–Miocene) made of carbonate rocks of chalky and calcarenite limestone with marly occurrences mainly in the Oligocene and lower Cretaceous	21,000 km^2 (for the coastal portion of this aquifer system)	TDS between 450 and 3000 ppm	Not well documented, but the Eocene and Upper Cretaceous aquifers have the highest potential as groundwater resources in terms of quality and quantity. Agricultural use: 80%, urban use: 20%. There is a monitoring system for water levels and water quality (not well maintained and not regularly observed)	GWA	650 Mm3/yr	385 Mm3/yr

TDS, total dissolved solids

Table 2.3.4.2 presents an overview of the results of the analysis of the aquifer questionnaires and is intended to provide a visual indication of the potential areas of concern for the aquifers studied. The analysis considered five criteria:

6. Pollution from nutrients
7. Pollution from other substances
8. Dependency on the aquifer for domestic uses
9. Links between the aquifer and ecosystems
10. Salinization.

Based on the responses provided by the national expert in the aquifer questionnaire, a score of 0-3 was assigned to each criterion, and a colour was used to indicate the relative level of concern: very low (white), low (green), medium (yellow), high (red).

Table 2.3.4.2. Overview of Libya coastal aquifers analysed

Aquifer name	Nutrients	Other pollutants	Dependency for domestic uses	Links with ecosystems	Salinization
North-west Libya (Gefara Plain)					

Note: While there are three main coastal aquifers listed in the aquifer card for Libya, it was only possible to obtain the information necessary to complete the detailed aquifer questionnaire for one of these aquifers, the North-west Libya aquifer.

Legal matrix[8]

Libya had adopted a comprehensive Water Code (1982), complemented by pieces of legislation related to water resources such the Environmental Protection Law (2003) and various Decrees and Decisions by the Council of Ministers.

Robust attention is given to water abstraction in specific coastal areas, with severe limitations, or even banning.

8. The information on legal aspects shown in the Final Report is only a summary, focused on groundwater and coastal aquifers, of the very extensive assessment which can be found in UNEP/MAP, UNESCO-IHP, 2015, "Legal, institutional and policy aspects of coastal aquifer management – Regional report", Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership), Paris.

Table 2.3.4.3. Policy and legal aspects of water management

Water policies and strategies / Water resources strategy 2000-2025	
Main principles and objectives	Objectives: • Reduce the deficit in the water budget • Prevent water quality deterioration Strategy components: • Minimize the water budget deficit (WDM) • Develop conventional and non-conventional water resources • Protect water resources from pollution • Recover the costs of providing water • Develop human and institutional capacities • Improve and strengthen water legislation • Promote technical cooperation in the field of water resources management
Consideration of groundwater and of coastal aquifers	Groundwater represents 97% of total water use. It occurs in renewable coastal aquifers in the north and in large non-renewable aquifers in the southern and central basins. In 2006, extraction from coastal aquifers amounted to 1673 Mm3 or 34% of total groundwater extraction. The strategy emphasizes the importance of protecting coastal aquifers by reducing their water budget deficit through inter-basin water transfer from the south and development of non-conventional resources such as desalination and treated wastewater
Legal framework (main principles and measures)	
Water ownership	Water is in public ownership (Law No. 3 of the 1982 Water Code)
Groundwater consideration	Law No. 3 of 1982 Water Code
Coastal aquifers consideration	Decree No. 791 for the year 1982: • Covering additional water demand for existing or new projects in the Gefara Plain and the western coastal belt by extracting additional water from the first aquifer is totally prohibited • Drilling new or substitute water wells in the Gefara Plain is prohibited • The Benghazi plain area is under "restricted water use" and drilling new production wells in the northern part of the Benghazi plain is totally prohibited • The first aquifer in the area between Khoms and Misurata is put under an absolute ban for additional groundwater abstraction • The El-Marj Plain area is put under an "absolute ban" for additional groundwater abstraction Seawater intrusion (coastal aquifers) is given special attention in Article 41 of the environmental protection law which pointed to the cautious use of aquifers to ensure no intrusion of seawater or water from other formations of higher salinity or lower quality. Article 4 of Decision No. 791 of 1982 necessitates the application of collective irrigation in areas experiencing water shortages as a result of continuing decline of the water table in the first aquifer, as well as in areas with signs of seawater intrusion. Article 5 on the regulations for domestic water exploitation states that: 1. it is not allowed to pump additional groundwater in excess of current rates to cover domestic use for coastal cities all along the coastline 2. necessary measures must be taken to assess the current and future demand for domestic water use in coastal cities through the establishment of desalination plants. Article 6 of the regulations for industrial water exploitation states that water requirements of industrial projects shall be met through seawater desalination or from deep aquifers either directly, or after treatment, if necessary.

WDM, water demand management

2.3.5 Morocco

The aquifers of Morocco's Mediterranean coast are relatively small (<200 km^2), all of alluvial type and mostly unconfined. They are important for the local rural economy and constitute a source mainly for agriculture, but also for local domestic water supply and industrial uses. The Bou Areg aquifer is connected with the regionally important Nador coastal wetland and related ecosystems. Groundwater discharges to the Mediterranean have been evaluated at 24 Mm3/yr. High precipitation rates (460 mm/yr), ensure elevated recharge rates (>100 mm/yr).

Issues of concern: High, and growing coastal population density (> 500 inhabitants/km^2) drives coastal aquifer degradation, compounded by lack of WWTPs, unregulated use for irrigation, and the use of fertilizers. Growing salinization –often beyond the limits for irrigation - is generalized and mostly linked to excessive extractions and continuing use for irrigation, interactions with saline surface waters (Bou Areg), and locally to seawater intrusion (Nador).

Nutrients enrichment is common in both agricultural and urban areas.

Table 2.3.5.1. Main coastal aquifers in Morocco

Aquifer name	Hydrogeology	Extent	Salinity	Main uses	Entity responsible for management	Recharge (Mm3/yr)	Abstraction (Mm3/yr)
Amsa	Unconfined aquifer composed of coarse alluvial sediments	3.8 km^2	Good water quality (TDS < 0.5 g/l); no problems with salinization.	Ensures potable water supplies to rural areas as well as some small touristic areas	Agence du Bassin Hydraulique du Loukkos	0.4 (from precipitation and the oued Amsa)	Not known
Azla	Unconfined aquifer composed of Quaternary alluvial sediments from the oued Azla	2.5 km^2	Good water quality; no problems with salinization	Ensures potable water supplies to rural areas as well as some small touristic areas	Agence du Bassin Hydraulique du Loukkos	0.3 (from precipitation and the oued Azla)	Not known
Bou Areg	Unconfined aquifer composed of Quaternary formations of silty gravel and limestone	190 km^2	Moderate to severe salinization problems (TDS ranging from 2 - 4.5 g/l)	Ensures irrigation water for agricultural areas. Monitoring for groundwater levels, nitrogen compounds and salinity.	Agence du Bassin Hydraulique de la Moulouya	20.5 (from precipitation, the oued Selouane and irrigation return flows)	9.7 (Irrigation)
Rhiss Nekor	Multilayer aquifer composed of Plio-Quaternary alluvial formations that are detrital in nature (pebbles, gravel, sand and silt)	100 km^2	Moderate to severe salinization problems (TDS ranging from 1.6 – 5 g/l)	Ensures a part of the potable water supplies of the city of Al Hoceima as well as the potable water supplies of rural areas and water for irrigation of agricultural areas. Monitoring for groundwater levels, nitrogen compounds, salinity and heavy metals.	Agence du Bassin Hydraulique du Loukkos	12.6 (from precipitation, the oueds Rhiss and Nekor, and irrigation return flows)	3.47 (Potable water and irrigation)
Laou	Multilayer aquifer composed of (i) an upper layer of Quaternary alluvial deposits containing sand, gravel and silt and (ii) a lower layer of sand, gravel and Villafranchian conglomerates	18 km^2	Good water quality (TDS generally less than 1 g/l)	Ensures a part of the potable water supplies for the oued Laou settlement, as well as the potable water supplies of rural areas and water for irrigation for agricultural areas. Monitored for groundwater levels only (no monitoring of water quality).	Agence du Bassin Hydraulique du Loukkos	16 (from precipitation, the oued Laou and irrigation return flows)	0.3 (Potable water and irrigation)
Martil-Alila	Multilayer aquifer composed of (i) an upper layer of Quaternary alluvial deposits containing silt and sand and (ii) a lower layer of Plio-Quaternary conglomerates of sandstone and limestone	116 km^2	Water of the upper layer is of low quality, with salinity levels reaching 15 g/l as the result of seawater intrusion	Ensures the potable water supplies for the city of Martil as well as the potable water supplies of rural areas and water for agriculture and industry. Monitored for groundwater levels, nitrogen compounds, salinity and heavy metals.	Agence du Bassin Hydraulique du Loukkos	31.4 (from precipitation, the oueds of Martil and Alila and irrigation return flows)	9.1 (potable water, irrigation and industry)

Aquifer name	Hydrogeology	Extent	Salinity	Main uses	Entity responsible for management	Recharge (Mm3/yr)	Abstraction (Mm3/yr)
Negro	Unconfined aquifer composed of Plio-Quaternary alluvial sediments made up of gravels and pebbles with an argilo-sandy matrix	8 km^2	Generally good water quality with low salinity (less than 0.5 g/l) except in the coastal zone where salinity levels can exceed 2 g/l	Ensures the potable water supplies for rural areas, irrigation for small farms as well as watering for hotels and green spaces. Monitored for groundwater levels, nitrogen compounds and salinity.	Agence du Bassin Hydraulique du Loukkos	1.9 (from precipitation the oued Negro and irrigation return flows)	0.3 (rural potable water and irrigation)
Smir	Unconfined aquifer composed of Plio-Quaternary alluvial deposits made up of gravels, pebbles and sandy clays	10 km^2	Generally good water quality except in the zones where seawater intrusion occurs (salinity levels can reach 2 g/l).	Ensures the potable water supplies for the city of Tétouan, coastal settlements, and rural areas, as well as water supplies for agriculture. Monitored for groundwater levels, nitrogen compounds and salinity.	Agence du Bassin Hydraulique du Loukkos	2 (from precipitation, the oued Smir and irrigation return flows)	1.8 (potable water and irrigation)

TDS, total dissolved solids

Table 2.3.5.2 presents an overview of the results of the analysis of the aquifer questionnaires and is intended to provide a visual indication of the potential areas of concern for the aquifers studied. The analysis considered five criteria:

11. Pollution from nutrients
12. Pollution from other substances
13. Dependency on the aquifer for domestic uses
14. Links between the aquifer and ecosystems
15. Salinization.

Based on the responses provided by the national expert in the aquifer questionnaire, a score of 0-3 was assigned to each criterion, and a colour was used to indicate the relative level of concern: very low (white), low (green), medium (yellow), high (red).

Table 2.3.5.2. Overview of Morocco coastal aquifers analysed

Aquifer name	Nutrients	Other pollutants	Dependency for domestic uses	Links with ecosystems	Salinization
Bou Areg					
Ghis-Nekkor					
Martil-Alila					
Negro					
Oued Laou					
Smir					

While there are eight main coastal aquifers listed in the aquifer card for Morocco, it was only possible to obtain the information necessary to complete the detailed aquifer questionnaires for six of these aquifers.

Legal matrix[9]

Morocco adopted a Water Law (no. 10-95) (1995) with the objectives of promoting the sustainable management of water resources by basin. Modern principles such as integrated management, "user-pays" or "polluter-pays" were introduced. The water law provided a relatively comprehensive framework for the water sector. However, its adoption left some gaps such drought or flood management, fee recovery, sanitation, wastewater rejected to the sea and desalination.

Nine basin agencies were established across the entire national territory with considerable responsibilities for surface and groundwater such delivering permits and concessions for the development of groundwater.

9. The information on legal aspects shown in the Final Report is only a summary, focused on groundwater and coastal aquifers, of the very extensive assessment which can be found in UNEP/MAP, UNESCO-IHP, 2015, "Legal, institutional and policy aspects of coastal aquifer management – Regional report", Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership), Paris.

Table 2.3.5.3. Policy and legal aspects of water management

Water policies and strategies / National strategy for the water sector (2009)	
Main principles and objectives	The three pillars of the national strategy for water are: 1. Demand management and enhancing the value of water: more efficient use and water savings in all sectors (drinking water, irrigation, industrial and touristic water) 2. The management and development of water supply: - Mobilization of conventional water resources: realization of big and small dams, and interbasin water transfers - Mobilization of non-conventional water resources: desalination of seawater, demineralization of brackish groundwater, reuse of treated wastewater and collection of rainwater 3. Preservation and protection of water resources, natural habitat and fragile zones: - Preservation of groundwater resources: governance model, reinforcement of control systems on groundwater abstractions, establishment of protection banning perimeters and development of artificial recharge of aquifers - Protection of the quality of water resources: sanitation plans and treatment of wastewater, national programme of prevention and fight against industrial pollution, implementation of the national plan for management of domestic and assimilated wastes - Conservation of hydrographic basins, oases and wetlands; protection of springs; programme for protection of wetlands and natural lakes; fight against desertification; protection of the coastline Establish accompanying measures, especially: • the modernization of information systems and reinforcement of means and competences • continuation of legal and institutional reforms • tariff and financing systems
Consideration of groundwater and of coastal aquifers	Groundwater is considered a precious and strategic resource for the supply of domestic water, to be preserved and used in the frame of rational and integrated management which will guaranty its equilibrium and perenniality for future generations
Legal framework (main principles and measures)	
Water ownership	All water resources are part of the public domain (Water Law no. 10-95 of 1995)
Consideration of groundwater	Groundwaters are ruled by the Water Law (no. 10-95 of 1995)
Consideration of coastal aquifers	None

2.3.6 Palestine

Palestine's Gaza Strip has one coastal aquifer which extends into the territory of Egypt and Israel. The average annual rainfall in the Gaza strip is about 320 mm/year, which results in total rainfall of about 116 MCM/year for the whole area. The aquifer is 10-15 km wide, with a thickness ranging from 0 m in the east to about 200 m at the coastline. The major source of renewable groundwater in the aquifer is rainfall. The total rainfall recharge to the aquifer is estimated to be approximately 45 MCM/year. The remaining rainwater evaporates or dissipates as runoff during the short periods of heavy rainstorms. The lateral inflow to the aquifer is estimated at between 10 and 15 MCM/year. Some recharge is available from the major surface flow (Wadi10 Gaza). However, because of the extensive extraction from Wadi Gaza by Israel, this recharge is limited to, at best, 2 MCM during the ten days the wadi actually flows in a normal year. As a result, the total freshwater recharge at present is limited to approximately 60 MCM/year. The major uses of this aquifer are domestic activities including the supply of drinking water, irrigation, industry and livestock. Currently, the Gaza aquifer is monitored by a multipurpose groundwater monitoring network, which is used for observing the groundwater levels and the nitrate and chloride content. The existing water level monitoring network includes 135 wells and 39 piezometers (small-diameter pipes) that have been distributed all over the Gaza Strip since 1972. The existing groundwater quality monitoring network has 700 wells for chloride monitoring and 450 wells for nitrate monitoring.

Issues of concern

The major water quality problems are high salinity and high nitrate concentrations in the aquifer. The high salinity levels are the result of over-extraction from the shared aquifer (extracting more groundwater than is replaced by recharge processes), which causes draw-down of the groundwater (resulting in seawater intrusion) and up-coning of the underlying saline water. The presence of nitrates in the aquifer can be attributed to use of fertilizers in local agricultural activities. The quality of the groundwater in this aquifer is further compromised by the discharge of untreated domestic wastewater in the wadis that are hydraulically connected to the aquifer. The effects of climate change – including reduced amounts of precipitation – are expected to place increasing pressures on the groundwater resources of the Gaza coastal aquifer.

10. A wadi is a dry (ephemeral) riverbed that only contains water during times of heavy rain.

Table 2.3.6.1. Main coastal aquifers in Palestine

Aquifer name	Hydrogeology	Extension	Salinity	Main uses	Entity responsible for management	Recharge	Abstraction
Gaza coastal aquifer	Unconfined in porous deposits – only coastal	365 km^2	Local but severe salinization	Domestic supply, Irrigation, industry and livestock	Palestinian Water Authority	60	180

Table 2.3.6.2 presents an overview of the results of the analysis of the aquifer questionnaires and is intended to provide a visual indication of the potential areas of concern for the aquifers studied. The analysis considered five criteria:

16. Pollution from nutrients
17. Pollution from other substances
18. Dependency on the aquifer for domestic uses
19. Links between the aquifer and ecosystems
20. Salinization.

Based on the responses provided by the national expert in the aquifer questionnaire, a score of 0-3 was assigned to each criterion, and a colour was used to indicate the relative level of concern: very low (white), low (green), medium (yellow), high (red).

Table 2.3.6.2. Overview of Palestine coastal aquifers analysed

Aquifer name	Nutrients	Other pollutants	Dependency for domestic uses	Links with ecosystems	Salinization
Gaza coastal aquifer					

Legal matrix[11]

In the absence of an independent Palestinian State, the scope of jurisdiction of the Palestinian legislature and government and, hence, the scope for application of domestic Palestinian water legislation, is determined by the Israeli-Palestinian Agreement on the West Bank and the Gaza Strip (Washington, DC, 28 September 1995) (hereinafter "Interim Agreement"). Under the terms of the Interim Agreement, the Palestinian legislature and government (i.e. the Palestinian National Authority, PNA) has (a) a territorial and (b) a functional jurisdiction. The former covers the Gaza Strip, with some limited exceptions, and Areas A and B of the West Bank, to the exclusion of Area C, which remains under direct Israeli occupation and control (article XVII of the Interim Agreement). Areas A, B and C make up 18%, 21% and 61% of the West Bank territory, respectively, being home to, respectively, 46%, 36% and 18% of the Palestinian West Bank population.

11. The information on legal aspects shown in the Final Report is only a summary, focused on groundwater and coastal aquifers, of the very extensive assessment which can be found in UNEP/MAP, UNESCO-IHP, 2015, "Legal, institutional and policy aspects of coastal aquifer management – Regional report", Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership), Paris.

Table 2.3.6.3. Policy and legal aspects of water management

Water policies and strategies / National Water Strategy 2014-2032	
Main principles and objectives	• Reinforce sustainable water resources management • Establish cooperation framework for sustainable development of water supply and wastewater services among the various stakeholders • Increase the quantity of water delivered to citizens • Maximize the volume of water available for irrigation • Provide reliable access to quality water at affordable prices • Reduce inequalities among regions and localities • Improve sanitation to protect the natural water resources from pollution and depletion
Consideration of groundwater and of coastal aquifers	The Strategy includes an overview of the status of the aquifer and concrete objectives to restore it by tackling the root causes of its deterioration. It aims to reduce total groundwater abstraction from the coastal aquifer in the Gaza Strip from the current rate of 200 MCM/year to 70 MCM/year in 2032, by increasing the water supply to the Gaza Strip by desalination of seawater as the main additional source; by use of treated wastewater for irrigation; by improving non-revenue water management; and (possibly) by importing water.
Legal framework (main principles and measures)	
Water ownership	Public property (Water Law 14/2014)
Groundwater consideration	The Water Law applies to groundwater
Coastal aquifers consideration	None

2.3.7 Tunisia

The area covered by coastal aquifers in Tunisia is about 25,000 km^2 or nearly 15% of the total area of the country. Tunisian coastal aquifers vary greatly in size and are mostly contained in quaternary formations of sand and sandstone deposits in both confined and unconfined states. Agriculture accounts for the dominant use of groundwater from both shallow and deep aquifers. In shallow aquifers, agriculture is the only use, while in some deep aquifers there is also a small amount of groundwater used for drinking water. Shallow coastal aquifers are strongly related to the Mediterranean Sea and salty marshes.

Annual rainfall varies greatly from one region to another, from 500-800 mm/yr in the north to 50-100 mm/yr in the south. About half of all shallow coastal aquifers are characterized as overextracted. Groundwater levels have been monitored since the 1950s while monitoring for groundwater quality (salinity, nitrogen compounds) began in 1998.

Issues of concern

Sea water intrusion and significant reduction in borehole yields are widespread and severe. There are some local but serious cases of polluted water being drawn into aquifers.

Table 2.3.7.1. Main coastal aquifers in Tunisia

Aquifer name	Hydrogeology	Extent	Salinity	Main uses	Entity responsible for management	Recharge (Mm3/yr)	Abstraction (Mm3/yr)
Chegarnia-Sidi Abicha-Oued El Khairat	Unconfined, multi-layer in sand and sandstone formations	121 km^2	Oued El Khairat: Shallow aquifer (TDS from 2.0 to 5.0 g/l), Deep Aquifer (TDS from 1.5 to 3.8 g/l) Chegarnia: Shallow aquifer (TDS from 1.0 to 3.0 g/l), Deep aquifer (TDS from 1.0 to 4.0 g/l)	Oued El Khairat: Shallow aquifer –agriculture (100%), Deep Aquifer – agriculture (23%); potable water (72%) Chegarnia: Shallow aquifer – agriculture (100%), Deep aquifer – agriculture (87%); potable water (13%)	Direction Générale des Ressources en Eau	10	11
Côte oriéntale	Unconfined, multi-layer in sand, sandstone and limestone formations	500 km^2	Côte oriéntale shallow aquifer (TDS from 2.0 to 7.0 g/l) Deep aquifers (TDS from 0.4 to 5.9 g/l)	Côte oriéntale shallow aquifer – agriculture (100%), Deep aquifers – mainly agricultural uses, with some potable water and industrial uses	Direction Générale des Ressources en Eau	61	64
Gabes Shallow (North and South)	Unconfined, multi-layer in sand formations	1,235 km^2	Gabes North shallow aquifer (TDS from 3.0 to 8.0 g/l) Gabes South shallow aquifer (TDS from 2.5 to 10 g/l)	Agriculture (100%)	Direction Générale des Ressources en Eau	13	14
Grombalia	Unconfined and semi-confined in sand and sandstone formations	400 km^2	Grombalia shallow aquifer (TDS from 1.5 to 4.0 g/l) Grombalia deep aquifers (TDS from 0.2 to 11.1 g/l)	Grombalia shallow aquifer – agriculture (100%), Deep aquifers – mainly agricultural uses, with some potable water and industrial uses	Direction Générale des Ressources en Eau	60	125
Mahdia-Ksour Essef-Sidi Alouane	Unconfined and multi-layer in sand and sandstone formations	815 km^2	Mahdia-Ksour Essef shallow aquifer (TDS from 3.0 to 15.0 g/l)	Agriculture (100%)	Direction Générale des Ressources en Eau	3	7
Mornag	Unconfined and multi-layer in sand and sandstone formations	223 km^2	Mornag shallow aquifer (TDS from 1.0 to 6.0 g/l)	Agriculture (100%)	Direction Générale des Ressources en Eau	7	12
Ras Jebel	Unconfined in sand formations	42 km^2	Ras Jebel shallow aquifer (TDS from 2.0 to 5.0 g/l)	Agriculture (100%)	Direction Générale des Ressources en Eau	8	11
Sahel de Sfax Deep	Confined, multi-layer in sand formations	7,224 km^2	Sahel de Sfax deep aquifer complex (TDS from 0.8 to 10.3 g/l)	Miocene aquifer - agriculture (30%), potable water (40%), industry (30%); Mio-Pliocene aquifer – agriculture (98%), potable water (1%) and industry (1%)	Direction Générale des Ressources en Eau	35	32

Aquifer name	Hydrogeology	Extent	Salinity	Main uses	Entity responsible for management	Recharge (Mm3/yr)	Abstraction (Mm3/yr)
Sahel de Sfax Shallow	Unconfined, multi-layer in sand formations	4,910 km^2	Sahel de Sfax shallow aquifer complex (TDS from 0.5 to 5.8 g/l)	Agriculture (100%)	Direction Générale des Ressources en Eau	30	44
Tabarka	Unconfined , multi-layer in sand formations	21 km^2	Tabarka shallow aquifer (TDS from 0.3 to 3.0 g/l)	Agriculture (100%)	Direction Générale des Ressources en Eau	0.5	0.2

Table 2.3.7.2 presents an overview of the results of the analysis of the aquifer questionnaires and is intended to provide a visual indication of the potential areas of concern for the aquifers studied. The analysis considered five criteria:

21. Pollution from nutrients
22. Pollution from other substances
23. Dependency on the aquifer for domestic uses
24. Links between the aquifer and ecosystems
25. Salinization.

Based on the responses provided by the national expert in the aquifer questionnaire, a score of 0-3 was assigned to each criterion, and a colour was used to indicate the relative level of concern: very low (white), low (green), medium (yellow), high (red).

Table 2.3.7.2. Overview of Tunisia coastal aquifers analysed

Aquifer name	Nutrients	Other pollutants	Dependency for domestic uses	Links with ecosystems	Salinization
Chegarnia-Sidi Abicha-Oued El Khairat					
Côte Orientale					
Gabes Shallow					
Grombalia					
Mahdia-Ksour Essaf-Sidi Alouane					
Mornag					
Ras Jebel					
Sahel de Sfax Deep					
Sahel de Sfax Shallow					
Tabarka					

Legal matrix[12]

Tunisia adopted a Water Code with relatively exhaustive provisions and which reserves an important part for the consideration of groundwaters. The Water Code was revised in 2014, and it is expected that the revision will be adopted in 2015. The Water Code includes considerations of the impact of climate change on water resources and ecological uses such as in wetlands.

The ministry in charge of the environment is currently elaborating an environmental code. This will deal, inter alia, with the sustainable management and preservation of groundwaters. The code is currently under discussion, and will be implemented once all stakeholders adopt it.

12. The information on legal aspects shown in the Final Report is only a summary, focused on groundwater and coastal aquifers, of the very extensive assessment which can be found in UNEP/MAP, UNESCO-IHP, 2015, "Legal, institutional and policy aspects of coastal aquifer management – Regional report", Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership), Paris.

Table 2.3.7.3. Policy and legal aspects of water management

Water policies and strategies: the national strategy for the protection of groundwaters (2010-2014)	
Main principles and objectives	Efficiency, sustainability and preservation of groundwaters with improved management of conventional water and reinforcement of the fight against pollution
Consideration of groundwater and of coastal aquifers	The strategy deals with groundwater
Legal framework (main principles and measures)	
Water ownership	Water ownership
Consideration of groundwater	Consideration of groundwater
Consideration of coastal aquifers	Consideration of coastal aquifers

2.3.8 Turkey

The General Directorate of State Hydraulic Works (DSI) is the institution responsible for all water resources in Turkey.

Eleven of Turkey's 25 hydraulic basins are located along the coast of the Mediterranean Sea. These correspond to the following basins, which are listed along with their official basin numbers: Marmara (2), Northern Aegean (4), Gediz (5), Küçük Menderes (6), Büyük Menderes (7), the Western Mediterranean (8), Antalya (9), the Eastern Mediterranean (17), Seyhan (18), Asi (19) and Ceyhan Basin (20). There are karst aquifers with significant groundwater discharges to the sea in a number of these basins, and these are vital to aquatic life.

The average annual precipitation in Turkey is 643 mm, with about 70% of the total precipitation falling from October to March. This corresponds to approximately 501 billion m3 per year of water from precipitation. It is estimated, however, that the annual exploitable water potential – under current technical and economic constraints – is about 112 billion m^3, of which 95 billion m^3 are available from surface water sources, 3 billion m3 from water flowing into Turkey from neighbouring countries and 14 billion m^3 from groundwater.

In 2011, 50 billion m^3 of water was consumed in Turkey, of which 36 billion m^3 was for irrigation (72%), 7 billion m^3 was for domestic uses (14%) and 7 billion m3 was for industrial uses (14%). This represents a consumption of 45% of the annual exploitable water potential of 112 billion m3, and studies are under way to determine how to maximize this potential by 2023.

Issues of concern

In common with many coastal aquifers in the Mediterranean, Turkey's coastal aquifers are at risk of saltwater intrusion resulting from overextraction of groundwater resources. At the same time, the quality of groundwater in some of these aquifers may also be impacted by agricultural activities (e.g. the risk of pollution by nitrates and pesticides); by leaching of pollutants from solid waste storage facilities; and from leaking septic tanks, among other causes.

Legal matrix[13]

There are numerous laws related to water which regulate public sector activity by, for example, defining the responsibilities for the construction of water networks, operation and maintenance obligations, and their financing. Special legislation on the harmful effects of water has been enacted, such as that for flood control, drainage and sewerage. Turkey is about to complete studies for enactment of an integrated water law.

13. The information on legal aspects shown in the Final Report is only a summary, focused on groundwater and coastal aquifers, of the very extensive assessment which can be found in UNEP/MAP, UNESCO-IHP, 2015, "Legal, institutional and policy aspects of coastal aquifer management – Regional report", Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership), Paris.

Table 2.3.8.1. Policy and legal aspects of water management

Water policies and strategies	
Main principles and objectives	Turkey's water policy can best be characterized by its desire to gain independence from imported energy sources; to increase production levels of agriculture and to achieve food security; and to satisfy increasing water demand from industry, urban and rural populations
Consideration of groundwater and of coastal aquifers	None
Legal framework (main principles and measures)	
Water ownership	Groundwater is under the ownership of the government (Law no. 167 on Groundwater)
Consideration of groundwater	The major law for the management of coastal aquifers as well as groundwaters is Law no. 167 on Groundwater *(Yeraltı Suları Hakkında Kanun)*, passed in 1960
Consideration of coastal aquifers	None

2.4 GROUNDWATER-RELATED COASTAL WETLANDS

In the context of its contribution to the MedPartnership, UNESCO-IHP undertook an assessment of 26 representative groundwater-related coastal wetlands in the Mediterranean region with the Technical University of Cartagena, the University of Valencia, the Polytechnic University of Catalonia and the Spanish Geological Survey. The full findings of the assessment appear in the report: "Main hydro(geo)logical characteristics, ecosystem services and drivers of change of 26 representative Mediterranean groundwater-related coastal wetlands" (UNEP-MAP, UNESCO-IHP, 2015a), and key sections are drawn upon in the present chapter.

Wetlands are landscape features characterized by the permanent or temporary presence of shallow water depth or a shallow water table. They have high plant productivity, are rich in wildlife and show high species diversity. Since the early stages of civilization, wetlands have been drained, landfilled and ultimately destroyed, with the purpose of obtaining arable land, expanding human habitats, avoiding diseases and also because they were considered useless. In some areas, the disappearance of wetlands extends to 80% of the original surface. Providentially, in the last decades wetlands have been acknowledged as essential elements in supporting the ecological processes that sustain life on the planet. They are also widely recognized as providing an extensive variety of services for humankind (Acreman and Miller, 2006). Moreover, they exert a significant influence on the hydrological cycle and, in turn, are influenced by its components, especially groundwater.

Groundwater is vital for many ecosystems, providing crucial support to plants and animals, especially during droughts. "Shallow" groundwater, in particular, near the earth's surface, is an essential source of water for many ecosystems, maintaining important wetland habitats and recharging rivers and streams in times of low rainfall (Fan and others, 2013). Many wetlands are related to groundwater and most of them are even partially or entirely dependent on it, so that any action related to groundwater exploitation may affect wetlands functioning and even their existence. Wetlands located in coastal areas are more probably linked to groundwater than those located in continental areas for two reasons:

1. Shallow water tables are very close to the soil surface in coastal zones, and groundwater usually feeds the existing topographic depressions temporarily or permanently
26. Coastal zones are also the areas where groundwater flow paths of medium to large size discharge to the soil surface.

Thus, many groundwater-related coastal wetlands occur in areas where there are shallow groundwater tables or where groundwater discharges to the surface, but some are linked to deep groundwater flows ascending to the soil surface in the coastal zone. Human-triggered modifications of landscape and land-use activities may produce significant impacts on wetlands and their functions.

As a result of regional and local groundwater processes, coastal wetlands 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, peatlands, mudflats and saltpans, which are mostly the result of the geological processes originating the wetland (including tectonic, erosional, deltaic/estuarine, aeolian and coastal sedimentation processes). Artificial coastal wetlands such as salinas, rice fields, excavated channels and ponds, may also owe most of their ecological functionality to the presence of groundwater. Both natural and artificial groundwater-related wetlands are abundant along the Mediterranean coastal zone.

Wetlands deliver a wide range of ecosystem services that contribute to human well-being. According to the Millennium Ecosystem Assessment (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.

In groundwater-related coastal wetlands many ecosystem services are derived or supported by the presence of groundwater inflow because of its role in regulating the hydrology 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 consequent benefits for people.

Many wetlands around the world have been degraded or destroyed, and their capacity for offering ecosystem services diminished due to both anthropogenic and natural causes. In the Millennium Ecosystem Assessment terminology the factors that induce direct changes in the wetlands functioning are the so-called **drivers of change**. The drivers of change are the causes of shifts in the ecological status of the ecosystems and their capacity for producing services. 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 those of other ecosystems. Direct and indirect drivers of this degradation are mostly associated with human activities. Direct drivers directly affect the ecosystem concerned. In the case of wetlands, they mainly include infrastructure and urban development, land conversion, water withdrawal or disposal, eutrophication and pollution, overharvesting and overexploitation, and the introduction of invasive alien species (Millennium Ecosystem Assessment, 2005).

Indirect drivers are those that, from a wider extension, affect ecosystems through their consequences, such as population growth, increasing economic activity and development, and climate change.

As part of MedPartnership, a preliminary assessment of 26 major Mediterranean groundwater-related coastal wetlands was performed, considering:

1. the general geological and hydrogeological characteristics
2. the status and evolution trends of the ecosystem services
3. the drivers that induce changes in wetlands functioning.[14]

14. This work has benefited from the experience gained by some of the authors in two previous studies of similar aim and scope: the Spanish Millennium Ecosystems Assessment, carried out from 2009 to 2011 in Spain (http://www.ecomilenio.es), and the IGCP-604 Project *Hydrological components of the groundwater-wetlands interactions: international cooperation for developing a new conceptual framework in Ibero-American wetlands,* carried out from 2011 to 2014 (http://www.mdp.edu.ar/hidrogeologia/IGCP604/description.php), whose goal was to gain knowledge of the interactions between groundwater, wetlands and humans in the Ibero-American countries and Spain.

2.4.1 METHODOLOGICAL APPROACH

Data gathering

Three templates were designed and distributed to the national experts to compile the necessary data related to particular coastal wetlands in their countries in a standardized manner. The aim and content of each template is as follows:

1. Wetlands General Data Form
   - Name of the wetland and country
   - Wetland type: A classification system was designed specifically for this study
   - Local climate: average rainfall (mm/year); average temperature (°C); average evapotranspiration (mm/year); seasonality (high/low)
   - Underlying lithology: siliceous sediments; carbonated sediments; carbonate rocks; evaporite rocks; metamorphic rocks; volcanic rocks; intrusive rocks
   - Morphometry (max-average): surface area (km^2); elevation (masl); depth (m); length (m); width (m)
   - Wetland genetic processes: tectonic; erosive; dissolution; volcanic; floodplain; delta/estuary; dune morphology; coastal sedimentation; artificial
   - Wetland sediments: sandy; silty; clayey; organic-rich; peat
   - Main water sources: rainfall on the wetland; runoff in the basin; deep groundwater; shallow groundwater; sea (tidal/wave); fluvial inundation; artificial
   - Groundwater flow type: flow through; recharge area; discharge area open; discharge area closed, saline; discharge area closed, fresh; crypto-wetland; variable
   - Hydroperiod: permanent; seasonal; variable
   - Hydrochemistry: electrical conductivity (mS/cm); dominant (>50%) anion/anions; dominant (>50%) cation/cations
   - Groundwater dependence: dominant; shared; secondary
   - Dominant vegetation: forest; shrubs; bushes; prairie; halophytic vegetation; phreatophyte vegetation
   - Trophic state: oligotrophic; mesotrophic; eutrophic; hypereutrophic
   - Functionality: almost unaltered; moderately altered; highly altered; artificial
   - Current 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
   - Management status: Ramsar site; Man and the Biosphere Programme (MAB), Natural reserve/Other; Unprotected; Protection regulation; Management authority; Users' involvement

2. Wetlands services contributing to human well-being. Global assessment of status and trends Form (Ecosystem services Form). Designed to compile information related to specific ecosystem services provided by the groundwater-related wetlands inventoried. Three main groups of ecosystem services have been considered:
   - Provisioning (products obtained from ecosystems)
   - Regulating (benefits obtained from regulation processes)
   - Cultural (nonmaterial benefits obtained from ecosystems)

3. Main direct drivers of change in wetland systems Form (Drivers of change Form). To evaluate the drivers of change to groundwater-related wetlands and services, the following main seven categories and subcategories (particular drivers within each main group) have been used:
   - Resource exploitation. Three main resources have been considered: water, biological materials and mineral materials
   - Changes in land use altering the capacity to maintain ecological health or causing ecosystem loss

- Modification of the hydrological cycle (causing hydrological changes compared to the natural regime in terms of water amount)
- Pollution (causing changes in the physical, chemical and/or biological quality of wetland water, sediments and/or biota)
- Alteration of biological community structure and ecosystem functioning (causing changes in the provision of any kind of ecosystem services)
- Effects associated with changes (occurrence of these effects resulting from the existence of other drivers)
- Global and climate changes (changes in the patterns of these drivers).

To evaluate ecosystem services, a code based on colours and arrows has been used to evaluate the *drivers of change* considered in the activity. Colours refer to qualitative degree of impact of changes promoted by a particular driver on wetland ecological integrity; arrows show a prognosis of the future impact of the driver of change in the most probable future scenario.

Twenty seven (27) wetlands were inventoried and reported on by the expert representatives of the 13 Mediterranean countries participating in MedPartnership. However, after performing checks, it was realized that one of the wetlands reported – Deir El-Nouriyeh, in Lebanon – was not really a wetland, but a vegetated vertical cliff that constitutes a relevant site for migrating birds. The site is included in the Ramsar list, but from the scientific point of view it is not a wetland. Thus, in agreement with the Lebanon national expert it was decided to exclude this site from the report, and only twenty six (26) wetlands have been evaluated.

2.4.2 MAIN RESULTS

Wetlands genesis

The majority of the wetlands evaluated (23 of 26) have their origin in the interaction of several geological processes such as delta/estuary dynamics, dune morphology, coastal sedimentation and fluvial plain processes. Some of these mechanisms operate at local scale and others at regional scale. Thus, to design and conduct efficient conservation programmes for wetlands it is necessary to know the geological processes originating and controlling wetlands evolution. This means there is a need to perform integrated geological and hydrogeological studies at different spatial scales.

Water salinity

Most of the evaluated wetlands are brackish to hypersaline, and a notable number have variable salinity in different areas and/or periods, ranging from slightly saline to hypersaline.

Wetlands functionality

Most of the studied wetlands (24) are reported as having their functionality altered in different degrees. Half of the wetlands are moderately altered, and in the remainder the alteration is high to very high.

Evaluation of services status	Evaluation of services trend
High: The service is performing 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

Source: UNEP-MAP, UNESCO-IHP (2015a)

Groundwater dependence, groundwater flow type and wetlands hydroperiod

Groundwater is reported to play a Dominant role in a small number of wetlands (4), a Shared role in most of the wetlands (19), a Secondary role in only two wetlands, and a Variable role in one of the inventoried wetlands. In addition, most of the wetlands (18) do not show a dominant groundwater flow type but variable combinations of basic flow types, with the majority of the wetlands showing a combination of two types: some behave as groundwater flow-through zones, and others as groundwater discharge open areas. A notable number of the wetlands evaluated have a Permanent hydroperiod (17); a few are Seasonal (2) and 7 have a Variable hydroperiod. Combining the information provided on groundwater role, groundwater flow type and hydroperiod, *it can be concluded that groundwater is probably a main supporting factor to the ecological functioning of most of the coastal Mediterranean wetlands.*

Current state of knowledge

From the information reported by the country experts it seems that there is abundant scientific and technical information about most of the wetlands evaluated. For many of them there are even very specialized data such as chemical, isotopic, biological and socioeconomic information. Moreover, a good number of wetlands maintain monitoring surveys of wetland water levels, water quality, groundwater levels and/or groundwater quality. This suggests that the inventoried wetlands are relevant elements for the participating countries. Moreover, this result shows that, for most of the inventoried wetlands, part of the information needed to understand wetlands functioning and their relationships with groundwater, and to evaluate their functionality and evolution trends, is already available.

Management status

The majority (25) of the wetlands evaluated have one or more protection figures: in 22 wetlands there is a minimum level of protection provided by their designation as nature reserves or similar; 16 wetlands are Ramsar sites; 16 wetlands have a Management authority, 11 have some Protection regulation and 3 of (Tawurga Spring, in Libya; Dalaman and Dalyan wetlands, in Turkey) have some type of Users' involvement in the management of the wetland. The fact that the majority of the reported wetlands have been considered as elements worth being protected suggests that most of the countries participating in this activity are conscious of the relevant role that wetlands play for the well-being of their environment in general, including human well-being.

Only one of the 26 wetlands inventoried does not have any type of protection: the Akkar Plain, in Syria. The coastal zone in Syria is one of the scarce natural resources of the country, and provides important economic, transport, residential and recreational functions, all of which depend on its appealing landscape, cultural heritage, natural resources, and rich marine and terrestrial biodiversity, to which the Akkar Plain wetlands contribute notably. It is desirable that in the near future the Akkar Plain wetlands could be included within an integrated management plan of the entire Syrian coastal zone.

Performance status of the main types of ecosystem services in the Mediterranean groundwater-related coastal wetlands evaluated

A main result is that most of the Provisioning, Regulating and Cultural services evaluated are performing at a Low level in the whole set of wetlands inventoried. This conclusion is consistent with the results of similar evaluations performed around the world in comparable studies.

A second main result is that, although most of the services evaluated have been reported as Non-existent, there are sound reasons to think that this result is more apparent than real; many of the services reported as not existing are known to be performed around the world by the major part of the wetlands located in areas with similar climate, hydrological and socioeconomic conditions as those in the Mediterranean coastline. This result could derive from different reasons, among them a limited knowledge of ecosystem services by Earth scientists around the Mediterranean basin, limited access to the information relevant to assess these aspects, lack of time to use and integrate this information, or a combination of motivations.

Evolution trends of the main types of ecosystem services in the Mediterranean groundwater-related coastal wetlands evaluated

A very small number of specific Provisioning, Regulating and Cultural services are reported as *Very rapidly increasing* their level of performance. A larger, but also reduced, number of services are reported as *Moderately* increasing their level of performance. Cultural Services are those mostly showing this trend. Most of the services of the three types are reported as *Continuing* their level of performance. Provisioning Services are those where this pattern is more common. A moderate number of services are reported as *Decreasing* their performance, either *Moderately* or *Very rapidly*. Provisioning Services are, again, reported as those most commonly presenting this pattern.

A notable result is that one of the wetlands evaluated, the wetland of Wadi Gaza, is rapidly losing the ability to provide very basic Provisioning services. A very clear indicator of the general deterioration in this wetland is that it is the only one reported as losing Cultural services.

Most of the evaluated services are reported as not changing (*Continuing*) their level of performance in nearly all the wetlands inventoried.

Impact of the main types of drivers of change on the functioning of the Mediterranean groundwater-related coastal wetlands

The most frequently reported impact for almost every type of driver of change is *Non-existent, followed* by *Low*. The drivers most reported as not existing are those related to the main category *Changes in land* use, followed by those related to *Resources exploitation*.

The number of drivers reported as having some degree of impact, regardless if it is *Low*, *Moderate* or *High*, is very modest and far smaller than expected. The drivers most reported as causing *Low*, *Moderate* and *High* impacts are those of the main category *Resource exploitation*, followed by those related to *Changes* in land use and by those related to *Modification of the hydrological regime*. The drivers related to the main categories *Pollution* and *Alteration of biological community structures and ecosystem functioning* are mostly reported as *Non-existent* or as *Unknown*. This rather surprising information provided by national experts is likely to have been affected by limitations of time (and perhaps of material possibilities) to access and process the existing, relevant scientific and technical information potentially useful in assessing these aspects.

Figure 2.4.2.1. Main reported results on the general characteristics of the coastal wetlands

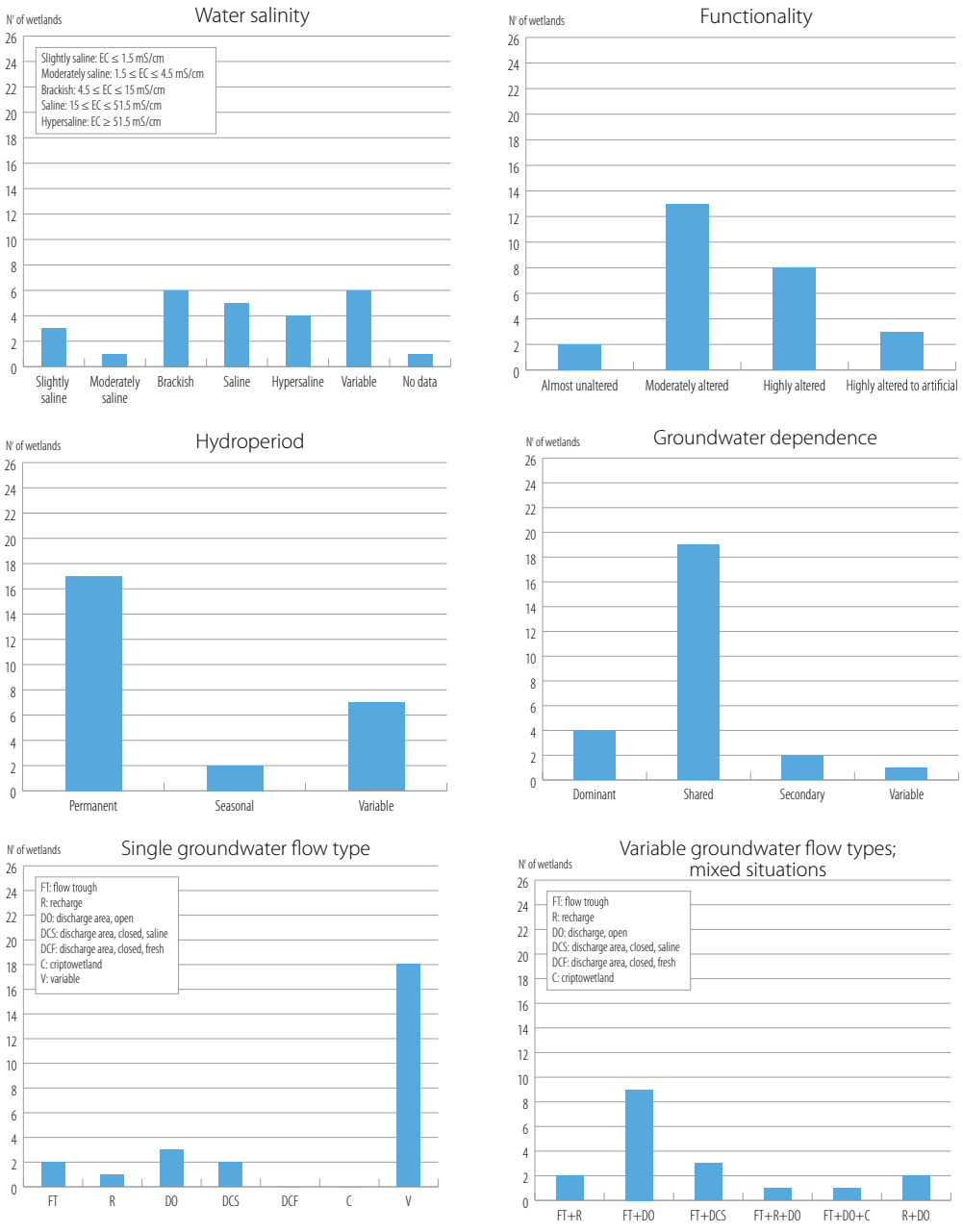


Figure 2.4.2.2. Reported management status for the evaluated wetlands

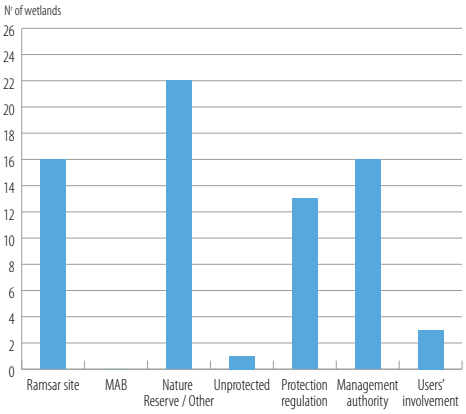


Figure 2.4.2.3. Mediterranean groundwater-related coastal wetlands inventoried – main direct drivers of change in wetland systems

Inventory number	Name of wetland, country	Type	PROVISIONING SERVICES																REGULATING SERVICES							CULTURAL SERVICES					
			Natural production of food						Artificial production of food																					
			Cropping	Livestock	Fishing	Fruit collection	Hunting	Other	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	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	Butrinti, Albania	2H		→	→				→			→	→						→			→				→				→	
2	Guerbes, Algeria	2HKN	↗	→	→		?	?		→		→	→	→	→			→	↘	→	→					→	→	→	→	→	
3	Hutovo Blato, Bosnia and Herzegovina	2ENPQS	→	→	↗	→	↗	→		→		→	→	→			↑	→	↑	↘	↑	→	↘	↘	↘	↘	↘	→	↘	↘	
4	Neretva Delta, Croatia	2AHJ	→	→	→	↗	→			↗		↘	→						↗	↘	↘	↘				↗	↗	↗		↗	↗
5	Lake Mariut, Egypt	1A			↘				→					?	→			?	↘	?	→	?			?				→	→	
6	Tyre Beach, Lebanon	3Q	→		→	↗	→		→	→		→	→			→		?	→	→		→	?		→	→	→	↗	↗	↗	
7	Tawurgha Spring, Libya	3D	→	→		→				→		↘	↘						→			→			→	↗	↗	↗	↗	↗	?
8	Skadarsko Lake, Montenegro	2A	→	→	↗	→	↗	→		→		→	→	→	↗			→	↑	→	↑	→	↘	↘	↘	↗	↗	↗	→	→	
9	Tivatska solila, Montenegro	1R	?	→	?	?	↗	?				→	↗	→				→	→	→	→	?	↘	↘	↘	↑	→	↗	→	→	
10	Bou Areg Lagoon, Morocco	2AL	?	→	→	?		?	?	→		→	→	→	→			→	↘	→	→				↗	↗	↗	↗	→	→	
11	Moulouya Estuary, Morocco	2HKN	?	→	↘	?		?		→			↘					→	↘						→	→	→	↗	→		
12	Oued Laou Estuary, Morocco	2HKN	?		↘	?				→			→						↘						→	→	→	→	→		
13	Wetland of Wadi Gaza, Palestine	2AHJ		→	↓		↘		↓	→		↓	↗						↘	↗	↘	↘				↘	→	↘	↓	↓	
14	Akkar Plain, Syria	2EHN	↑	↗		↑	?	?	→	↑		→	↗						↘	→	→				?	→	→	→			
15	Korba (Cap Bon), Tunisia	1BHIQ	?	→	→	?	?	?		→		→	→	→	→			→	↘	→	→				↗	↗	↗	↗	→	→	
16	Yumurtalık Lagoon, Turkey	1AHI	↗	→	→	→	→		→	↗		↘	↘	↓	↓	↓	↓	↓	→	↗		↗		→	→	→	↗	↗	↗	→	→
17	Akyatan Lagoon, Turkey	1AHI	↗	→	→	→	→		→	→		↘	↘	↓	↓	↓	↓	↓	→	↗		→		→	→	→	→	→	↗	→	→
18	Tuzla Lagoon, Turkey	1AHI	↗	→	→	→	→		→	→		↘	↘	↓	↓	↓	↓	↓	→	↗		→		→	→	→	→	→	↗	→	→
19	Dipsiz Wetland, Turkey	1B	→	→	→		→		→	→		→	→	↓	↓	↓	↓	↓	→	↗		→		→	→	→	→	→	↗	→	→
20	Göksu Delta, Turkey	2AIP	→	→	→	→	→		→	→		↘	↘	↓	↓	↓	↓	↓	→	→		↗		→	→	→	↗	↗	↗	→	→
21	Dalaman Wetlands, Tukey	1AIP	↗	↘	↘	→	→		→	→		→	→	↓	↓	↓	↓	↓	→	↗		↗		→	→	↗	→	→	↗	→	→
22	Dalyan Wetlands, Turkey	1AIP	→	↘	↗	→	→		↗	→		→	→	↓	↓	↓	↓	↓	→	↗		↗		→	→	↗	→	→	→	→	→
23	Büyük Menderes Delta, Turkey	2AHI	→	↘	→	→	→		↗	↗		↘	↘	↓	↓	↓	↓	↓	→	→		↗		→	→	→	↗	→	↗	→	→
24	Küçük Menderes Delta, Turkey	1AIP	→	↘	→	→	→		→	↗		↘	↘	↓	↓	↓	↓	↓	→	↘		↗		→	→	→	→	↘	↗	→	→
25	Gediz Delta, Turkey	2AIP	→	↘	→	→	→		→	↗		↘	↘	↓	↓	↓	↓	↓	→	↘		↗		→	→	↗	↗	↗	↗	→	→
26	Gökçeada Lagoon, Turkey	1AHI	→	↘		→	→			→		→	→	↓	↓	↓	↓	↓	→	→		→		→	→	→	→	↗	→	→	→

Status of services

- High
- Moderate
- Low
- Non-existent
- Unknown

Trends of services

- ↑ Very rapidly increasing
- ↗ Moderately increasing
- → Continuing
- ↘ Moderately decreasing
- ↓ Very rapidly decreasing
- ? Unknown

Figure 2.4.2.3.(Continued) Mediterranean groundwater-related coastal wetlands inventoried – main direct drivers of change in wetland systems

Inventory number	Name of wetland, country	Type	Resource exploitation: Water abstraction: From wetland	Water abstraction: From tributaries	Water abstraction: Groundwater next to the wetland	Water abstraction: Groundwater basin	Biological exploitation: Crops	Biological exploitation: Forest	Biological exploitation: Cattle raising	Biological exploitation: Fishing	Biological exploitation: Others	Mineral exploitation: Fuel	Mineral exploitation: Salts	Mineral exploitation: Soils	Mineral exploitation: Rocks	Mineral exploitation: Others	Changes in land use: Deforestation	Changes in land use: Reforestation	Changes in land use: Forest management	Changes in land use: Replacement of species	Changes in land use: Extensive agriculture	Changes in land use: Extensive cattle raising	Changes in land use: Urbanization	Changes in land use: Roads	Changes in land use: Others	Modification of the hydrological cycle: Drainage	Modification of the hydrological cycle: Input of excess irrigation	Modification of the hydrological cycle: Storage usage	Modification of the hydrological cycle: Artificial recharge	Modification of the hydrological cycle: Input of urban wastewater	Modification of the hydrological cycle: Others	Pollution: Agricultural diffuse pollution	Pollution: Atmospheric diffuse pollution	Pollution: Urban/industrial point source pollution	Alteration of biological community structures and ecosystem functioning: Invasive exotic species	Alteration of biological community structures and ecosystem functioning: Native species extinction	Alteration of biological community structures and ecosystem functioning: Alteration of biogeochemical cycles	Alteration of biological community structures and ecosystem functioning: Fragmentation	Effects associated with changes: Chemical water quality	Effects associated with changes: Biological water quality	Effects associated with changes: Oxidation by lowering water table	Effects associated with changes: Increased erosion	Effects associated with changes: Soil destruction	Global and climate changes: Rainfall	Global and climate changes: Temperature	Global and climate changes: Sea level rise
1	Butrinti, Albania	2H		→		→				→			→										↗	↗						→										↘	↗	↗
2	Guerbes, Algeria	2HKN		→	→	↗	↗		→							→				→	↗	→	→	→		→	↗	↗		→		↗								↘	↗	↗
3	Hutovo Blato, Bosnia and Herzegovina	2ENPQS	↑	↑	↑	↑	→		→	↗				→							↗	→	→	→	→		→	→	↑	→	→		→		↘	→	↗	↗	↑	↗	↗	↗	↗	→	→	↗	↗
4	Neretva Delta, Croatia	2AHJ	→	→	↗	↗	↗		→	→												↗			↗	→		→	↗		→		↗			↗	↗	↗	↗	↗				→	→	→
5	Lake Mariut, Egypt	1A	→							→			→									↗			→	→	→	↗	↗		→		↗	↗					↗	↗					↗	↗
6	Tyre Beach, Lebanon	Q3		↗		↗	↗			→										→	↗			→		→	↗	↗		→		→				→			↗	↗				→	→	↗
7	Tawurgha Spring Libya	3D	→		↗	↗	→		→												↗	→	↑	↗		→	→	→		↗		→			↗	→	↗	↗	↗	→			→	→	→
8	Skadarsko Lake, Montenegro	2A	↗	↗	↗	↗	↗		→	→							→			→	→	→	→	→		→	→	→		→		→				→	→	→	→	→	↘	↗	↗
9	Tivatska solila, Montenegro	1R	↗	↗	↗	↗	→		→					→			→				→	→	↗	→		→	→	→		→		→								→	→	↘	↗	↗
10	Bou Areg Lagoon, Morocco	2AL			→	↗	↗		→	→										→	→		→	→		→	→	↗		→		↗				↗			↗		↘	↗	↗
11	Moulouya Estuary, Morocco	2HKN		↗	↗	↗	→		→	→											→	→	→	→		→	→		→	→		↘		↗					↗	→	→	→	↗	↗	↗
12	Oued Laou Estuary, Morocco	2HKN		↗	↗	↗	→		→	→											→	→	↗	→		→	→			→		→		↗		↗	↗			→	↗	↗	↗
13	Wetland of Wadi Gaza, Palestine	2AHJ	↘	↗	↗	↗		→	→	↓				↗	↗		↗		↘		↘			↗				→	↗	↗	↗		→	→	→	↗	→	→		↗	↗		↗	↗	↗	↗	↗
14	Akkar plain, Syria	2EHN		→	→	↗	↗		→													↗	→	↗		→	→	↗		→		↗			↑	↑		↗	↗			→	↗	↗	↗
15	Korba (Cap Bon), Tunisia	1BHIQ		→	→	↗	↗			→							→				→	↗	→	→	→		→	↗	↗	↗	→		↗							↗				↘	↗	↗
16	Yumurtalik Lagoon, Turkey	1AHI	→	↘		↗	↗	↘	→	→			→								→	→								→		→									↗					
17	Akyatan Lagoon, Turkey	1AHI	→	↘		↗	↗	→	→	→									→		→	→								→		→									↗					
18	Tuzla Lagoon, Turkey	1AHI	→			↗	↗	↘	→	→									→		→	→								→		→									↗					
19	Dipsiz Wetland, Turkey	1B	→			↗	→	↘	→	→			→								→	→								→		→									↗					
20	Göksu Delta,Turkey	2AIP	→	↘		↗	→	↘	→	→											→	→								→		→									↗					
21	Dalaman Wetlands, Tukey	1AIP	→	↘		↗	↗	↘	→	→											→		↗							→		→									↘					
22	Dalyan Wetlands, Turkey	1AIP	→	↘		↗	→	↘	→	→											→									→		→									↘					
23	Büyük Menderes Delta, Turkey	2AHI	→	↘		↗	→	↘	→	→											→									→		→									↗					
24	Küçük Menderes Delta, Turkey	1AIP	→	↘		↗	→	↘	→	→											→									→		→									→					
25	Gediz Delta, Turkey	2AIP	→			↗	→	↘	→	→			→								→		↗							→		→									↘					
26	Gökçeada Lagoon,Turkey	1AHI	→			↗	→	↘	→	→																				→		→									→					

Impact of drivers

- High
- Moderate
- Low
- Non-existent
- Unknown

Trends of drivers

- ↑ Very rapidly increasing
- ↗ Moderately increasing
- → Continuing
- ↘ Moderately decreasing
- ↓ Very rapidly decreasing

3.

SUPPLEMENT ON COASTAL AQUIFERS FOR TRANSBOUNDARY DIAGNOSTIC ANALYSIS OF THE MEDITERRANEAN SEA LARGE MARINE ECOSYSTEM

3.1 METHODOLOGICAL APPROACH

The approach adopted for conducting the coastal aquifer supplement to the TDA of the Mediterranean Sea LME consisted in focusing on the "main issues of transboundary concern" already identified by the 2005 TDA, and describing those situations all along the Mediterranean coasts where the degradation in quality and quantity of coastal aquifers contributes to various issues of transboundary concern.

The "general" causes of degradation of coastal aquifers of the Mediterranean Sea are:

1. Domestic, agricultural and industrial wastes contaminating shallow coastal aquifers
2. Over-exploitation, inducing salinization and seawater intrusion
3. Land-use practices and/or climate variability and change that reduces natural recharge rates.

Where these forms of aquifer degradation are occurring, they will compound the severity of some of the main issues of transboundary concern (2005 TDA):

- Land-based pollution:
  - (i) Point sources (excess nutrients, toxics and persistent toxic substances, PTS)
  - (ii) Non-point sources (mostly nutrients from agriculture, and sediments)
- Degradation and conversion of critical habitats: sea grass meadows, coastal wetlands and lagoons
- Anthropogenic pressures on coastal zones.

The Diagnostic Supplement identifies where this is happening, whenever possible; what are the specific causes at each site, including legal and socioeconomic aspects; and possible solutions, if any (aquifer rehabilitation may be beyond reach in some instances)

3.2 FINDINGS

The availability and quality of freshwater resources is a critical issue for the population of the Mediterranean. Water demand in the region doubled during the second half of the 20th century and is now an aggregate of 290 km^3 per year. The "*water poor" Mediterranean population – those with less than 1000 m*3 per capita per year – was 108 million in 2000 and could reach 165 million by 2025 (in nine southern and eastern Mediterranean countries), and many of them live along the coasts. Of this latter population, 63 million (compared with 45 million in 2000) would be experiencing shortage; that is, having less than 500 m^3 per capita per year. The exploitation index of renewable natural resources (defined as the ratio of withdrawals from renewable natural water resources, including coastal aquifers, to average renewable water resources) is high in Egypt and Israel. In Libya, withdrawal is now close to, or exceeds, natural resources. This index is increasing in all southern and eastern countries. It should also be noted that in Libya, Israel and the Palestinian Authority, more than 10% of the water supply is taken from non-renewable resources (i.e. fossil aquifers). As well as decreasing supply, the decreased quality of freshwater results in additional stress on water resources to satisfy the demand for drinking water, and directly impacts the biodiversity of the basin.

Coastal aquifers

Coastal aquifers are of particular importance. They constitute a key source of freshwater for human uses including drinking and, by discharging into the Mediterranean, contribute to the shallow marine environment and coastal habitats. Submarine groundwater discharges from coastal aquifers are estimated to be 13 billion m^3/yr and account for about one quarter of the total freshwater inflow into the Mediterranean. In the southern, central, Levantine and Adriatic sub-basins there are few surface watercourses, and coastal aquifers dominate the aggregate discharge of freshwater. Karstic aquifers are particularly vulnerable to saline intrusion and surface contamination, especially in the open karst systems exposed to anthropogenic contaminants. Freshwater seepage from karstic coastal aquifers that dominate large sections of the southern Mediterranean and the eastern Adriatic coasts mediate the transport of agriculture-derived nutrients, chemicals and other substances into the sea, thereby degrading critical wetland habitats. These underground karstic aquifer systems constitute habitats for unique types of biodiversity.

Growing pressure on groundwater supplies, saltwater intrusion, coastal aquifer salinization, nutrient and contaminant transport are the major issues of transboundary concern affecting most if not all Mediterranean coastal aquifers.

Table 3.2.1, based on questionnaire responses, provides a synoptic summary of the TDA Supplement findings for the coastal aquifers analysed for the diagnostic assessment. Two issues emerge as the main causes of concern:

In 75% of all aquifers salinization is growing, due mostly to seawater intrusion, and secondarily to influx of deeper saline groundwater. In both cases this alarming phenomenon is caused by overexploitation of the freshwater aquifer (extractions exceeding recharge), due and/or compounded by overall high human dependency on water from the coastal aquifers, and by growing climatic variability. While rehabilitation of the aquifer's water quality might be beyond reach in most cases, reversing the trend and halting the inflow of saline waters in the aquifer might be feasible by adopting and enforcing appropriate water extraction policies, and in some instances (high population density areas), through managed artificial recharge schemes

The qualitative values of the indicators shown in the table are based on the scarce monitoring data that exist for many aquifers, as well as on the present inadequate level of understanding of the role of aquifers in coastal dynamics, in particular the role of groundwater in sustaining freshwater ecosystems along the coasts. In fact, the generally Low pollution from nutrients, and the Low-Medium ranking assigned to coastal ecosystems dependency on groundwater, provide a misleading picture that does not reflect the real situation

Lack of modern monitoring systems is generalized in the region. This situation precludes the implementation of effective coastal aquifer management schemes and of the urgently needed coping strategies to combat salinization, nutrient pollution and the impacts of climatic variability and change.

Table 3.2.1. Environmental and socioeconomic indicators of the current state of Mediterranean coastal aquifers based on questionnaire responses

Aquifer name/country	Pollution from nutrients	Pollution from other pollutants	Human dependency for domestic uses	Links with ecosystems	Salinization
Albania					
Buna	Low	Low	High	Medium	High
Cika	Low	Low	High	Very Low	High
Dukati	Low	Low	High	Medium	Medium
Mati	Low	Low	High	Medium	High
Tragiasi	Low	Low	High	Very Low	High
Vjosa	Low	Low	High	Medium	High
Algeria					
Collo-Teleza	Medium	Low	High	Medium	Medium
Comp. Dunaire Terga	Low	Low	High	Very Low	Medium
Plaine de la Mitidja	Medium	Low	High	Medium	High
Annaba	High	Medium	High	High	Medium
Bosnia and Herzegovina					
Trebišnjica	Low	Low	High	Medium	Medium
Croatia					
Sibenik Rogoznica	Low	Low	High	Very Low	Medium
Istra	Low	Low	Medium	Very Low	High
Neretva	Low	Low	High	Medium	Medium
Ravni Kotari	Low	Low	Medium	Medium	Medium
Egypt					
North Nile Delta	High	High	Medium	Medium	High
North Sinai	Low	Low	Medium	Medium	High
North-west coast	Low	Low	Medium	Medium	High
Lebanon					
Afka	Low	Low	Medium	Very Low	Very Low
Beirut	Very Low	Low	Medium	Low	High
Chekka	Very Low	Low	Medium	Low	Low
Damour	Very Low	Low	Medium	Low	High
South	Low	Low	High	Low	Very Low
Tripoli	Very Low	Low	Medium	Low	Low
Tyr-Saida	Low	Low	Medium	Low	Low
Zarka	Low	Low	Medium	Low	Very Low
Libya					
Gefara Plain	Low	Low	Medium	Low	High
Montenegro					
Boka Bay	Low	Low	High	Low	High
Bojana	High	Low	High	Medium	High
Morocco					
Bou-Areg	High	Medium	Medium	Medium	High
Ghis-Nekkor	Low	Low	Medium	Medium	Medium
Martil-Alila	High	High	High	Very Low	High
Negro	Low	Very Low	High	Medium	Low
Oued laou	Low	Very Low	Medium	Medium	Low
Smir	Low	Very Low	High	Medium	Low
Palestine					
Gaza	Medium	Low	High	Medium	High
Tunisia					
Chegarnia-Sidi Abicha	Very Low	Very Low	High	Medium	High
Côte Orientale	Low	Very Low	Medium	Medium	High
Gabes Shallow	Very Low	Very Low	Medium	Medium	High
Grombalia	Medium	Very Low	Medium	Very Low	Low
Mahdia	Low	Very Low	Medium	Medium	High
Mornag	Low	Very Low	Medium	Very Low	Low
Ras Jebel	High	Very Low	Medium	Very Low	High
Sahel Sfax Deep	Very Low	Very Low	Medium	Very Low	High
Sahel Sfax Shallow	Low	Very Low	Medium	Medium	High
Tabarka	Low	Very Low	Medium	Very Low	Very Low
Colour Coding		Very Low	Low	Medium	High

Coastal wetlands

Assessment of groundwater dependency of all major Mediterranean coastal wetlands has confirmed that they are all dependent on coastal aquifers to various degrees, and that their functioning is being impaired by the deceasing water quantity and quality of the coastal aquifers feeding the wetlands.

Coastal aquifers support coastal freshwater and brackish water habitats with rich biodiversity. Such habitats include coastal wetlands, which provide critical ecosystem services such as securing health and productivity of fisheries; sustaining nursery and breeding habitats for near-shore commercial and recreational fisheries; and filtering and detoxifying by suspension feeders and submerged vegetation. They are also important resting sites for migrating birds. Degradation of coastal aquifers can heavily impact wetlands and humid areas. The threats to wetlands from aquifer mismanagement are twofold:

- The overuse of coastal aquifers can result in the drying up of the wetlands dependent upon them
- Saline intrusion and pollution, which occur when coastal aquifers are over-exploited, and pollutants introduced into the aquifers, can degrade the health and functioning of wetlands.

The loss of the filtering functions of wetlands due to declining freshwater quality, including groundwater, is linked to the increasing occurrence of harmful algal blooms, fish and shellfish kills, beach closures and oxygen depletion. Increasingly, loss of or change in vegetation in coastal ecosystems has affected the ability of these systems to protect against shore erosion, coastal flooding and storm events.

Tables 3.2.2 and 3.2.3 summarize the results of the Mediterranean Wetland Assessment carried out as part of the Coastal Aquifers Component of MedPartnership. They show growing and alarming pressures due, in particular, to groundwater extraction, urbanization and diffuse pollution from agriculture for 15 of the 26 main Mediterranean wetlands.

Table 3.2.2. Status and trends of ecosystem services provided by Mediterranean groundwater-related wetlands

Country	Groundwater-related coastal ecosystems	Ecosystem services status			
		Fishing	Agriculture	Water purification	Cultural; Education
Albania	Butrinti				
Algeria	Guerbes				
BiH	Hutovo Blato				
Croatia	Neretva Delta				
Egypt	Lake Mariut				
Lebanon	Tyre Beach				
Libya	Tawurgha Spring				
Montenegro	Skadarsko Lake				
	Tivatska Solita				
Morocco	Bou Areg Lagune				
	Estuaire Moulouya				
	Estuaire Oued Laou				
Palestine	Wadi Gaza				
Syria	Akkar Plain				
Tunisia	Cap Bon				
Turkey	Yumurtalik Lagoon				
	Akyatan Lagoon				
	Tuzla Lagoon				
	Dipsiz Wetland				
	Goksu Delta				
	Dalaman Wetlands				
	Dalyan Wetlands				
	Büyük Menderes Delta				
	Küçük Menderes Delta				
	Gediz Delta				
	Gokceada Lagoon				

Ecosystem services delivery status	High	Moderate	Low stable	Low decreasing	N/A	Unknown

Table 3.2.3. Level of impact of drivers of change to Mediterranean groundwater-related wetlands

Country	Groundwater-related coastal ecosystems	Drivers of change: level of impact					
		Groundwater abstractions in basin	River water abstractions in basin	Urbanization	Pollution from agriculture	Erosion/soil loss	Climate change: rainfall
Albania	Butrinti						
Algeria	Guerbes						
BiH	Hutovo Blato						
Croatia	Neretva Delta						
Egypt	Lake Mariut						
Lebanon	Tyre Beach						
Libya	Tawurgha Spring						
Montenegro	Skadarsko Lake						
	Tivatska Solita						
Morocco	Bou Areg Lagune						
	Estuaire Moulouya						
	Estuaire Oued Laou						
Palestine	Wadi Gaza						
Syria	Akkar Plain						
Tunisia	Cap Bon						
Turkey	Yumurtalik Lagoon						
	Akyatan Lagoon						
	Tuzla Lagoon						
	Dipsiz Wetland						
	Goksu Delta						
	Dalaman Wetlands						
	Dalyan Wetlands						
	Büyük Menderes Delta						
	Küçük Menderes Delta						
	Gediz Delta						
	Gokceada Lagoon						

Level of impact of drivers of change	High/Moderate	Low	NA	Unknown	N/A

Policy, legal and institutional aspects

Recognizing that sustainable management of coastal groundwater resources and aquifers depends not only on adequate scientific knowledge of these systems, UNESCO-IHP was charged with undertaking an assessment of the legal, policy and institutional aspects of coastal aquifer management in the countries participating in the MedPartnership. The results of this assessment appear in the document entitled "Legal, institutional and policy aspects of Coastal Aquifer Management – Regional Report" (UNEP-MAP, UNESCO-IHP, 2015b) and key sections are drawn upon in the present chapter.

The review of the countries' policy, legal and institutional frameworks allows us to draw the following conclusions, and to provide recommendations with the aim of improving the management of coastal aquifers.

National-level findings and recommendations: policies, practices and legislation

Little consideration of groundwater in national policies and legal frameworks. In most of the national policies and legal frameworks of the participating countries, groundwater in general receives limited attention, is regulated in a uniform way and the same management considerations are provided for very diverse situations. Any new water legislation needs to systematically introduce sound groundwater governance frameworks and to introduce provisions related to protection of recharge zones, limits on pollution levels in discharge of solid and liquid waste, and others[15]

Lack of awareness of coastal aquifers and their importance. Even more than groundwater, coastal aquifers are almost totally forgotten in the national frameworks related to water. There should be plans to raise awareness of decision makers about their importance as water resources in the coastal zone, and about their specificities due to their interaction with the sea. There should also be plans to develop and improve the capacities in the ministries in charge of water on the issue of coastal aquifers, and to disseminate this knowledge to the various institutions/agencies involved in the management of water resources in the coastal zone

Developing knowledge and capacities. The countries face the general problem of the lack of available, reliable data needed to assess both the groundwater potential and the quality and quantity of groundwater resources. They also face the general problem of a lack of monitoring systems, which require financial resources. The number of qualified personnel to perform the monitoring of groundwater resources is limited, and the available technical qualifications are not sufficient. Consideration needs to be given to making a concerted effort towards capacity building in this area, as well as enhancing existing training. To achieve this, close relations need to be developed between the

15. See the results and recommendations of the Groundwater Governance Project (GEF, FAO, UNESCO, IAH)

academic water community and decision makers to improve water resources management. The planning of groundwater management should be based on the available knowledge (in terms of both quantity and quality) and the anticipated needs of the end users of water

Developing water savings. Excessive use (and waste) of water can be linked to the lack of valuation of groundwater resources, and very low tariffs or even absence of any fee or tariff. Reasonable and equitable water tariffs should be introduced. Considering that agriculture is the highest water-consuming sector, the introduction of crops requiring less water has to be considered, as well as the adoption of water-saving irrigation techniques. Guidelines from organizations specialized in agriculture are available and could be disseminated in the participating countries

Developing alternative water resources (non-conventional water resources). Alternative water resources such as the use of treated wastewater for irrigation or artificial recharge (or other) or desalination (including the extraction of brackish water from coastal aquifers, and the disposal of brine) can reduce pressure on groundwater resources and coastal aquifers. Guidelines and examples of good practice could be prepared and disseminated through regional workshops and training. The general introduction of new technologies to help maintain equilibrium in the aquifer between it and the sea is worth considering, as well as proposing prevention measures drawing on best practices identified in other projects at the level of the Mediterranean basin

Considering the effects of climate change on coastal aquifers. So far national policies and legislation have not integrated any consideration of the effects of climate change on coastal aquifers. The role of aquifers as a water reservoir – a buffer – in the face of climate change is now well acknowledged. However, coastal aquifers, with their close relation to the sea, might also be affected by sea level rise. New evaluations and studies on these possible effects should be planned in the near future

Introducing modern principles of water management to legislation. Most national legislation on water resources in the participating countries lacks overall legal principles related to sustainable use, pollution prevention, the precautionary approach, "user pays", "polluter pays" and public involvement (the participatory approach). Neither do they consider specific ecosystems such as coastal wetlands dependent on groundwater, which need a special framework for their management (protected areas or other). Introduction of environmental principles into national legislation is strongly recommended. A tariff structure needs to be adopted, based on the costs and volumes of groundwater consumed, and considering the principles of social equity

Enforcement/acceptability of the legal measures. Existing groundwater provisions in national legislation are often ignored and not respected. There is a general problem of lack of enforcement of these provisions. Issues such as illegal wells or broken water meters are widespread, causing serious threats to and mismanagement problems within coastal aquifers

ICZM. Any legislation/policy related to the integrated management of the coastal zone should integrate the management of coastal water resources, pay special attention to coastal aquifers and consider harmonizing all existing instruments on the coast and in the marine environment. With respect to coastal aquifers, such policy/legislation should integrate an obligation for monitoring, as required by the ICZM Protocol (article 9).

National level findings and recommendations: Institutions

Overlapping and gaps in responsibilities between ministries in charge of water resources. This is common in most of the countries. It creates barriers to effective actions to promote groundwater management, due to the conflict of jurisdiction in water management and the lack of communication between institutions in charge of water management. This results in limited coordination among the various agencies involved in the management of coastal aquifers. The governance of the water sector needs general improvement. A high-level water board, including all ministries directly and indirectly involved in water management, could be established to coordinate actions and agree upon water policies and legislation. To improve the management of coastal aquifers, it is recommended that specific entities for coastal aquifers are set up within the existing institutions in charge of groundwater. Best practices need to be disseminated and incorporated into the institutional working modalities

Encourage public-private partnerships in the water resources domain. Services such as the treatment of wastewater and its distribution to farmers, or desalinization, can be handled by the private sector. Example of such practices and success stories could be disseminated to the countries for development in the coastal zone, where different economic interests are in competition for use of water resources

Encourage stakeholder engagement in the Water Sector (water governance). The size and nature of the water challenges ahead require a coordinated effort among policy makers and the wide range of stakeholders who play a role in, and are affected by, actions and outcomes in the water sector. Stakeholder engagement is a decisive factor in the ability of governments to successfully address and overcome the challenges they are facing in supplying and managing water. At times of financial constraints, the public sector is particularly challenged by increased demands from citizens to be more engaged in how public policy decisions are made. Accordingly, highlighting the importance of stakeholder engagement when designing and implementing water policy and projects is highly recommended.

Regional level findings and recommendations

Even if this progress of the consideration of coastal aquifers is to be fully acknowledged, there are still gaps to be filled. To raise awareness of coastal aquifers at the regional level and integrate their specificities into coastal zone management strategies and plans, the following are recommended:

- Encouraging the countries concerned to deposit their instruments of ratification, acceptance, approval or accession of/to the ICZM Protocol
- Uptake of the IMF (prepared in the frame of the MedPartnership project by UNESCO-IHP, PAP/RAC and GWP-Med) and its consideration of coastal aquifers when establishing management plans
- Creating a platform for the exchange of knowledge and technologies adapted for coastal aquifers between countries in the region
- Using and continuing the development of the online coastal aquifer database for the Mediterranean region
- Considering the findings and recommendations of the coastal aquifer supplement prepared by UNESCO-IHP in future actions in the region, and pursuing its adoption as a main document under the MAP process.

Table 3.2.4. Legal aspects: summary of main findings on present conditions (Adriatic countries)

Legal framework	Adriatic countries			
	Albania	BiH	Croatia	Montenegro
Water ownership	State	State	State	State
Groundwater consideration	Under Water Law(s)	Under Water Law(s)	Under Water Law(s)	Under Water Law(s)
Specific provisions for coastal aquifers	No	No	No	Law on Public Maritime Domain covers submarine springs and near-shore wells
Basin management	Yes	Yes	Yes	Yes
Planning instruments	IWRM	Water management strategy		Water management strategy. ICZM Strategy
Regulations on GW abstractions	Yes	Yes	Yes, except for "general"* uses	Yes, except for "general"** uses
Regulations on GW quality	Yes	Yes	Yes	Yes
Sanitary protection zones (wells, springs, aquifers)		Yes	Yes	Yes
Ratification of ICZM Protocol	Yes		Yes	Yes

* For households, bathing and recreation, from first aquifer.
** i.e. without use of any equipment or construction information provided by country. GW, groundwater. Grey cells: no information provided by countries; white cells: yes; orange cells: no.

Table 3.2.5. Legal aspects: summary of main findings on present conditions (southern and eastern Mediterranean countries)

Legal framework	Southern and eastern Mediterranean countries								
	Algeria	Egypt	Lebanon	Libya	Morocco	Palestine	Syria	Tunisia	Turkey
Water ownership	State	No information	State	State	State	State		State	State
Groundwater consideration	Under Water Law(s)	Under Water Law(s)	Ministerial Decrees	Under Water Law(s)	Under Water Law(s)	Under Water Law(s)		Under Water Law(s)	Law on GW (167/1960)
Specific provisions for coastal aquifers	No	No	No	Prohibition (Decree 791/1982) of any new GW extraction in coastal aquifers	No	No		No	Under GW Law
Basin management	Yes			Yes	Yes				
Planning instruments	Executive Decree		National Water Sector Strategy		National Water Plan				
Regulations on GW abstractions	Yes	Yes***	Yes	Yes	Yes	Yes		Yes	Yes
Regulations on GW water quality		Yes	Yes	Yes	Yes	Yes		Yes	
Sanitary protection zones (wells, springs, aquifers)	Yes				Yes	Yes		Yes	
Ratification of ICZM Protocol		Yes	Yes		Yes	Yes			

*** Permission required for drilling water wells and installing pumps. GW, groundwater. Grey cells: no information provided by countries; white cells: yes; orange cells: no.

3.3 CONCLUDING REMARKS

The extensive work carried out as part of this sub-component has allowed the drawing of a number of general conclusions valid for all countries involved. First of all, the importance of coastal aquifers within the context of the coastal zone including the shallow marine environment has been fully confirmed. It can be now stated, based on solid information, that:

- coastal aquifers are a major water resource along the Mediterranean coastline, and often represent the main source of drinking water for the growing littoral populations
- submarine groundwater discharges are large, and in places superior to surface water inflows; hence, coastal aquifers contribute to and sustain shallow marine ecosystems
- major coastal wetlands, lagoons, humid zones and coastal habitats, providing very valuable services and contributing to coastal livelihoods and biodiversity, are all in part or totally dependent on groundwater regimes.

In spite of all this, the regional picture that emerges from assessment of the current state of these critically important resources is one of generalized neglect and progressive degradation. Findings in fact show that:

- generalized coastal groundwater degradation contributes to exacerbating issues of transboundary concern at the LME level, such as nutrient pollution, habitat and coastal freshwater dependent ecosystems degradation
- expert opinions and the existing quantitative data indicate a regionally preponderant medium to high level of contamination from nutrients, other hazardous substances and salinization, the latter being often attributed to seawater intrusion
- scientific knowledge and public awareness of coastal aquifers is scanty or non-existent in most countries. Monitoring is occasional at best, lacks modern technologies and strategic, multi-purpose design
- as a consequence, management frameworks for coastal groundwater are absent, and these resources are not formally recognized as critical for the sustainability of coastal developments, and as being highly vulnerable
- unregulated exploitation is common, and no quality-quantity safeguards exist or are applied. Conflicts among uses (agriculture, domestic, tourism, environment, energy, etc.) are common and potentially disruptive
- in spite of the abundant scientific information on Mediterranean wetlands, and of the frequent existence of some kind of protection scheme, most of the wetlands are reported as having their functionality altered in different degrees. Half of the wetlands are moderately altered, and the other half are highly to very highly altered
- no specific laws or policies exist in the vast majority of the countries protecting and regulating the use of coastal groundwater that take into account its strategic value, its high vulnerability to contamination and its interactions with the sea. General water laws apply, normally with little or no discrimination between surface and groundwater. The same is true for the institutional settings
- the present ICZM Protocol includes very limited consideration of coastal groundwater.

This alarming situation calls for the full attention of policy makers at both national and regional levels.

SUPPLEMENT ON COASTAL AQUIFERS FOR TRANSBOUNDARY DIAGNOSTIC ANALYSIS OF THE MEDITERRANEAN SEA LARGE MARINE ECOSYSTEM

Table 3.3.1. Summary of findings

TDA of the Mediterranean Sea LME – 2005			TDA of the Mediterranean Sea LME: Coastal aquifers supplement		
Major perceived environmental concerns in the Mediterranean Sea LME	**Statement of the causes**	**Main issues of transboundary concern**	**Contribution of coastal aquifers degradation to issues of transboundary concern**	**Coastal aquifers likely to be causing impacts, and level of risk**	**Causes of degradation: environmental and legal aspects**
Decline in biodiversity	Pollution (sewage, oil, nutrients), invasive species, introduced species, land reclamation, river damming and flow modification, over-fishing, by-catch and adverse effects of fishing gear and uses on marine habitats (e.g. bottom trawling), solid waste disposal at sea, uncontrolled tourist presence in ecologically sensitive areas as well as inadequate public and stakeholder awareness, and inadequate or non-existent legislation and available means of enforcement	Land-based pollution	Submarine discharges of contaminated groundwater polluting coastal waters	**High** Annaba (Algeria), North Nile delta (Egypt), Bou-Areg (Morocco), Martil-Alila (Morocco), Bojana (Montenegro), Ras Jebel (Tunisia) **Medium** Collo-Teleza (Algeria), Plaine de la Mitidja (Algeria), Gaza (Palestine), Grombalia (Tunisia)	Domestic, agricultural and industrial solid and liquid wastes contaminating shallow unconfined coastal aquifers Lack of adequate coastal zone land-use planning tools (coastal aquifer comprehensive vulnerability mapping) and policies Weak enforcement of existing laws and regulations, and of sanitary groundwater protection zones Lack of, or weak, monitoring capacity and protocols
		Degradation and conversion of critical habitats: sea grass meadows; coastal wetlands and lagoons	Impaired aquifer function in sustaining coastal lagoons and wetlands and the services they provide due to pollution, over-exploitation, seawater intrusion and/or reduced natural recharge. Modifications of near-shore habitats due to sea water intrusion or to reduced submarine discharges of groundwater	**High** Istra (Croatia), North Nile Delta (Egypt), North Sinai (Egypt), Beirut (Lebanon), Damour (Lebanon), Tyr Saida (Lebanon), Bou-Areg (Morocco), Martil-Alila (Morocco), Boka Bay (Montenegro), Bojana (Montenegro), Chegarnia-Sidi Abicha-Oued El Khairat (Tunisia), Côte Orientale (Tunisia), Gabes (Tunisia), Mahdia-Ksour Essaf-Sidi Alouane (Tunisia), Ras Jebel (Tunisia), Sahel de Sfax deep and shallow (Tunisia) **Medium** Šibenik-rogoznica (Croatia), Neretva (Croatia), Ravni Kotari (Croatia), Ghis-Nekkor (Morocco)	Land use practices causing growing impermeability of land surface Climate variability and change reducing natural recharge rates
Decline in sea-water quality	Land-based sources of marine pollution, both point and non-point, determine increasing trends in eutrophication and its related oxygen deficiency and bloom of nuisance species; presence of hotspots of pollution (125 identified by TDA) leading to decline in overall water quality, loss of coastal habitats and biodiversity, and human health problems	Land-based pollution: (i) point sources (excess of nutrients, persistent toxic substances) (ii) non-point sources (mostly nutrients from agriculture, and sediments)	Submarine discharges of contaminated groundwater polluting shallow coastal waters	**High** Annaba (Algeria), North Nile delta (Egypt), Bou Areg (Morocco), Martil-Alila (Morocco), Bojana (Montenegro), Ras Jebel (Tunisia) **Medium** Collo-Teleza (Algeria), Plaine de la Mitidja (Algeria), Gaza (Palestine), Grombalia (Tunisia)	Domestic, agricultural and industrial wastes contaminating shallow unconfined coastal aquifers Lack of adequate coastal zone land-use planning tools (coastal aquifer comprehensive vulnerability mapping) and policies Weak enforcement of existing laws and regulations, and of sanitary groundwater protection zones Lack of, or weak, monitoring capacity and protocols
		Anthropogenic pressures on coastal zones	Reduced submarine discharges of high-quality groundwater	**High** Istra (Croatia), North Nile Delta (Egypt), North Sinai (Egypt), Beirut (Lebanon), Damour (Lebanon), Tyr-Saida (Lebanon), Bou-Areg (Morocco), Martil-Alila (Morocco), Boka Bay (Montenegro), Bojana (Montenegro), Chegarnia-Sidi Abicha-Oued El Khairat (Tunisia), Côte Orientale (Tunisia), Gabes (Tunisia), Mahdia-Ksour Essaf-Sidi Alouane (Tunisia), Ras Jebel (Tunisia), Sahel de Sfax deep and shallow (Tunisia) **Medium** Sibenik Rogoznica (Croatia), Neretva (Croatia), Ravni Kotari (Croatia), Ghis-Nekkor (Morocco)	Over-exploitation of coastal groundwater Loss of permeability of the land surface – deforestation, urban, touristic and industrial developments – causing reduced rainwater infiltration

TDA of the Mediterranean Sea LME – 2005			TDA of the Mediterranean Sea LME: Coastal aquifers supplement		
Major perceived environmental concerns in the Mediterranean Sea LME	**Statement of the causes**	**Main issues of transboundary concern**	**Contribution of coastal aquifers degradation to issues of transboundary concern**	**Coastal aquifers likely to be causing impacts, and level of risk**	**Causes of degradation: environmental and legal aspects**
Human health risks	Pollutants that degrade the ecosystem also present risks to human health, including heavy metals, organochlorines, pesticides and hydrocarbons, and also microbial and viral pollution. In addition, the response of the ecosystem to stress may induce toxicity that may affect humans, such as toxic dinoflagellates that in some instances arise from eutrophic conditions. Primary pathways for human health risks include ingestion of water or seafood products, contact with contaminated seawater (or in some cases, beaches), and perhaps contact with contaminated seafood (for marine products workers)	Land-based pollution	Submarine discharges of contaminated groundwater polluting shallow coastal waters	**High** Annaba (Algeria), North Nile delta (Egypt), Bou-Areg (Morocco), Martil-Alila (Morocco), Bojana (Montenegro), Ras Jebel (Tunisia) **Medium** Collo-Teleza (Algeria), Plaine de la Mitidja (Algeria), Gaza (Palestine), Grombalia (Tunisia)	Domestic, agricultural and industrial wastes contaminating shallow unconfined coastal aquifers. Lack of adequate coastal zone land-use planning tools (coastal aquifer comprehensive vulnerability mapping) and policies Weak enforcement of existing laws and regulations, and of sanitary groundwater protection zones Lack of, or weak, monitoring capacity and protocols
		Anthropogenic pressures on coastal zones	Loss of coastal ecosystem services	Annaba (Algeria), Neretve (Croatia), Ravni Kotari (Croatia), North Nile Delta (Egypt), North Sinai (Egypt), Bou-Areg (Morocco), Martil-Alila (Morocco), Bojana (Montenegro), Chegarnia-Sidi Abicha-Oued El Khairat (Tunisia), Côte Orientale (Tunisia), Gabes (Tunisia), Sahel de Sfax shallow (Tunisia)	Impaired aquifer function in sustaining coastal lagoons and wetlands
			Coastal aquifer salinization	**High** Istra (Croatia), North Nile Delta (Egypt), North Sinai (Egypt), Beirut (Lebanon), Damour (Lebanon), Tyr-Saida (Lebanon), Bou-Areg (Morocco), Martil-Alila (Morocco), Boka Bay (Montenegro), Bojana (Montenegro), Chegarnia-Sidi Abicha-Oued El Khairat (Tunisia), Côte Orientale (Tunisia), Gabes (Tunisia), Mahdia-Ksour Essaf-Sidi Alouane (Tunisia), Ras Jebel (Tunisia), Sahel de Sfax deep and shallow (Tunisia) **Medium** Sibenik Rogoznica (Croatia), Neretva (Croatia), Ravni Kotari (Croatia), Ghis-Nekkor (Morocco)	Over-extraction of groundwater
			High human dependency on coastal groundwater for domestic purposes	High to medium in all coastal aquifers	Lack of alternative high-quality sources

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4.

PILOT PROJECTS: SUMMARY OF RESULTS

In addition to the inventory and characterization of coastal aquifers (making them visible) feeding into the TDA supplement, the Coastal Aquifers sub-component of MedPartnership included a number of pilot demonstrations, or projects, dedicated to coastal aquifers. These aimed to test new integrated management approaches and assessment technologies often novel to the region.

These pilot projects deal with four major themes:

- Coastal aquifer vulnerability mapping in different hydrogeologic environments
- Low-cost assessment methods (hydro-geochemistry)
- Assessment methodologies for groundwater-related coastal ecosystems: coastal wetlands and lagoons
- Integrated management frameworks: expanding ICZM policies and plans to include consideration of coastal aquifers.

The results obtained with the pilots have been critical in various ways. They have in fact:

- strengthened the capacity of country institutions, agencies and academia in issues related to coastal aquifers and groundwater
- helped in sharing expertize and information among MedPartnership countries
- fostered compliance with regional policies (ICZM Protocol)
- tested assessment and management practices and approaches novel to the region.

Particularly because of the latter point, the results of the pilot projects have been taken into full consideration when identifying the priority actions needed to reverse coastal aquifer degradation trends, and definition of the sub-regional action plans.

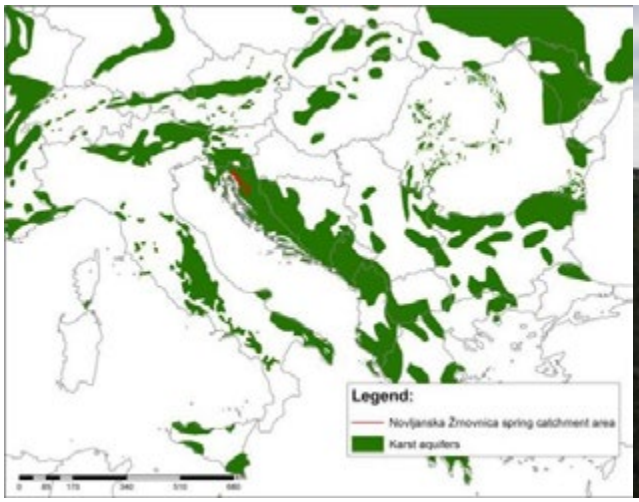
In this Final Report only the key aspects of each pilot demonstration are summarized in the following sections, grouped according to the themes above.

4.1 VULNERABILITY MAPPING

4.1.1 Vulnerability mapping of Novljanska Zrovnica karstic spring catchment area, Croatia

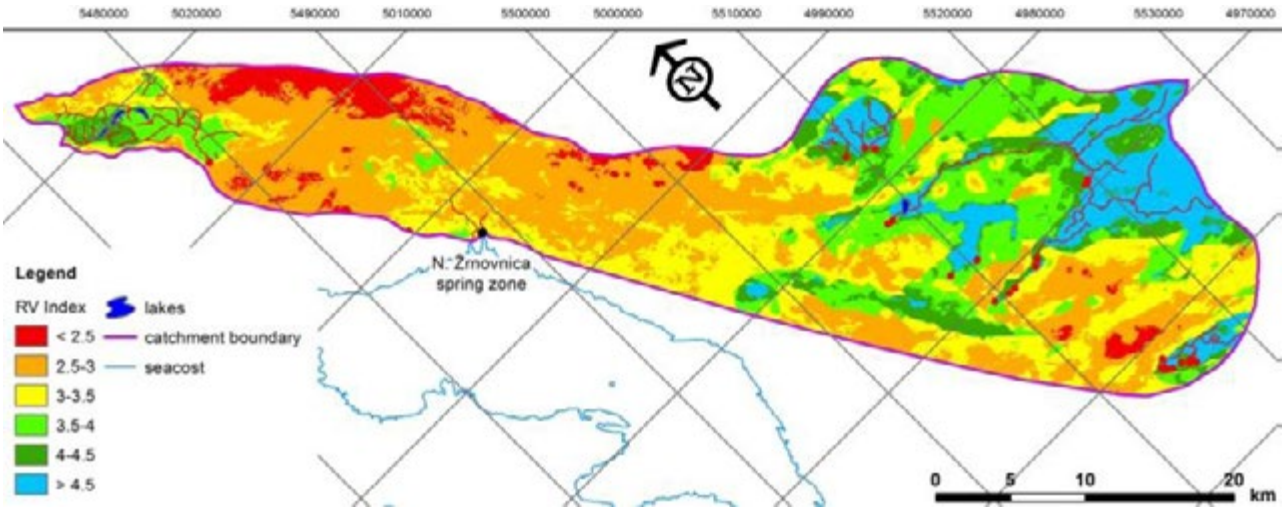
Location

Croatia, N. Dalmatia



Description

The pilot project consisted in a comparative review of four methods for assessing the intrinsic vulnerability of karstic groundwater to pollution: the PI (Germany), the COP (Spain), SINTACS (Italy) and Drastic (USGS) and applying them to the Novljanska Zrovnica karstic spring catchment area in Croatia, which is a good representative of the whole Dinaric karst coastal area. This exercise allowed a new method better suited for Dinaric karst terrains (Karst Aquifers Vulnerability Assessment, KAVA) to be developed and tested. The methods analysed, including KAVA, do not consider vulnerability to seawater intrusion.



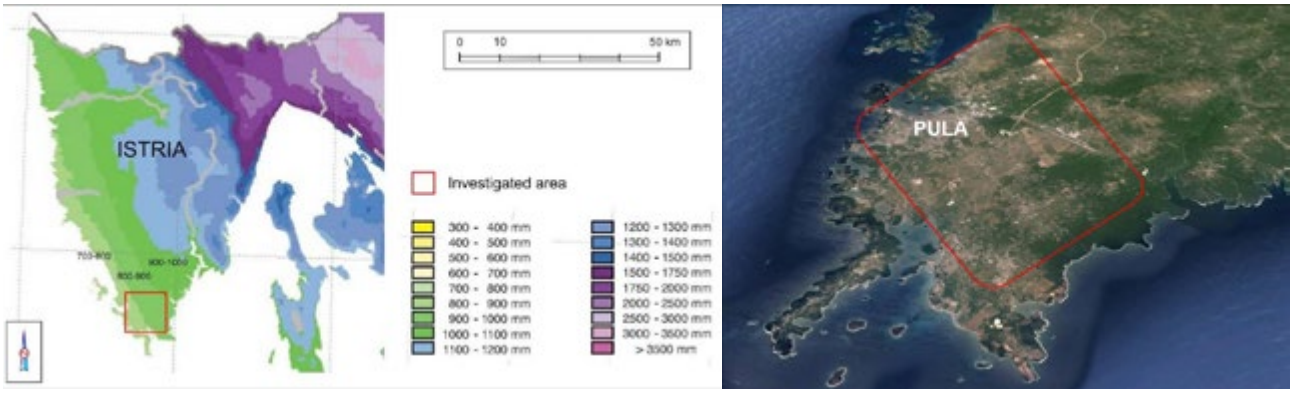
Implementing entity: University of Zagreb – Faculty of Geotechnical Engineering

RV Index, resource vulnerability index.

4.1.2 Vulnerability mapping of the Pula coastal aquifer, Croatia

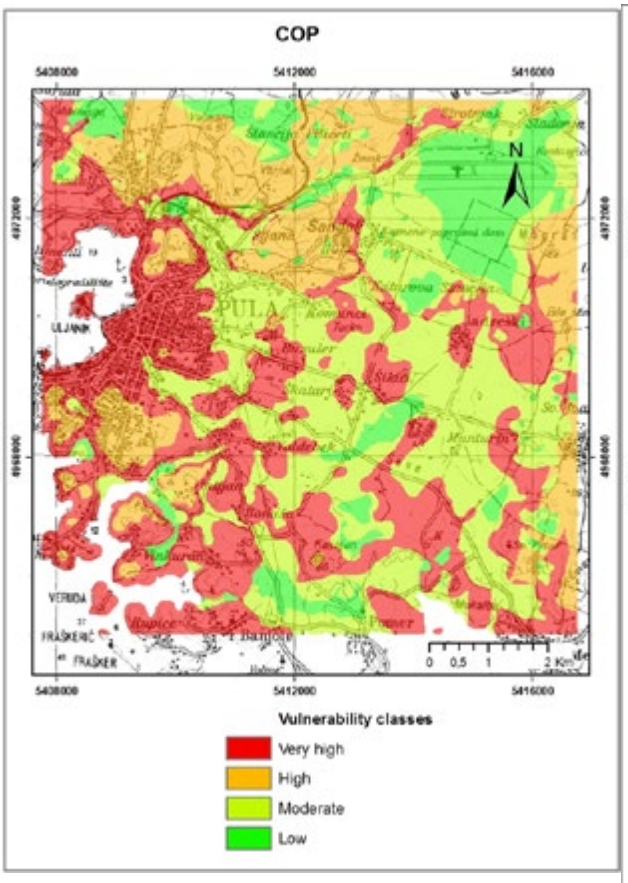
Location

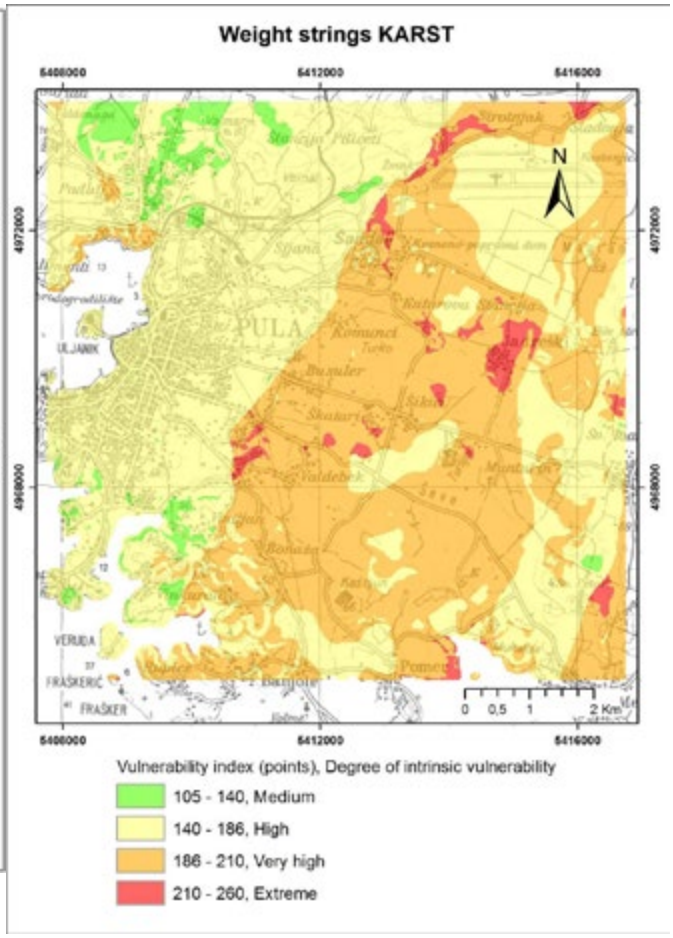
Croatia, Istria



Description

The vulnerability of the Pula coastal aquifer was analysed with the SINTAKS method (Civita and De Maio, 2000a, b) and by the COP method derived from the conceptual model "European Approach" developed within COST Action 620 (Zwahlen, 2004). The site chosen was representative of high population density and urbanization in coastal karst terrains. Great attention was given to the properties of soil cover, which were researched in more detail. It was confirmed they have a positive impact on reducing the vulnerability of karst aquifers, mainly in the event of contamination from the ground surface. Sewage systems – and in this area numerous permeable septic tanks – are generally buried in the carbonate bedrock below protective covers. In this situation it is assumed that the bulk of contamination or increased nitrate concentrations in most of the water supply wells originated in wastewater, not from agriculture as usually believed. This could be determined by isotope studies (not part of this project). This karst aquifer is in direct contact with the sea. Previous analysis of saltwater intrusions show that this influence extends up to 1 km inland. The methods used in this pilot project to assess intrinsic vulnerability (SINTACS and COP) are not suitable for the analysis of this impact.



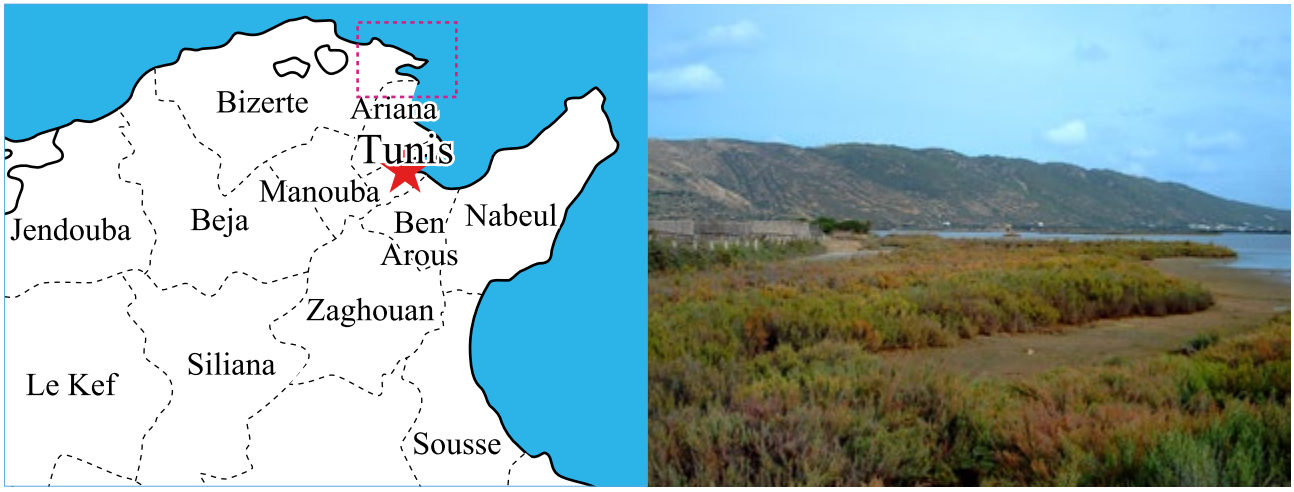


Implementing entity: Croatian Geological Survey

4.1.3 Merging vertical, horizontal and "sea level rise vulnerability" to map "comprehensive vulnerability", Tunisia

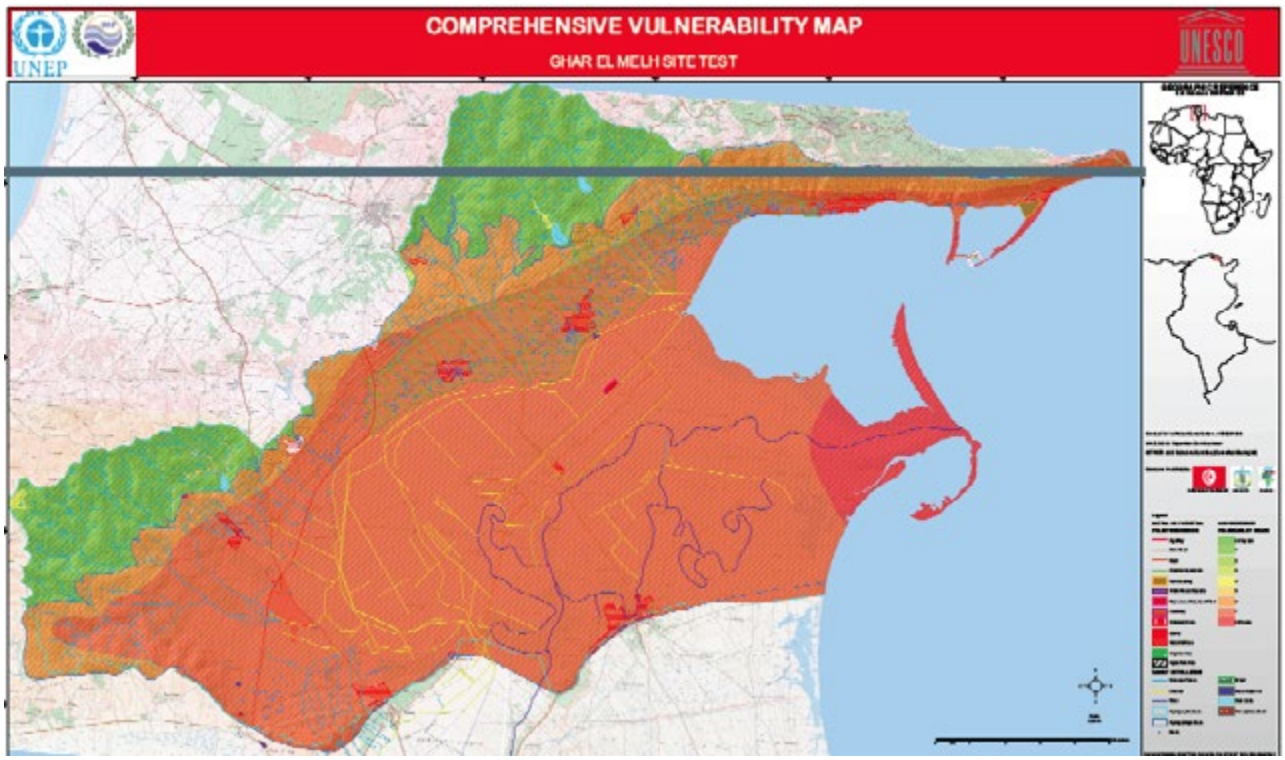
Location

Ghar El Melh, Tunisia



Description

The pilot project developed and tested a new methodology, Aquifer Comprehensive Vulnerability Mapping (ACVM) which comprises: (i) a new methodology for mapping horizontal vulnerability associated with saltwater intrusion; and (ii) a new methodology for merging vertical and horizontal vulnerability in order to map "comprehensive vulnerability" in coastal areas. This method is the only one taking into consideration marine water intrusion into coastal aquifers, and hence highly replicable in all coastal areas. It has been tested in the estuary of the Medjerda River and proven effective in providing useful indications on land uses and practices that impact negatively on alluvial coastal aquifer functions and integrity.



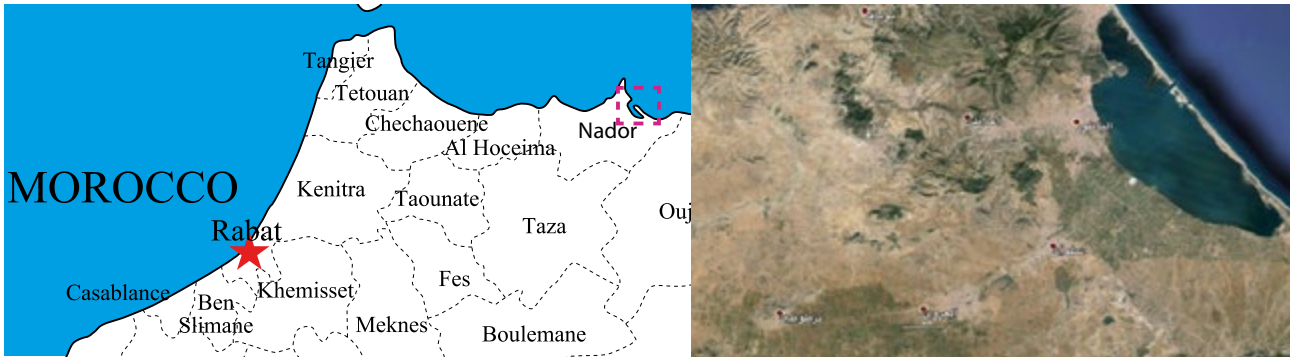
Implementing entity: Dr S. Carrubba, with the support of Tunisia's Office of Hydraulic Inventory and Researches (BIRH) the Water Resources Department (DGRE) and the Ministry of Agriculture, Water Resources and Fisheries, and the co-financing of Italy's Ministry of the Environment and Protection of Land and Sea.

4.2 HYDROGEOCHEMICAL DIAGNOSTIC TOOLS

4.2.1 A hydrogeochemical-based approach for managing transition areas: Nador Lagoon, Morocco

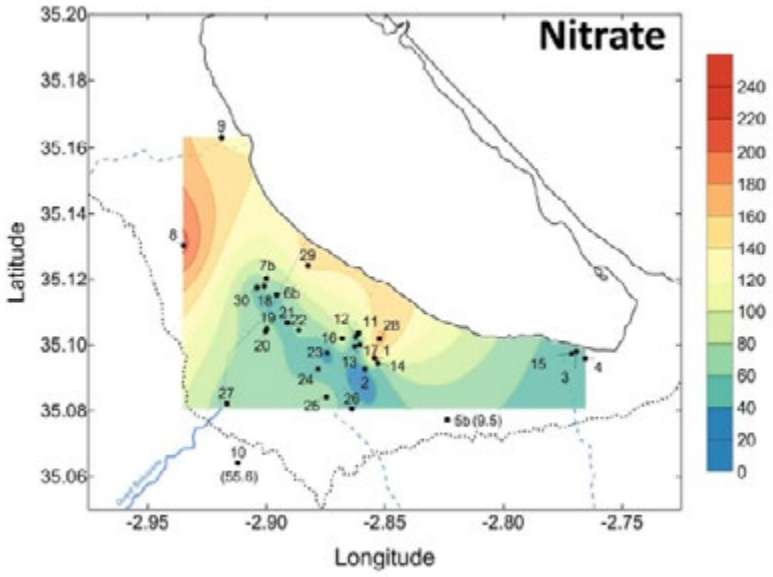
Location

Nador Lagoon, Morocco



Description

The pilot tested hydrogeochemical tools to identify sources of groundwater contamination and mixing processes between the aquifer, surface water and lagoon. The geochemical and isotopic (δ2H, δ18O, δ13C, δ15NNO3 and δ18ONO3) characterization of the Bou Areg alluvial coastal aquifer in north Morocco was based on samples collected during two surveys in November 2009 and June 2010, and enabled identification of runoff from the mountain regions and agricultural return flows as the main sources of the aquifer recharge. The high salinization of the aquifer is partly due to intensive agriculture and is also associated with the intrinsic qualities of the catchment. The isotopic signal of dissolved nitrates allowed identification of three main sources of nitrogen in the system: (i) fertilizers; (ii) soil organic matter; (iii) manure and septic tank effluent. Statistical treatment of the data highlighted the absence of saline water intrusion from the lagoon.



Implementing entity: Ca Foscari University, Venezia

4.3 COASTAL ZONE MANAGEMENT PLANS

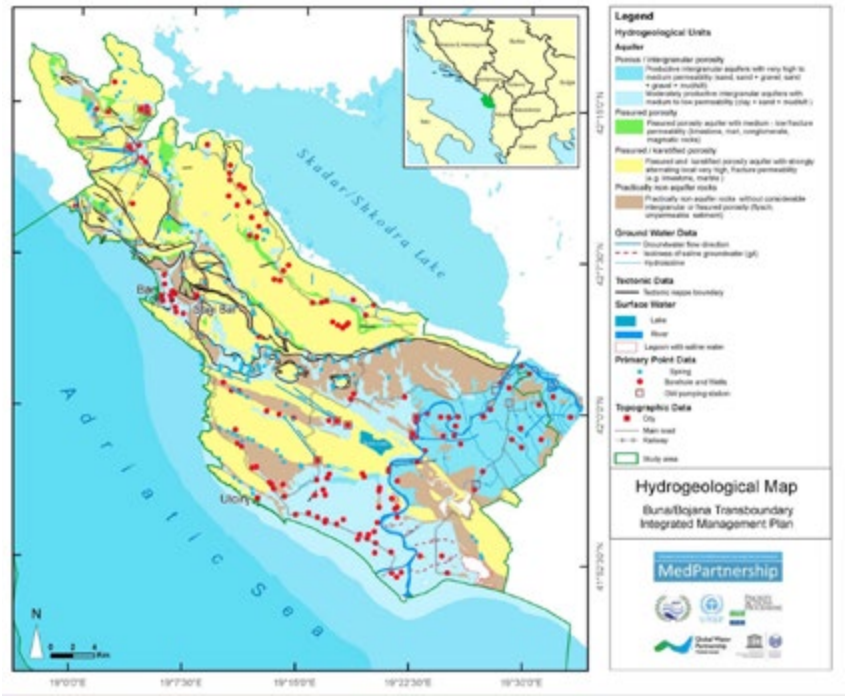
4.3.1 Transboundary integrated management plan of the Buna/Bojana coastal area, Albania and Montenegro

Location

Buna-Bojana Delta: Albania, Montenegro

Description

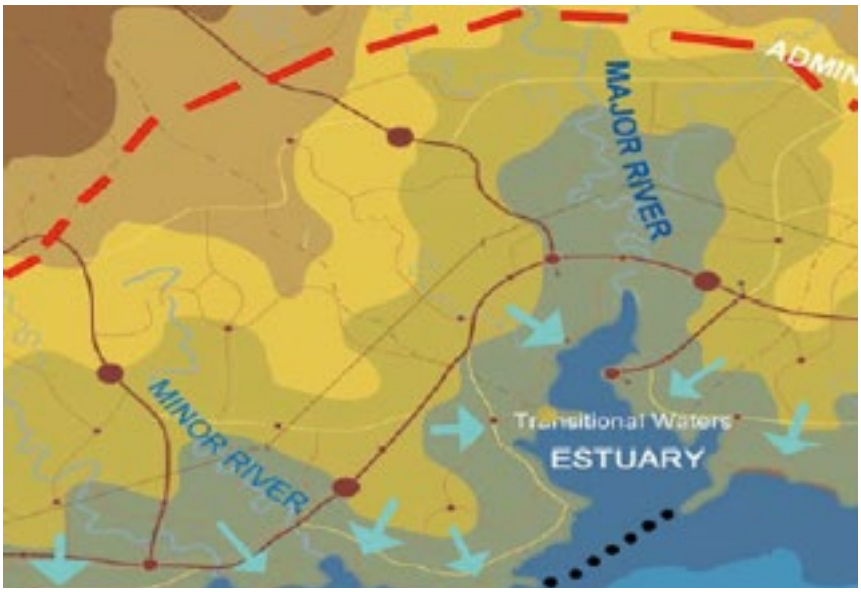
The Buna/Bojana integrated management plan integrates established methodologies for IWRM, biodiversity, ICZM and coastal aquifers management into a single IMF, with climate change as a cross-cutting issue. The Plan also seeks the optimal combination of these approaches within the transboundary area of Montenegro and Albania, bringing together, therefore, the administrative structures of the two states and their relevant localities. The Buna/Bojana River with its catchment and coastal waters provide the common physical thread linking the two countries; a hydrological system underpinning natural and socioeconomic processes.



Implementing entity: PAP RAC, GWP-Med, UNESCO IHP, and the Geological Surveys of Albania and Montenegro

4.3.2 Towards converging management approaches for the Mediterranean coastal zone: an integrative methodological framework – ICZM, IWRM and coastal aquifers management

General methodology applicable to all coastal areas of the Mediterranean



Description

The Integrative Methodological Framework (IMF) and Planning Guidelines are intended to:

- identify possibilities and solutions for converging coastal, river basin, aquifer and groundwater management, and also considering the implementation of the ecosystem approach
- integrate climate change considerations as a cross-cutting issue throughout the planning and implementation processes in coastal zones
- support the active involvement of stakeholders and the general public in the planning and management of coastal zones.

The IMF approach gives special emphasis to coastal aquifer management. The goals of coastal aquifer management and planning are to protect, enhance and – to the extent possible – restore the status of all bodies of coastal groundwater, prevent their pollution and deterioration, ensure a balance between groundwater abstraction and replenishment and reduce sea water intrusion processes. Groundwater is frequently a water resource extensively abstracted for domestic uses and industry, but mostly for irrigated agriculture.

COASTAL ZONE USE CAPABILITY with RESPECT TO COASTAL AQUIFERS INTEGRITY

VULNERABILITY MAP UNITS			ACTIVITIES									
LAND UNIT	GEOLOGY	COMPREHENSIVE VULNERABILITY OF COASTAL AQUIFERS	Fish Farming	Solid waste disposal	Surface disposal of untreated liquid wastes	Heavy construction	Excavation, and extraction of natural materials	Devegetation	Use of herbicides, pesticides, insecticides	Irrigation	Cemeteries	Groundwater abstraction
Northern slopes	Permeable sands & calcarenites	MEDIUM		0	0	0		X	X		0	
	Impermeable Marls and clays	LOW										
Coastal Plain	Recent alluvial deposits and beach sands	HIGH		0	0	0	0	0	X		X	X
Estuary	Deltaic deposits at sea level	VERY HIGH	X	XX	XX	XX	XX	X	XX		XX	XX
Coastal wetlands	Salt water marsh			X								

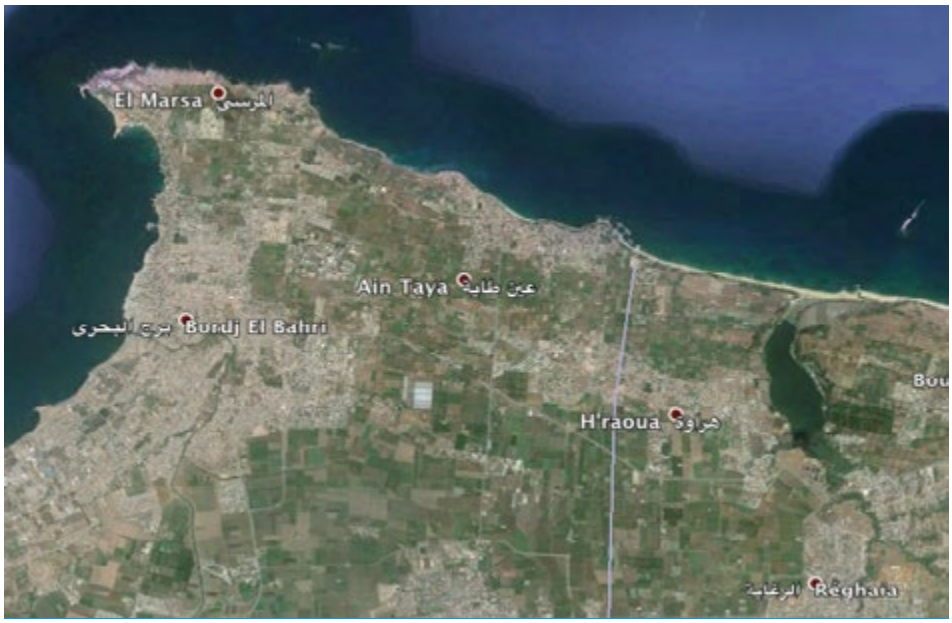
SIGNIFICANT PROBLEMS UNLIKELY
UNDESIRABLE PROBLEMS LIKELY X
UNDESIRABLE SIGNIFICANT PROBLEMS LIKELY XX
POSSIBLE PROBLEMS 0
NOT APPLICABLE

Implementing entity: GWP-Med, PAP RAC, UNESCO-IHP

4.3.3 Reghaia coastal zone plan, Algeria

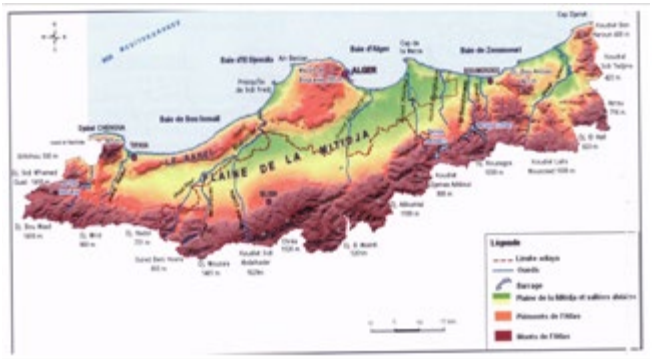
Location

Reghaia, Algeria

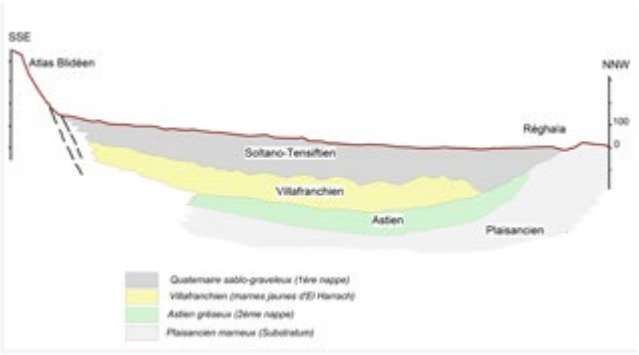


Description

The main objective of this pilot coastal planning exercise was to prepare an integrated management plan based on a fully fledged diagnostic of the current state of the coastal zone of Reghaia, and of the degradation processes active in the area (aggressive urbanization, demographic growth, alarming pollution) as well as the key resources and development potential. Among them coastal aquifers – in particular the Mitidja alluvial aquifer – play a fundamental role in sustaining human livelihoods and ecosystems. Aquifer protection measures are incorporated into the Reghaia Plan.



(Mimouni 2010) (Haouchine 2013)



(Haouchine 2013)

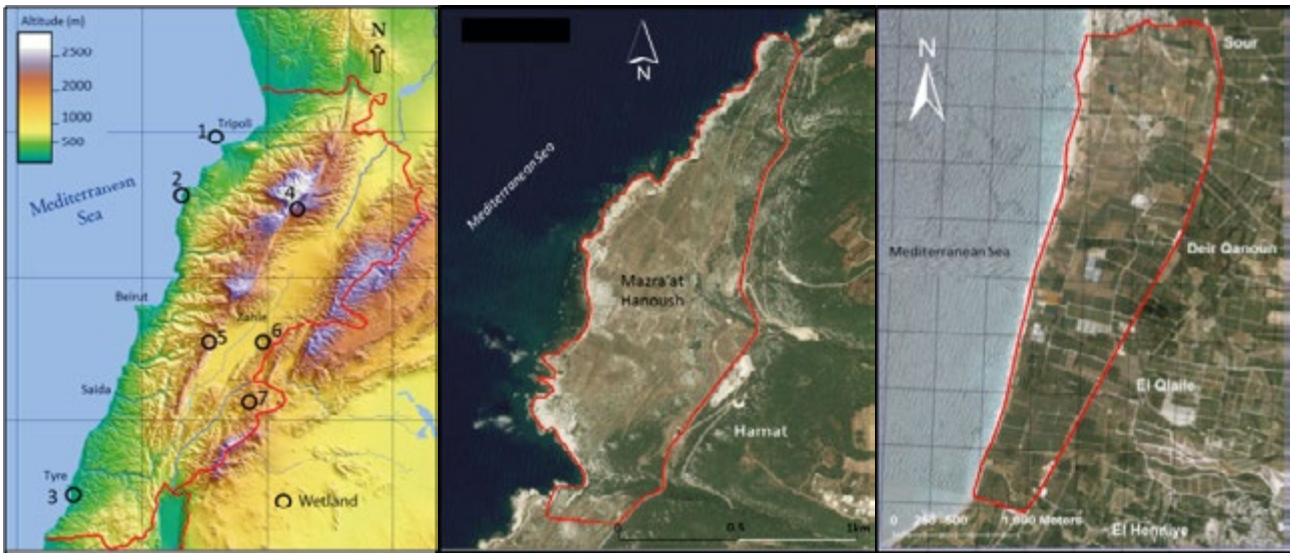
Implementing entity: PAP RAC, with the support of Algeria's Ministry of Water Resources and Environment and contributions from UNESCO-IHP

4.4 WETLAND CHARACTERIZATION

4.4.1 Impact of climate change on water resources of the coastal wetlands of Lebanon

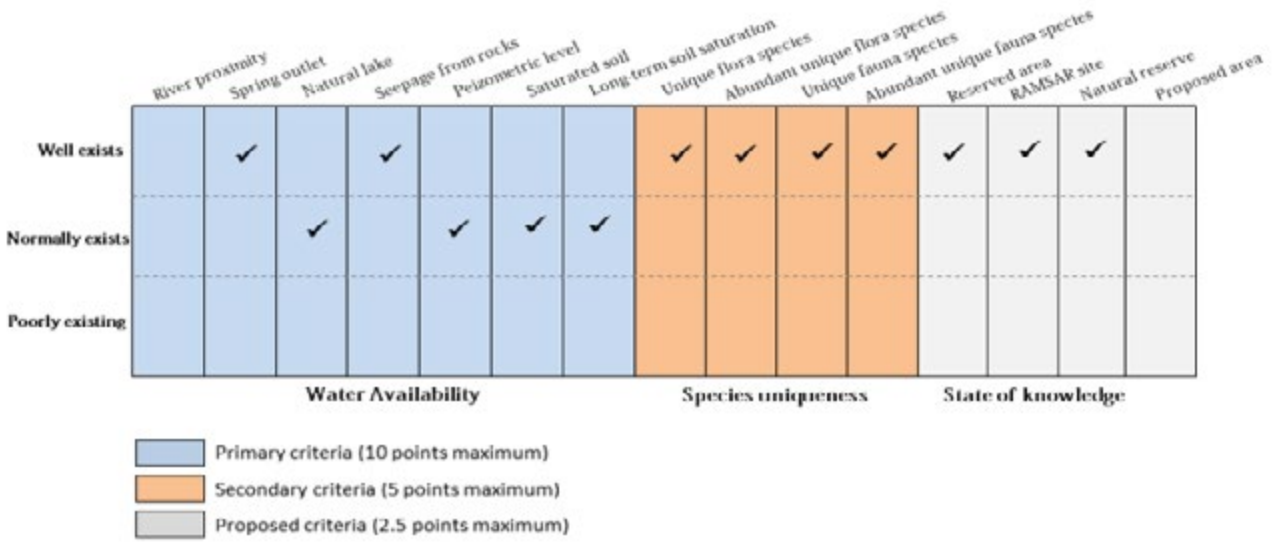
Location

Coastal zone of Lebanon



Description

Changing climatic conditions, with a special emphasis on changing rainfall patterns and temperature increase, have a primary role in affecting wetlands in Lebanon, notably those with a fragile hydrologic balance. Two sites were investigated: the Ras Ech-Chekkaa Cliffs and Tyre Beach. The first was found not to be in conformity with the definition of a wetland. Both sites were found to be impacted by human and climatic pressures.



Implementing entity: Lebanese National Council for Scientific Research

5.

SUB-REGIONAL ACTION PLANS FOR MEDITERRANEAN COASTAL AQUIFERS

The general purpose of the Plans is to aim to a situation where:

- there are appropriate and implemented legal, regulatory and institutional frameworks for coastal groundwater and dependent ecosystems that enhance public guardianship and collective responsibility, permanent engagement of stakeholders and beneficial integration with other sectors, including other uses of the subsurface space and its resources
- all major coastal aquifer systems are properly assessed, and the resulting information and knowledge are available and shared, making use of up-to-date information and communication techniques
- plans are prepared and implemented for the priority aquifers
- groundwater management agencies – locally, nationally and internationally – are resourced and their key tasks of capacity building, resource and quality monitoring, and promoting demand management and supply-side measures are secured
- incentive frameworks and investment programmes foster sustainable, efficient coastal groundwater use and adequate groundwater resources protection.[16]

While this vision might possibly be attainable only in a distant future, actions can – and must – be taken now to reverse the degradation trends of coastal aquifers, coastal habitats and other natural resources, and to introduce elements of sustainability.

Guidance from the Groundwater Governance Project

Guiding principles and priority actions for improved groundwater management and effective institutions have been established as a result of the initiative "Groundwater Governance – A Global Framework for Action" (2011-2015), a joint effort of the Global Environment Facility (GEF), the Food and Agriculture Organization of the United Nations (FAO), UNESCO's International Hydrological Programme (UNESCO-IHP), the International Association of Hydrogeologists and the World Bank. These principles and actions are fully applicable to coastal aquifers, and the MedPartnership countries are encouraged to take these into consideration as they take measures to reinforce their legislation and policies on groundwater. [http://www.groundwatergovernance.org]

Preparation of sub-regional action plans: the process

Component 1 of MedPartnership represents an attempt to integrate river basin management, ICZM and – for the first time – consideration of coastal aquifers into marine protection, based on the recognition that the integrity of marine ecosystems largely depends on natural processes and human interactions occurring in adjoining coastal lands.

The findings of the Assessment (Chapter 2), the conclusion of the TDA Supplement (Chapter 3) and the results achieved by the pilot demonstrations (Chapter 4), combined with the additional information provided by national experts in the national reports, form the body of knowledge necessary to move from assessments and diagnostics to remedial action.

Based on all this information, national consultations were held in all countries involved in the coastal aquifers sub-component among national responsible entities, coastal zone stakeholders and water users. These consultations facilitated debate and agreement on the country position with respect to the legal, institutional and policy reforms, and the investments deemed necessary for addressing the most pressing concerns and barriers relating to coastal aquifers and their role in coastal zone health.

Following the national consultations, two sub-regional consultations were held, one for the Adriatic basin countries, and one for the south, central and Levantine basin countries . The objective was to reach agreement on two *harmonized plans of priority actions needed to reverse coastal aquifer degradation trends, and to improve knowledge and management capacity.*

To facilitate national and sub-regional dialogue among countries, and to inform the discussions at decision maker level, UNESCO formulated the following suggestions and recommendations.

National Level Actions

1. Strengthening knowledge as a necessary basis for coastal aquifer and coastal zone management. This would include, as a first step for high priority aquifers only:
   (i) The further improvement of the *inventory and characterization produced* by MedPartnership, through in-depth systematic assessments using hydrogeochemical techniques and low-cost geophysical investigations, among others; assessing seawater intrusion and aquifer salinization; identifying other sources of contamination; mapping water and land uses; inventorying wells; estimating abstractions and related energy consumption
   (ii) The identification of major *submarine discharge zones, and assessment of flows* and contaminant loads
   (iii) The systematic *mapping of groundwater vulnerability in the coastal zone,* using methods accounting for both vertical and horizontal vulnerability, and defining local land uses and human activities compatible with the various classes of vulnerability
   (iv) The design and testing on the ground of *modern multi-purpose monitoring networks*
   (v) The assessment and *diagnostic of coastal ecosystems dependent on* priority aquifers, and the strengthening of management capacity related to ecosystem services and their evolution trends, and on the strong relationships existing between groundwater flows, wetlands services and human well-being
2. Building effective institutions. Laws and regulations should provide for water well development licensing at the appropriate scale, and for controlling localized "point" pollution. Laws and regulations should also impose data sharing and facilitate important processes such as balancing competing or conflicting interests among stakeholders,

16. Groundwater Governance project, 2015, GEF, FAO, UNESCO IHP, IAH, World Bank.

and coordination with urban and rural land uses and with the management of the entire subsurface space. As far as government organizations are concerned, it is preferred to have a national unit or a dedicated team that ensures horizontal cooperation across different levels and the interface with other sectors. Governments should seek for the systematic engagement of stakeholders. The preferred action is to create permanent mechanisms: this can be in the form of water user groups and groundwater forums.

3. Experiment with conjunctive water resources management in pilot coastal areas. All water resources in the coastal zone, including surface, groundwater and treated wastewater, should be managed conjunctively and strategically, with a view to maximizing use efficiency, balancing conflicting uses and avoiding aquifer salinization by eliminating over-exploitation and preventing seawater intrusion, and mitigating the impacts of climate change and variability. Managed aquifer recharge using treated wastewater, or excess runoff during floods, can play a key role in preventing saline water intrusion, and enhance aquifer performance.

Regional Level Actions

The Barcelona Convention has been extended to address the coastal areas. The Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities deals with groundwater as a land-based source point of pollution to the Mediterranean Sea, therefore covering a limited aspect of the management of coastal aquifers. The objective here is the protection of the sea (as indicated in the Protocol's title) and not the proper management of the coastal aquifers as an important source of water in the coastal zone. The Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA) offers protection for areas such as coastal wetlands, which often in the coastal zone depend on coastal aquifers, but the SPA Protocol does not cover coastal aquifers as such. The ICZM Protocol is the one dealing the most with water resources in the coastal zone and mentions coastal aquifers as such and specifies a monitoring requirement for the Parties.

The progress of the consideration of coastal aquifers is to be acknowledged, but there are still gaps. To raise awareness about coastal aquifers at the regional level and integrate their specificities in coastal zones management strategies and plans, the following is recommended:

- Encourage the countries concerned to deposit their instruments of ratification, acceptance, approval or accession of/to the ICZM Protocol
- Uptake of the IMF (prepared as a pilot in the frame of the MedPartnership project by UNESCO-IHP, PAP/RAC and GWP-Med) and its consideration of coastal aquifers in ICZM guidelines and policies
- Create a platform for the exchange of knowledge and technologies between countries in the region adapted for coastal aquifers
- Consider the findings and recommendations of the TDA coastal aquifer supplement prepared by UNESCO-IHP in future actions in the region, and pursue adoption of the coastal aquifers sub-regional action plans under the MAP processes.

Sections 5.1 and 5.2 are a verbatim report of the texts of the sub-regional action plans formally agreed upon by the country representatives.

5.1 ADRIATIC BASIN: PRIORITY ACTIONS RECOMMENDED BY NOMINATED REPRESENTATIVES OF ALBANIA, BOSNIA AND HERZEGOVINA, CROATIA AND MONTENEGRO, 14 MAY 2015, IN SPLIT, CROATIA (MERLA, 2015)

UNESCO-IHP is responsible for assisting the MedPartnership countries in the preparation of a regional action plan on coastal aquifers for the Mediterranean, including a set of actions for the countries sharing Adriatic Basin (Albania, Bosnia and Herzegovina, Croatia and Montenegro). As a first step in this process, UNESCO-IHP prepared a number of synthetic documents to capture the key findings of the regional assessments and case studies carried out for coastal aquifers and groundwater and furthermore proposed possible orientations for actions at national and regional levels. The countries subsequently organized individual national consultations to debate these findings and recommendations in preparation of the sub-regional consultation organized in Split on 13 and 14 May.

The following are the priority actions agreed upon by Albania, Bosnia and Herzegovina, Croatia and Montenegro.

These actions are aimed at the sustainable use of coastal aquifers and at the mitigation of the main transboundary environmental concerns identified in the 2005 TDA for the Mediterranean Large Marine Ecosystem.

National Level Actions

A. Strengthening knowledge of major aquifers as a necessary element for coastal zone management

The systematic *mapping of groundwater vulnerability to pollution and salinization in the coastal zone*, including from

human-induced seawater intrusion, and defining local land uses and human activities compatible with the various classes of vulnerability. As a first step, countries recommend the implementation of large-scale demonstration projects, including field surveys (e.g.: hydro-geochemistry, well inventories) and the gathering of new data, in three important coastal aquifers representing different hydrogeological settings (karst and non-karst). Participants agreed that the Buna/Bojana Delta, the Neretva Delta and the catchment area of springs in the Dubrovnik coastal zone would be good candidates for this activity. The identification of major *submarine groundwater discharge zones*, and assessment of flows and contaminant loads. The design and testing on the ground of *modern multi-purpose monitoring networks*. This will enable countries to generate new data to upgrade the level of knowledge of coastal aquifers and to respond more effectively to emergency situations related to release of pollutants (e.g. leakage from fuel tanks) or early detection of other problems such as salinization.

B. Building effective institutions

Countries agreed on the following specific actions that would support the goal of building effective institutions for groundwater management:

- Incorporate consideration of coastal aquifers and groundwater in evolving water and other relevant legislation and policy instruments.
- Seek solutions to groundwater management challenges with a transboundary aspect (example of sanitary protection zones governed by requirements from different countries).
- Consider systematic stakeholder participation as a cornerstone of water resources management, including coastal aquifers.
- Establish water user groups in coastal areas to encourage the strategic, equitable use of water resources in the context of competing water uses and users.

Regional Level Actions

Encourage the concerned countries to deposit their instruments of ratification, acceptance, approval or accession of/to the ICZM Protocol.

Consider the findings and the recommendations of the TDA Coastal Aquifer Supplement in future actions in the region, and pursue the adoption of the present Action Plan under the UNEP/MAP processes.

Uptake of the Integrative Methodological Framework - developed in the context of MedPartnership and tested in the Buna-Bojana area - and its consideration of coastal aquifers in ICZM guidelines and policies.

Create a mechanism for the exchange of knowledge, data and technologies between countries in the region adapted for coastal aquifers.

Raise awareness on the importance of coastal aquifers to human livelihoods, ecosystem health and economic development, through the organization of events that inform and educate policy makers and actors from other sectors (e.g.: tourism, agriculture) on the role of coastal aquifers in the wider development agenda of the region.

Countries also voiced their interest in the following themes:

- The impact of sea-level rise and climatic variability (including local weather fluctuations and extreme events) on coastal aquifers.
- The impact of human activities that can change aquifer recharge regimes, with urbanization and infrastructure often decreasing recharge particularly in karst areas. The implementation of managed aquifer recharge schemes in coastal areas as a means to combat seawater intrusion.
- The development and use of a harmonized set of 'core indicators' for groundwater for the region. Capturing synergies between the DIKTAS project, the Neretva Delta project and the MedPartnership project. The need to raise awareness, particularly in the tourism industry, on the degradation of seawater quality and biodiversity due to contaminant discharges from aquifers.

FINAL RECOMMENDATION

Countries called for continuing support from the GEF, UNEP/MAP, and UNESCO for the implementation of the action plan and the strengthening of countries' capacity to sustainably manage their coastal resources.

Country representatives

Albania

- Pellumb Abeshi, General Director of Environmental Policies, Ministry of Environment, Forestry and Water Management, MedPartnership and GEF Focal Point for Albania
- Hamdi Beshku, Researcher, Albanian Geological Survey, Hydrogeology Centre
- Irma Balla, Legal Expert

Bosnia and Herzegovina

- Senad Oprašić, Head of Environmental Protection Department, Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina, MedPartnership and GEF Focal Point for Bosnia and Herzegovina
- Boban Jolović, Department Head, Department for Geological Information System, Geological Survey of the Republic of Srpska, Bosnia and Herzegovina
- Selma Osmanagić-Klico, Researcher, Samostalni istraživač, Sekretar Instituta, Secretary of HEIS, Hydro-Engineering Institute Sarajevo

Croatia

- Ivan Radić, Senior Expert Advisor, Ministry of Environmental and Nature Protection, Service for Marine

and Coastal Protection, MedPartnership Focal Point for Croatia

- Želimir Pekaš, Chief Engineer, Croatian Waters, Department of Water Use
- Romana Knežević, Legal Expert, Water Management Directorate, Ministry of Agriculture
- Jure Margeta, Professor, Faculty of Civil Engineering, Architecture and Geodesy University

Montenegro

- Jelena Knezevic, Adviser to the Minister, Ministry of Sustainable Development and Tourism, MedPartnership and MAP Focal Point for Montenegro
- Dragan Radojević, Head of Department, Hydrogeology, Geotechnic and Water Concession, Geological Survey of Montenegro
- Neda Dević, Independent Geologist

5.2 SOUTH, CENTRAL AND LEVANTINE BASINS: PRIORITY ACTIONS RECOMMENDED BY NOMINATED REPRESENTATIVES OF EGYPT, LEBANON, LIBYA, MOROCCO, PALESTINE AND TUNISIA, 10 JUNE 2015, IN RABAT, MOROCCO (MERLA AND STEPHAN, 2015)

The following are the priority actions agreed upon by Algeria, Egypt, Lebanon, Libya, Morocco, Palestine, and Tunisia. Not all countries were able to attend the consultation. Among those absent, Libya, Tunisia and Lebanon have organized National Consultations and submitted reports of their conclusions and recommendations, Algeria will submit the report of the National Consultation soon. It has been agreed that the conclusions reached in Rabat will be shared for comments with the countries that were not able to attend.

The agreed upon priority actions listed below are aimed at the protection and sustainable use of coastal aquifers, at maintaining the integrity of dependent coastal ecosystems, and at mitigating the negative impacts, identified by the TDA Coastal Aquifers Supplement, on the transboundary Mediterranean Large Marine Ecosystem.

National Level Actions

Strengthening knowledge of major aquifers as a necessary element for coastal zone management

The systematic *mapping of groundwater vulnerability to pollution and salinization in the coastal zone,* including from human-induced seawater intrusion, and definition of local land uses and human activities compatible with the various classes of vulnerability.

Countries suggest applying the methodology as demonstration in the following coastal aquifers in the case of a follow-up project:

(i) Gaza coastal aquifer (Palestine)

(ii) Martil coastal aquifer (Morocco)

(iii) Northern Nile Delta (Egypt)

(iv) Cenomanian coastal aquifer (Lebanon)

The identification of major *submarine groundwater discharge zones,* including the assessment of total flows and contaminant loads, and of their linkages to shallow marine ecosystems (the identification methods such as, monitoring, modeling or use of space techniques would depend on each country etc.).

The design and implementation of *modern multi-purpose monitoring networks* including early alarm systems to monitor the progress of seawater intrusion, and other emergency situations, as expansions of existing systems, whenever the case.

The assessment of the technical – economic and environmental feasibility of Managed Aquifer Recharge schemes, using treated wastewater and/or floodwaters, in coastal areas characterized by extreme groundwater stress such as Palestine.

The integration of the results, whenever available, of the MedPartnership complementary project on the coastal impacts of climatic variability and change in the Mediterranean, into the Coastal Aquifers Supplement, and priority actions definition process.

Consider traditional knowledge and practices as means to protect coastal aquifer integrity and enhance sustainability.

Building effective institutions

Countries agreed on the following recommendations for action that would support the goal of building effective institutions for coastal aquifers management:

Incorporate consideration of groundwater and coastal aquifers in evolving water and other relevant legislation and policy instruments.

Consider systematic stakeholder participation and establishment of water user groups as a cornerstone of water resources management, to encourage the strategic, equitable use of water resources in the context of competing water uses and users, along the lines of the "contrat de nappe" in Morocco.

Strengthen the capacities of managers in the administrations, researchers and promote research on coastal aquifers

Enhance cross-sectoral cooperation and form broadly based multi-ministry task forces or equivalent bodies tasked to plan and implement efficient water management systems in coastal zones.

Apply a reasonable tariff for groundwater supply and abstraction thresholds.

Regional Level Actions

Encourage the concerned countries to deposit their instruments of ratification, acceptance, approval or accession of/to the ICZM Protocol.

Consider the findings and the recommendations of the TDA Coastal Aquifer Supplement in future actions in the region, and pursue the adoption of the present Action Plan under the UNEP/MAP processes.

Uptake of the Integrative Methodological Framework - developed in the context of MedPartnership and tested in the Buna-Bojana area (Albania-Montenegro) - and its consideration of coastal aquifers in ICZM guidelines and policies.

Create a mechanism for enhanced Mediterranean cooperation and the exchange of knowledge, data and technologies between countries in the region adapted for coastal aquifers.

Countries also voiced their interest in the following themes:

- The impact of climatic variability (including local weather fluctuations and extreme events) on coastal aquifers.
- The development and use of a harmonized set of 'core indicators' for coastal aquifers for the region.

FINAL RECOMMENDATION

Countries called for continuing support from the GEF, UNEP/MAP, and UNESCO-IHP for the implementation of the action plan and the strengthening of countries' capacity to sustainably manage their coastal resources.

Country representatives

Algeria

- Mr Samir Grimes, Project focal point

Egypt

- Ms Heba Sharawy, Project focal point, Egyptian Environmental Affairs Agency
- Mrs Nahed El Sayed El Arabi Abdel-Aziz, National Water Research Centre

Lebanon

- Ms Lara Samaha, Project focal point, Ministry of Environment
- Mr Samer Al-Hashem, Ministry of Environment
- Mr Nadim Farajallah
- Mr Raphael Sfeir
- Mr Amin Shaban, CNRS Lebanon

Libya

- Mr Mustafa Soliman, Project focal point, Environment General Authority
- Mr Omar Salem, General Water Authority
- Mr Rashid Elfutaisi, General Water Authority
- Mr Nassir Bsher Madi, MED POL- UNEP/MAP Focal point

Morocco

- Ms Nassira Rheyati, Project focal point, Ministère délégué chargé de l'Environnement
- Mr Jaouad Filali Moutei, Ministère délégué chargé de l'Eau
- Mme Rachida LYAZIDI, Ministère délégué chargé de l'Eau
- Mr Hafid El Oualja, Ministère délégué chargé de l'Environnement
- Mr Mohamed Reda Aoulad Mansour, Agence de Bassin Hydraulique du Loukos
- Mr Boubker Houadi, Agence de Bassin Hydraulique de Moulouya
- Mr NourEddine Serrhini, Agence de Bassin Hydraulique du Sebou
- Mr Mohamed Aboufirass

Palestine

- Mr Samer Kalbouneh, Project focal point
- Mr Khalid Qahman, Environment Quality Authority
- Mr Abdelaziz Rayyan, Environment Quality Authority
- Mr Ahmad Yaqubi, Palestinian Water Authority

Tunisia

- Mr Mohamed Ali Ben Temessek, Project focal point, Ministry of Environment
- Ms Awatef Larbi ép. Messaï, Ministry of Environment

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MANAGEMENT OF COASTAL AQUIFERS AND GROUNDWATER

In the framework of the GEF/UNEP-MAP Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem, UNESCO-IHP executed the sub-component on "Management of coastal aquifers and groundwater" with the aim of reversing the trends of over-extraction and degradation in the quality of coastal aquifers through policy interactions to provide appropriate capacity and technology for groundwater management.

To this end, UNESCO-IHP has undertaken an inventory and characterization of main Mediterranean coastal aquifers and groundwater-related wetlands and has also assessed the legal, policy and institutional aspects of coastal aquifer management in the region. The knowledge gained from these activities – as well as the experience from eight pilot projects – has enabled UNESCO-IHP to demonstrate how the degradation of coastal aquifers contributes to issues of transboundary concern identified in the Transboundary Diagnostic Analysis for the Mediterranean Sea (TDA-MED).

Furthermore, a set of priority actions on coastal aquifers was agreed upon among the participating countries of the MedPartnership following a series of consultations at the national and regional level organized by UNESCO-IHP. These actions can serve as a basis for future interventions for the protection and sustainable management of coastal aquifers in the Mediterranean region.

The present report sets forth the key findings and products of the UNESCO-IHP activities, including the coastal aquifers supplement to the TDA-MED and the sub-regional action plans on coastal aquifers.