TWAP
TRANSBOUNDARY WATERS ASSESSMENT PROGRAMME

Transboundary Waters: A Global Compendium

Water System Information Sheets: Northern Africa & Western Asia

Volume 6 - Annex H: Northern Africa & Western Asia

UNEP

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Volume 6-Annex H

Transboundary Waters: A Global Compendium

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igrac — International Groundwater Resources Assessment Centre

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GLOBAL CHANGE IGBP — International Geosphere-Biosphere Programme

IUCN

SIWI

CUNY — The City University of New York

OSU — Oregon State University

Center for International Earth Science Information Network — Earth Institute | Columbia University

CESR — Center for Environmental Systems Research

DeltAlliance

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UNESCO — United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

GLOBAL CHANGE IGBP — International Geosphere-Biosphere Programme

NOAA

GESAMP — Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection

DALHOUSIE UNIVERSITY — Inspiring Minds

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UNEP WCMC

CERMES

UBC — Sea Around Us

TAT — Tokyo University of Agriculture and Technology

Assessment Team: The Open Ocean

UNESCO — United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

GOOS — Global Ocean Observing System

WCRP — World Climate Research Programme

GACS — Global Alliance of CPR Surveys

PML — Plymouth Marine Laboratory

CERMES

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Administrative Boundaries: Source of administrative boundaries used throughout the assessment: The Global Administrative Unit Layers (GAUL) dataset, implemented by FAO within the CountrySTAT and Agricultural Market Information System (AMIS) projects.

Contents (Volume 6, Annex H)

Preface

The Global Environment Facility (GEF) approved a Full Size Project (FSP), "A Transboundary Waters Assessment Programme: Aquifers, Lake/Reservoir Basins, River Basins, Large Marine Ecosystems, and Open Ocean to catalyze sound environmental management", in December 2012, following the completion of the Medium Size Project (MSP) "Development of the Methodology and Arrangements for the GEF Transboundary Waters Assessment Programme" in 2011. The TWAP FSP started in 2013, focusing on two major objectives: (1) to carry out the first global-scale assessment of transboundary water systems that will assist the GEF and other international organizations to improve the setting of priorities for funding; and (2) to formalise the partnership with key institutions to ensure that transboundary considerations are incorporated in regular assessment programmes to provide continuing insights on the status and trends of transboundary water systems.

The TWAP FSP was implemented by UNEP as Implementing Agency, UNEP's Division of Early Warning and Assessment (DEWA) as Executing Agency, and the following lead agencies for each of the water system categories: the International Hydrological Programme (IHP) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) for transboundary aquifers including groundwater systems in small island developing states (SIDS); the International Lake Environment Committee Foundation (ILEC) for lake and reservoir basins; the UNEP-DHI Partnership – Centre on Water and Environment (UNEP-DHI) for river basins; and the Intergovernmental Oceanographic Commission (IOC) of UNESCO for large marine ecosystems (LMEs) and the open ocean.

The five water-category specific assessments cover 199 transboundary aquifers and groundwater systems in 43 small island developing states, 204 transboundary lakes and reservoirs, 286 transboundary river basins; 66 large marine ecosystems; and the open ocean, a total of 756 international water systems. The assessment results are organized into five technical reports and a sixth volume that provides a cross-category analysis of status and trends:

Volume 1 – ***Transboundary Aquifers and Groundwater Systems of Small Island Developing States: Status and Trends***
Volume 2 – ***Transboundary Lakes and Reservoirs: Status and Trends***
Volume 3 – ***Transboundary River Basins: Status and Trends***
Volume 4 – ***Large Marine Ecosystems: Status and Trends***
Volume 5 – ***The Open Ocean: Status and Trends***
Volume 6 – ***Transboundary Water Systems: Crosscutting Status and Trends***

A ***Summary for Policy Makers*** accompanies each volume.

Volume 6 presents a unique and first global overview of the contemporary risks that threaten international water systems in five transboundary water system categories, building on the detailed quantitative indicator-based assessment conducted for each water category. As a supplement to Volume 6, this global compendium of water system information sheets provides baseline relative risks at regional and system scales. The fact sheets are organized into 14 TWAP regions and presented as 12 annexes. Volume 6 and the compendium are published in collaboration among the five independent water-category based TWAP Assessment Teams under the leadership of the Cross-cutting Analysis Working Group, with support from the TWAP Project Coordinating Unit.

The technical teams of the Transboundary Waters Assessment Programme(TWAP) assessed transboundary aquifers, lakes & reservoirs, river basins, and large marine ecosystems and prepared information (fact) sheets for water systems that were evaluated. Each fact sheet provides basic geomorphological information and presents baseline values of quantitative indicators that were used to establish relative risk levels. The water system fact sheets are organized into 14 TWAP regions that were used in the Crosscutting Analysis described in Volume 6. The regional compilations are presented as 11 annexes (A-K) of a global compendium, combining Southern & Southeastern Asia into one annex (I), and the Pacific Island Countries, Australia & Antarctica into another (Annex K). Each annex highlights contemporary regional risks as well as water system-specific risks. The annexes are:

Annex A. Transboundary waters of Northern America
Annex B. Transboundary waters of Central America & the Caribbean
Annex C. Transboundary waters of Southern America
Annex D. Transboundary waters of Eastern, Northern & Western Europe
Annex E. Transboundary waters of Eastern Europe
Annex F. Transboundary waters of Western & Middle Africa
Annex G. Transboundary waters of Eastern & Southern Africa
Annex H: Transboundary waters of Northern Africa & Western Asia
Annex I: Transboundary waters of Southern & Southeastern Asia
Annex J: Transboundary waters of Eastern & Central Asia
Annex K: Transboundary waters of the Pacific Island Countries, Australia & Antarctica

In the case of the open ocean, which is the largest transboundary water system of planet earth, selected quantitative indicator maps prepared by the Open Ocean Assessment Team, are compiled in Annex L to highlight the contemporaneous state of the global ocean.

Annex L: Selected indicator maps for the open ocean

All information sheets and indicator maps for the open ocean may be downloaded individually from the following websites:

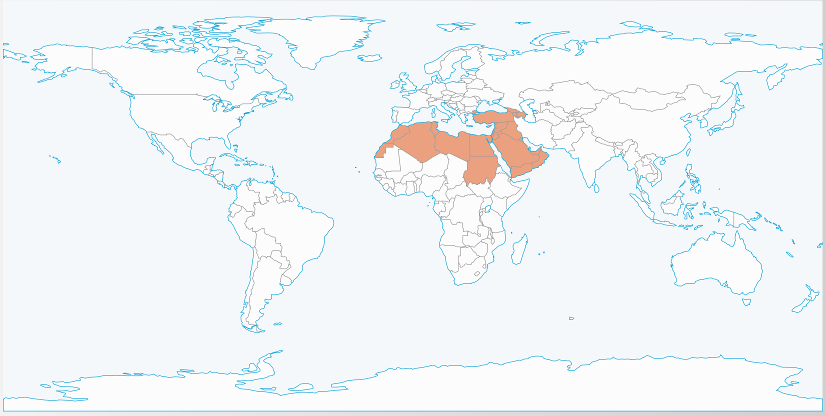
Transboundary Aquifers: http://twapviewer.un-igrac.org
Transboundary Lakes/ Reservoirs: http:/ilec.lakes-sys.com/
Transboundary River Basins: http://twap-rivers.org
Large Marine Ecosystems: http://onesharedocean.org
Open Ocean: http://onesharedocean.org

All TWAP publications are available for download at http://www.geftwap.org

Over the long term, it is envisioned that these baseline information sheets will continue to be updated by future assessments at multiple spatial and temporal scales to better track the changing states of transboundary waters that are essential in sustaining human wellbeing and ecosystem health.

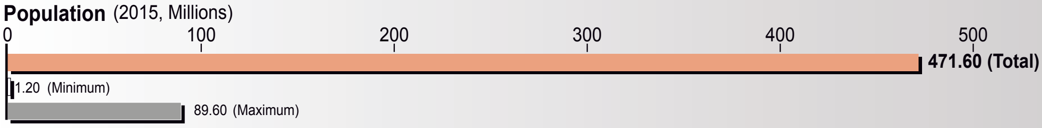
Regional Risks by Theme

TRANSBOUNDARY WATERS: NORTHERN AFRICA & WESTERN ASIA

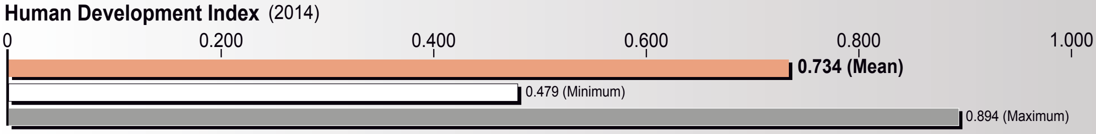


The region belongs to the High HDI Group with a regional HDI average of 0.734 and a population reaching 472 million in 2015.
Contemporary risks of water systems by water category and theme expressed as percentages are shown at top right. Pooling across 51 transboundary water systems (bottom left), 63% suffer from moderate to highest socioeconomic risk; 73% from moderate to highest governance risk; and 72% from moderate to highest biophysical risk. On average, the region's transboundary waters (bottom right) are subject to moderate socioeconomic risk, low governance risk and moderate biophysical risk. Aquifers and Lakes are at low risk across risk themes, while river basins and LMEs are at moderate risk.

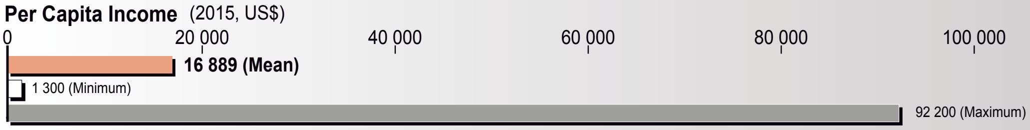
Population (2015, Millions)



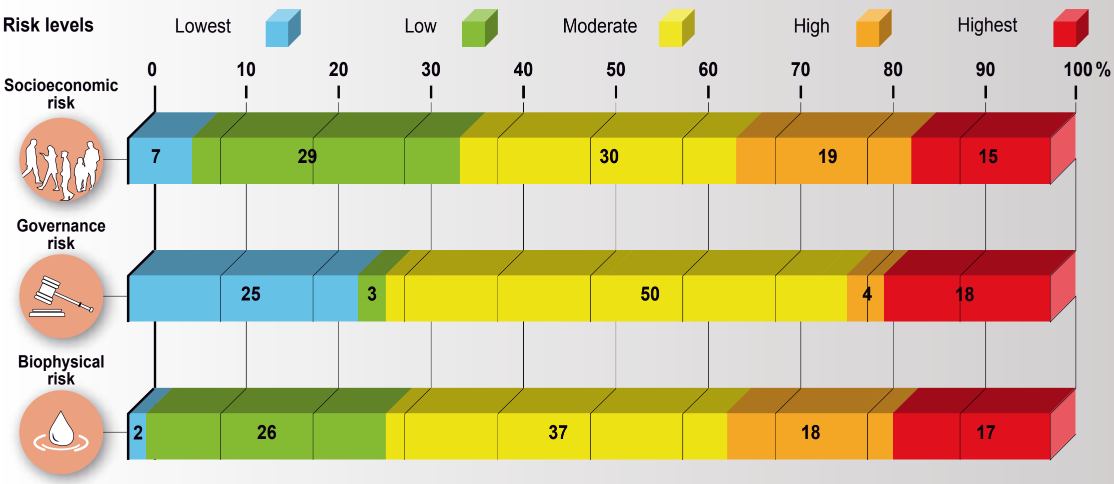
Human Development Index (2014)



Per Capita Income (2015, US$)

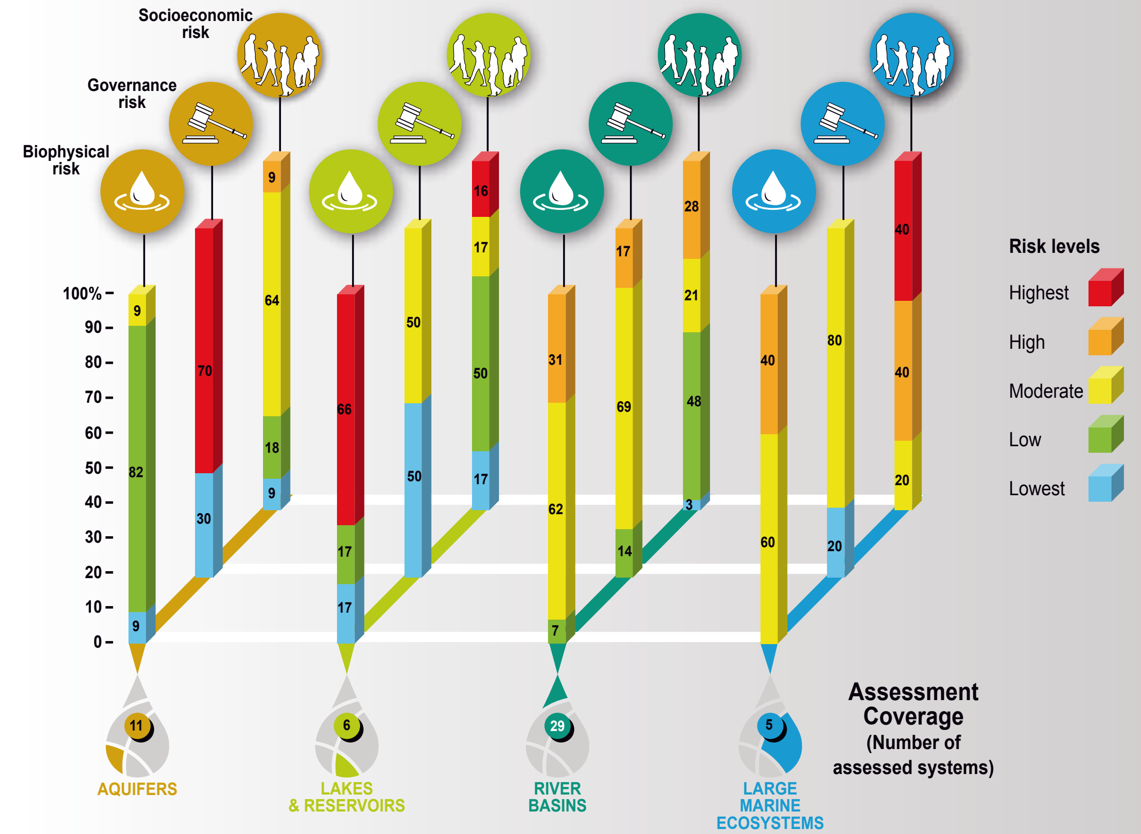


Contemporary Risks by Theme

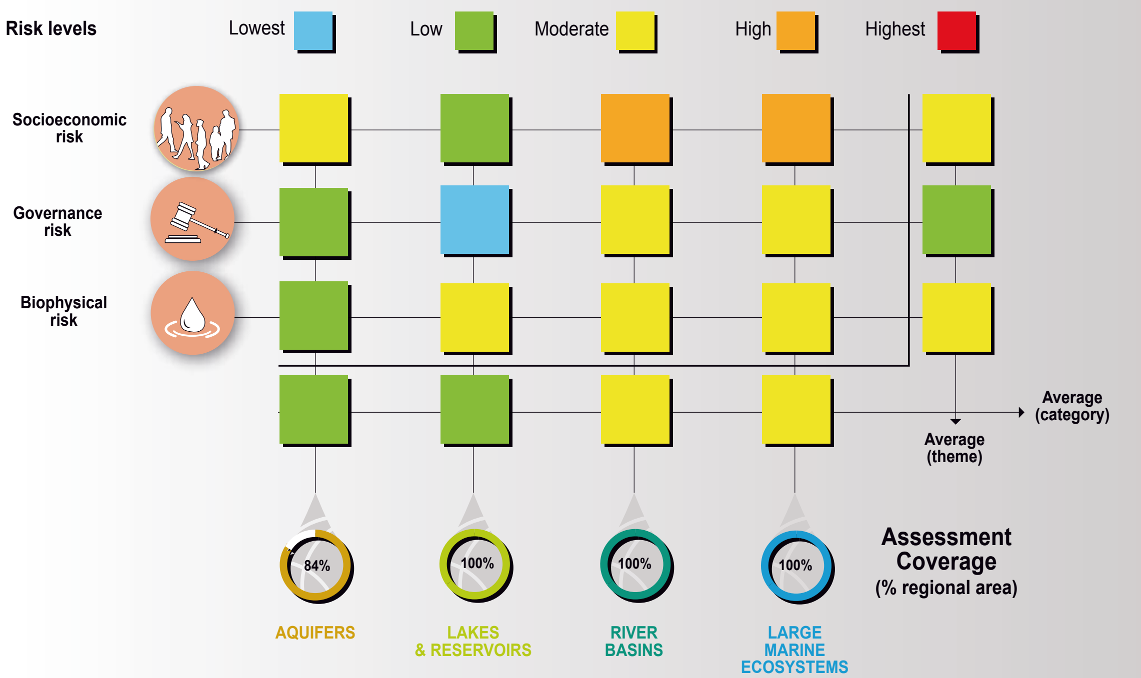


Regional Risks by Water Category

Contemporary Risks by Water Category



Average Risks



1. Baggara Basin
2. Basalt Aquifer System (West): Yarmouk Basin
3. Gedaref
4. Irhazer-Iullemeden Basin
5. Merged:
   5A. Tawil Quaternary Aquifer System: Wadi Sirha Basin
   5B. Saq-Ram Aquifer System (West)
6. Merged:
   6A. Umm er Radhuman-Dammam Aquifer System (South): Rub' Al Khali
   6B. Wajid Aquifer System
   6C. Wasia-Biyadh-Aruma Aquifer System (South): Tawila-Mahra/ Cretaceous Sands
   6D. Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin
7. Merged:
   7A. Wasia-Biyadh-Aruma Aquifer System (North)L Sakaka-Rutba
   7B. Umm er Radhuman-Dammam Aquifer System (North): Widyan-Salman
   7C: Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin
8. Neogene Aquifer System (North-West), Upper and Lower Fars
9. Northwest Sahara Aquifer System (NWSAS)
10. Nubian Sandstone Aquifer System (NSAS)
11. Senegalo-Mauretanian Basin
12. Sudd Basin
13. Taoudéni Basin

Irrigated farming in Libyan desert with water from the Nubian Sandstone Aquifer, 2016.

NASA Earth Observatory

Water mined from aquifers are stored in reservoirs (dark blue) and used for irrigation in Libya's massive water project called Grand Omar Mukhtar

Jesse Allen, NASA using data from NASA/GSFC/METI/ERSDAC/JAROS & US/Japan ASTER Science Team

AF53 - Baggara Basin

Geography

Total area TBA (km^2): 213 600

No. countries sharing: 4

Countries sharing: Central African Republic, South Sudan, Sudan

Population: 3 600 000

Climate Zone: Semi-arid

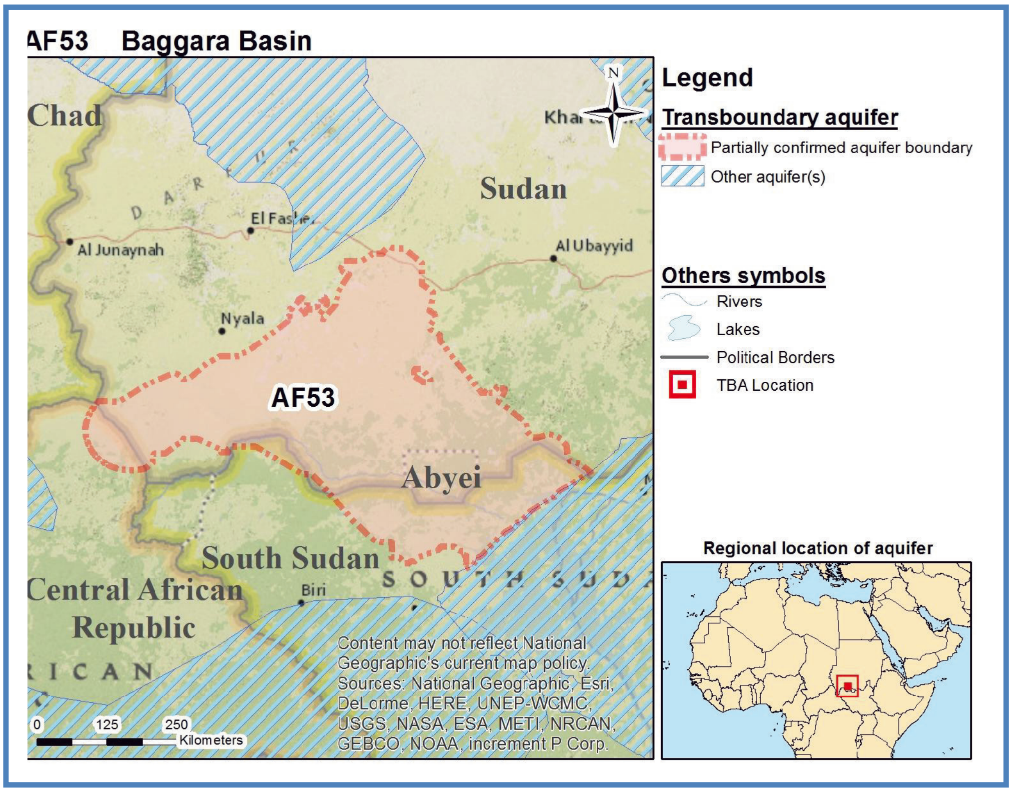
Rainfall (mm/yr): 620

Hydrogeology

Aquifer type: Multi-layered system

Degree of confinement: Mostly confined with some parts unconfined

Main Lithology: Sedimentary rocks – sandstone



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate

AF53 - Baggara Basin

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Central African Republic							3			
South Sudan	1	28					25	10	D	D
Sudan	1	65		100			15	10	D	E
Disputed land*							13			
TBA level							**17**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.
* To define country segments of the transboundary aquifers the country borders from FAO Global Administrative Unit Layers (2013) was used.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Abyei	49	2800	-44	-65	2	2	0	1
Central African Republic	210	47 000	-35	-56	35	35	0	0
South Sudan	73	2600	-41	-61	2	2	2	1
Sudan	22	1300	-38	-59	2	2	2	1
TBA level	**39**	**2000**	**-39**	**-60**	**2**	**2**	**2**	**1**

AF53 - Baggara Basin

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Abyei	0	17	61	130	<1	0	0
Central African Republic	2	4	57	120	<1	0	0
South Sudan	1	28	61	130	<1	0	0
Sudan	0	17	61	130	<1	0	1
TBA level	**0**	**19**	**61**	**130**	**<1**	**0**	**0**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Abyei								
Central African Republic								
South Sudan	60		350	Aquifer mostly confined, but some parts unconfined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits	Secondary porosity: Fractures	
Sudan			400			High primary porosity fine/ medium sedimentary deposits		
TBA level								

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

It is a multi-layered system that is mostly confined with some unconfined parts. The average water level is 60 m within South Sudan. The average thickness of the aquifer system varies from 350 m to 400 m (South Sudan, Sudan).

AF53 - Baggara Basin

Hydrogeological aspects

The basin is composed of the Umm Ruba formation that is unconformable and overlying the Nubian formation. The main lithology within the South Sudan part is sedimentary rocks – sandstone. They are characterized by a high primary porosity of fine/ medium sedimentary deposits with secondary porosity: fractures, and a high horizontal connectivity. The total groundwater volume within the system is in the order of 773 km^3. The mean annual recharge, which is 100% through natural recharge, within Sudan and South Sudan is approximately 185 Mm^3/yr. The estimated recharge area within South Sudan is over an area of 141 000 km^2. The predominant source of recharge is through precipitation over the aquifer area (South Sudan). The main discharge mechanism has not been recorded.

Linkages with other water systems

No interlinkages with other water systems were apparent from the available information.

Environmental aspects

Natural water quality is generally good with an average TDS content of 500 -800mm and from the information that was made available no inferior water quality was recorded. Data is not available on anthropogenic groundwater pollution or on the extent of shallow groundwater over the aquifer area.

Socio-economic aspects

Annual groundwater abstraction was in the order of 14.70 Mm^3 /yr within Sudan and South Sudan. Data is not available on the total amount of fresh water abstraction over the aquifer area.

Legal and Institutional aspects

No Transboundary Agreement exists, nor is it under preparation. Within South Sudan the National Institution is in place, but it is not fully operational. In Sudan no Institution currently exists for TBA management.

Emerging Issues

Support in legal and institutional development is needed at both the National and Regional level.

Contributors to Global Inventory

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Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
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Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator
Charles Lopero Mario	Ministry of Electricity, Dams, Irrigation and Water Resources	South Sudan	charlesonly2002@yahoo.com, onlylopero@gmail.com	Lead National Expert

Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Information was made available for 2 of the 4 TBA countries and it was adequate to describe the aquifer in general terms Some quantitative information was also made available allowing for the calculation of some of the indicators at the national level.

AF53 - Baggara Basin

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

Request:
If you have additional data or information about this transboundary aquifer that can improve the quality of this information sheet and the underlying database, please contact us via email at info@un-igrac.org. If appropriate, the information will be uploaded to the database of transboundary aquifers and will also be used in new versions of this information sheet.

References:
- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: September 2015

AS142 - Basalt Aquifer System (West): Yarmouk Basin

Geography

Total area TBA (km^2): 6900

No. countries sharing: 2

Countries sharing: Jordan, Syria

Population: 1 700 000

Climate zone: Arid

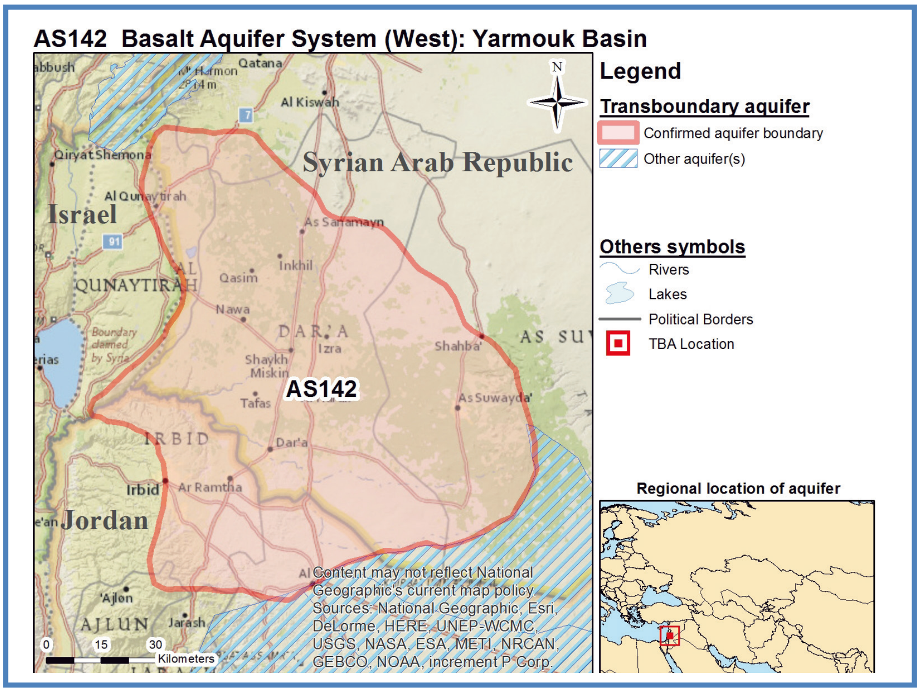
Rainfall (mm/yr): 320

Hydrogeology

Aquifer type: Multiple 4-layered, hydraulically connected

Degree of confinement: Mostly unconfined, some parts confined

Main Lithology: Crystalline and Sedimentary rock



No cross-section provided

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

AS142 - Basalt Aquifer System (West): Yarmouk Basin

TWAP Groundwater Indicators from Global Inventory

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Jordan							390			
Syrian Arab Republic							201			
TBA level	**<1**	**<1**	**90**		**220**		**250**	**>1000**	**D**	**D**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Jordan								
Syrian Arab Republic								
TBA level				**Aquifer mostly unconfined, but some parts confined**	**Crystalline rock: Basalt**		**Secondary porosity: Fractures**	

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

AS142 - Basalt Aquifer System (West): Yarmouk Basin

Aquifer description

Aquifer geometry

The Yarmouk Basin constitutes the western section of the Basalt Aquifer Complex. It extends between the Jebel al Arab Mountain, the Hauran Plateau and the south-eastern foothills of Mount Hermon. In the south-west, the Basalt Aquifer stretches into the Golan Heights to Lake Tiberias. Surface water divides have been used to define the boundary of the basin. This aquifer system consists of 4 hydraulically connected layers. It is mostly unconfined although some parts are confined. The thickness of the aquifer system, including aquitards, varies from 100 to 300 m.

Hydrogeological aspects

The predominant aquifer lithology consists of crystalline and sedimentary rock (basalt and limestone). System replenishment is medium (20-100 mm/annum), amounting to an average recharge of about 93Mm^3/annum. Water percolates mainly through several volcanic layers in a recharge area of just over 5000 km^2. A secondary type of porosity is predominant that allows for a low vertical connectivity between the layers. The transmissivity values recorded across the aquifer states range between 30m^2/d and 1300m^2/d.

Linkages with other water systems

Recharge is mainly through precipitation over the aquifer area while discharge takes place via a large number of springs, mainly the Yarmouk Basin in Syria (see Appendix 1).

Environmental aspects

The natural groundwater quality does not satisfy local standards in about 10% of aquifer area due to natural salinity (see Appendix 2). This natural salinity affects only the superficial layers of the aquifer system. These layers are also subject to groundwater pollution from agricultural practices as evidenced by salinization, nitrogen species and pesticides.

Socio-economic aspects

A total of about 180Mm^3/annum of groundwater is abstracted by the two Aquifer States. Large-scale expansion of groundwater abstraction in some parts of the Yarmouk Basin in Syria has led to a groundwater depletion of 1.5 m/annum and is likely to have affected natural flow and discharge patterns within a larger radius and may have contributed to the hydrological decline of the Yarmouk River. This has long been a point of conflict between Jordanian and Syrian authorities.

Legal and Institutional aspects

National institutions for the management of groundwater exist in both aquifer states but no formal Transboundary Agreement has been made. There are groundwater-related provisions in the 1987 agreement regarding the utilization of the waters of the Yarmouk River.

Priority issues

Indications are that the annual groundwater abstraction from the groundwater system is double the annual replenishment to the system. Available data indicates that abstraction, impacting the groundwater reserves, also has negative effects on surface water in the basin. This is a priority issue. Systematic monitoring of abstraction and of the surface water / groundwater system status and trends, both in terms of quantity and quality, is urgently required under a Bi-lateral Agreement.

AS142 - Basalt Aquifer System (West): Yarmouk Basin

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
Lamine Babasy	Observatoire du Sahara et du Sahel	Tunisia	lamine.babasy@oss.org.tn	Regional coordinator
Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator

Considerations and recommendations

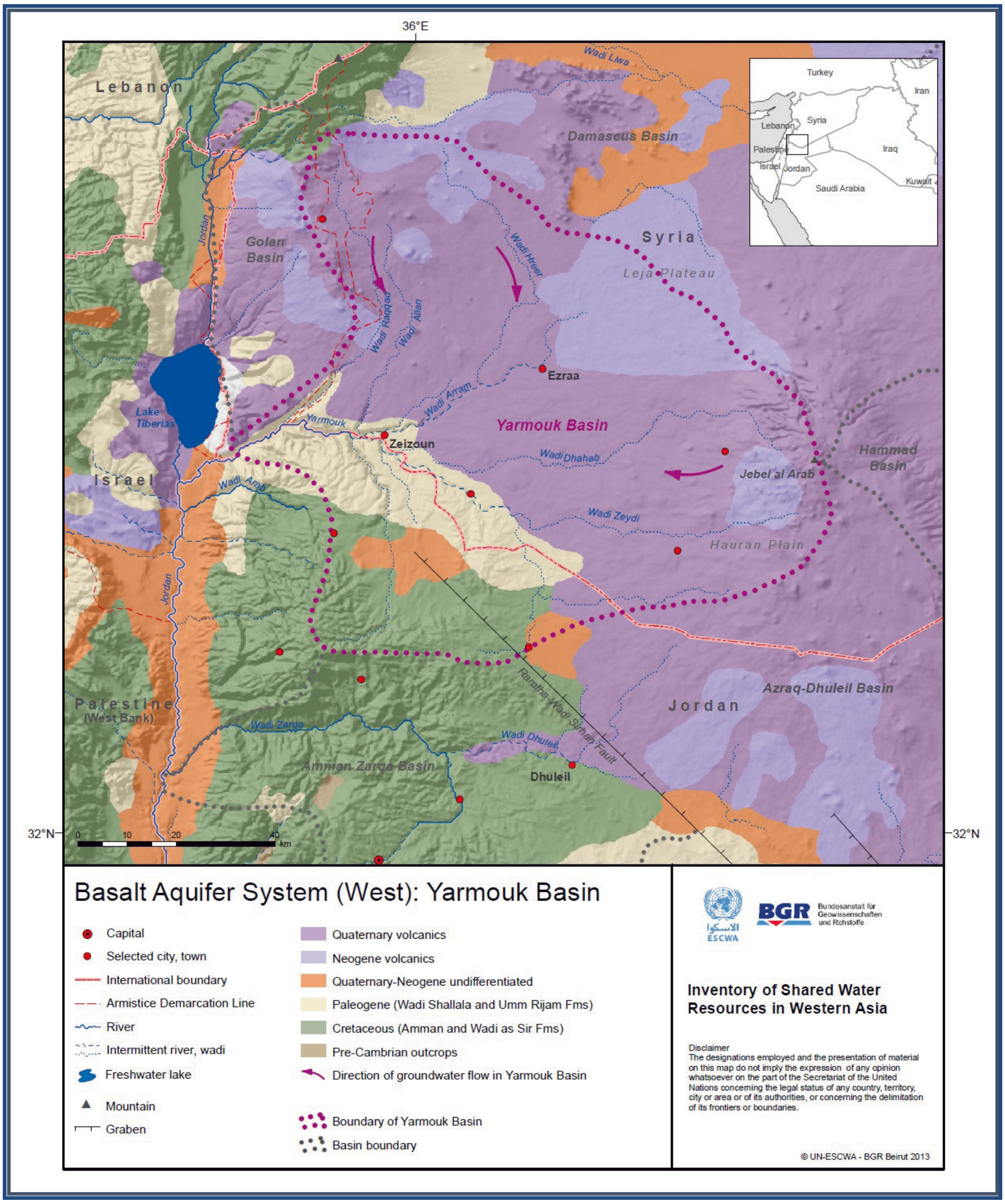
Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

For the transboundary aquifers of Western Asia, data are only available at the level of the complete aquifer and not of the country segments. All this data as well as information elements in the aquifer description are coming from a comprehensive, United Nations-led inventory to catalogue and characterize transboundary surface and groundwater resources in the Middle East (Source: UN-ESCWA and BGR (United Nations Economic and Social Commission for Western Asia; Bundesanstalt für Geowissenschaften und Rohstoffe). 2013. Inventory of Shared Water Resources in Western Asia. Beirut).

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

AS142 - Basalt Aquifer System (West): Yarmouk Basin

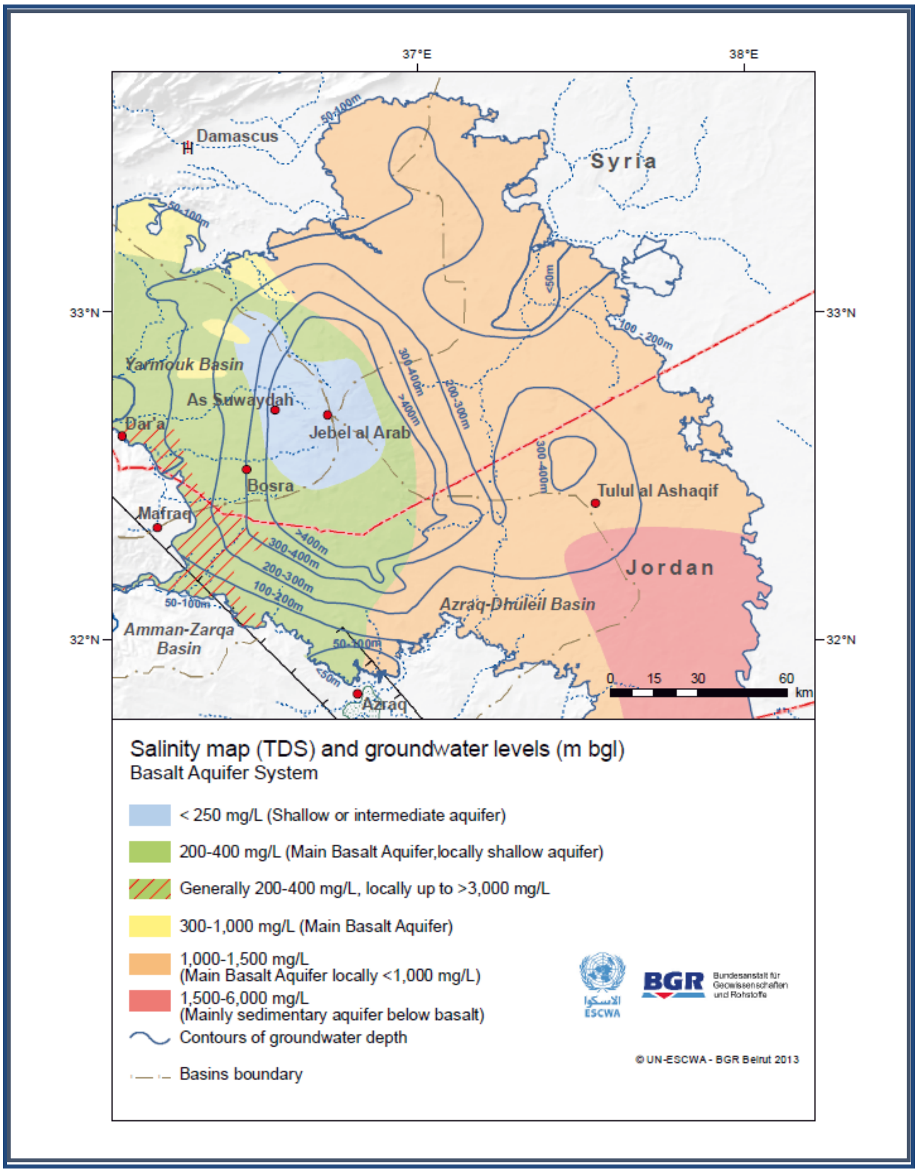
Appendix 1: AS142



Map showing the groundwater flow and discharge areas within the Basalt Aquifer System (West): Yarmouk Basin

AS142 - Basalt Aquifer System (West): Yarmouk Basin

Appendix 2: AS142



Groundwater salinity map - TDS of the Basalt Aquifer System (West): Yarmouk Basin

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

AS142 - Basalt Aquifer System (West): Yarmouk Basin

For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

Request:
If you have additional data or information about this transboundary aquifer that can improve the quality of this information sheet and the underlying database, please contact us via email at info@un-igrac.org. If appropriate, the information will be uploaded to the database of transboundary aquifers and will also be used in new versions of this information sheet.

References:

- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: May 2017

AF61 - Gedaref

Geography

Total area TBA (km^2): 51 000

No. countries sharing: 3

Countries sharing: Eritrea, Ethiopia, Sudan

Population: 1 600 000

Climate Zone: Semi-arid

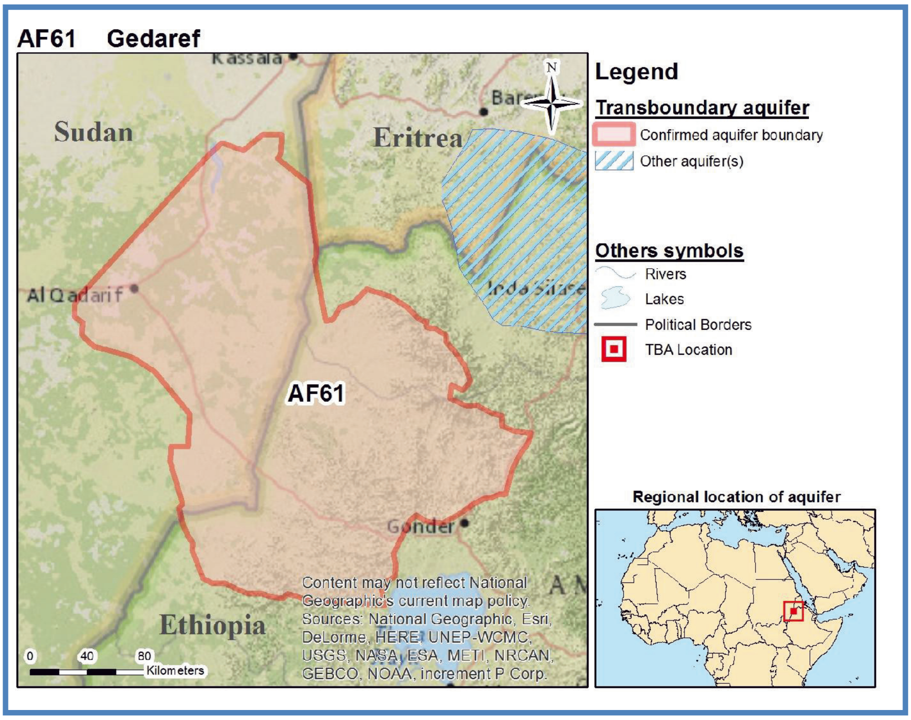
Rainfall (mm/yr): 790

Hydrogeology

Aquifer type: Multiple 3-layered hydraulically connected

Degree of confinement: Mostly confined, but some parts are unconfined

Main Lithology: Sedimentary rocks - Sandstone



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate

AF61 - Gedaref

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Eritrea							20			
Ethiopia	2	35					43	290	D	
Sudan							19			
TBA level							**32**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).

(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.

(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).

(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.

(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).

(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Eritrea	26	1700	-19	-38	80	80	0	0
Ethiopia	69	1400	-19	-34	75	79	0	75
Sudan	32	1500	-28	-51	4	7	2	1
TBA level	**52**	**1400**	**-22**	**-40**	**41**	**55**	**1**	**20**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Eritrea	1	15	53	100	1	3	10
Ethiopia	1	48	43	76	1	4	13
Sudan	1	22	59	130	<1	0	1

AF61 - Gedaref

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
TBA level	**1**	**36**	**48**	**90**	**1**	**3**	**10**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Eritrea								
Ethiopia	63		350	Mostly confined, but some parts unconfined	crystalline basalts	Low primary porosity	Secondary porosity (fractures)	5
Sudan								
TBA level								

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

It is a multiple layered hydraulically connected system that is mostly confined, but some parts are unconfined. Within the Ethiopian portion, where it is a 3-layered system, the average depth to the water table is 63 m and the average thickness of the aquifer system is 350 m.

Hydrogeological aspects

The predominant lithology consists of crystalline basalts that are characterized by a low primary porosity and relatively high secondary porosity (fractures) that have a high horizontal and vertical connectivity. The transmissivity values are low with an average value of 5 m^2/d. The total groundwater volume is 40 km^3 (Ethiopia). The mean annual recharge is 385 Mm^3/yr over an area of about 4 100 km^2. With the cyclical droughts that are characteristic in the area the mean recharge reduces to 95 Mm^3/yr (Ethiopia).

Linkages with other water systems

The predominant source of recharge is through precipitation over the aquifer area, and the predominant discharge mechanism is through river base flow.

Environmental aspects

Within Ethiopia about 12 % of the aquifer does not satisfy national drinking standards mainly due to high contents of natural nitrates. Some pollution within the superficial layers has been observed but the data is not available to determine the percentage of the aquifer area that has been affected.

AF61 - Gedaref

Socio-economic aspects

During 2010 the annual groundwater abstraction on the Ethiopian side was 3.2 Mm^3/yr of which 70% of this amount was used water for agricultural purposes.

Legal and Institutional aspects

No Transboundary Agreement is in place. No information on the National Institutes within the countries was recorded.

Emerging Issues

The cause of the high natural nitrates within parts of the aquifer should be further investigated.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christellis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
Lamine Babasy	Observatoire du Sahara et du Sahel	Tunisia	lamine.babasy@oss.org.tn	Regional coordinator
Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator
Dessie Habtemariam	Addis Ababa University	Ethiopia	dessienedaw@yahoo.com	Lead National Expert
Tadesse	Ministry of Water and Energy	Ethiopia	twtesfaye@gmail.com	Contributing national expert

Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Only 1 of the 3 TBA countries has provided information. Information was adequate to describe the aquifer in general terms. Some quantitative information was also available, and 50% of the indicators could be calculated at the national level.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

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AF61 - Gedaref

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- All other data: TWAP Groundwater (2015).

Version: September 2015

AF56 - Irhazer-Iullemeden Basin

Geography

Total area TBA (km^2): 510 000

No. countries sharing: 5

Countries sharing: Algeria, Benin, Mali, Niger, Nigeria

Population: 18 000 000

Climate Zone: Semi-arid

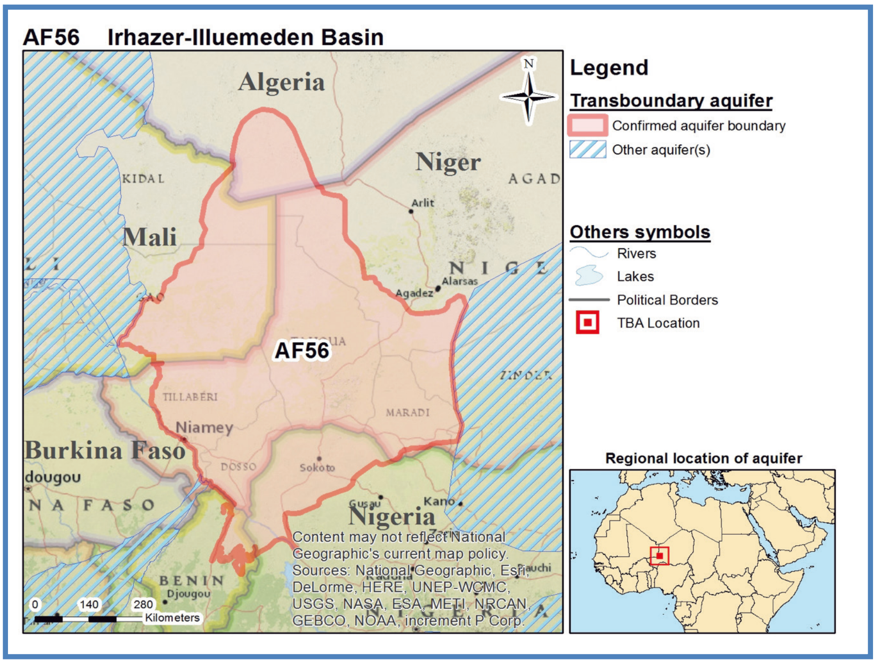
Rainfall (mm/yr): 310

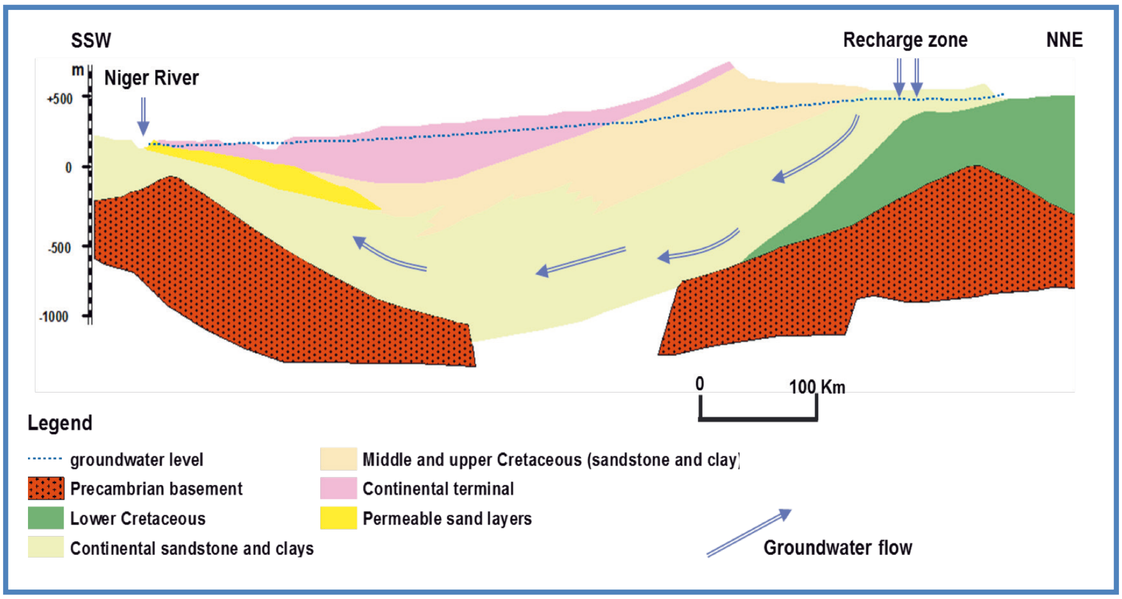
Hydrogeology

Aquifer type: Multiple layered hydraulically connected system

Degree of confinement: mostly confined, but some parts are unconfined

Main Lithology: sedimentary rocks –sandstones and sediments - gravel





Cross section along the NE to SW part of the aquifer

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate

AF56 - Irhazer-Iullemeden Basin

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Algeria							<1			
Benin	190	6800	90				28		D	
Mali	<1	230					1	<5		B
Niger							37			
Nigeria							110		B	
TBA level							**36**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Algeria	<1	17	50	30	17	17	0	0
Benin	120	3900	-34	-60	63	89	14	0
Mali	35	23 000	-22	-52	28	28	0	0
Nigeria	180	1400	-31	-55	38	89	17	86
Niger	52	1500	-30	-59	25	86	4	34
TBA level	**61**	**1700**	**-29**	**-57**	**31**	**87**	**9**	**60**

UNEP gef United Nations Educational, Scientific and Cultural Organization International Hydrological Programme igrac International Groundwater Resources Assessment Centre

AF56 - Irhazer-Iullemeden Basin

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Algeria	0	<1	45	94	50	2	11
Benin	0	32	68	160	<1	0	4
Mali	1	2	83	210	<1	0	0
Nigeria	1	120	65	160	2	3	14
Niger	0	35	96	250	1	1	8
TBA level	**0**	**36**	**83**	**210**	**1**	**1**	**8**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Algeria								
Benin	15		120	Aquifer mostly unconfined, but some parts confined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits	No secondary porosity	
Mali	34	18	200	Aquifer mostly confined, but some parts unconfined	Sedimentary rocks - Sandstone	Low primary porosity intergranular porosity	Secondary porosity: Fractures	60
Niger								
Nigeria				Aquifer mostly unconfined, but some parts confined	Sediment - Gravel	Very high primary porosity gravels/ pebbles		
TBA level								

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

This is a multiple layered hydraulically connected system that contains 2 main aquifer horizons in Mali and 3 main aquifer horizons in Benin. The aquifer is mostly confined, but some parts are unconfined. The average depth to the water table varies from 15 m to 34 m (Benin, Mali). The average depth to the top of the aquifer is 18 m within Mali, while the average thickness of the aquifer system varies from 100 m to 200 m (Benin, Mali).

AF56 - Irhazer-Iullemeden Basin

Hydrogeological aspects

The predominant aquifer lithology consists of sedimentary rocks –sandstones (Benin, Mali), and sediments – gravel (Nigeria). The integranular aquifer is characterised by a low primary porosity with secondary porosity fractures(Mali) to a very high primary porosity with no secondary porosity (Benin). It furthermore has a low to high horizontal and vertical connectivity (Benin, Mali). The average transmissivity is 60 m^2/d within Mali. The total groundwater volume is 2194 km^3 (Mali, Nigeria). There is no seasonal difference in recharge that has been reported on and the recharge, that is 100% due to natural conditions, varies from very low in the north to very high in the south. The average recharge is 1670 Mm^3/yr (Benin, Mali). The main recharge area within Nigeria covers an area of 60 000 km^2.

Linkages with other water systems

The predominant source of recharge is from precipitation over the aquifer area (Benin, Mali), and from runoff along river systems (Niger, Nigeria). The predominant discharge mechanism is through river base flow (Benin, Nigeria) and through evapotranspiration (Mali).

Environmental aspects

Around 8% of the natural water within the superficial layers is unsuitable for drinking water purposes within Benin, and the main causes have not been recorded. Within Mali and Nigeria there is a high natural salinity level, but data is not available on the % of the aquifer area that has been affected. This is over a significant part of the aquifer in Nigeria where excessive Fluorides are also encountered. Some anthropogenic groundwater pollution has been identified (Benin, Mali, Nigeria), and this is in significant amounts in Benin although it is limited to the superficial layers, but the data is not available to determine the percentage of the aquifer area that has been affected. Within Benin around 8% of the aquifer has shallow groundwater of less than 5m depth. Within Mali around 5% of the aquifer area is covered with groundwater dependent ecosystems.

Socio-economic aspects

Within Mali the annual groundwater abstraction during 2010 that was based on expert judgement was 0.40 Mm^3. Data is not available on the total amount fresh water that was abstracted over the aquifer area.

Legal and Institutional aspects

Nigeria reports on an Agreement with limited scope for TBA management signed by all parties. Benin reports that no agreement currently exists, nor is under preparation. Mali reports on a Dedicated Transboundary Institution that is in place, but not fully operational. No information was recorded with regard to the mandate and capacity of the National Institutes.

Emerging issues

The current status of the TBA Agreement must be confirmed as well as the effectiveness and status of the Transboundary Institute with regard to TBA management.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Cheikh Becaye Gaye	Université Cheikh Anta Diop	Senegal	cheikhbecayegaye@gmail.com	Regional coordinator
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
Lamine Babasy	Observatoire du Sahara et du Sahel	Tunisia	lamine.babasy@oss.org.tn	Regional coordinator
Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator

AF56 - Irhazer-Iullemeden Basin

Name	Organisation	Country	E-mail	Role
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Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Only 3 of the 5 TBA countries have provided information. Information was adequate to describe the aquifer in general terms. Some quantitative information was also available, but not sufficient to calculate all of the indicators at the national levels.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

AF56 - Irhazer-Iullemeden Basin

Request:
If you have additional data or information about this transboundary aquifer that can improve the quality of this information sheet and the underlying database, please contact us via email at info@un-igrac.org. If appropriate, the information will be uploaded to the database of transboundary aquifers and will also be used in new versions of this information sheet.

References:

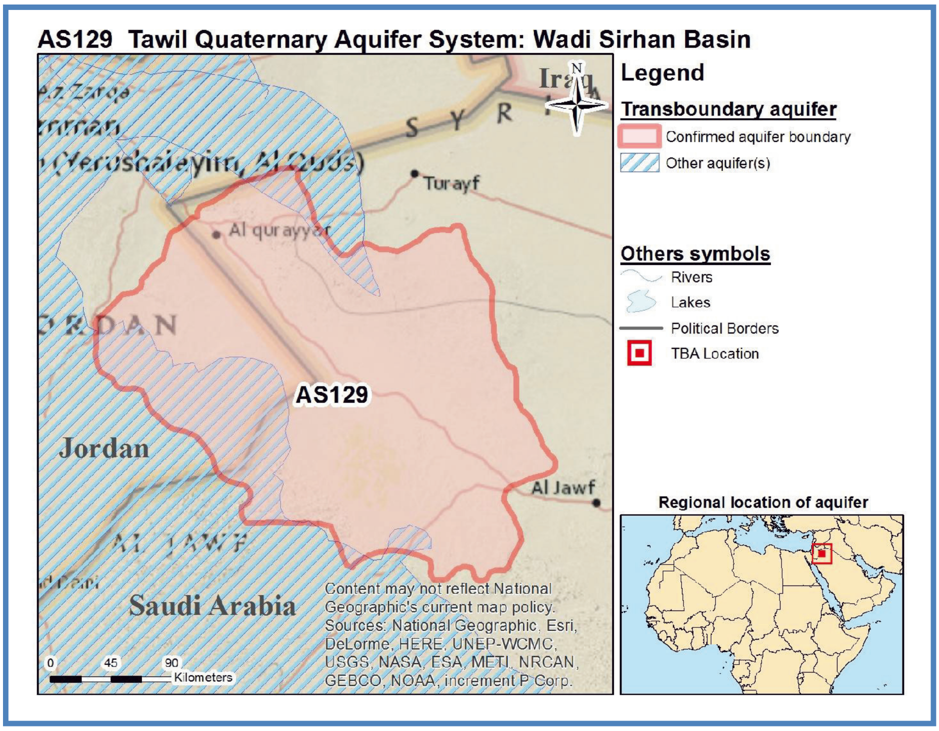
- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

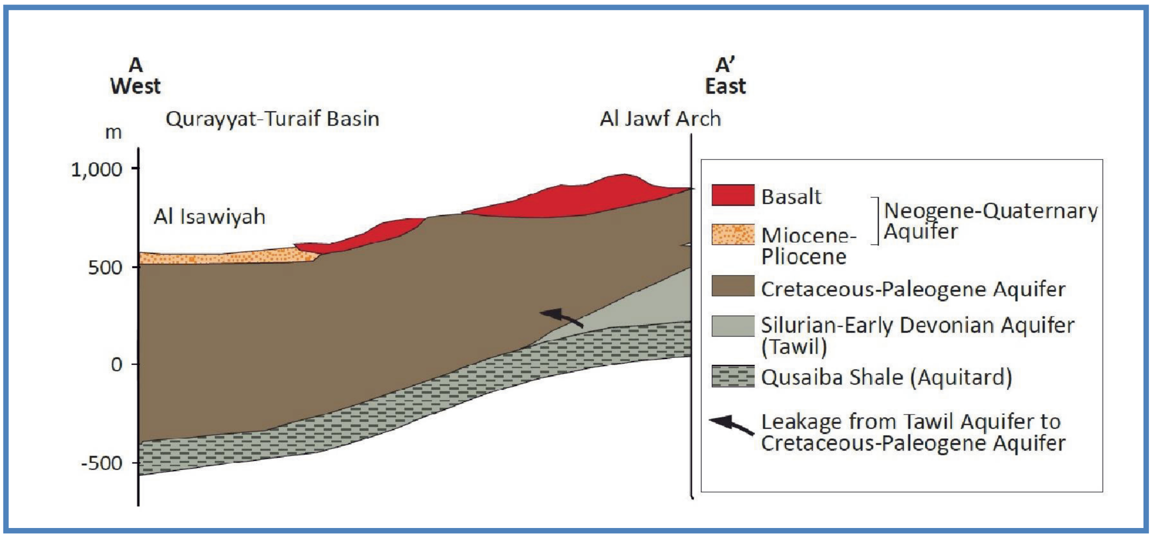
Version: May 2017

AS129 - Tawil Quaternary Aquifer System: Wadi Sirhan Basin

Geography
Total area TBA (km^2): 46 000
No. countries sharing: 2
Countries sharing: Jordan, Saudi Arabia
Population: 220 000
Climate zone: Arid
Rainfall (mm/yr): 55

Hydrogeology
Aquifer type: Multiple 4-layered, hydraulically connected
Degree of confinement: Mostly confined
Main Lithology: Sedimentary /Crystalline rock





Geological Cross-section across part of the aquifer (W – E)

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

AS129 - Tawil Quaternary Aquifer System: Wadi Sirhan Basin

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Jordan							2			
Saudi Arabia										
TBA level	**1**	**140**	**80**				**5**	**>1000**	**D**	**D**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Jordan								
Saudi Arabia								
TBA level				**Aquifer mostly confined, but some parts unconfined**	**Sedimentary rock: Sandstone**	**High primary porosity fine/medium sedimentary deposits**		

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

AS129 - Tawil Quaternary Aquifer System: Wadi Sirhan Basin

Aquifer description

Aquifer geometry
The Wadi Sirhan Basin is situated in Jordan and Saudi Arabia and forms a central depression surrounded by basalt and sedimentary plateau areas in the north and south. Geo-structural and surface drainage features were used to approximate the boundaries of this system, which comprises 4 hydraulically connected layers. It is mostly confined although some parts are unconfined. The thickness of the aquifer system, including aquitards, varies from 1600 m to 2200m.

Hydrogeological aspects
The main aquifer lithology comprises sedimentary and crystalline rocks - basalt, alluvium, limestone and sandstones with some marl. System natural replenishment is very low (0-2 mm/annum), amounting to an average recharge of 30 Mm^3/annum. Primary type of porosity is predominant that allows low vertical connectivity between layers. Transmissivity values recorded across the aquifer states range between 430 m^2/d to 15 000 m^2/d.

Linkages with other water systems
A limited amount of recharge occurs in a high plateau area through wadi beds. Discharge is into mudflats and sabkhas within the basin (see Appendix 1).

Environmental aspects
Natural groundwater quality does not satisfy local drinking water standards in about 20% of aquifer area, mainly due to natural high salinity within the superficial layers of the aquifer system. Some anthropogenic pollution does occur and it is vulnerable to pollution from agricultural practices. Salinization and nitrogen species are the most dominant pollutants affecting groundwater quality.

Socio-economic aspects
A total of 2 300 Mm^3/annum of groundwater is abstracted by Saudi Arabia while the Jordanian part of the system has not been developed yet.

Legal and Institutional aspects
National Institutions for the management of groundwater exist in both Aquifer States but no formal agreement has been made.

Hot spot
This aquifer system is vastly over-exploited in relation to its mean annual replenishment. The main issue for this TBA is the rapid expansion of large commercial farms with centre-pivot irrigation systems, which seriously overdraft fresh groundwater from the Saudi (upstream) part of the system without any governmental controls. This has led to an increase in groundwater salinity which endangers human health and also poses a long-term negative effect on the quality of groundwater in the Jordanian (downstream) part. Strict rules and measures are needed to regulate the exploitation of groundwater for commercial farms. There also needs to be a systematic monitoring of abstraction and groundwater level and quality trends in both countries under a Bilateral Agreement.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
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Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator

AS129 - Tawil Quaternary Aquifer System: Wadi Sirhan Basin

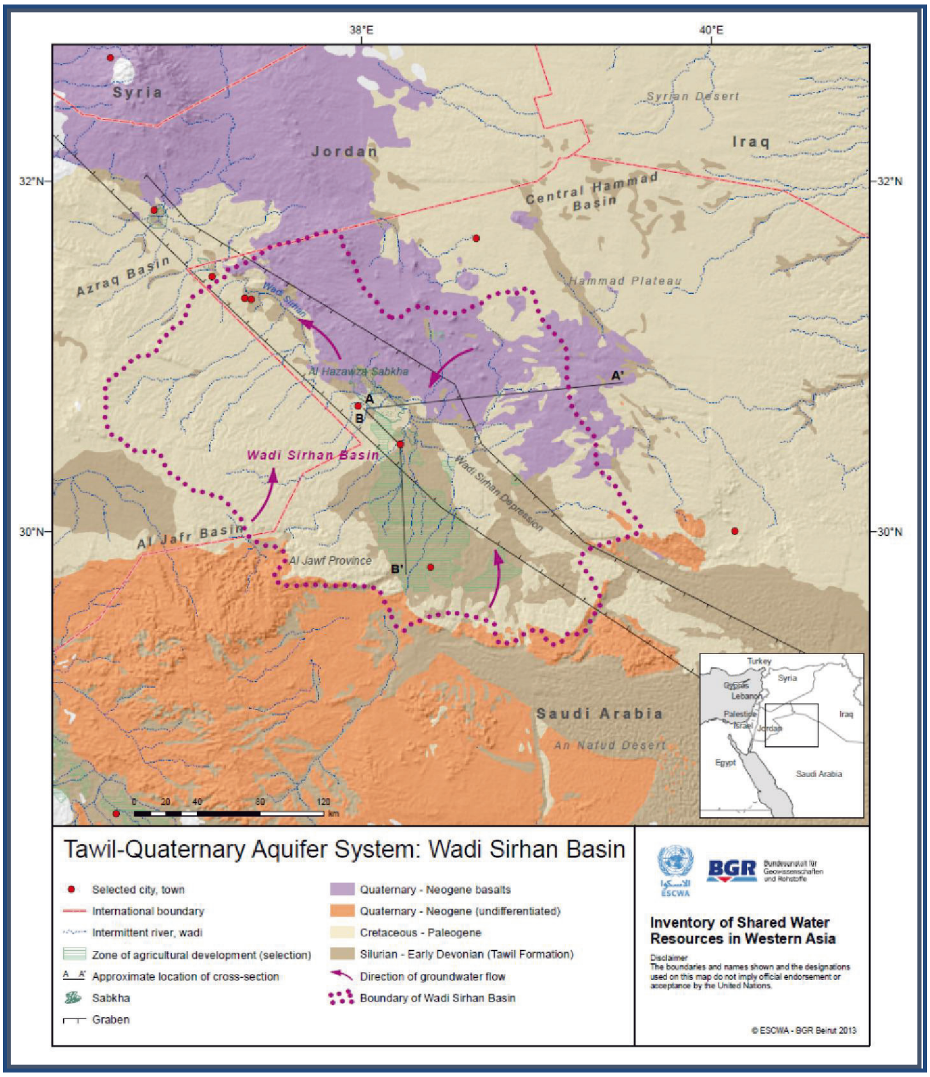
Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

For the transboundary aquifers of Western Asia, data are only available at the level of the complete aquifer and not of the country segments. All this data as well as elements for the aquifer description are coming from a comprehensive, United Nations-led inventory to catalogue and characterize transboundary surface and groundwater resources in the Middle East (Source: UN-ESCWA and BGR (United Nations Economic and Social Commission for Western Asia; Bundesanstalt für Geowissenschaften und Rohstoffe). 2013. Inventory of Shared Water Resources in Western Asia. Beirut).

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Appendix 1: AS129



Map showing Groundwater flow and discharge within the Tawil Quaternary Aquifer System: Wadi Sirhan Basin

AS129 - Tawil Quaternary Aquifer System: Wadi Sirhan Basin

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

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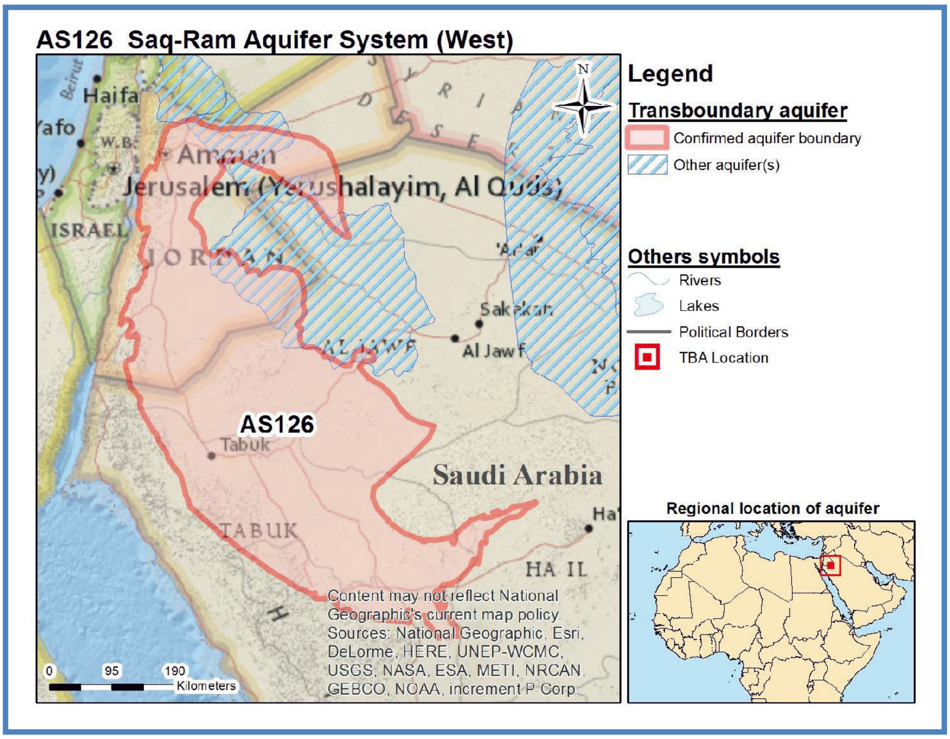
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

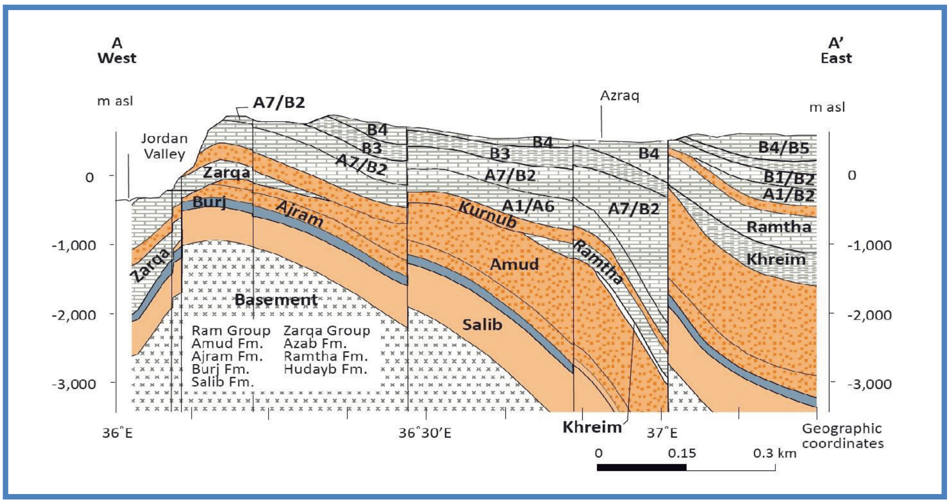
Version: October 2015

AS126 - Saq-Ram Aquifer System (West)

Geography
Total area TBA (km^2): 150 000
No. countries sharing: 2
Countries sharing: Jordan, Saudi Arabia
Population: 4 400 000
Climate zone: Arid
Rainfall (mm/yr): 74

Hydrogeology
Aquifer type: Multiple 3-layered, hydraulically connected
Degree of confinement: Mostly confined, some parts unconfined
Main Lithology: Sedimentary rocks - sandstones





Geological Cross-section across part of the Aquifer (E – W)

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

AS126 - Saq-Ram Aquifer System (West)

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Jordan							81			
Saudi Arabia							6			
TBA level	**1**	**20**	**70**		**0**	**B**	**29**	**>1000**	**E**	**F**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).

(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.

(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).

(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.

(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).

(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Av. Transmissivity (m^2/d)
Jordan								
Saudi Arabia								
TBA level				**Aquifer mostly confined, but some parts unconfined**	**Sedimentary rock: Sandstone**	**High primary porosity fine/medium sedimentary deposits**		**1300**

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

AS126 - Saq-Ram Aquifer System (West)

Aquifer description

Aquifer geometry

Geo-structural and physiographic features as well as the approximate extent of exploitable area were used to approximate the boundaries of this western transboundary part of the system as opposed to an eastern part lying entirely within Saudi Arabia. The system comprises 3 hydraulically connected layers. It is mostly confined although some parts are unconfined. The thickness of the aquifer system, including aquitards, varies from 2500m to 250m.

Hydrogeological aspects

The dominant aquifer lithology is sedimentary rocks – sandstones. The system normally receives a recharge of about 90Mm³/annum of freshwater that may increase to nearly 400 Mm³/annum due to extreme events. The freshwater percolates through a recharge area of approximately 35 000 km². Primary type of porosity is predominant that allows low vertical connectivity between layers. Transmissivity values recorded across the aquifer states range between 3 700 and 90 m²/d with an average of 1 300 m²/d.

Linkages with other water systems

There is evidence for a limited amount of recharge in high plateau and escarpment areas through the sandstones outcrop. The main and final discharge zone for the system is the Dead Sea but some discharge also occurs en-route in the form of springs and baseflow in deeply incised wadis that eventually discharge into the Dead Sea (see Appendix 1).

Environmental aspects

Groundwater quality does not satisfy local drinking water standards in about 30% of aquifer area, mainly in the superficial layers of the aquifer system that become vulnerable to pollution from agricultural practice. Rising levels of salinity and nitrates have been observed in these areas.

Socio-economic aspects

A total of about 1 130 Mm³/annum of groundwater is abstracted by the two aquifer states. Abstraction in Jordan at the present is significantly less than in Saudi Arabia.

Legal and Institutional aspects

National Institutions for the management of groundwater exist in both aquifer states and some measures have been taken in recent years to establish some kind of Bilateral Agreement.

Hot spot

The main issue for this TBA is the occurrence of natural nucleides such as radon and radium that could seriously limit the future use of the groundwater. These isotopes may be originating from the underlying Basement but are also found in overlying confining layers. The highest concentration of radium isotopes has been in confined areas. Detailed studies of such areas are required. Abstraction far exceeds the annual recharge and steps towards joint management need to be speeded up.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
Lamine Babasy	Observatoire du Sahara et du Sahel	Tunisia	lamine.babasy@oss.org.tn	Regional coordinator
Yusuf Al-Mooji	Observatoire du Sahara et du Sahel (OSS)	Tunisia	mooji46@yahoo.com	Regional coordinator

AS126 - Saq-Ram Aquifer System (West)

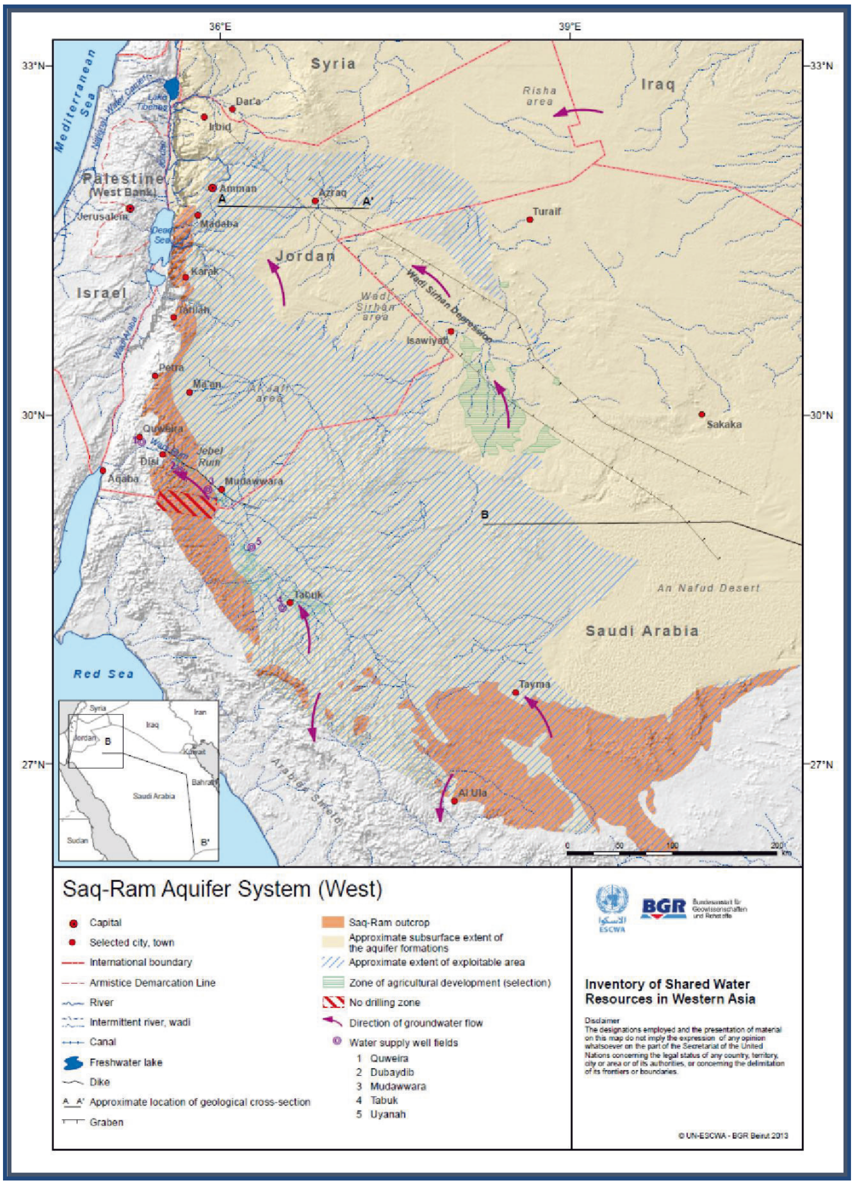
Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Both TBA countries contributed to the information. Information was adequate to describe the aquifer in general terms. Some quantitative information was also available, but not enough to calculate indicators.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Appendix 1: AS126



Map showing Aquifer flow and discharge within the Saq-Ram Aquifer System (West)

AS126 - Saq-Ram Aquifer System (West)

Colophon

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- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: December 2015

AS141 - Umm er Radhuma-Dammam Aquifer System (South): Rub' al Khali

Geography

Total area TBA (km^2): 670 000

No. countries sharing: 4

Countries sharing: Oman, Saudi Arabia, United Arab Emirates, Yemen

Population: 4 200 000

Climate zone: Arid

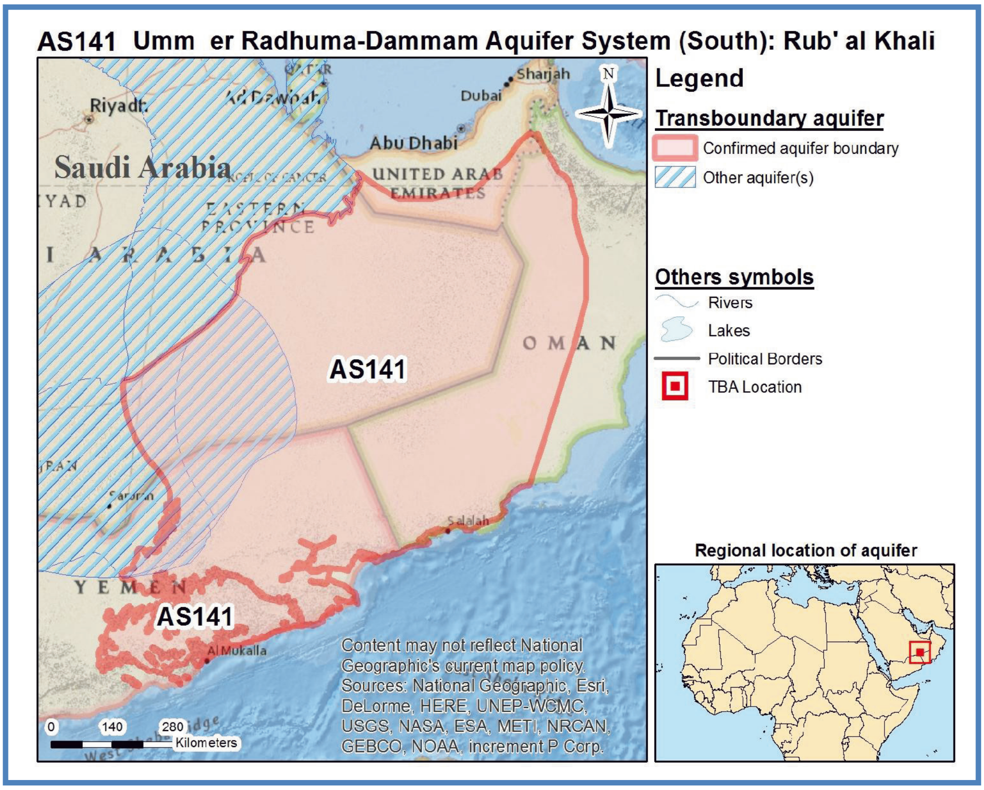
Rainfall (mm/yr): 57

Hydrogeology

Aquifer type: Multiple 3-layered, hydraulically connected

Degree of confinement: Mostly confined, some parts unconfined

Main Lithology: Sedimentary rocks - limestone and dolomites with some evaporites



No cross-section provided

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

AS141 - Umm er Radhuma-Dammam Aquifer System (South): Rub' al Khali

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Oman							3			
Saudi Arabia							7			
United Arab Emirates							18			
Yemen							7			
TBA level	**10**	**1700**	**20**				**6**	**<5**	**D**	**D**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Oman								
Saudi Arabia								
United Arab Emirates								
Yemen								

AS141 - Umm er Radhuma-Dammam Aquifer System (South): Rub' al Khali

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
TBA level				**Aquifer mostly confined, but some parts unconfined**	**Sedimentary rock: Limestone**		**Secondary porosity: Dissolution**	

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

The southern section of the Umm er Radhuma-Dammam Aquifer System extends from the Gulf coast in the north and the Oman Mountains in the south-east over about 800 km, stretching across the vast Rub' al Khali Desert, the Dhofar-Najd Plain in Oman, and the northeastern Hadhramaut-Al Mahra Plateau in Yemen. Geo-structural and physiographic features were used to approximate the boundaries of this system, which comprises 3 hydraulically connected layers. It is mostly confined although some parts are unconfined. The thickness of the aquifer system, including aquitards, varies from 280m to 600m.

Hydrogeological aspects

The predominant aquifer lithology consists of sedimentary rocks - limestone and dolomites with some evaporites. System replenishment is very low to low (0-20 mm/annum), amounting to an average recharge of about 7000 Mm^3/annum of freshwater, but a higher value of 10 000 Mm^3/annum due to extreme events has been recorded. This huge amount of natural recharge water percolates through an area of approximately 650 000 km^2. A secondary type of porosity is predominant that allows for low vertical connectivity between the layers. Transmissivity has a high variability across the Aquifer States, ranging between 5m^2/d and 480m^2/d.

Linkages with other water systems

Recharge occurs via surface flow in a large network of wadi channels during desert-type storm events. Discharge occurs from springs in elevated areas or as saline and hyper-saline waters that form sabkhas in lowlands (see Appendix 1).

Environmental aspects

Groundwater is fresh to hypersaline and quality does not satisfy local standards in about 80% of the aquifer area (see Appendix 2). Superficial layers of the aquifer system are also vulnerable to anthropogenic pollution from oil/ gas production and transport activities. Hydrocarbons are the most important pollutants affecting the groundwater quality.

Socio-economic aspects

A total of 53 Mm^3/annum of groundwater is abstracted, largely in Oman. Uses are agricultural and domestic as well as water injection for the oil industry in Oman.

AS141 - Umm er Radhuma-Dammam Aquifer System (South): Rub' al Khali

Legal and Institutional aspects

National institutions for the management of groundwater exist in both aquifer states but no formal Transboundary Agreement has been made.

Priority issues

This aquifer system is in an early stage of development and would therefore constitute a good opportunity to initiate a comprehensive joint management strategy in order to avoid sustainability issues in the long term. A present issue for this TBA is the upconing of thermal saline water and the potential risk of pollution from the expansion of oil and gas production. Mapping and protection of aquifer areas with freshwater is required and special measures may be needed to protect the system from hydrocarbon pollution.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
Lamine Babasy	Observatoire du Sahara et du Sahel	Tunisia	lamine.babasy@oss.org.tn	Regional coordinator
Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator

Considerations and recommendations

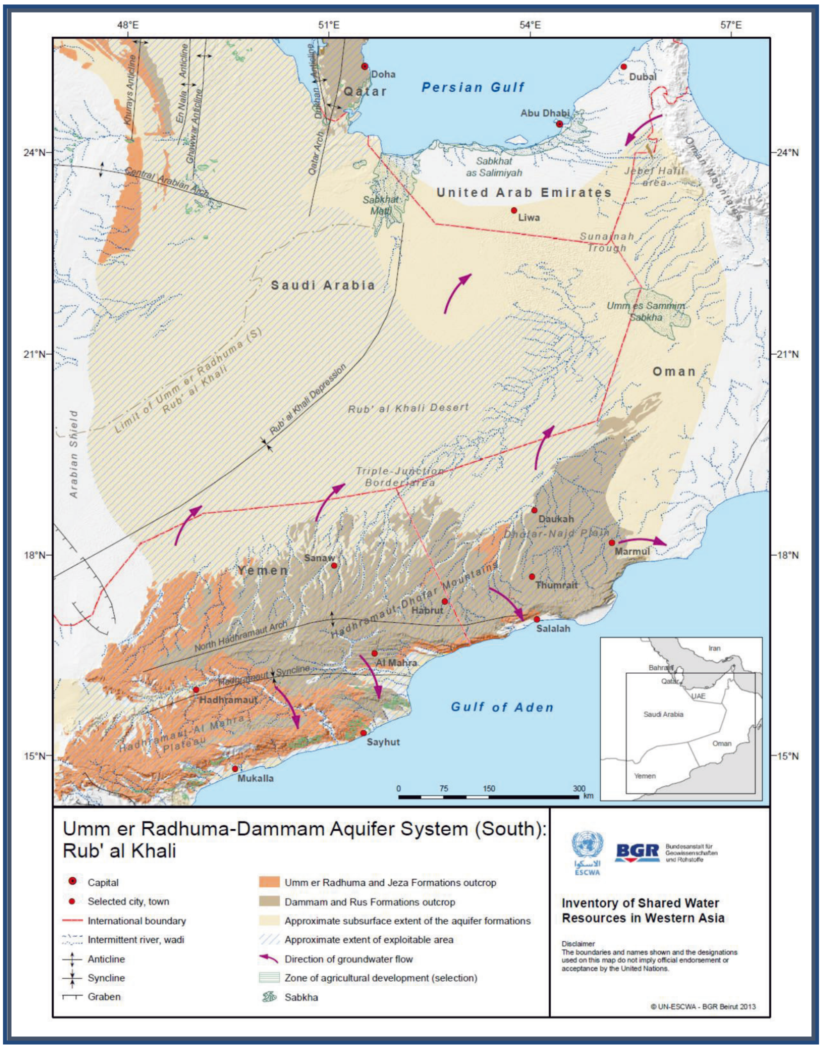
Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

For the transboundary aquifers of Western Asia, data are only available at the level of the complete aquifer and not of the country segments. All this data as well as information elements in the aquifer description are coming from a comprehensive, United Nations-led inventory to catalogue and characterize transboundary surface and groundwater resources in the Middle East (Source: UN-ESCWA and BGR (United Nations Economic and Social Commission for Western Asia; Bundesanstalt für Geowissenschaften und Rohstoffe). 2013. Inventory of Shared Water Resources in Western Asia. Beirut).

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

AS141 - Umm er Radhuma-Dammam Aquifer System (South): Rub' al Khali

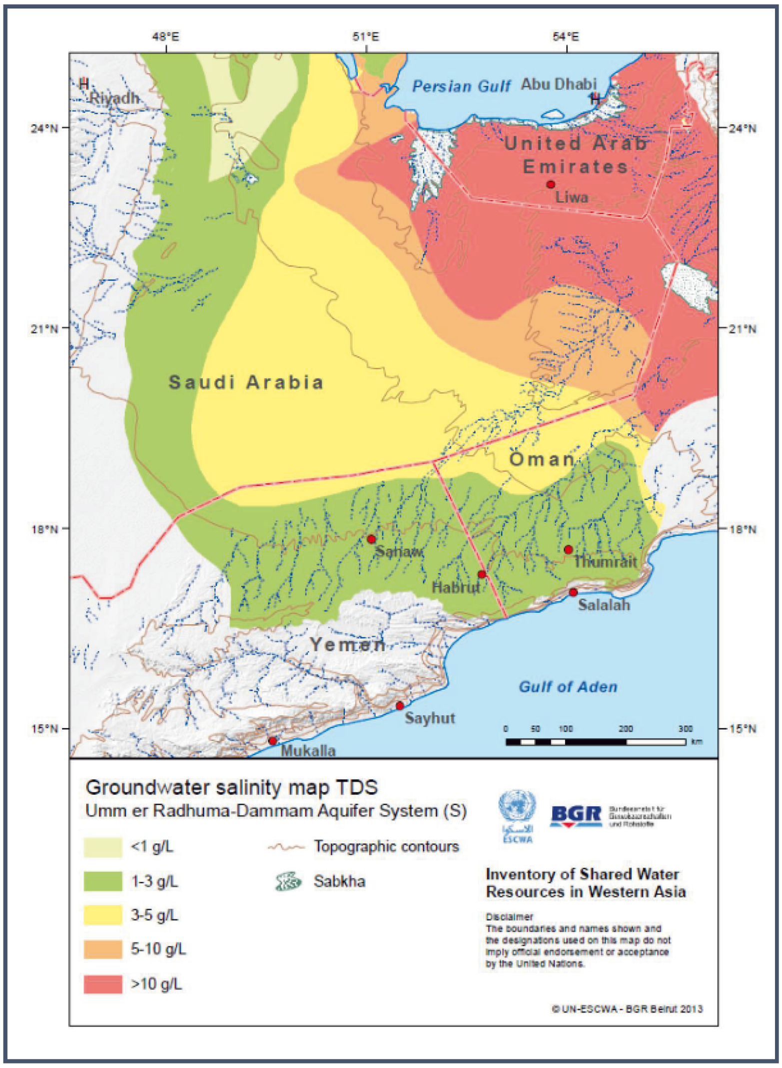
Appendix 1: AS141



Map showing groundwater flow and discharge areas within the Umm er Radhuma-Dammam Aquifer System (South): Rub' al Khali

AS141 - Umm er Radhuma-Dammam Aquifer System (South): Rub' al Khali

Appendix 2: AS141



Groundwater salinity map - TDS of the Umm er Radhuma-Dammam Aquifer System (South): Rub' al Khali

Colophon

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For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

AS141 - Umm er Radhuma-Dammam Aquifer System (South): Rub' al Khali

Request:
If you have additional data or information about this transboundary aquifer that can improve the quality of this information sheet and the underlying database, please contact us via email at info@un-igrac.org. If appropriate, the information will be uploaded to the database of transboundary aquifers and will also be used in new versions of this information sheet.

References:
- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
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- All other data: TWAP Groundwater (2015).

Version: October 2015

AS131 - Wajid Aquifer System

Geography

Total area TBA (km^2): 380 000

No. countries sharing: 2

Countries sharing: Saudi Arabia, Yemen

Population: 4 000 000

Climate zone: Arid

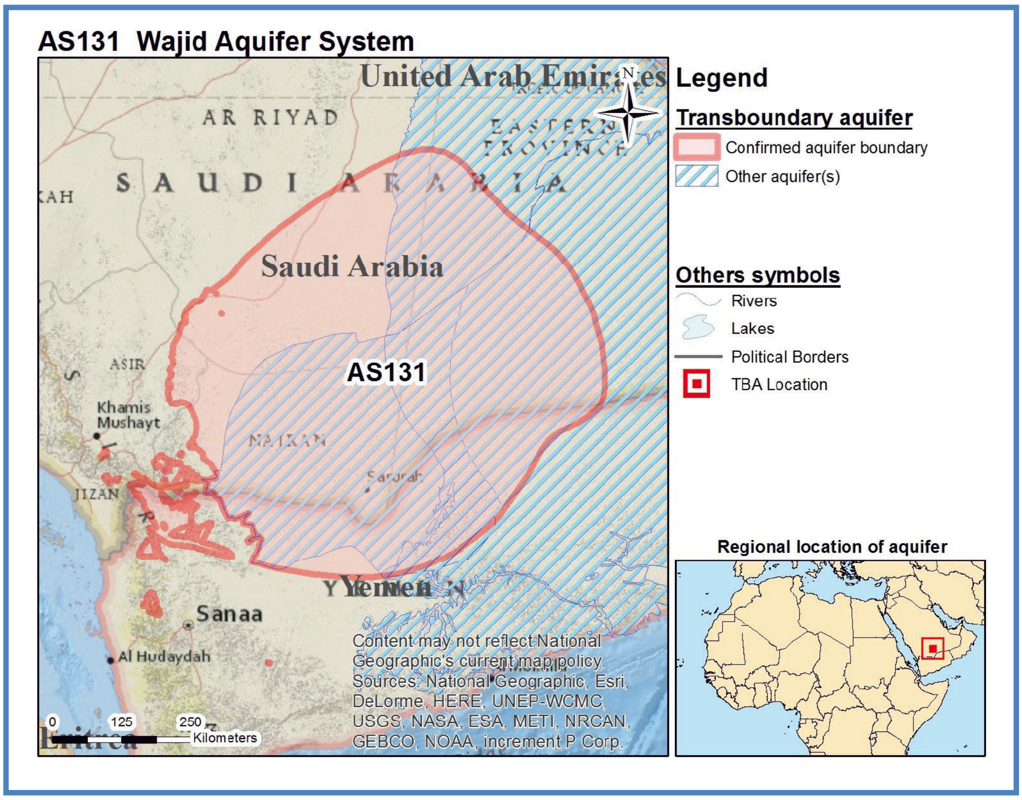
Rainfall (mm/yr): 61

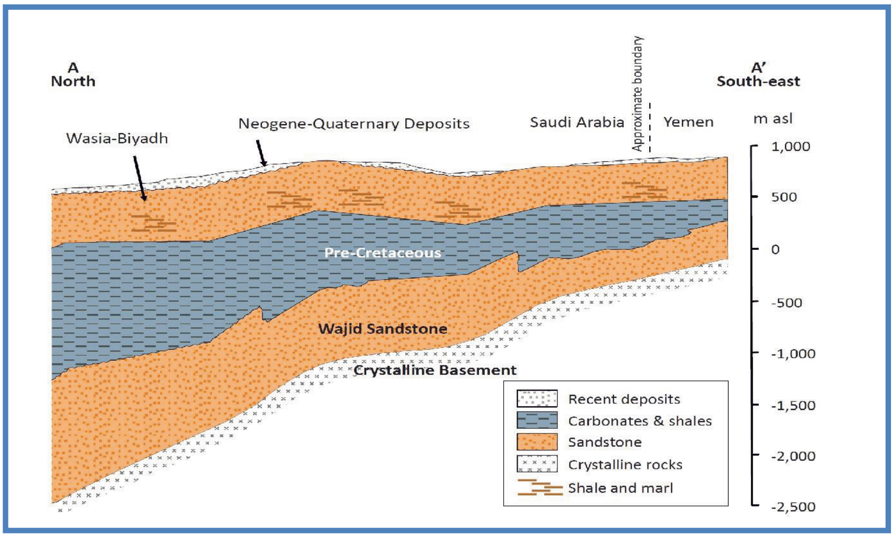
Hydrogeology

Aquifer type: Multiple 4-layered, hydraulically connected

Degree of confinement: Mostly confined, some parts unconfined

Main Lithology: Sedimentary rock - sandstones





Cross-section across part of the system (N – SE)

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

AS131 - Wajid Aquifer System

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Saudi Arabia							10			
Yemen							12			
TBA level	**<1**	**44**	**95**		**3**		**10**	**>1000**	**4**	**4**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).

(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.

(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).

(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.

(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).

(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Saudi Arabia								
Yemen								
TBA level				**Aquifer mostly unconfined, but some parts confined**	**Sedimentary rock: Sandstone**	**High primary porosity fine/medium sedimentary deposits**		**1300**

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

AS131 - Wajid Aquifer System

Aquifer description

Aquifer geometry

The Wajid Sandstones are made up of two permeable formations, the Upper and Lower Wajid Sandstones, which are separated by a less permeable shale formation. Geo-structural and physiographic features were used to approximate the boundaries of this system, which comprises 4 hydraulically connected layers. It is mostly confined although some parts are unconfined. The thickness of the aquifer system, including aquitards, varies from 100m to 900m.

Hydrogeological aspects

The predominant aquifer lithology consists of sedimentary rock – sandstones. System replenishment from natural sources is very low to low (0-20 mm/annum), amounting to about 175 Mm^3/annum to 240 Mm^3/annum of freshwater recharge. This natural recharge water percolates through an area of approximately 26 000 km^2. The primary type of porosity is predominant that allows low vertical connectivity between layers. Transmissivity across the Aquifer States ranges between 50 m^2/d and 7000 with an average of 1 300 m^2/d.

Linkages with other water systems

Recharge occurs via runoff and flash floods in a network of wadi channels descending from the Asir Mountains. Discharge occurs in the form of sabkhas along fracture zones inside Saudi Arabia (see Appendix 1).

Environmental aspects

Groundwater is fresh to slightly brackish (700-1000 mg/l TDS) and only in in about 5% of aquifer area does quality not satisfy local drinking water standards. Superficial layers of the aquifer system are vulnerable to pollution from agricultural practice and salinization, nitrogen species and pesticides are the most important pollutants affecting groundwater quality.

Socio-economic aspects

A total of 2400 Mm^3/annum of groundwater is abstracted, mainly in Saudi Arabia and predominantly for agricultural use.

Legal and Institutional aspects

National Institutions for the management of groundwater exist in both Aquifer States but no formal Transboundary Agreement has been made.

Hot spot

This system has been heavily exploited in certain areas that will soon be economically exhausted, as predicted by a number of studies. In addition, groundwater may contain significant amounts of radionuclides of natural origin that are potentially hazardous to human health. A thorough study and assessment of the current conditions of groundwater in the system, in terms of both quantity and quality, becomes a priority. Joint monitoring and management of the over-exploited aquifer system under a bilateral agreement is essential.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
Lamine Babasy	Observatoire du Sahara et du Sahel	Tunisia	lamine.babasy@oss.org.tn	Regional coordinator
Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator

AS131 - Wajid Aquifer System

Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

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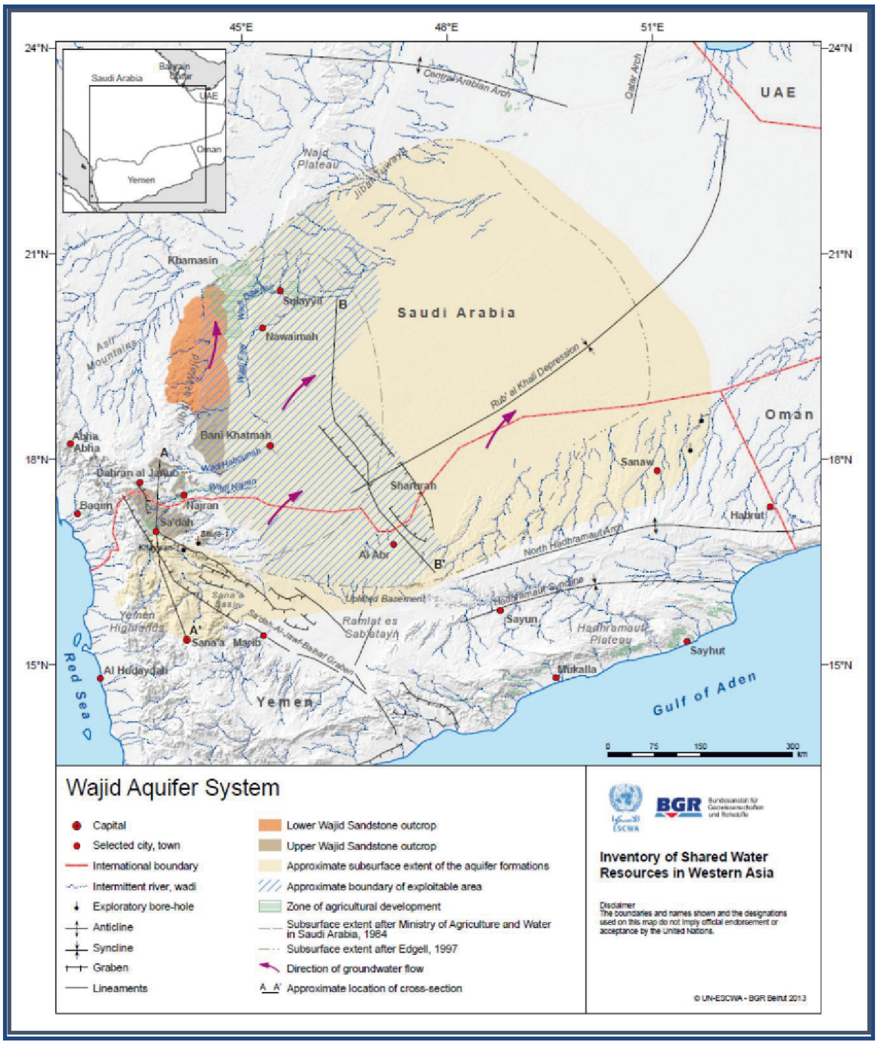
Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Appendix 1: AS131



Map showing Groundwater flow and discharge within the Wajid Aquifer System

AS131 - Wajid Aquifer System

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

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- All other data: TWAP Groundwater (2015).

Version: October 2015

AS139 - Wasia-Biyadh-Aruma Aquifer System (South): Tawila-Mahra/Cretaceous Sands

Geography

Total area TBA (km^2): 160 000

No. countries sharing: 2

Countries sharing: Saudi Arabia, Yemen

Population: 870 000

Climate zone: Arid

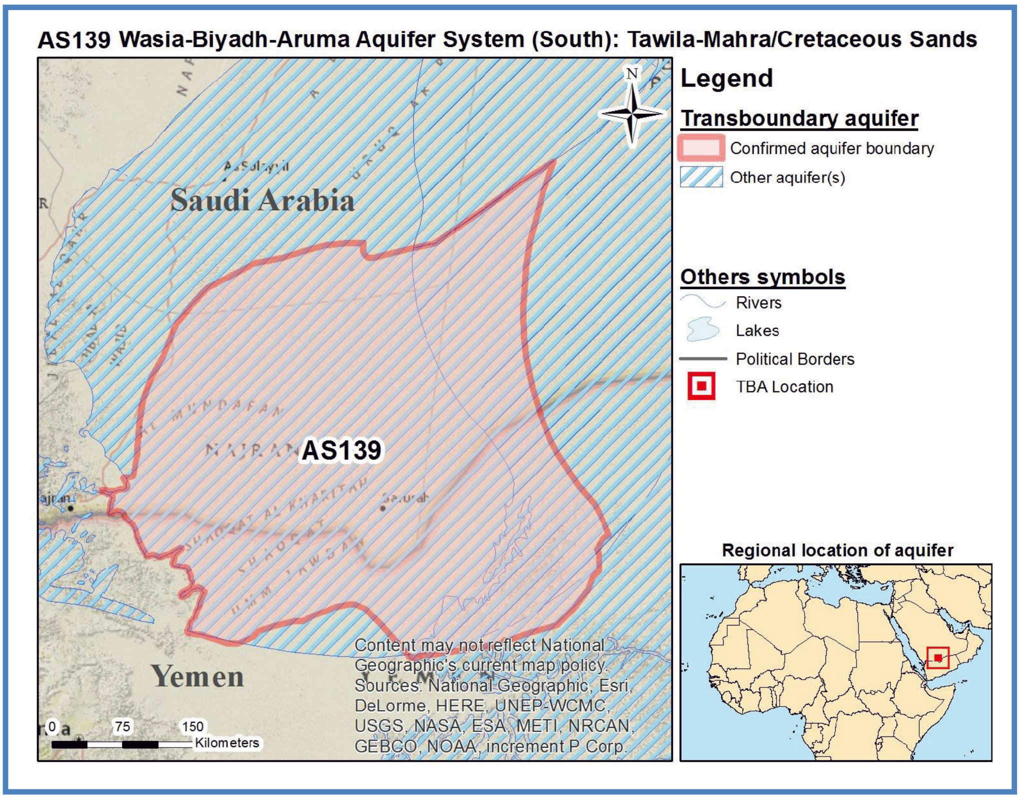
Rainfall (mm/yr): 61

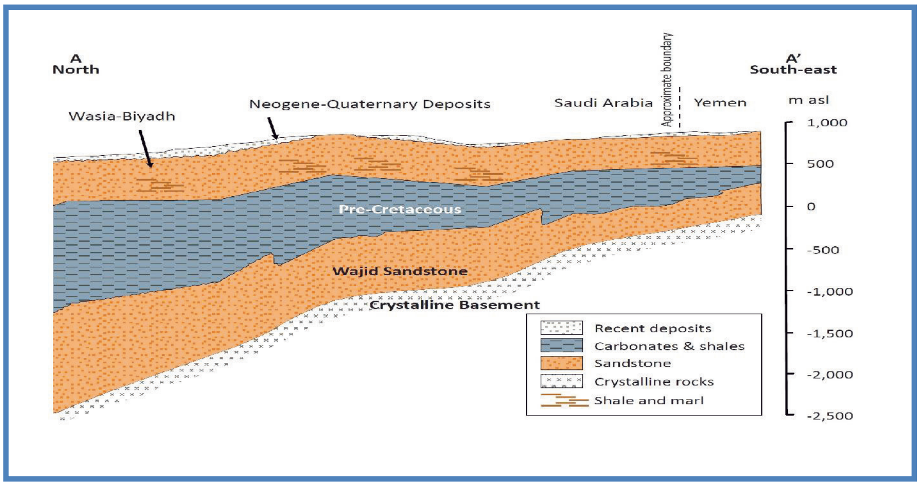
Hydrogeology

Aquifer type: 2-layered, hydraulically connected

Degree of confinement: Mostly confined, some parts unconfined

Main Lithology: Sedimentary rocks - sandstones with some marls and siltstones





Geological Cross-section across part of the system (N – SE)

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

AS139 - Wasia-Biyadh-Aruma Aquifer System (South): Tawila-Mahra/Cretaceous Sands

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Saudi Arabia							7			
Yemen							4			
TBA level	**3**	**580**	**90**				**6**		**D**	**D**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).

(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.

(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).

(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.

(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).

(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Saudi Arabia								
Yemen								
TBA level				**Aquifer mostly confined, but some parts unconfined**	**Sedimentary rock: Sandstone**	**High primary porosity fine/medium sedimentary deposits**		

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

AS139 - Wasia-Biyadh-Aruma Aquifer System (South): Tawila-Mahra/Cretaceous Sands

Aquifer description

Aquifer geometry

The Wasia-Biyadh Sandstones merge with the Aruma in the southern areas of Saudi Arabia to constitute the so-called Cretaceous Sands. These sandstones extend across the Rub' al Khali Depression into Yemen where stratigraphically correlatable sandstones exist (the so-called Tawila-Mahra Group), thus forming a transboundary aquifer system denoted here as the Wasia-Biyadh-Aruma Aquifer System (South). Geo-structural and physiographic features were used to approximate the boundaries of this system, which comprises 2 hydraulically connected layers. It is mostly confined although some parts are unconfined. The thickness of the aquifer system, including aquitards, varies from 100m to 1000m.

Hydrogeological aspects

The predominant aquifer lithology consists of Sedimentary rocks - sandstones with some marls and siltstones. System replenishment from natural sources is very low (0-2 mm/annum), amounting to an average recharge of about 500Mm^3/annum across an area of approximately 56 000 km^2. The primary type of porosity is predominant that allows high vertical connectivity between layers. Transmissivity across the aquifer states ranges between 200 m^2/d and 730 m^2/d.

Linkages with other water systems

Limited recharge occurs in localized areas, either directly from rainfall or indirectly via coarse aeolian sand dunes and fractured outcrop zones. There are no visible signs of discharge on the surface (see Appendix 1).

Environmental aspects

Groundwater is fresh (400-800 mg/l TDS) and quality does not satisfy local drinking water standards in only about 10% of aquifer area, particularly in superficial layers of the aquifer system.

Socio-economic aspects

Abstraction of groundwater from the system is known to be very limited because of its remoteness (for desert nomads and border posts), but the potential is there in both Aquifer States.

Legal and Institutional aspects

National Institutions for the management of groundwater exist in both Aquifer States but no formal Transboundary Agreement has been made.

Emerging issues

No priority issue exists at the present, as abstraction from the system is limited. This large reservoir of fresh groundwater is an important resource for the economic development of the Sharurah/Al Abr area in the future. It may also prove to be a source of water for more distant but rapidly developing urban areas in both Saudi Arabia and Yemen. The existence of radon in the sandstones needs to be assessed since it may become a limiting factor in the long-term.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
Lamine Babasy	Observatoire du Sahara et du Sahel	Tunisia	lamine.babasy@oss.org.tn	Regional coordinator
Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator

AS139 - Wasia-Biyadh-Aruma Aquifer System (South): Tawila-Mahra/Cretaceous Sands

Considerations and recommendations

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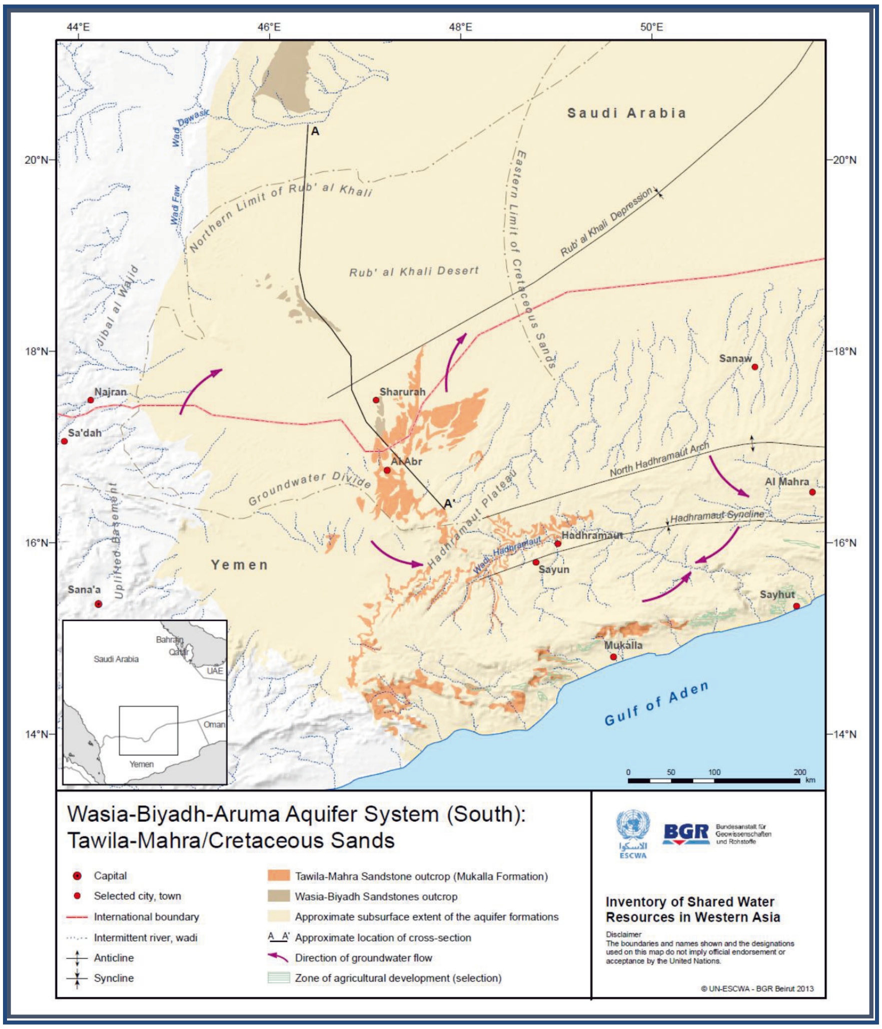
Appendix 1: AS139



Wasia-Biyadh-Aruma Aquifer System (South): Tawila-Mahra/Cretaceous Sands: indicating Groundwater flow directions

AS139 - Wasia-Biyadh-Aruma Aquifer System (South): Tawila-Mahra/Cretaceous Sands

Colophon

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- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

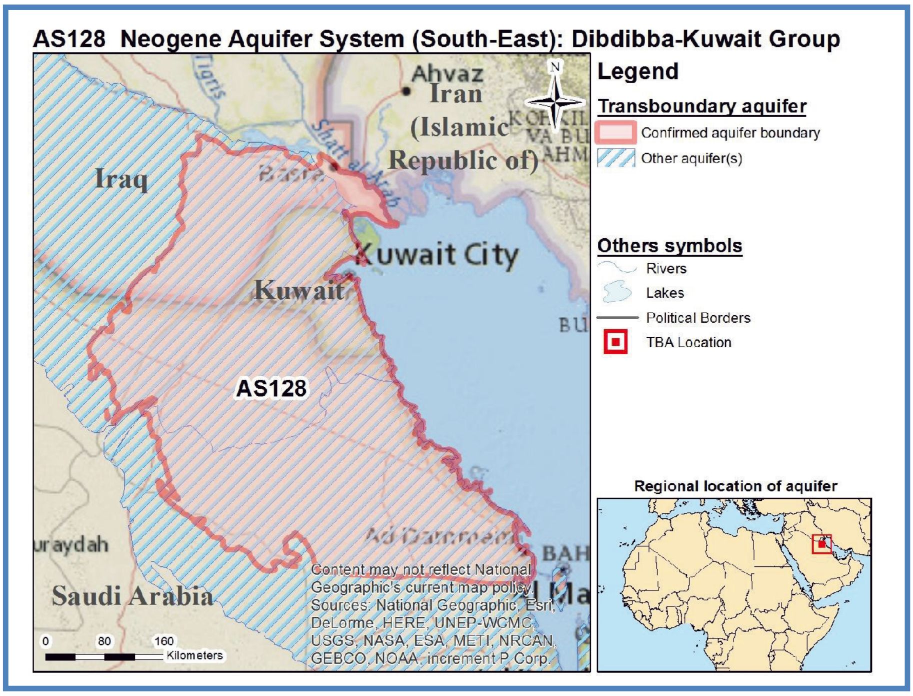
AS128 - Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

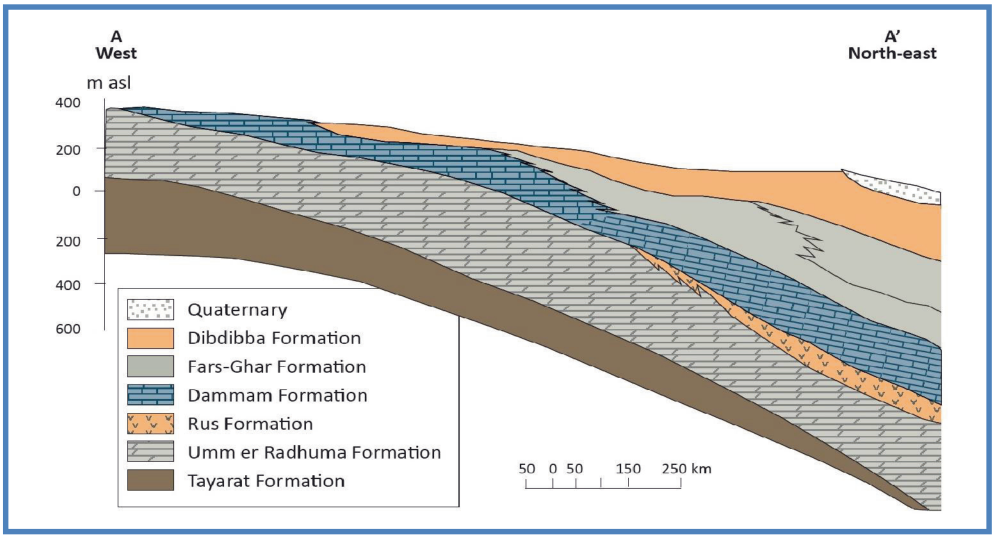
Geography

Total area TBA (km^2): 150 000
No. countries sharing: 3
Countries sharing: Iraq, Kuwait, Saudi Arabia
Population: 4 900 000
Climate zone: Arid
Rainfall (mm/yr): 140

Hydrogeology

Aquifer type: Multiple 3-layered, hydraulically connected
Degree of confinement: Mostly unconfined, some parts confined
Main Lithology: Sediment - sand





Geological Cross-section along part of the System (W – NE)

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

AS128 - Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Iraq							72			
Kuwait							130			
Saudi Arabia							7			
TBA level	**<1**	**12**	**10**				**32**	**790**	**D**	**D**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Iraq								
Kuwait								
Saudi Arabia								
TBA level			**150**	**Aquifer mostly unconfined, but some parts confined**	**Sediment - Gravel**	**High primary porosity fine/medium sedimentary deposits**		

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

AS128 - Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

Aquifer description

Aquifer geometry

The Neogene Aquifer System (South-East) represents the northern extension of the Neogene Aquifers, which overlie the Paleogene Formations in the north-east of the Arabian Platform. Geo-structural and physiographic features were used to approximate the boundaries of the system. It consists of 3 layers of unconsolidated sediments that are hydraulically connected, and is mostly unconfined although some parts are confined. The total thickness of the aquifer system varies from 30m to 550m with an average of 150 m.

Hydrogeological aspects

System replenished from natural sources is very low to low (0-20 mm/annum), amounting to about 58Mm^3/annum of freshwater, but a dramatic increase of recharge to 2700 Mm^3/annum due to extreme events has been recorded. Water infiltrates through coarse sediments in a recharge area of 82 000 km^2. Primary type of porosity is predominant and vertical connectivity between the sediment layers is low. Transmissivity values recorded across the aquifer states range between 10m^2/d and 2200m^2/d.

Linkages with other water systems

Recharge is mainly by surface and sub-surface flow in an extensive wadi system as well as direct infiltration of rainfall during rainstorm events. Natural discharge occurs mainly in the Gulf coastal area and the Shatt al Arab lowlands, through evaporation from shallow water tables and seepage into overlying Quaternary sediments, riverbeds and sabkhas (see Appendix 1).

Environmental aspects

Groundwater is brackish to saline (2500 mg/l to 15 000 mg/l TDS) and quality does not satisfy local standards in about 90% of aquifer area due to natural salinity. This natural salinity affects a significant part of the aquifer system. Some pollutants have also been reported.

Socio-economic aspects

A total of about 460 Mm^3/annum of groundwater is abstracted, mainly by Iraq and Kuwait. The use is mainly agricultural.

Legal and Institutional aspects

National Institutions for the management of groundwater exist in all of the Aquifer States but no formal Transboundary Agreement has been made.

Hot spot

The aquifer system is very heavily over-exploited in relation to its mean annual replenishment. The main issue for this TBA is that the limited volume of fresh groundwater occurs in lenses that are vulnerable to salinization and hydrocarbon pollution due to their proximity to oilfields as well as upconing of saline water from the underlying Paleogene aquifer system. A close monitoring of water quality in the downstream and coastal areas is required. A Bilateral Agreement is essential to monitor and manage the pumping regime of the transboundary aquifer.

UNEP gef United Nations Educational, Scientific and Cultural Organization International Hydrological Programme igrac International Groundwater Resources Assessment Centre

AS128 - Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
Lamine Babasy	Observatoire du Sahara et du Sahel	Tunisia	lamine.babasy@oss.org.tn	Regional coordinator
Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator

Considerations and recommendations

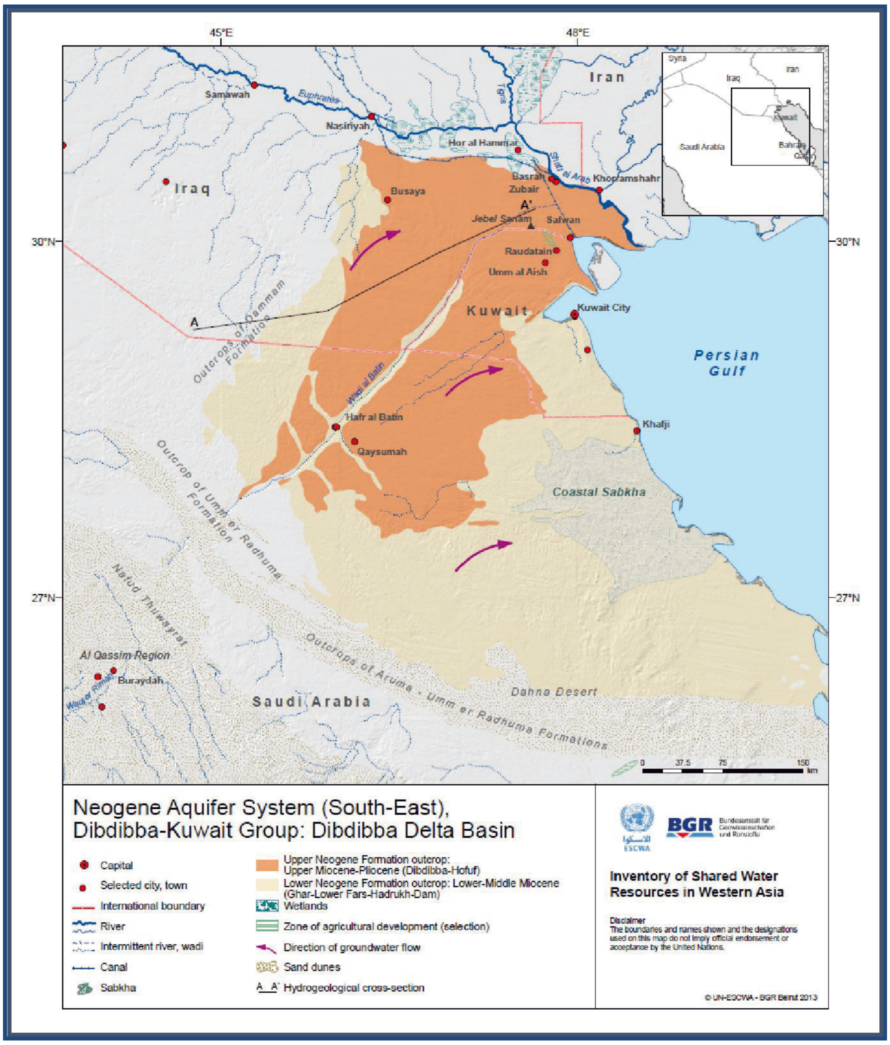
Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

For the transboundary aquifers of Western Asia, data are only available at the level of the complete aquifer and not of the country segments. All this data as well as information elements in the aquifer description are coming from a comprehensive, United Nations-led inventory to catalogue and characterize transboundary surface and groundwater resources in the Middle East (Source: UN-ESCWA and BGR (United Nations Economic and Social Commission for Western Asia; Bundesanstalt für Geowissenschaften und Rohstoffe). 2013. Inventory of Shared Water Resources in Western Asia. Beirut).

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

AS128 - Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

Appendix 1: AS128



Map showing groundwater flow directions and discharge areas within the Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

AS128 - Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

Request:
If you have additional data or information about this transboundary aquifer that can improve the quality of this information sheet and the underlying database, please contact us via email at info@un-igrac.org. If appropriate, the information will be uploaded to the database of transboundary aquifers and will also be used in new versions of this information sheet.

References:
- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

AS127 - Wasia-Biyadh-Aruma Aquifer System (North): Sakaka-Rutba

Geography

Total area TBA (km^2): 84 000

No. countries sharing: 2

Countries sharing: Iraq, Saudi Arabia

Population: 560 000

Climate zone: Arid

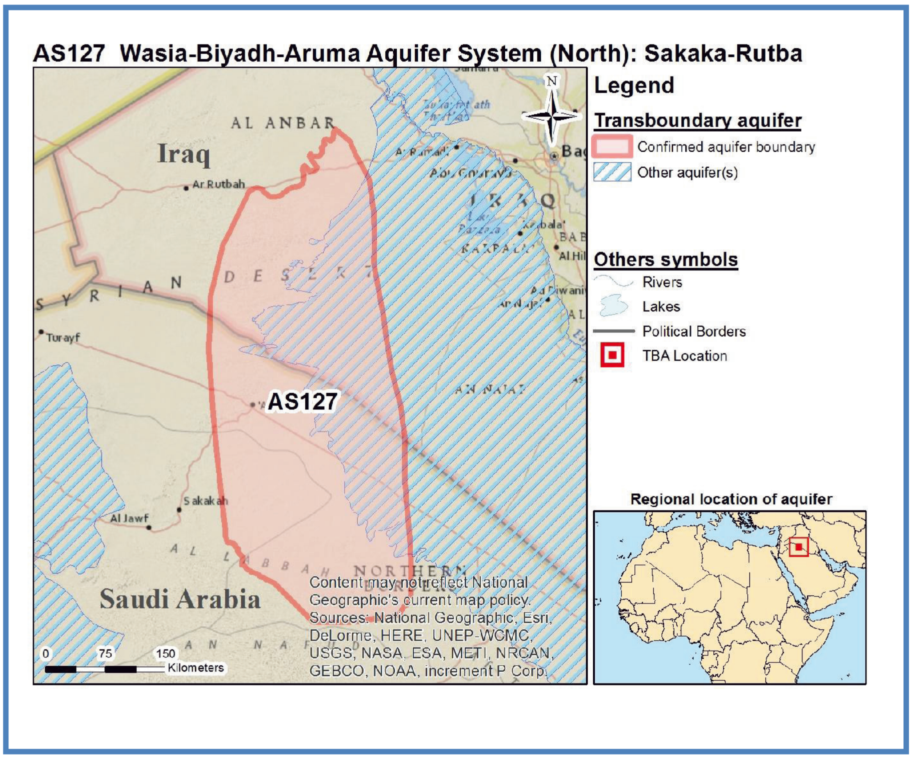
Rainfall (mm/yr): 87

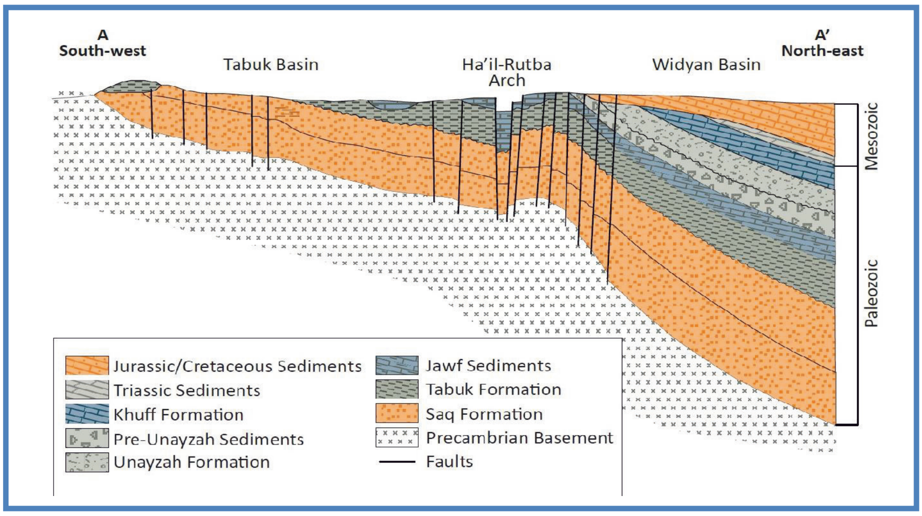
Hydrogeology

Aquifer type: Multiple 4-layered, hydraulically connected

Degree of confinement: Mostly confined, some parts unconfined

Main Lithology: Sedimentary rock - sandstones, locally calcareous or argillaceous





Geological Cross-section across part of the system (NW – SE)

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

AS127 - Wasia-Biyadh-Aruma Aquifer System (North): Sakaka-Rutba

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Iraq							12			
Saudi Arabia							3			
TBA level	**3**	**440**	**80**				**7**	**10**	**D**	**D**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Iraq								
Saudi Arabia								
TBA level				**Aquifer mostly confined, but some parts unconfined**	**Sedimentary rock: Sandstone**	**High primary porosity fine/medium sedimentary deposits**		

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

AS127 - Wasia-Biyadh-Aruma Aquifer System (North): Sakaka-Rutba

Aquifer description

Aquifer geometry

The Wasia-Biyadh-Aruma Aquifer System (North) lies on a high plain (400-800 m) that extends across the western Rutba High in Iraq and the Widyan Plain in Saudi Arabia. Geo-structural and physiographic features were used to approximate the boundaries of this system, which comprises 4 hydraulically connected layers. It is mostly confined although some parts are unconfined (outcrop areas). The thickness of the aquifer system, including aquitards, varies from 70m to 690m.

Hydrogeological aspects

The main aquifer lithology is sedimentary rock - sandstones that are locally calcareous or argillaceous. The system replenishment from natural sources is very low to low (0-20 mm/annum) and amounts to an average of about 240Mm³/annum of freshwater (the figure needs to be confirmed). Primary type of porosity is predominant that allows low vertical connectivity between layers. The transmissivity across the Aquifer States ranges between 85m²/d and 8 600 m²/d.

Linkages with other water systems

Limited recharge occurs in localized areas, either directly from rainfall or via wadi channels and fractured outcrop zones. Discharge takes place in the form of sabkhas and mudflats inside Iraq (see Appendix 1).

Environmental aspects

Groundwater is fresh to slightly brackish (400-3,000 mg/l TDS) and the quality does not satisfy local drinking water standards in about 20% of aquifer area, particularly in superficial layers of the aquifer system.

Socio-economic aspects

A total of 30Mm³/annum of groundwater is abstracted across the two Aquifer States, mainly for domestic and agricultural use.

Legal and Institutional aspects

National Institutions for the management of groundwater exist in both aquifer states but no formal Transboundary Agreement has been made.

Emerging issues

No priority issue exists at the present as abstraction from the system is limited. The Wasia-Biyadh-Aruma Aquifer System is a promising aquifer system that could be used to encourage agricultural development in this pediment region, especially around the wadi areas where soils are fertile. The existence of radon in the sandstones needs to be assessed since it may become a limiting factor in the long term.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
Lamine Babasy	Observatoire du Sahara et du Sahel	Tunisia	lamine.babasy@oss.org.tn	Regional coordinator
Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator

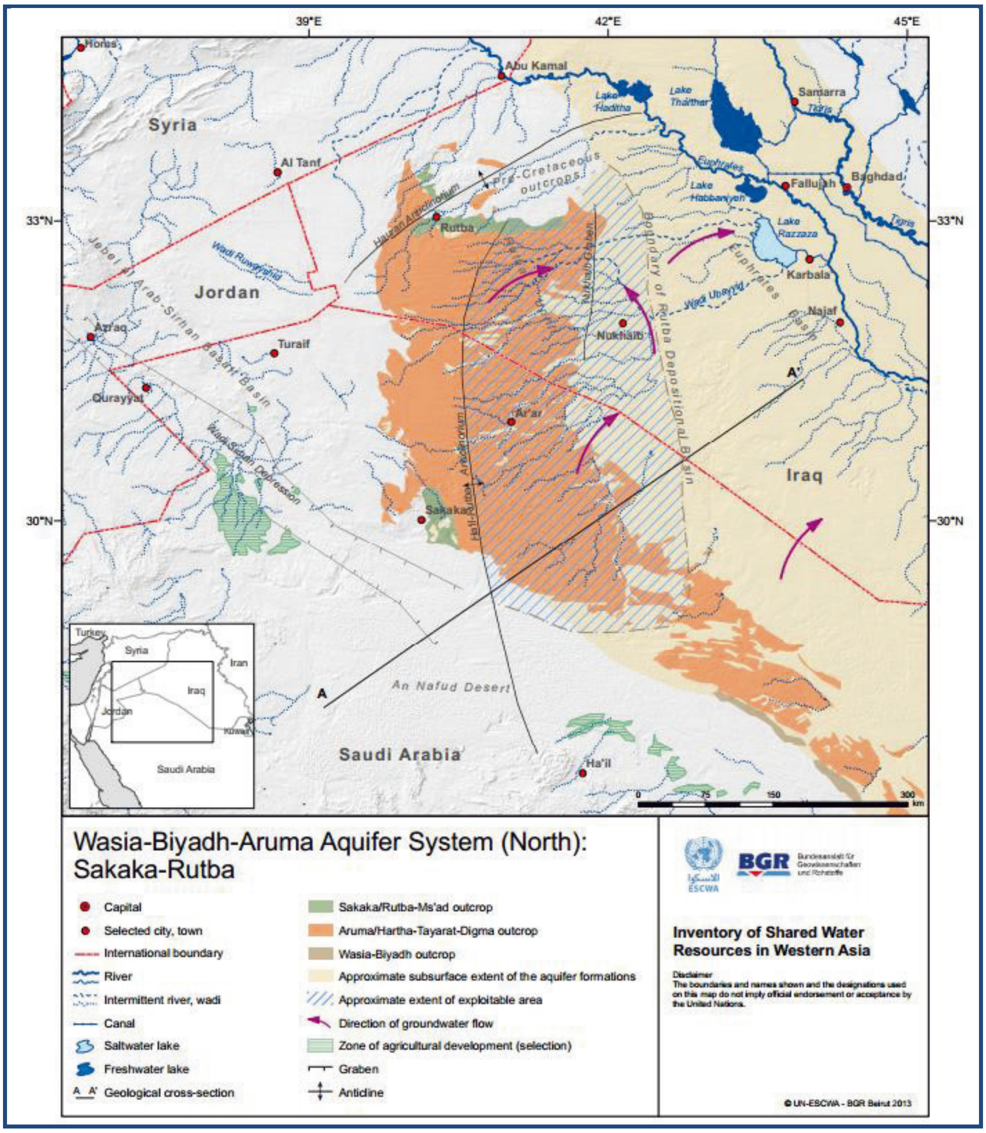
AS127 - Wasia-Biyadh-Aruma Aquifer System (North): Sakaka-Rutba

Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources. For the transboundary aquifers of Western Asia, data are only available at the level of the complete aquifer and not of the country segments. All this data as well as information elements in the aquifer description are coming from a comprehensive, United Nations-led inventory to catalogue and characterize transboundary surface and groundwater resources in the Middle East (Source: UN-ESCWA and BGR (United Nations Economic and Social Commission for Western Asia; Bundesanstalt für Geowissenschaften und Rohstoffe). 2013. Inventory of Shared Water Resources in Western Asia. Beirut).

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Appendix 1: AS127 - Map of the Wasia-Biyadh-Aruma Aquifer System (North): Sakaka-Rutba: - showing groundwater flow directions and discharge areas



AS127 - Wasia-Biyadh-Aruma Aquifer System (North): Sakaka-Rutba

Colophon

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For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

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- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

AS130 - Umm er Radhuma-Dammam Aquifer System (North): Widyan-Salman

Geography

Total area TBA (km^2): 240 000

No. countries sharing: 3

Countries sharing: Iraq, Kuwait, Saudi Arabia

Population: 6 800 000

Climate zone: Arid

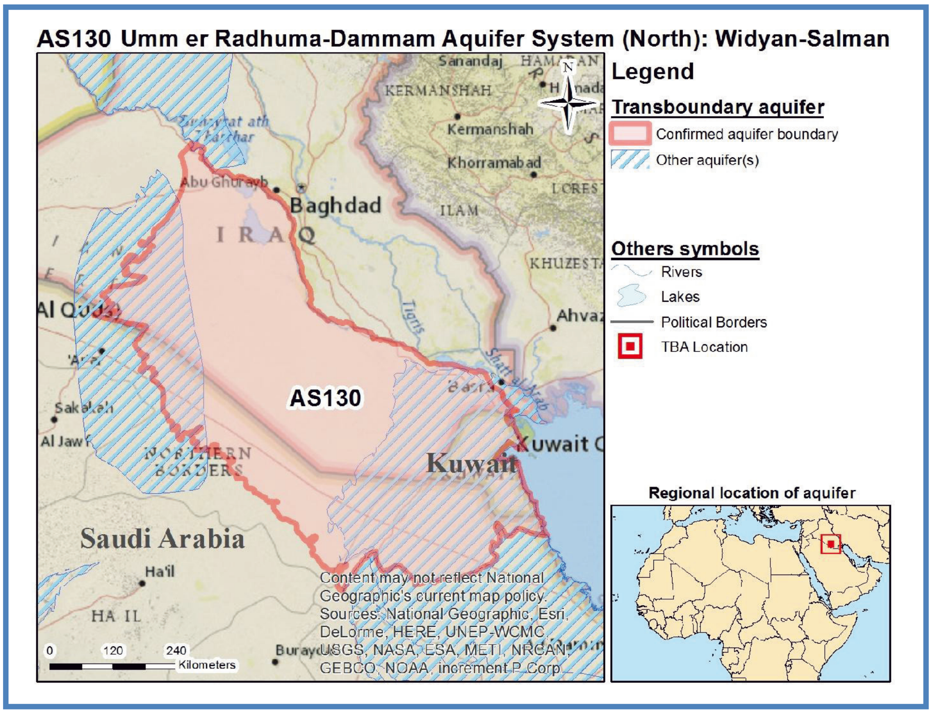
Rainfall (mm/yr): 110

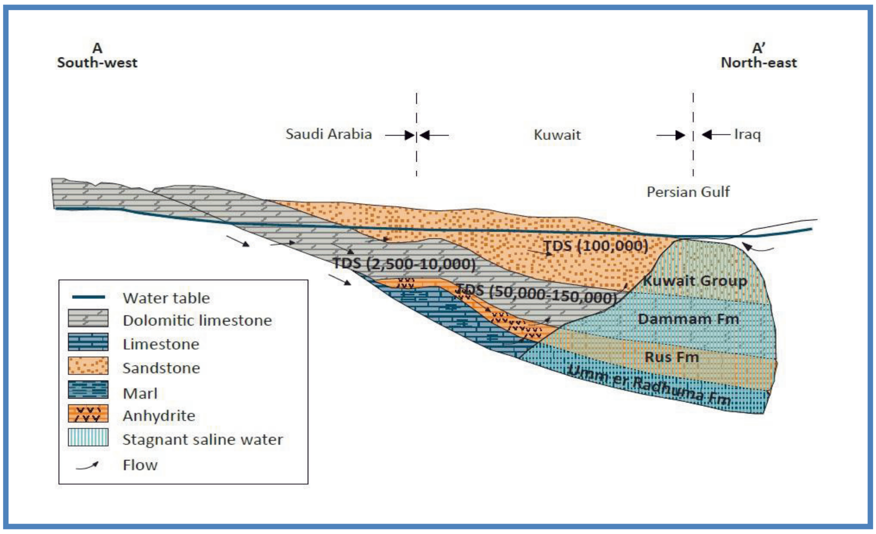
Hydrogeology

Aquifer type: 2-layered hydraulically connected,

Degree of confinement: Mostly confined some parts confined

Main Lithology: Sedimentary rocks - limestone and dolomites with some evaporites





Cross-section across part of the system (SW – NE)

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

AS130 - Umm er Radhuma-Dammam Aquifer System (North): Widyan-Salman

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Iraq							30			
Kuwait							130			
Saudi Arabia							5			
TBA level	**1**	**31**	**50**		**0**		**28**	**55**	**D**	**D**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Iraq								
Kuwait								
Saudi Arabia								
TBA level				**Aquifer mostly confined, but some parts unconfined**	**Sedimentary rock: Limestone**		**Secondary porosity: Dissolution**	

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

AS130 - Umm er Radhuma-Dammam Aquifer System (North): Widyan-Salman

Aquifer description

Aquifer geometry

The Umm er Radhuma and Dammam Formations constitute the main aquifers forming the shared aquifer system between Iraq, Kuwait and Saudi Arabia. Geo-structural and physiographic features were used to approximate the boundaries of this system, which comprises 2 hydraulically connected layers. It is mostly confined although some parts are unconfined. The thickness of the aquifer system, including aquitards, varies from 270m to 680m.

Hydrogeological aspects

The predominant aquifer lithology consists of sedimentary rocks - limestone and dolomite with some evaporites. System replenishment from natural sources is very low to low (0-20 mm/annum), amounting to about 210 Mm^3/annum of freshwater, but higher values up to 1 200 Mm^3/annum due to extreme events have been recorded. This natural recharge water percolates through an area of approximately 83 000km^2. Secondary type of porosity is predominant that allows for a low vertical connectivity between the layers. Extremely variable values have been recorded for transmissivity across the aquifer states, ranging between 3m^2/d and 4 700 m^2/d.

Linkages with other water systems

Recharge occurs through karstic and dissolution features in the limestones, mainly in the Umm er Radhuma outcrop areas. Discharge takes place through one lake and a large number of karst springs along the western bank of the Euphrates River in Iraq.

Environmental aspects

Groundwater quality does not satisfy local standards in about 50% of aquifer area due mainly to natural salinity, which affects a significant part of the aquifer system (see Appendix 1). No anthropogenic pollutants have been identified.

Socio-economic aspects

A total of 120 Mm^3/annum of groundwater is abstracted, mainly Kuwait and Iraq. Use is mainly agricultural, industrial and domestic.

Legal and Institutional aspects

National Institutions for the management of groundwater exist in both Aquifer States but no formal Transboundary Agreement has been made.

Hot spot

Abstraction makes up more than 50% of the mean annual replenishment. The resulting main issue for this TBA is rapid changes in hydraulic head which allows upconing of formation water at depth as well as for seawater intrusion. Groundwater quality deterioration has mainly affected Kuwait. Close monitoring of both groundwater quality and hydraulic gradients and re-evaluation of the pumping regime is urgently required. Effective joint management decisions could decrease the risk of salinization and make the aquifer system more sustainable.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
Lamine Babasy	Observatoire du Sahara et du Sahel	Tunisia	lamine.babasy@oss.org.tn	Regional coordinator
Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator

AS130 - Umm er Radhuma-Dammam Aquifer System (North): Widyan-Salman

Considerations and recommendations

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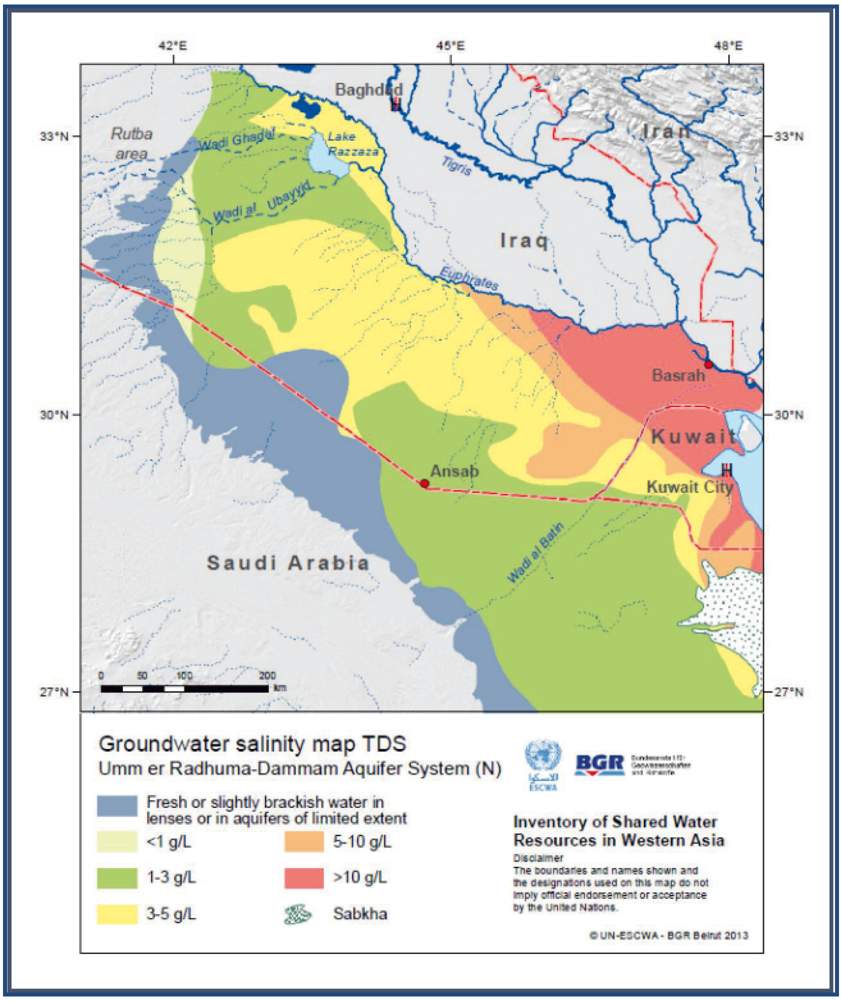
Appendix 1: AS130



Groundwater TDS salinity map of the Umm er Radhuma-Dammam Aquifer System (North): Widyan-Salman

AS130 - Umm er Radhuma-Dammam Aquifer System (North): Widyan-Salman

Colophon

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Request:
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References:

- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

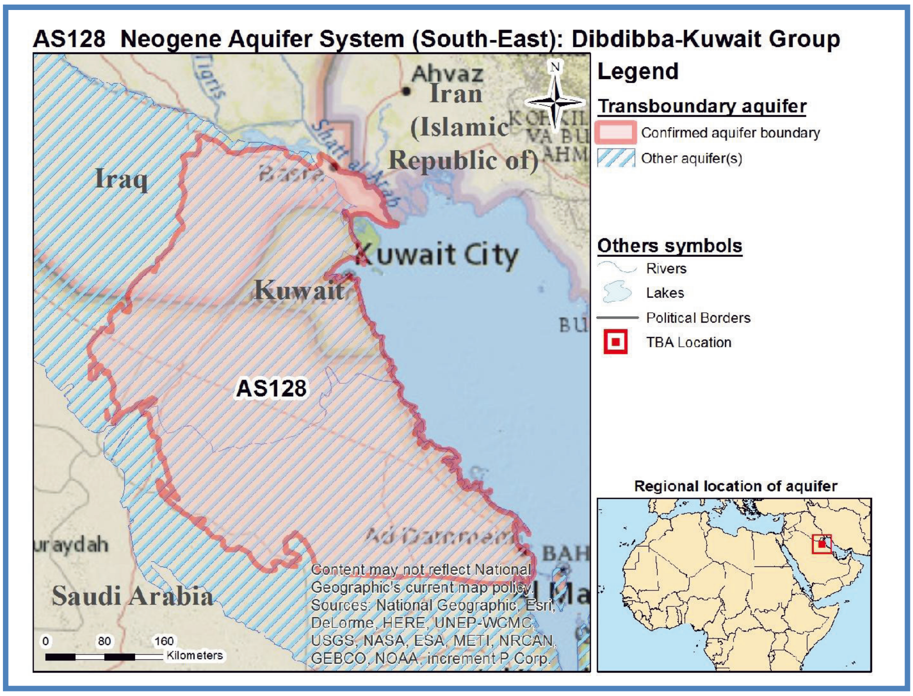
AS128 - Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

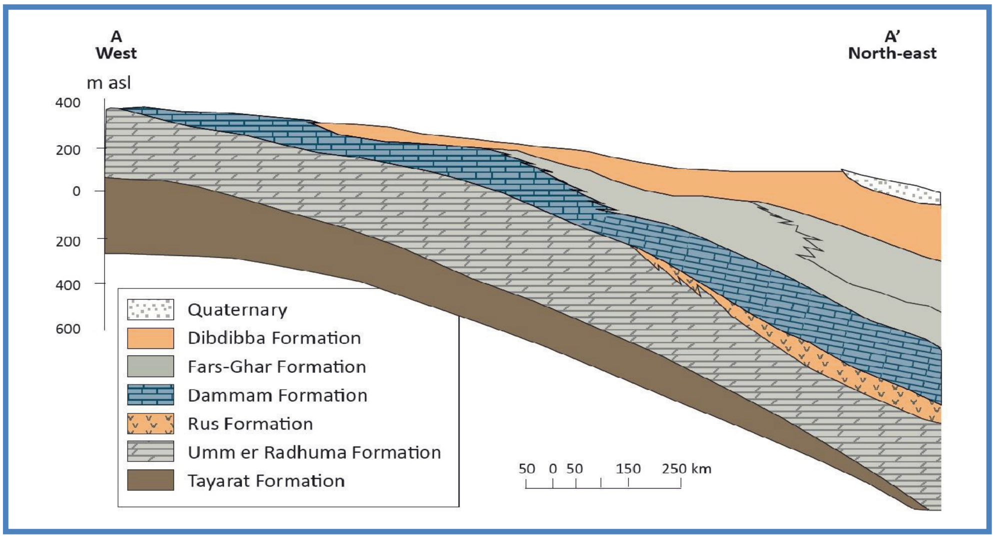
Geography

Total area TBA (km^2): 150 000
No. countries sharing: 3
Countries sharing: Iraq, Kuwait, Saudi Arabia
Population: 4 900 000
Climate zone: Arid
Rainfall (mm/yr): 140

Hydrogeology

Aquifer type: Multiple 3-layered, hydraulically connected
Degree of confinement: Mostly unconfined, some parts confined
Main Lithology: Sediment - sand





Geological Cross-section along part of the System (W – NE)

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

AS128 - Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Iraq							72			
Kuwait							130			
Saudi Arabia							7			
TBA level	**<1**	**12**	**10**				**32**	**790**	**D**	**D**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Iraq								
Kuwait								
Saudi Arabia								
TBA level			**150**	**Aquifer mostly unconfined, but some parts confined**	**Sediment - Gravel**	**High primary porosity fine/medium sedimentary deposits**		

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

AS128 - Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

Aquifer description

Aquifer geometry

The Neogene Aquifer System (South-East) represents the northern extension of the Neogene Aquifers, which overlie the Paleogene Formations in the north-east of the Arabian Platform. Geo-structural and physiographic features were used to approximate the boundaries of the system. It consists of 3 layers of unconsolidated sediments that are hydraulically connected, and is mostly unconfined although some parts are confined. The total thickness of the aquifer system varies from 30m to 550m with an average of 150 m.

Hydrogeological aspects

System replenished from natural sources is very low to low (0-20 mm/annum), amounting to about 58Mm^3/annum of freshwater, but a dramatic increase of recharge to 2700 Mm^3/annum due to extreme events has been recorded. Water infiltrates through coarse sediments in a recharge area of 82 000 km^2. Primary type of porosity is predominant and vertical connectivity between the sediment layers is low. Transmissivity values recorded across the aquifer states range between 10m^2/d and 2200m^2/d.

Linkages with other water systems

Recharge is mainly by surface and sub-surface flow in an extensive wadi system as well as direct infiltration of rainfall during rainstorm events. Natural discharge occurs mainly in the Gulf coastal area and the Shatt al Arab lowlands, through evaporation from shallow water tables and seepage into overlying Quaternary sediments, riverbeds and sabkhas (see Appendix 1).

Environmental aspects

Groundwater is brackish to saline (2500 mg/l to 15 000 mg/l TDS) and quality does not satisfy local standards in about 90% of aquifer area due to natural salinity. This natural salinity affects a significant part of the aquifer system. Some pollutants have also been reported.

Socio-economic aspects

A total of about 460 Mm^3/annum of groundwater is abstracted, mainly by Iraq and Kuwait. The use is mainly agricultural.

Legal and Institutional aspects

National Institutions for the management of groundwater exist in all of the Aquifer States but no formal Transboundary Agreement has been made.

Hot spot

The aquifer system is very heavily over-exploited in relation to its mean annual replenishment. The main issue for this TBA is that the limited volume of fresh groundwater occurs in lenses that are vulnerable to salinization and hydrocarbon pollution due to their proximity to oilfields as well as upconing of saline water from the underlying Paleogene aquifer system. A close monitoring of water quality in the downstream and coastal areas is required. A Bilateral Agreement is essential to monitor and manage the pumping regime of the transboundary aquifer.

AS128 - Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
Lamine Babasy	Observatoire du Sahara et du Sahel	Tunisia	lamine.babasy@oss.org.tn	Regional coordinator
Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator

Considerations and recommendations

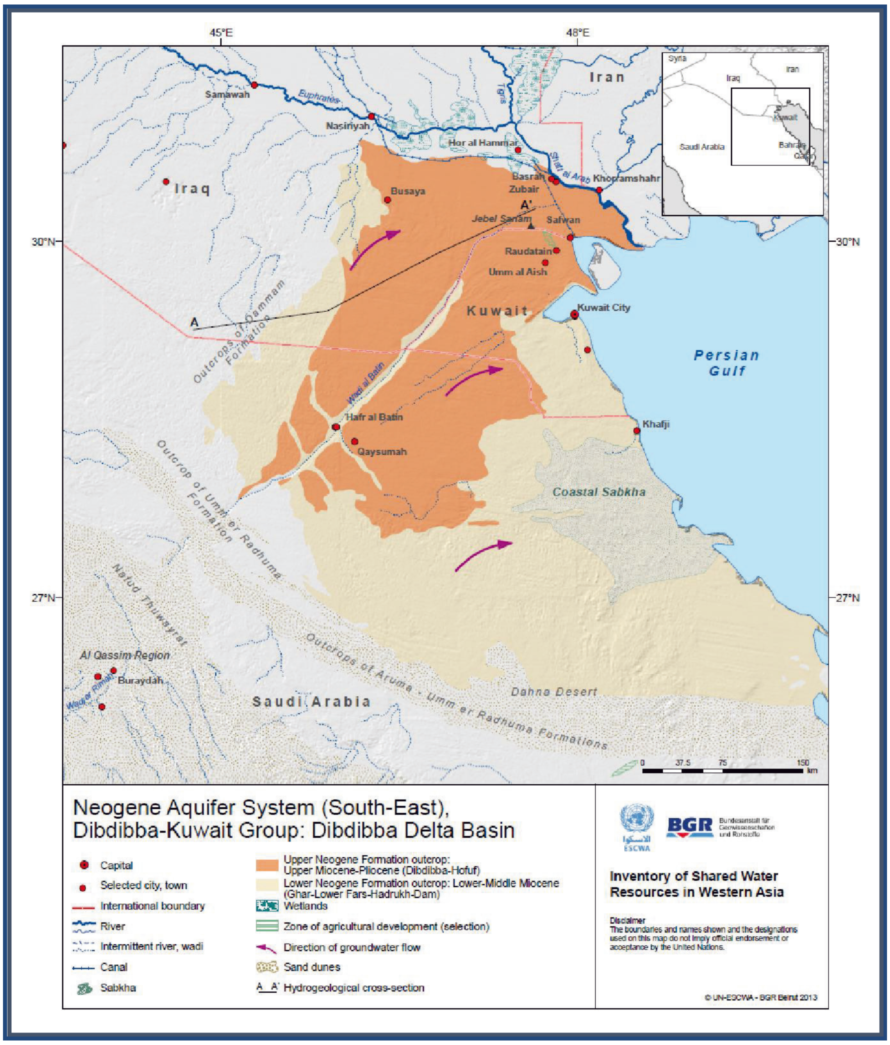
Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

For the transboundary aquifers of Western Asia, data are only available at the level of the complete aquifer and not of the country segments. All this data as well as information elements in the aquifer description are coming from a comprehensive, United Nations-led inventory to catalogue and characterize transboundary surface and groundwater resources in the Middle East (Source: UN-ESCWA and BGR (United Nations Economic and Social Commission for Western Asia; Bundesanstalt für Geowissenschaften und Rohstoffe). 2013. Inventory of Shared Water Resources in Western Asia. Beirut).

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

AS128 - Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

Appendix 1: AS128



Map showing groundwater flow directions and discharge areas within the Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

Colophon

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UNEP
gef
United Nations Educational, Scientific and Cultural Organization
International Hydrological Programme
igrac
International Groundwater Resources Assessment Centre

AS128 - Neogene Aquifer System (South-East), Dibdibba-Kuwait Group: Dibdibba Delta Basin

Request:
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- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: October 2015

AS125 - Neogene Aquifer System (North-West), Upper and Lower Fars

Geography

Total area TBA (km^2): 66 000

No. countries sharing: 2

Countries sharing: Iraq, Syria, Turkey

Population: 4 700 000

Climate zone: Semi-arid

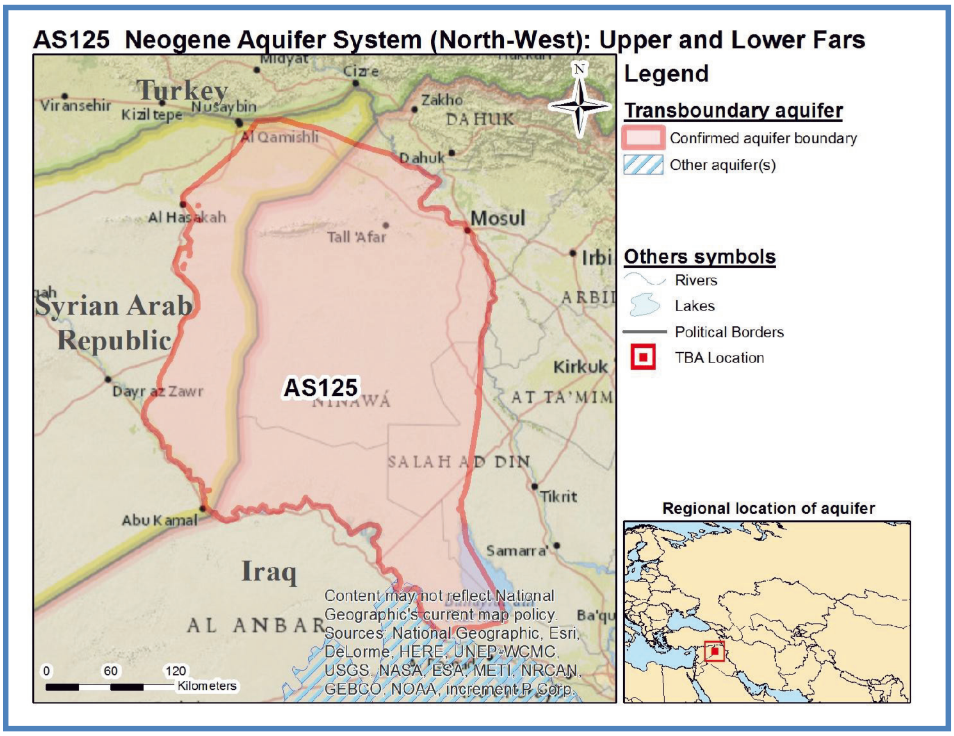
Rainfall (mm/yr): 260

Hydrogeology

Aquifer type: 2-layered, hydraulically connected

Degree of confinement: Mostly unconfined, some parts confined

Main Lithology: Sedimentary rock - sandstones, limestone, dolomites, marls and gypsum



No cross-section available

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate.

AS125 - Neogene Aquifer System (North-West), Upper and Lower Fars

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Iraq							51			
Syrian Arab Republic							130			
Turkey							130			
TBA level	**1**	**11**	**10**				**70**	**270**	**D**	**D**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).

(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.

(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).

(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.

(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).

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X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Iraq	89	1600	-43	-61	18	15	23	4
Syrian Arab Republic	73	620	-36	-51	70	46	72	40
Turkey	76	810	-32	-44	81	38	86	42
TBA level	**85**	**1200**	**-41**	**-58**	**52**	**30**	**58**	**7**

AS125 - Neogene Aquifer System (North-West), Upper and Lower Fars

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Iraq	1	56	57	110	5	2	5
Syrian Arab Republic	53	120	48	90	140	23	40
Turkey	18	94	32	54	110	23	39
TBA level	**14**	**71**	**53**	**100**	**34**	**8**	**16**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Iraq								
Syrian Arab Republic								
Turkey								
TBA level		**500**		**Aquifer mostly unconfined, but some parts confined**	**Sedimentary rock: Limestone**		**Secondary porosity: Dissolution**	**39**

* Including aquitards/aquicludes
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

The eastern part of the Upper and Middle Neogene Formations beneath the Mesopotamian Plain constitutes a shared aquifer system between Iraq and Syria. Geo-physiographic features were used to approximate the boundaries of the system. It consists of 2 layers of sedimentary formations that are hydraulically connected, and is mostly unconfined although some parts are confined. Maximum thickness is of the aquifer system is 1200 m and the average is 500 m.

Hydrogeological aspects

The main aqifer lithology is Sedimentary rock - sandstones, limestone, dolomites, marls and gypsum. System replenishment from natural sources (medium to high = 20 - >100 mm/annum) is normally about 53Mm³/annum, but higher values up to 110 Mm³/annum due to extreme events have been recorded. Secondary type of porosity is predominant but vertical connectivity between the sediment layers is high, possibly due to the effect of the sandstones. Transmissivity values recorded across the aquifer states range between 2 and 1300 m^2/d with an average of 39 m^2/d.

AS125 - Neogene Aquifer System (North-West), Upper and Lower Fars

Linkages with other water systems
Recharge is mainly through karstic features and groundwater seepage from overlying Quaternary deposits. Natural discharge is into surface water bodies and lakes (see Appendix 1).

Environmental aspects
Groundwater quality does not satisfy local standards in about 90% of aquifer area due to natural salinity. The water is brackish to saline (2000-4000 mg/l TDS), with 1000 mg/l in the recharge areas and 5000 - 20,000 mg/l in the discharge areas. No pollutants have been reported.

Socio-economic aspects
A total of about 150 Mm^3/annum of groundwater is abstracted within both Iraq and Syria, mainly for agricultural and domestic purposes.

Legal and Institutional aspects
National institutions for the management of groundwater exist in both aquifer states but no formal Transboundary Agreement has been made.

Hot spot
Nearly three times the annual average replenishment is presently abstracted from this aquifer system (given the recharge and abstraction figures provided). The main issue for this TBA is that fresh groundwater is restricted mainly to the top 15 - 25 m of the system which is sustained primarily by artificial recharge from surface drainage projects, using the Tigris and Euphrates surface water. The construction of large-diameter dug wells would allow for the withdrawal of freshwater from superficial layers, and avoid mixing with brackish water contained in deeper layers. Strict measures for protecting these surficial layers from polluted irrigation return flow are required. A Bilateral Agreement is urgently required under which the pumping regime of the transboundary aquifer can be monitored and managed.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
Lamine Babasy	Observatoire du Sahara et du Sahel	Tunisia	lamine.babasy@oss.org.tn	Regional coordinator
Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator

Considerations and recommendations

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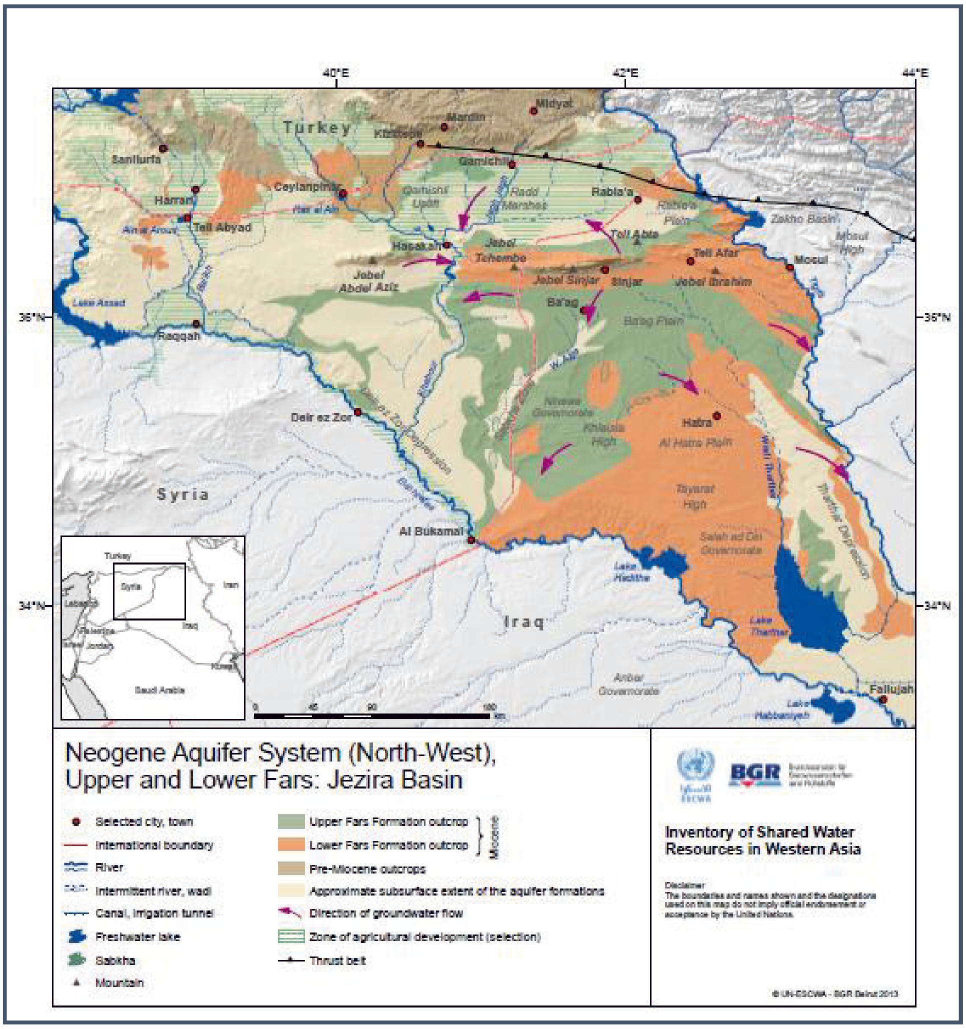
AS125 - Neogene Aquifer System (North-West), Upper and Lower Fars

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Appendix 1: AS125



Map of Neogene Aquifer System (North-West), Upper and Lower Fars Aquifer: showing groundwater flow and discharge

Colophon

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AS125 - Neogene Aquifer System (North-West), Upper and Lower Fars

For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

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- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: December 2015

AF69 - Northwest Sahara Aquifer System (NWSAS)

Geography

Total area TBA (km^2): 1 000 000

No. countries sharing: 3

Countries sharing: Algeria, Libya, Tunisia

Population: 6 900 000

Climate Zone: Arid

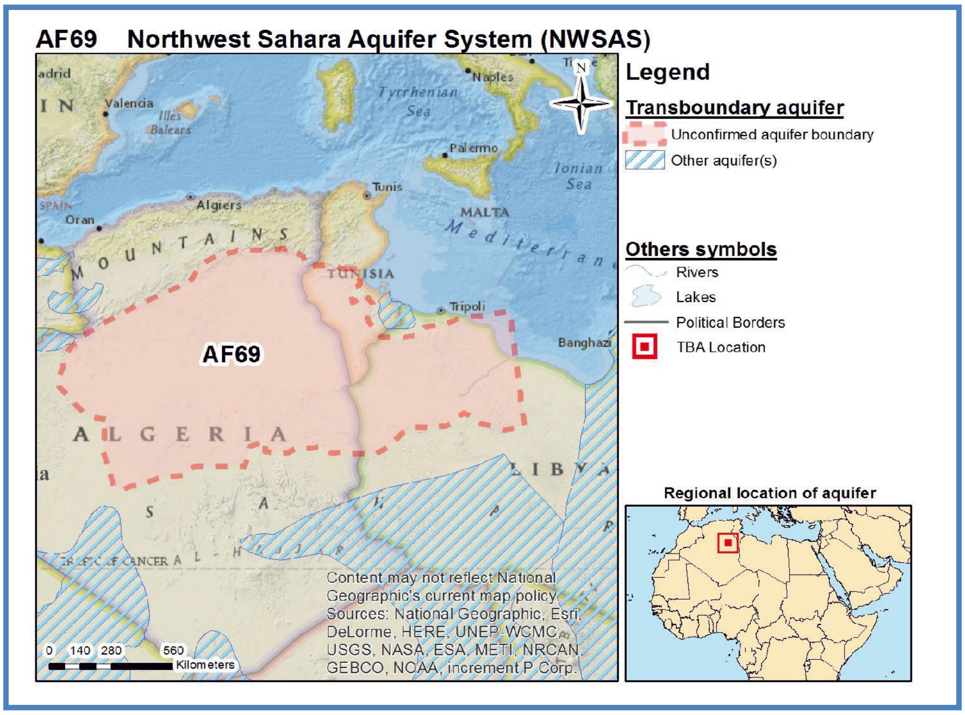
Rainfall (mm/yr): 59

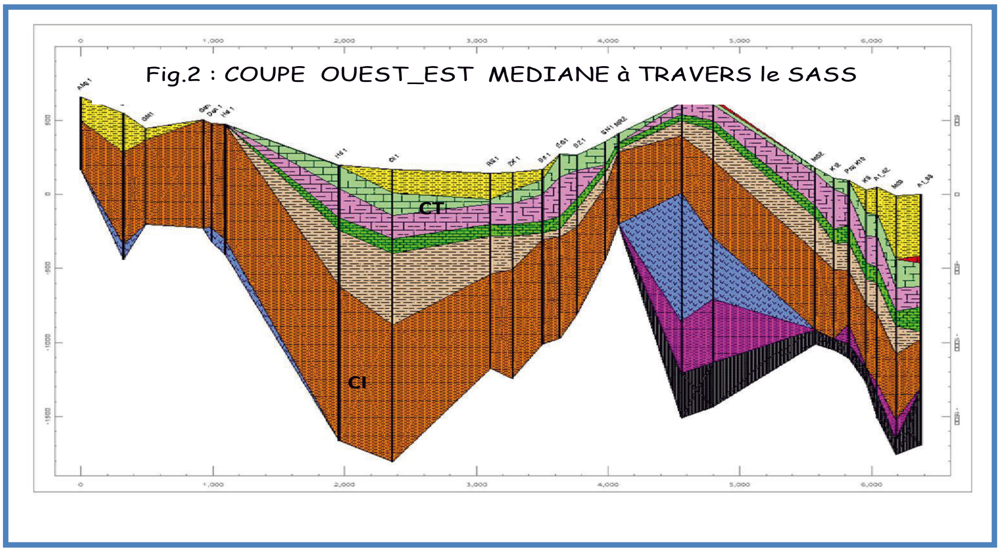
Hydrogeology

Aquifer type: Multi layered hydraulically connected system

Degree of confinement: Mainly confined though some parts are unconfined

Main Lithology: Sediment – sand





Geological cross-section over part of the Northwest Sahara Aquifer System (NWSAS)

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate

AF69 - Northwest Sahara Aquifer System (NWSAS)

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Algeria							6			
Libya							7			
Tunisia							13			
TBA level	**<1**	**<1**		**100**	**0**		**7**	**290 000**	**A**	**C**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Algeria	12	2100	-32	-44	55	16	90	0
Libya	9	1300	-27	-41	74	69	98	2
Tunisia	92	7300	-28	-39	76	53	84	1
TBA level	**17**	**2600**	**-31**	**-44**	**64**	**41**	**91**	**1**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Algeria	1	6	32	53	13	3	5
Libya	1	7	26	48	37	8	16

AF69 - Northwest Sahara Aquifer System (NWSAS)

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Tunisia	0	13	21	28	8	3	6
TBA level	**1**	**7**	**29**	**48**	**14**	**4**	**7**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Algeria								
Libya								
Tunisia								
TBA level	**20**	**370**	**1100**	**Aquifer mostly confined, but some parts unconfined**	**Sediment - Sand**	**High primary porosity fine/medium sedimentary deposits**	**Secondary porosity: Dissolution**	**1500**

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

It is a multi 2-layered hydraulically connected system that is mainly confined though some parts are unconfined. The average depth to the water table is 20 m while the average depth to the top of the aquifer is 370 m. The average full vertical thickness of the aquifer system is 1 100 m.

Hydrogeological aspects

The predominant aquifer lithology consists of sediment – sand that is calcareous in places and this has a high primary porosity with secondary porosity: through dissolution. It has a high horizontal and vertical connectivity. The total groundwater volume within Tunisia is 300 km^3. There is a significant difference of recharge between events and the average annual recharge, which is 100% through natural recharge, within Tunisia is 1 Mm^3/yr, and the amounts for the extreme events have not been recorded.

Linkages with other water systems

The predominant source of recharge within Tunisia is through runoff into the aquifer area. The main discharge mechanism is through outflow from springs.

Environmental aspects

Some of the natural groundwater is unsuitable for human consumption within mainly the superficial layers due to natural salinity but the data is not available to determine the percentage of the aquifer area that has been affected. Some anthropogenic groundwater pollution has been observed that is mainly due to salinisation from agricultural practices but the data is not available to determine the

AF69 - Northwest Sahara Aquifer System (NWSAS)

percentage of the aquifer area that has been affected. Data is not available on the extent of shallow groundwater and groundwater dependent ecosystems over the aquifer area.

Socio-economic aspects

The mean annual groundwater abstraction from the aquifer was 2 826 Mm^3/yr, and this amount represents the total amount of water that was abstracted over the entire aquifer area.

Legal and Institutional aspects

An Agreement with full scope for TBA management signed by all parties exists. The National Institute has a full mandate and capacity (Tunisia).

Emerging Issues

Nothing identified.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
Lamine Babasy	Observatoire du Sahara et du Sahel	Tunisia	lamine.babasy@oss.org.tn	Regional coordinator
Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator

Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Although all data was provided at the level of the complete aquifer only, some of the infomation is specific for Tunisia. Some of the indicators could be calculated at the TBA level.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

Request:
If you have additional data or information about this transboundary aquifer that can improve the quality of this information sheet and the underlying database, please contact us via email at info@un-igrac.org. If appropriate, the information will be uploaded to the database of transboundary aquifers and will also be used in new versions of this information sheet.

AF69 - Northwest Sahara Aquifer System (NWSAS)

References:

- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: September 2015

AF63 - Nubian Sandstone Aquifer System

Geography

Total area TBA (km^2): 2 500 000

No. countries sharing: 5

Countries sharing: Chad, Egypt, Libya, Sudan

Population: 93 000 000

Climate Zone: Arid

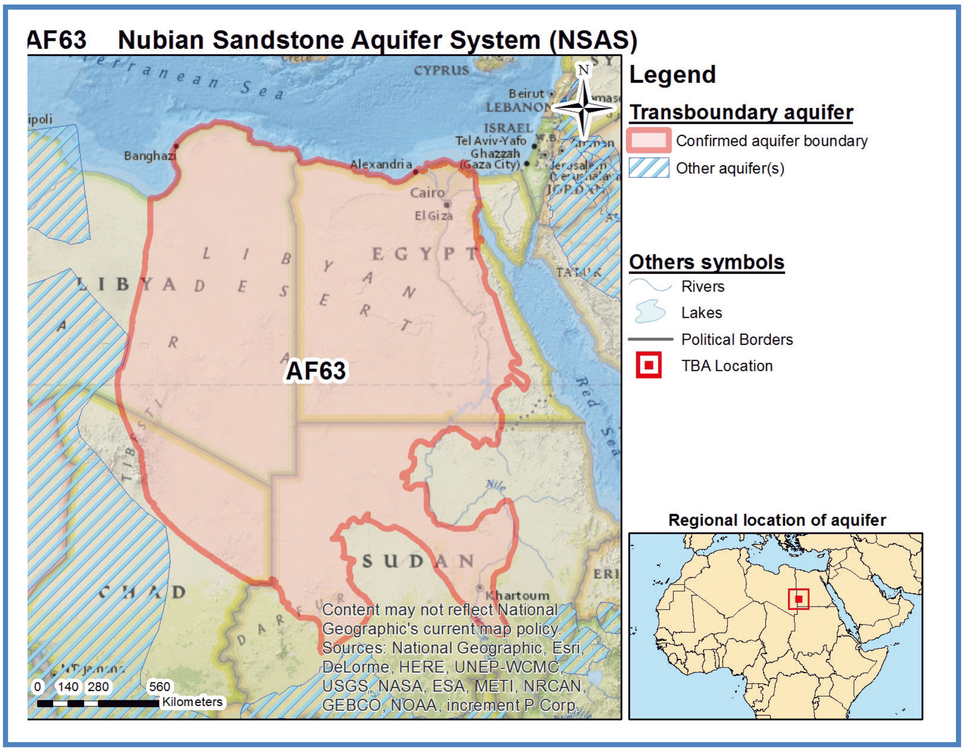
Rainfall (mm/yr): 30

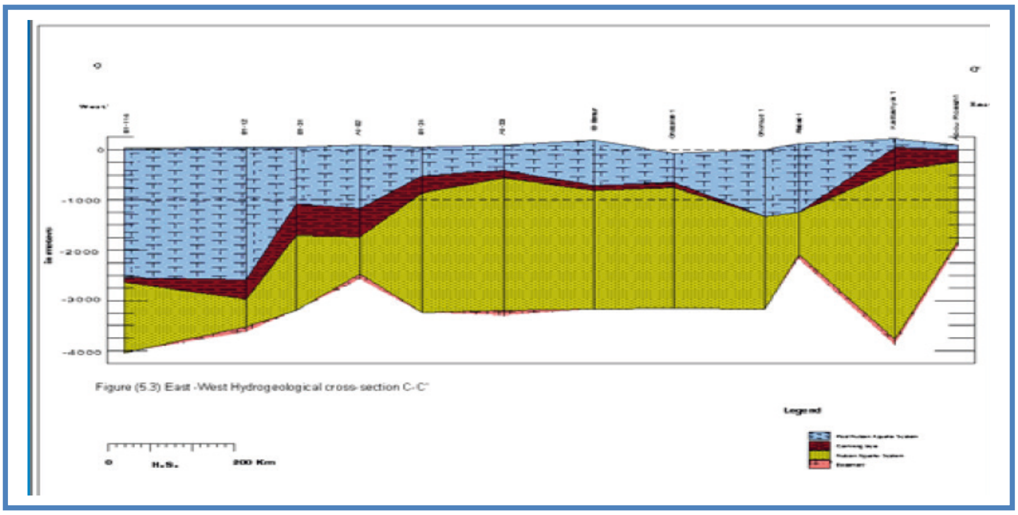
Hydrogeology

Aquifer type: Multiple layers hydraulically connected - single layered in Chad

Degree of confinement: Mostly confined, but some parts unconfined

Main Lithology: Sediments – sands, sedimentary rocks – sandstones





Geological cross-section of part of the Nubian Sandstone Aquifer (E –W)

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate

AF63 - Nubian Sandstone Aquifer System

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Chad	<1	<1					<1			
Egypt			10		1		99			
Libya							2			
Sudan							16			
Disputed land*							2			
TBA level	**<1**	**<1**					**38**	**>1000**	**A**	**D**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).

(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.

(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).

(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.

(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).

(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

* To define country segments of the transboundary aquifers the country borders from FAO Global Administrative Unit Layers (2013) was used.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Chad	1	2500	36	5	18	53	13	0
Egypt	55	580	-23	-32	4	39	3	0
Libya	11	5200	-31	-47	66	69	99	1
Matan al-Sarra	<1	<1	13 000	-100	2	2	0	0
Sudan	21	1200	-33	-52	2	2	2	1
TBA level	**27**	**740**	**-25**	**-37**	**5**	**39**	**4**	**0**

AF63 - Nubian Sandstone Aquifer System

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Chad	0	<1	63	140	1	-4	0
Egypt	2	95	31	50	12	4	4
Libya	1	2	26	48	12	2	4
Matan al-Sarra	0	5	60	130	120 000 000 000	0	-888
Sudan	0	18	61	130	1	0	0
TBA level	**1**	**37**	**34**	**59**	**10**	**3**	**3**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Chad	92			Aquifer mostly unconfined, but some parts confined				<5
Egypt	50	500	850	Aquifer mostly confined, but some parts unconfined	Sedimentary rocks - Sandstone			12000
Libya								
Ma'tan al-Sarra								
Sudan								
TBA level	**300**	**800**	**2500**	**Aquifer mostly confined, but some parts unconfined**	**Sediment - Sand**	**High primary porosity fine/medium sedimentary deposits**	**Secondary porosity: Dissolution**	**37**

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

This is largely a multiple layered hydraulically connected system although it is single-layered within Chad. The aquifer system is mostly confined, but some parts are unconfined. The average depth to

AF63 - Nubian Sandstone Aquifer System

the water table varies from 50m within Egypt to 92 m in Chad to 300 m within Sudan. The average depth to the top of the aquifer varies from 500 m in Egypt to 800 m within Sudan. The average total thickness of the aquifer system varies from 850 m within Egypt to 2500 m within Sudan.

Hydrogeological aspects
The major lithology consists of sediments – sands, and sedimentary rocks – sandstones and some limestones. Within Sudan this is characterised by a high primary porosity of fine to medium sedimentary deposits, with secondary porosity through dissolution with a high horizontal connectivity and a low vertical connectivity. The transmissivity values within the system show a wide variation with the average range value of 37 m^2/d in Sudan to 12 000 m^2/d within Egypt. There has been no mention of significant differences between years in terms of volume and frequency of recharge. The percentage of natural recharge was only recorded from Egypt and this is 100% due to natural conditions. The average annual recharge was only recorded by Sudan and this amounts to 14.5 Mm^3/yr, and this is an approximation based on expert judgement. The long term trend of groundwater depletion was recorded within Egypt and this indicates an average amount of 1 km^3/yr, and this is a rough estimate based on expert judgement.

Linkages with other water systems
The predominant source of groundwater recharge was only recorded from Sudan where it is through precipitation on the aquifer area. The natural discharge mechanism is through evapotranspiration within Egypt and through spring discharge in Sudan that amounts to 2 286 Mm^3/yr, and this amount was based on dedicated studies.

Environmental aspects
The percentage of natural water that is unsuitable for human consumption was only recorded from Egypt where this figure is 90%. This is over the entire thickness of the aquifer, whereas in Sudan this is only observed within the superficial layers. With regard to pollution of the aquifer this was only reported on by Egypt where no pollution has been identified. Data is not available on the extent of shallow groundwater or groundwater dependent ecosystems over the aquifer area.

Socio-economic aspects
The total amount of groundwater abstraction was only recorded from Egypt and Sudan, and this was 3286 Mm^3/yr. No water abstraction information was available from the other Aquifer States (see Appendix 1 for the major abstractions from the Nubian Sandstone).

Legal and Institutional aspects
There is an Agreement with full scope for TBA management signed by all parties. There is no mention of a Transboundary Institute. The National institutions are in place, but are not fully operational (reported at a TBA level).

Emerging Issues
The groundwater abstraction from this system exceeds natural recharge by orders of magnitude.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Abdelkader Dodo	Observatoire du Sahara et du Sahel	Tunisia	abdelkader.dodo@oss.org.tn	Regional coordinator
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AF63 - Nubian Sandstone Aquifer System

Name	Organisation	Country	E-mail	Role
Kadjangaba Edith	Université de N'Djaména et Moundou	Chad	edithkadjangaba@hotmai.fr	Lead National Expert
Nahed el Sayed El Arabi	Research Institute for Groundwater	Egypt	elarabinahed@gmail.com	Lead National Expert

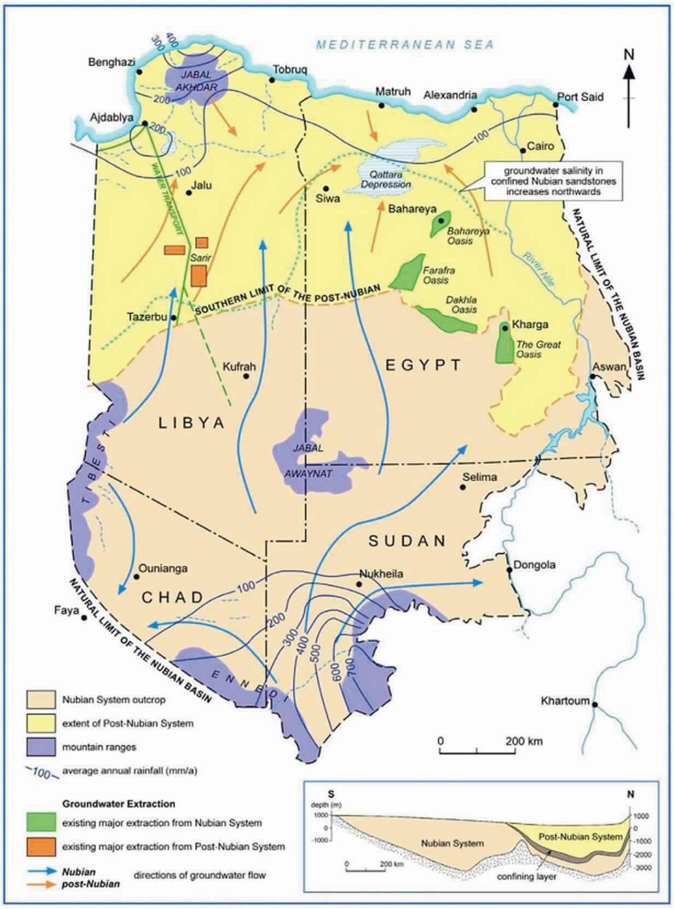
Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

For this Transboundary Aquifer the data has been provided at two levels i.e. the aquifer data are available at the level of country segments for 3 of the TBA countries, and at the aquifer level, even although the data at the national segment levels are not complete, or have not been provided by the remaining TBA countries. The information was sufficient to calculate some of the indicators.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Appendix 1: AF63



Major groundwater abstraction areas within the Nubian Sandstone Aquifer System

AF63 - Nubian Sandstone Aquifer System

Colophon

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Request:
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References:

- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: May 2017

AF58 - Senegalo-Mauretanian Basin

Geography

Total area TBA (km^2): 290 000

No. countries sharing: 5

Countries sharing: Gambia, Guinea Bissau, Mauritania, Senegal, Western Sahara

Population: 16 000 000

Climate Zone: Semi-arid

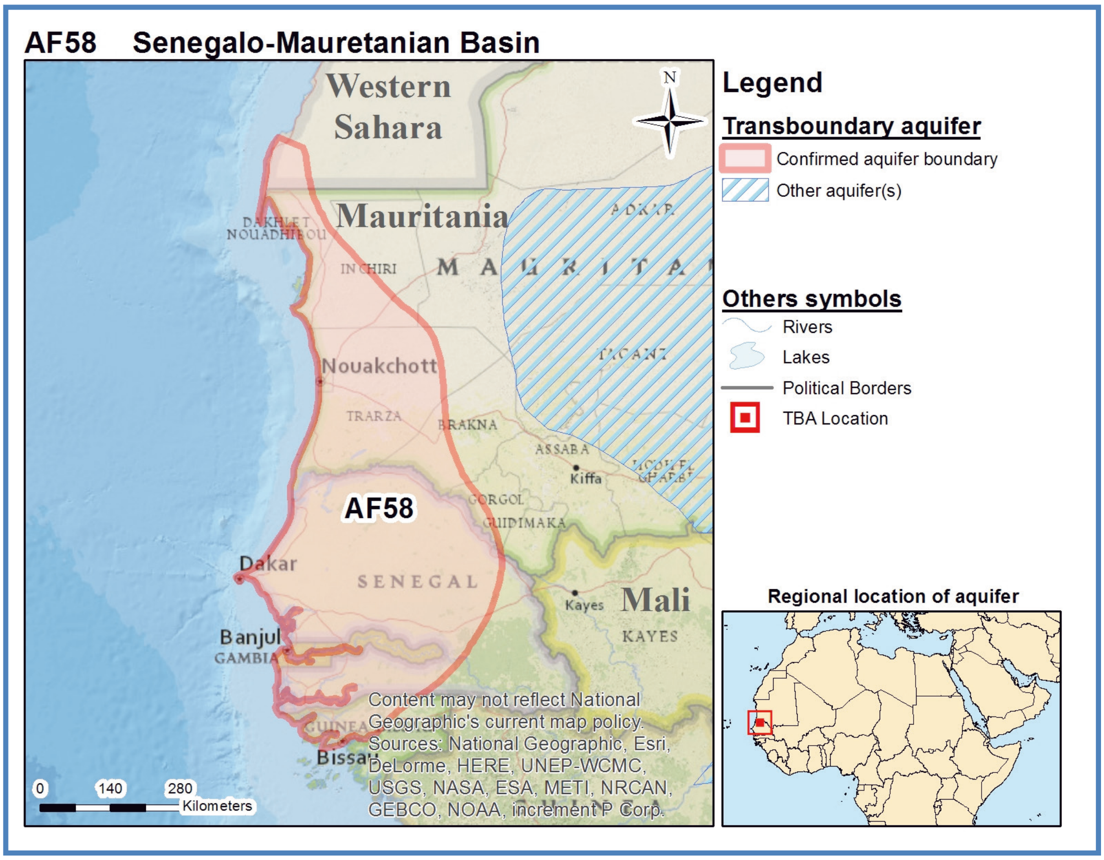
Rainfall (mm/yr): 460

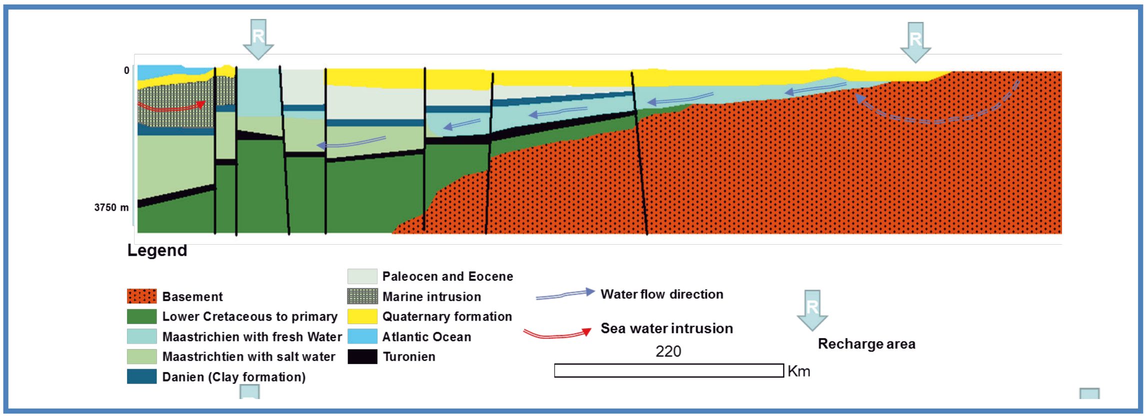
Hydrogeology

Aquifer type: Multiple layered hydraulically connected system

Degree of confinement: Mostly confined, some parts semi-confined to unconfined

Main Lithology: Sediment - sand





Geological cross-section of the Senegalo-Mauritanian Basin

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate

AF58 - Senegalo-Mauretanian Basin

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Gambia	0	0					140			C
Guinea Bissau							79			
Mauritania							16			
Senegal	1	9			1		77	85	D	C
Western Sahara							1			
TBA level	**1**	**8**	**75**			**25**	**56**	**230**		**B**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).

(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.

(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).

(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.

(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).

(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Gambia	210	2000	-35	-54	34	59	5	4
Guinea-Bissau	230	2700	-28	-49	19	31	13	6
Mauritania	160	12 000	-35	-54	16	52	2	24
Senegal	140	1800	-17	-22	14	58	6	6
Western Sahara	1	920	17 000	18 000	7	52	0	0
TBA level	**150**	**2800**	**-22**	**-33**	**15**	**54**	**5**	**8**

AF58 - Senegalo-Mauretanian Basin

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Gambia	-1	110	50	100	1	1	12
Guinea-Bissau	1	89	42	90	<1	0	3
Mauritania	0	13	48	99	1	0	1
Senegal	0	78	18	21	1	1	8
Western Sahara	0	1	38	74	4	-10 000	-890
TBA level	**0**	**54**	**24**	**38**	**1**	**1**	**5**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Gambia	25	25	390	Aquifer mostly semi-confined, but some parts unconfined	Sediment - Sand	High primary porosity fine/ medium sedimentary deposits	No secondary porosity	
Guinea Bissau								
Mauritania								
Senegal	34	250	260	Aquifer mostly confined, but some parts unconfined	Sediment - Sand	High primary porosity fine/ medium sedimentary deposits	No secondary porosity	<5
Western Sahara								
TBA level	**10**	**300**	**500**	**Aquifer mostly confined, but some parts unconfined**	**Sediment - Sand**	**High primary porosity fine/ medium sedimentary deposits**	**Secondary porosity: Dissolution**	**3000**

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

AF58 - Senegalo-Mauretanian Basin

Aquifer description

Aquifer geometry

The Senegalo-Mauritanian basin is composed of three hydraulically connected major aquifers i.e. the Maastrichtian (lower aquifer) and the Paleocene (middle aquifer), which are hydraulically connected, and the upper superficial Quaternary aquifer. Due to the structure of the horst and graben system, these aquifers are also compartmentalized into three hydrogeological units, i.e. the Diass compartment in the center, the confined Sébikotane compartment in the West and the confined/unconfined Pout compartment in the East (Madioune, 2012). The aquifer is mostly confined but some parts are semi-confined and unconfined. The average depth to the piezometric surface varies between 10 m to 34 (Senegal). The average depth to the top of the aquifer varies between 25 m in Gambia to 300 m within Mauritania. The average thickness of the aquifer system varies from 260 m in Senegal to 500 m within Mauritania.

Hydrogeological aspects

The predominant aquifer lithology is comprised of sediment – sands. The aquifers have a high primary porosity no secondary porosity except for Mauritania where secondary porosity- dissolution is characterised within the carbonate horizons. Furthermore the aquifers have a high horizontal and a low vertical connectivity. The average transmissivity values vary from less than 5 m^2/d within Senegal to 3040 m^2/d within Mauritania. The total groundwater volume within the aquifer system is 1620 km^3 (that excludes the amounts within Western Sahara and Guinea-Bissau). Within some of the countries such as Mauritania, there is significant difference between years in the recharge amounts but the average additional recharge amount has not been quantified. The average annual amount of recharge is 233 Mm^3/yr. The aerial extent of the recharge area within Senegal is over an area of 10 000 km^2. The long term trend of groundwater depletion between 2000 and 2010 was recorded within Senegal and this indicates an average amount of 0.0931 km^3.

Linkages with other water systems

The predominant source of recharge is through precipitation on the aquifer area. The natural discharge mechanism is through river base flow in Gambia, through discharge of springs in Mauritania, and through submarine outflow in Senegal.

Environmental aspects

Some of the aquifer's natural water is unsuitable for human consumption and this is only within the superficial layers within Senegal whereas it is over a significant part of the aquifer within Gambia and Mauritania. This has only been quantified in Mauritania where 23% is unsuitable. Within Gambia, Mauritania, and Senegal some of the aquifer has been polluted within the superficial layers (see appendix), although this is over significant parts of the aquifer within Gambia, but the data is not available to determine the percentage of the aquifer area that has been affected. Over some parts of the Pout compartment in the East high abstraction rates has caused continuous groundwater level decline, and a modification of the groundwater flow and groundwater quality issues highlighted by the salinization of some of the boreholes located in Sebikotane and Mbour pumping fields. No shallow groundwater areas or groundwater dependent ecosystems over the TBA were specified.

Socio-economic aspects

The total groundwater abstraction for 2010 was specified for Senegal and Mauritania and this was 385 Mm^3/yr. Abstraction from 5 well fields within the Pout compartment in the East is around 40 Mm^3/yr. The total amount of fresh water abstracted over the aquifer area has not been specified.

Legal and Institutional aspects

According to Senegal no Transboundary Agreement exists, nor is it under preparation. However it is reported by the Northern Africa countries that a dedicated Transboundary Institution with a full

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mandate and capacity does exist. Gambia and Senegal have reported on the National Institutions that have a full mandate and capacity.

Priority Issues

Over-abstraction over some parts of the Pout compartment in the East has resulted in a change in the groundwater flow regime and has also led to salinisation of parts of the aquifer. Abstraction along parts of the coast is also resulting in salinisation due to sea water intrusion. More attention needs to be given to this aspect with regard to management from a Transboundary perspective.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Cheikh Becaye Gaye	Université Cheikh Anta Diop	Senegal	cheikhbecayegaye@gmail.com	Regional coordinator
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Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

All of the TBA countries have contributed information. Quantitative information for the countries falling within the North Africa region (Mauritania, Western Sahara) was provided in a TBA level and not on a TBA country level. Some of the indicators were therefore possible to calculate at a TBA level and not on a country level for those countries.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

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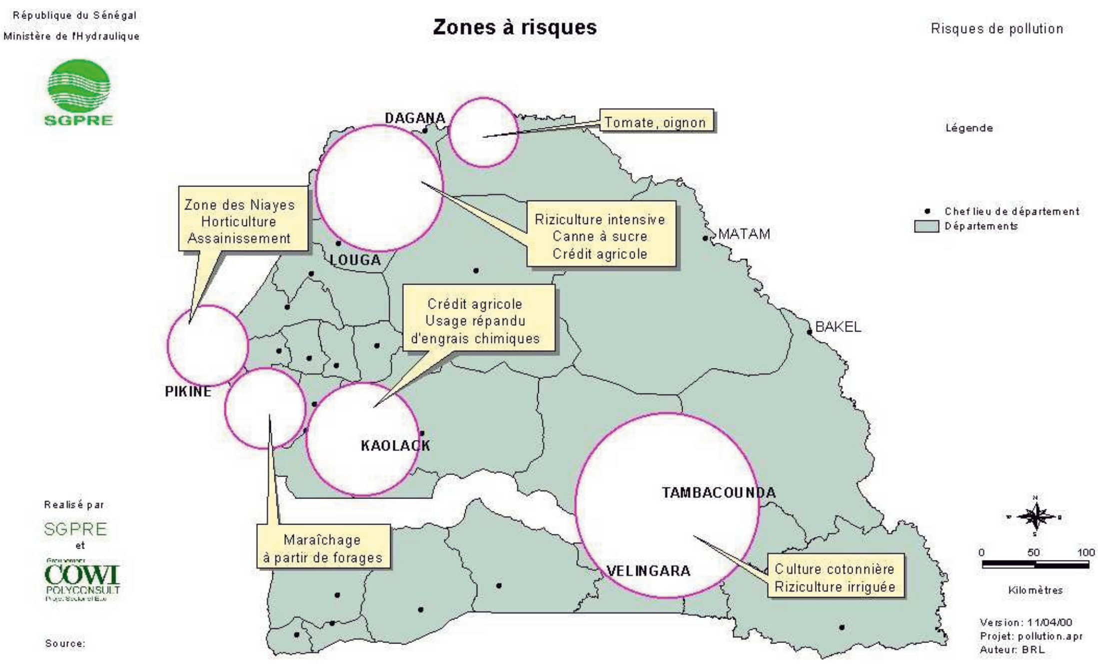
Appendix: AF58:



Groundwater pollution risk in Senegal

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

Request:
If you have additional data or information about this transboundary aquifer that can improve the quality of this information sheet and the underlying database, please contact us via email at info@un-igrac.org. If appropriate, the information will be uploaded to the database of transboundary aquifers and will also be used in new versions of this information sheet.

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References:

- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: July 2015

AF46 - Sudd Basin

Geography

Total area TBA (km^2): 330 000

No. countries sharing: 5

Countries sharing: Ethiopia, Kenya, South Sudan, Sudan

Population: 5 000 000

Climate Zone: Semi-arid

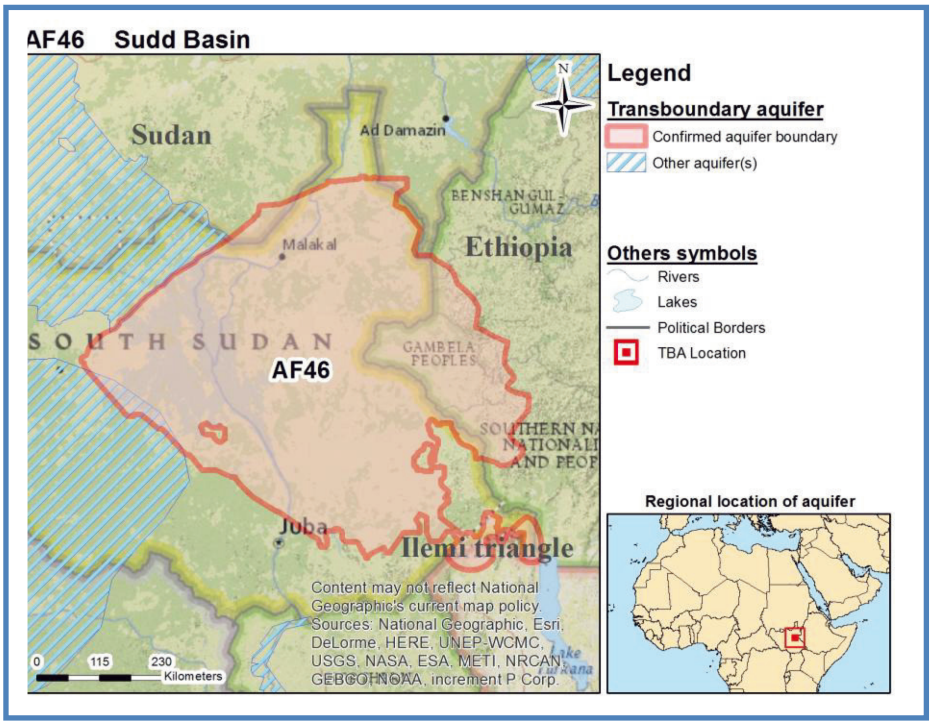
Rainfall (mm/yr): 890

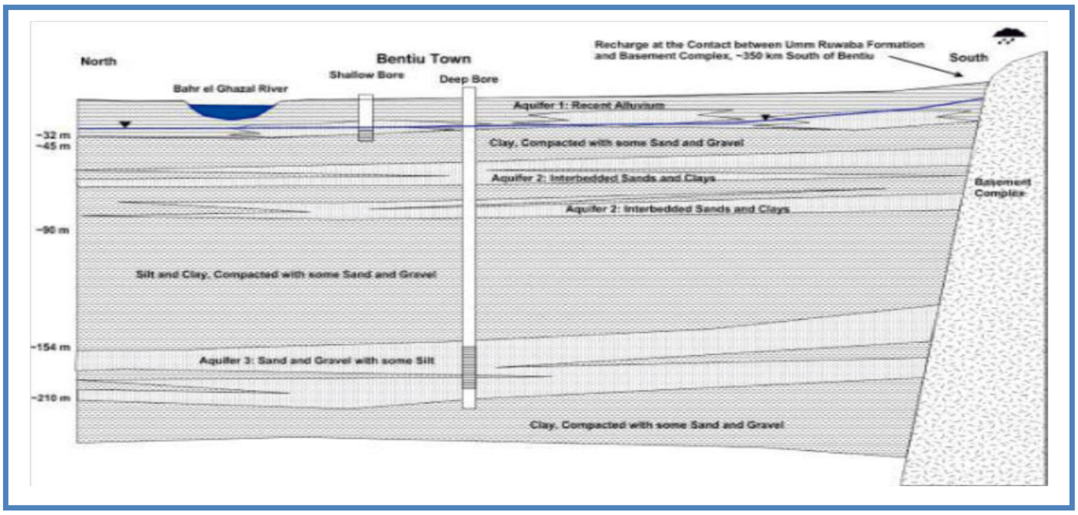
Hydrogeology

Aquifer type: Multi-layered system

Degree of confinement: Mostly confined but some parts are unconfined

Main Lithology: Sedimentary deposits and sedimentary rocks - sandstone





Conceptual cross-section of the southern part of the Sudd Basin

Map and cross-section are only provided for illustrative purposes. Dimensions are only approximate

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TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Ethiopia	3	120	100	40	0	B	22	<5	C	D
Kenya							4			
South Sudan	4	290	80	<5		B	14	<5		D
Sudan							12			
Disputed land*							4			
TBA level							**15**			

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).
(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.
(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).
(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.
(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).
(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).
X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.
* To define country segments of the transboundary aquifers the country borders from FAO Global Administrative Unit Layers (2013) was used.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use (%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Ethiopia	170	7200	-29	-41	68	78	1	0
Ilemi triangle	10	2300	32	29	2	2	0	0
Kenya	14	2800	17	12	10	10	0	0
South Sudan	320	20 000	-39	-58	2	3	2	0
Sudan	92	7700	-42	-63	4	4	0	1
TBA level	**290**	**17 000**	**-37**	**-56**	**12**	**16**	**1**	**0**

AF46 - Sudd Basin

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Ethiopia	3	24	44	78	<1	1	1
Ilemi triangle	0	4	62	140	<1	0	0
Kenya	0	5	60	130	<1	1	1
South Sudan	2	16	60	130	<1	0	0
Sudan	1	12	60	130	<1	0	0
TBA level	**2**	**17**	**57**	**120**	**<1**	**0**	**0**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Ethiopia	22	<5	100	Aquifer Mostly confined, but some parts unconfined	Sedimentary rocks - Sandstone	High Primary porosity fine/ medium sedimentary deposits	Secondary porosity: Fractures	110
Ilemi triangle								
Kenya								
South Sudan	30	20	42	Aquifer Mostly confined, but some parts unconfined	Sedimentary rocks - Sandstone	High Primary porosity fine/ medium sedimentary deposits	No Secondary porosity	22
Sudan								
TBA level								

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

This is a multi-layered system (3-layered within Ethiopia and South Sudan) that is mostly confined but some parts are unconfined. The average depth to the water table varies from 22 m within Ethiopia to 30 m within South Sudan. The average depth of the aquifer varies from <5 m within Ethiopia to 20 m below surface in South Sudan. The average depth of the aquifer system varies from to 42 m within South Sudan to 100 m within Ethiopia.

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Hydrogeological aspects

The major lithology is sedimentary deposits and sedimentary rocks that are characterized by a high primary porosity, with secondary porosity fractures and with a low to high horizontal connectivity and a low vertical connectivity. The average transmissivity values vary from 22 m^2/d in South Sudan to 110 m^2/d in Ethiopia. The total groundwater volume is 560 km^3 (Ethiopia, South Sudan). The annual amount of recharge is 1280 Mm^3/yr (Ethiopia, South Sudan). The extent of the recharge area within Ethiopia is 16 200 km^2.

Linkages with other water systems

The predominant source of recharge is through runoff into the aquifer within South Sudan. The most common discharge mechanism is through springs in Ethiopia and through groundwater flow into neighbouring aquifers within South Sudan.

Environmental aspects

Within Ethiopia <5% of the aquifer is not suitable for drinking water purposes (reasons not given) whereas in South Sudan this increases to 20 % and that is mainly caused by elevated amounts of Fluoride. Within Ethiopia some pollution within the superficial layers has been observed but the extent has not been specified. In South Sudan this increases to around 5% of the aquifer area and is polluted in significant parts of the aquifer. Within South Sudan around 10% of the aquifer area has shallow groundwater and around 50% of the area is covered with groundwater dependent ecosystems.

Socio-economic aspects

During 2010 the annual groundwater abstraction was 37.6 Mm^3 (Ethiopia, South Sudan). This was mainly used for domestic purposes. The total fresh water abstraction over the same period within the aquifer area was 16 000 Mm^3/yr from the same 2 countries, but this amount needs to be confirmed.

Legal and Institutional aspects

According to Ethiopia an Agreement with limited scope is under preparation, whereas in South Sudan no agreement is in place. Within Ethiopia the National Institute has a full mandate with limited capacity, whereas in South Sudan it has a limited mandate with limited capacity.

Emerging Issues

The scope and the necessary actions within the Agreement that is under preparation should be reviewed in order to promote more TBA cooperation between all of the Basin States.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
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AF46 - Sudd Basin

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Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

2 of the 4 countries contributed to the information. Information was adequate to describe the aquifer in general terms. Some quantitative information was also available, and this was sufficient to calculate the indicators at national levels.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.

For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

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References:
- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.

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- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: April 2017

AF64 - Taoudéni Basin

Geography

Total area TBA (km^2): 1 100 000

No. countries sharing: 3

Countries sharing: Algeria, Mali, Mauritania

Population: 4 500 000

Climate Zone: Arid

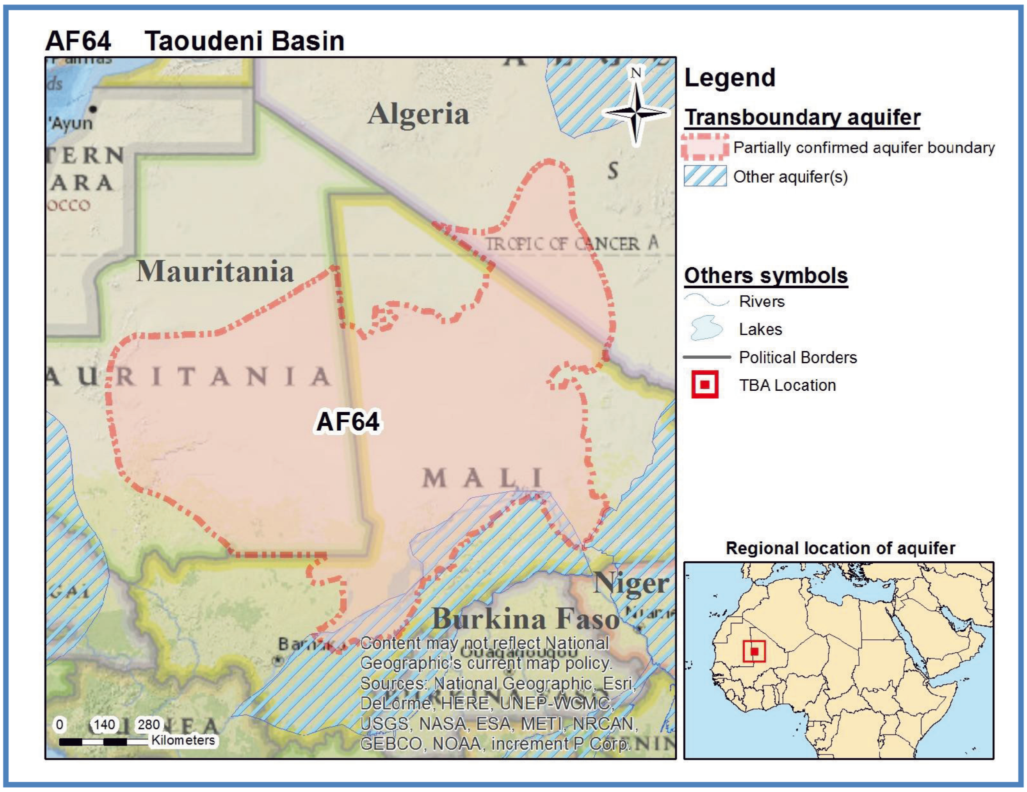
Rainfall (mm/yr): 110

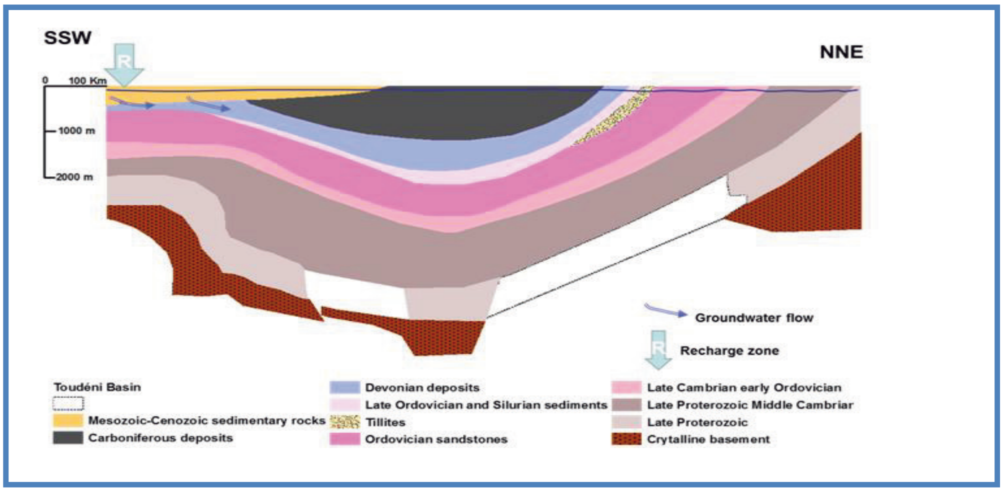
Hydrogeology

Aquifer type: Multilayered

Degree of confinement: Mostly unconfined, but some parts confined

Main Lithology: Sedimentary rocks –sandstone, and dolostones





Taoudeni Cross section (from the NE to SW) modified from lécorché et al 1989

Map and cross-section are provided for illustrative purposes. Dimensions are only approximate

AF64 - Taoudéni Basin

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Algeria							1			
Mali	17	2500					7	<5	C	A
Mauritania										
TBA level	**10**	**2500**	**100**		**64**			**<5**	**C**	**B**

(1) Recharge: This is the long term average recharge (in m^3/yr) divided by the surface area (m^2) of the complete country segment of the aquifer (i.e. not only the recharge area).

(2) Natural background groundwater quality: Estimate of percentage of surface area of aquifer where the natural groundwater quality satisfies local drinking water standards.

(3) Groundwater pollution: A. No pollution has been identified; B. Some pollution has been identified; Positive number: Significant pollution has been identified (% of surface area of aquifer).

(4) Groundwater development stress: Annual groundwater abstraction divided by recharge.

(5) Legal framework: A. Agreement with full scope for TBA management signed by all parties; B. Agreement with limited scope for TBA management signed by all parties; C. Agreement under preparation or available as an unsigned draft; D. No agreement exists, nor under preparation; E. Legal Framework differs between Aquifer States (see data at National level).

(6) Institutional Framework: A. Dedicated transboundary institution fully operational; B. Dedicated transboundary institution in place, but not fully operational; C. National/Domestic institution fully operational; D. National/Domestic institution in place, but not fully operational; E. No institution exists for TBA management; F. Institutional Framework differs between Aquifer States (see data at National level).

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Algeria	<1	5	2300	1900	16	16	0	0
Mali	200	29 000	-40	-63	0	1	0	0
Mauritania	3	2200	3	-21	56	52	98	52
TBA level	**98**	**24 000**	**-38**	**-61**	**3**	**27**	**1**	**1**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Algeria	0	1	33	56	160	-1800	-590
Mali	-1	7	74	180	<1	0	0
Mauritania	0	2	51	110	3	1	3
TBA level	**0**	**4**	**70**	**160**	<1	**0**	**0**

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Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Algeria								
Mali	40	10	200	Aquifer mostly unconfined, but some parts confined	Sedimentary rocks - Sandstone	High primary porosity fine/ medium sedimentary deposits	Secondary porosity: Fractures	100
Mauritania								
TBA level	270	130	400	Aquifer mostly unconfined, but some parts confined	Sedimentary rocks - Sandstone	Low primary porosity intergranular porosity	Secondary porosity: Fractures	400

* Including aquitards/aquicludes

X A value was provided in the questionnaire, but it was considered un-realistic and therefore removed from the table.

Aquifer description

Aquifer geometry

It is a multi-layered hydraulically connected system that is mostly unconfined, but some parts are confined (2 main layers with 3 layers in Mali). The average depth to the water table varies from 40 m in Mali to 270 m. The average depth to the top of the aquifer varies from 10 m (Mali) to 130 m. The average thickness of the aquifer system varies from 200 m in Mali to 400 m.

Hydrogeological aspects

The predominant aquifer lithology consists of sedimentary rocks – sandstones and dolostones. It is characterised by a low to high primary porosity, with secondary porosity fractures. It furthermore has a high horizontal and vertical connectivity. The average transmissivity value varies between 100 m^2/d (Mali) and 400 m^2/d. The total groundwater volume within the TBA that has been calculated needs to be reviewed for correctness. The mean annual recharge, that is 100% due to natural recharge, was calculated at 20 500 Mm^3/yr (this amount however needs to be reviewed).

Linkages with other water systems

The predominant source of recharge is through precipitation over the aquifer area. A significant amount of recharge into the Continental Intercalaire aquifer horizon comes from the Niger River system (see appendix). The major discharge mechanism is through evapotranspiration and in Mali the discharge is also largely through springs and this amounts to 1600 Mm^3/yr.

Environmental aspects

The percentage of natural groundwater quality that is not suitable for human consumption occurs over <5 % of the aquifer area. This is due to elevated levels of natural salinity that occurs mainly within the superficial layers. Some anthropogenic groundwater pollution has been observed mainly over the superficial layers but the data is not available to determine the percentage of the aquifer

AF64 - Taoudéni Basin

area that has been affected. Data was not available on the extent of shallow groundwater within the TBA. In Mali 7% of the aquifer area is covered with groundwater dependent ecosystems.

Socio-economic aspects

The total amount of groundwater that was abstracted form the aquifer during 2010 was estimated at 86 Mm^3. Data was not available on the total amount of fresh water abstraction over the aquifer area.

Legal and Institutional aspects

According to Mali there is reported to be an Agreement under preparation or available as an unsigned draft. According to Mali there is a Dedicated Transboundary Institution that is fully operational.

Emerging issues

The long-term trend of the water level over the entire aquifer must be jointly assessed.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Cheikh Becaye Gaye	Université Cheikh Anta Diop	Senegal	cheikhbecayegaye@gmail.com	Regional coordinator
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Ousmane Diakite	Direction Natinale de l'Hydraulique	Mali	diakito44@yahoo.fr	Contributing national expert
Amadou Zanga Traore	Ecole Nationale d'Ingénieurs - Abderhamane Baba Touré	Mali	amadou.z.traore@ufae.org/azangatraore@gmail.com	Lead National Expert
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Considerations and recommendations

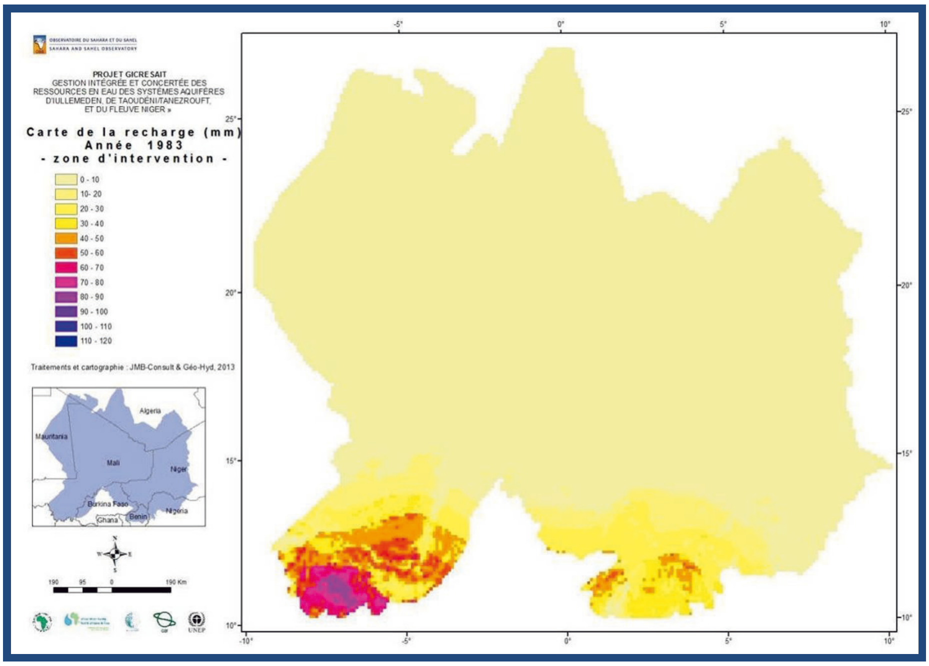
Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Information was contributed at a national level by 1 of the TBA countries while the information for the remaining countries was provided at the level of the complete aquifer. The total groundwater volume over the aquifer area that was calculated needs to be reviewed.

Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

AF64 - Taoudéni Basin

Appendix: AF64



Map showing the distribution of recharge over the Taoudéni Basin

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this transboundary aquifer information sheet has been made available by national and regional experts from countries involved in the TWAP Groundwater project. For aquifers larger than 20 000 km2 and which are not overlapping, additional data are available from modelling done by the Goethe University Frankfurt (Germany) as part of TWAP Groundwater. All data were compiled by UNESCO-IHP and the International Groundwater Resources Assessment Centre (IGRAC – UNESCO Category II Institute). Values given in the fact-sheet represent an approximate guide only and should not replace data obtained from recent local assessments. The editors of this information sheet are not responsible for the quality of the data.
For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

Request:

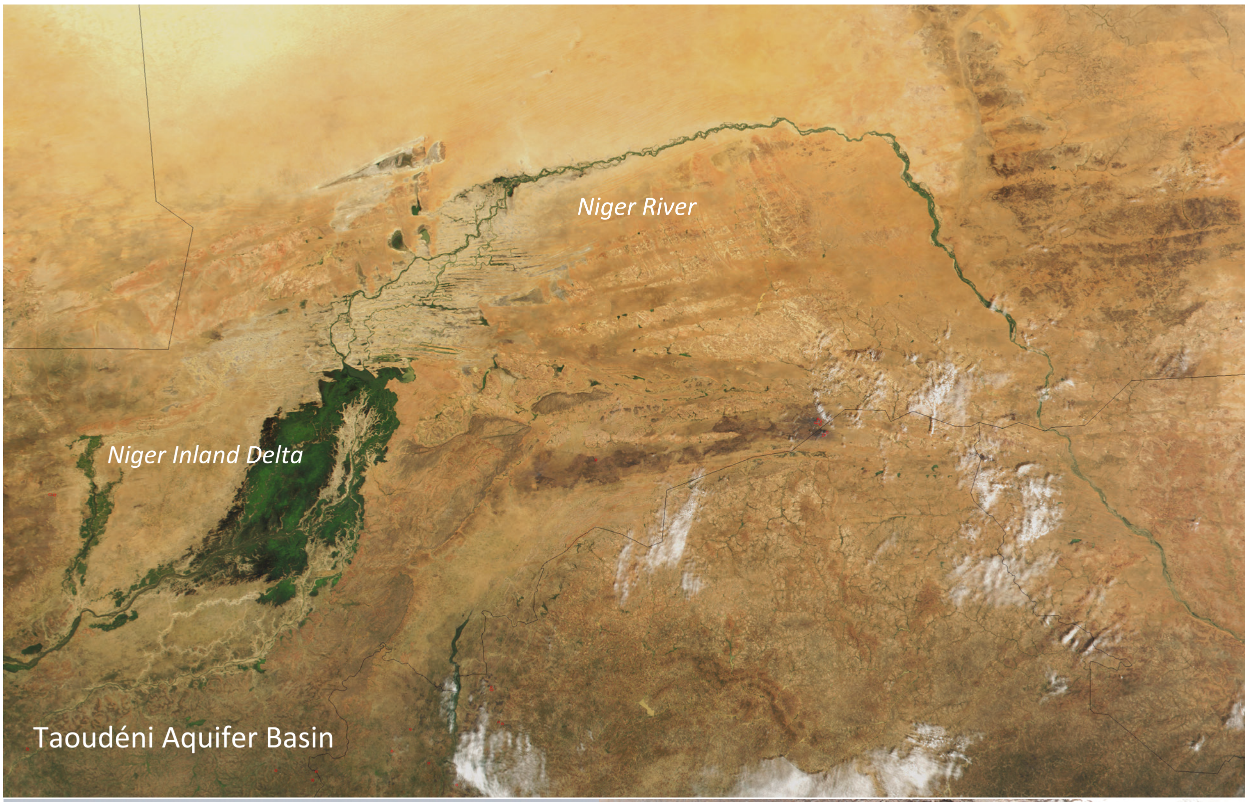
If you have additional data or information about this transboundary aquifer that can improve the quality of this information sheet and the underlying database, please contact us via email at info@un-igrac.org. If appropriate, the information will be uploaded to the database of transboundary aquifers and will also be used in new versions of this information sheet.

References:

- Population: Population has been calculated based on the aquifer map and grid information on population. Source population data: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. Gridded Population of the World, Version 3 (GPWv3): Population Count Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H42B8VZZ. Accessed Jan 2015.
- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
- Climate: Climate indicates the major climate zone which occurs in the aquifer area. If more than 1 climate zone is present the zone with the largest surface area was selected. Source climate data: ArcGIS Online (2015), Simplified World Climate zones. Owner: Mapping Our World GIS Education. Original map: National Geographic World Atlas for Young Explorers (1998).
- All other data: TWAP Groundwater (2015).

Version: September 2015

UNEP gef United Nations Educational, Scientific and Cultural Organization International Hydrological Programme igrac International Groundwater Resources Assessment Centre



Taoudéni Aquifer Basin

Jacques Descloitres, MODIS Land Rapid Response Team, NASA/ GSFC

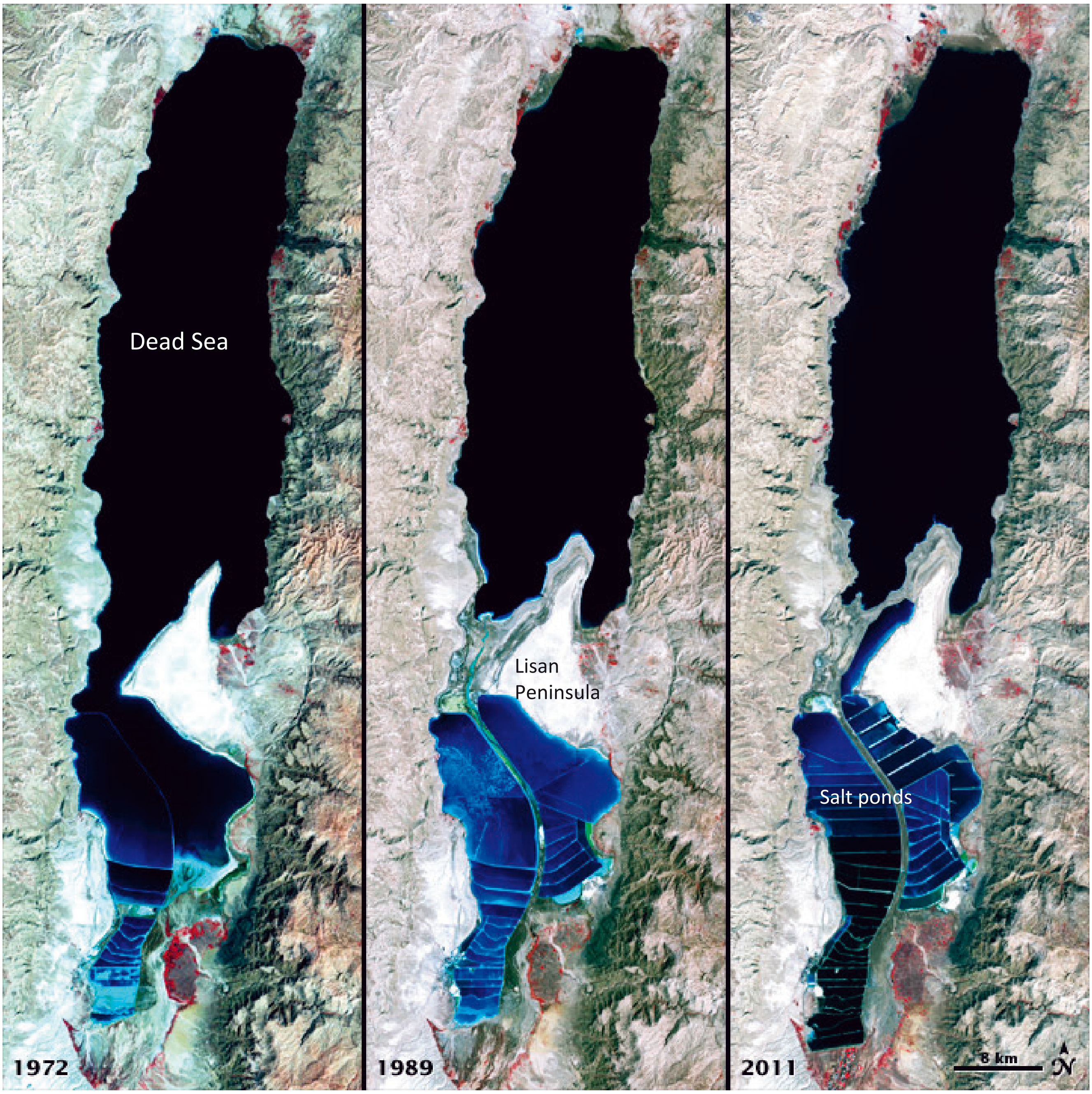
Hand-dug well, Mali

Concrete rings encasement of well on left photo

Cataclasite, CC -SA 3.0 Unported

1. Aras Su Qovsaginin Su Anbari
2. Caspian Sea
3. Dead Sea
4. Lake Darbandikhan
5. Lake Nasser/ Aswan
6. Sea of Galilee

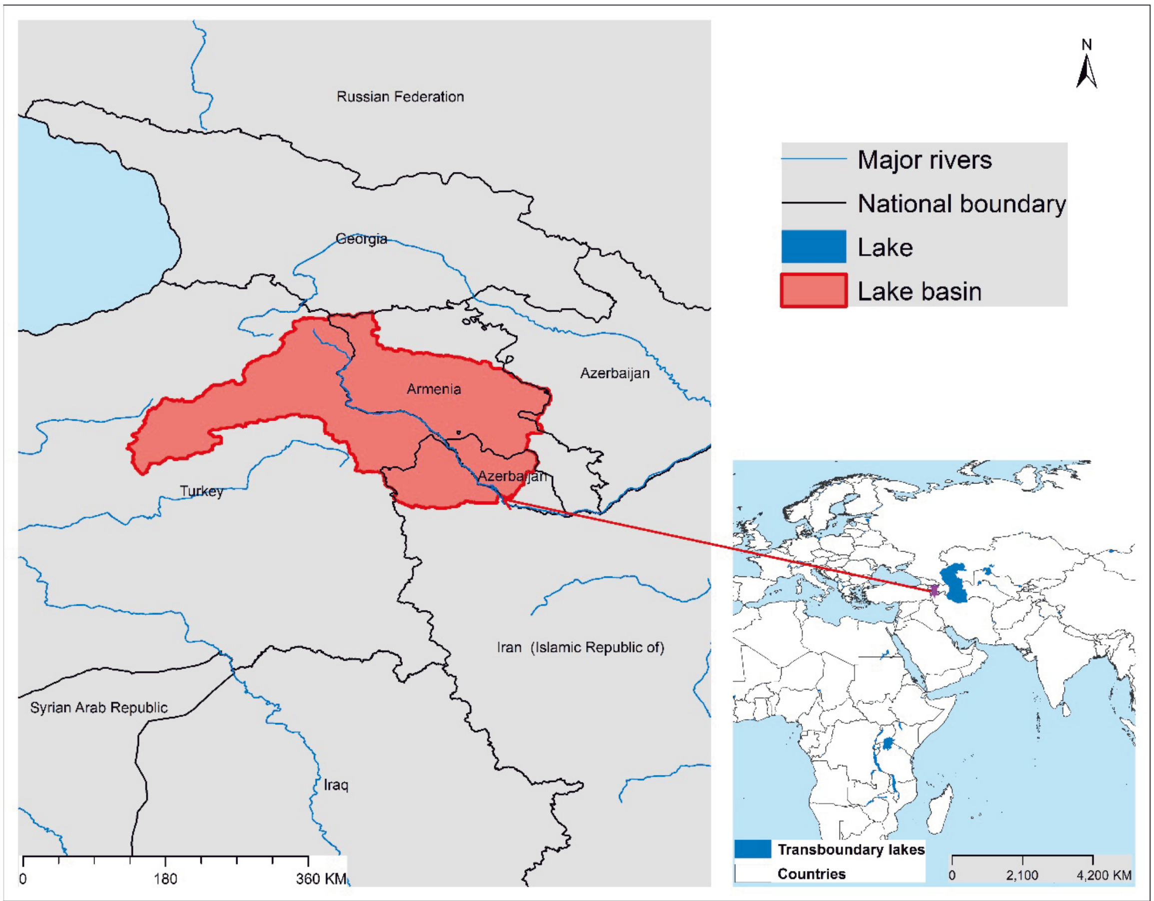
The Meadows Center for Water and the Environment
Texas State University
SHIGA UNIVERSITY



NASA Earth Observatory

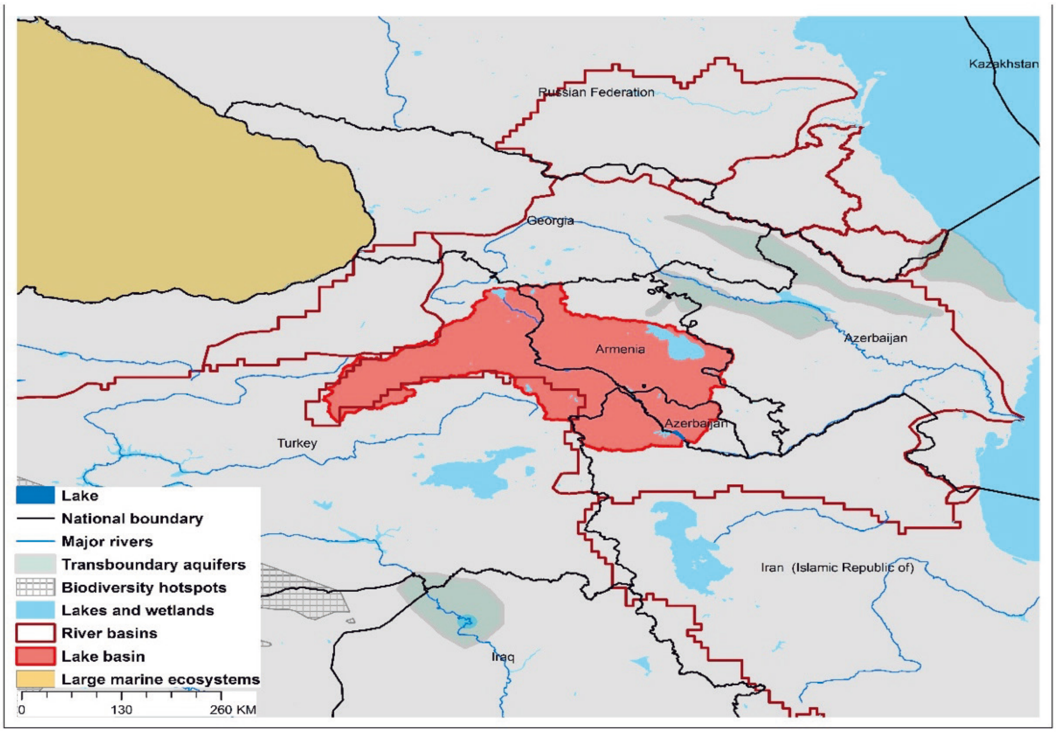
Aras Su Qovsaginin Su Anbari — Geographic Information

Aras Su Qovsaginin Su Anbari is a reservoir on the Aras River constructed for hydropower production, being shared by the Azerbaijan Republic and the Islamic Republic of Iran. Since its opening, the reservoir also has provided irrigation water for more than 400,000 ha of arable land in the two countries. At its normal water elevation, the reservoir capacity is 1.35 km^3. The reservoir has a long history of bilateral discussions between Iran and Azerbaijan regarding its operation and management. There is little information, however, regarding the need for GEF-catalyzed management interventions for any transboundary environmental issues.

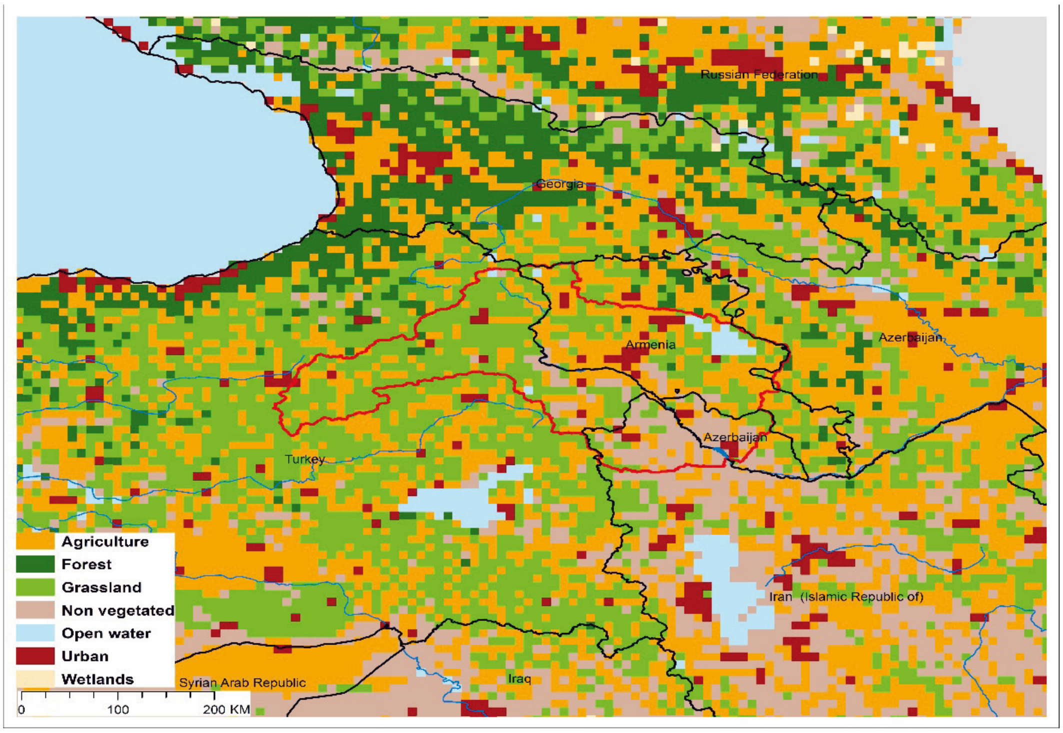


TWAP Regional Designation	Northern Africa & Western Asia; Southern Asia	**Lake Basin Population (2010)**	3,924,400
River Basin	Kura-Arkas	**Lake Basin Population Density (2010; # km^{-2})**	52.3
Riparian Countries	Azerbaijan, Islamic Republic of Iran	**Average Basin Precipitation ($mm\ yr^{-1}$)**	460.6
Basin Area (km^2)	49,434	**Shoreline Length (km)**	66.7
Lake Area (km^2)	52.1	**Human Development Index (HDI)**	0.73
Lake Area:Lake Basin Ratio	0.001	**International Treaties/Agreements Identifying Lake**	Yes

Aras Su Qovsaginin Su Anbari Basin Characteristics



(a) Aras Su Qovsaginin Su Anbari basin and associated transboundary water systems



(b) Aras Su Qovsaginin Su Anbari basin land use

Aras Su Qovsaginin Su Anbari Threat Ranking

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential threat risks be estimated on the basis of the characteristics of their drainage basins, rather than in-lake conditions. Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics.

The lake threat ranks were calculated with a spreadsheet-based interactive scenario analysis program, incorporating data and information about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services. These descriptive data for Aras Su Qovsaginin Su Anbari and the other transboundary lakes included lake and basin areas, population numbers and densities, areal extent of basin stressors on the lake, data grid size, and other components considered important from the perspective of the user of the data results. The scenario analysis program also provides a means to define the appropriate context and preconditions for interpreting the ranking results.

The Aras Su Qovsaginin Su Anbari threat ranks are expressed in terms of the Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and the Human Development Index (HDI) score, as well as combinations of these indices. However, it is emphasized that, being based on specific characteristics and assumptions regarding Aras Su Qovsaginin Su Anbari and its basin characteristics, the calculated threat scores represent only one possible set of lake threat rankings. Defining the appropriate context and preconditions for interpreting the lake rankings remains an important responsibility of those using the threat ranking results, including lake managers and decision-makers.

Table 1. Aras Su Qovsaginin Su Anbari Relative Threat Ranks, Based on Adjusted Human Water Security (Adj-HWS) and Reverse Biodiversity Threats, and Human Development Index (HDI) Score

(Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank		Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank		Human Development Index (HDI) Score	Relative HDI Rank
0.89	15		0.47	45		0.73	36

It is emphasized that the Aras Su Qovsaginin Su Anbari rankings above are discussed here within the context of the management and decision-making process, rather than as strict numerical ranks. Based on its geographic, population and socioeconomic assumptions used in the scenario analysis program, the calculated Adj-HWS score for Aras Su Qovsaginin Su Anbari indicates a moderately high threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Aras Su Qovsaginin Su Anbari, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a low threat rank, compared to the other transboundary lakes. Management interventions directed to improving the biodiversity status must be viewed with caution, however, since we lack sufficient knowledge and experience to accurately predict the ultimate impacts of biodiversity manipulations and preservation efforts. Further, the RvBD scores indicate the relative sensitivity of a lake basin to human activities, and high threat scores *per se* do not necessarily justify management interventions. Such interventions may actually increase biodiversity degradation, noting that many developed countries have already fundamentally degraded their biodiversity because of economic development activities. Thus, activities undertaken to address the Adj-HWS threats may actually degrade the biodiversity status and resources, even if the health and socioeconomic conditions of the lake basin stakeholders are improved as a result of better conditions, thereby increasing stakeholder resource consumption.

The relative Human Development Index (HDI) places the Aras Su Qovsaginin Su Anbari basin in a moderately low threat rank in regard to its health, educational and economic status.

Table 2. Aras Su Qovsaginin Su Anbari Threat Ranks, Based on Multiple Ranking Criteria

(Scores for Adj-HWS, RvBD and HDI ranks are presented in Table 1; the ranks may differ in some cases because of rounding of figures; Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

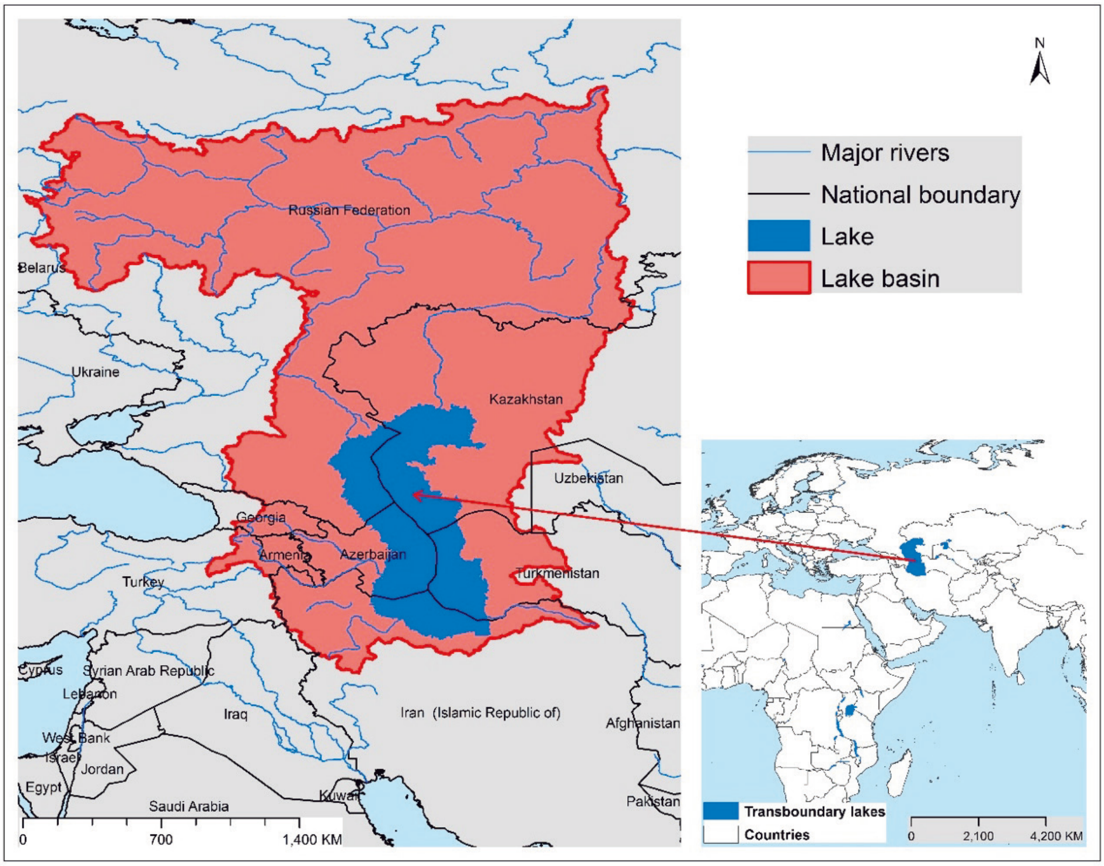
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
15	35	45		59	33		50	26		94	34

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores place Aras Su Qovsaginin Su Anbari in the upper half of the threat ranks. The relative threat decreases when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Aras Su Qovsaginin Su Anbari exhibits an overall moderately high threat ranking.

Interactions between the ranking parameters for Aras Su Qovsaginin Su Anbari indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Aras Su Qovsaginin Su Anbari must be considered on the basis of educated judgement and accurate representations of its situation. A fundamental question will be how can one decide a given management intervention will produce the greatest benefit(s) for the greatest number of people in the Aras Su Qovsaginin Su Anbari basin? Accurate answers to such questions for Aras Su Qovsaginin Su Anbari, and other transboundary lakes, will require a case-by-case assessment approach that considers the specific lake situation and the anticipated improvements from specific management interventions, as well as interactions with water systems to which the lake is linked.

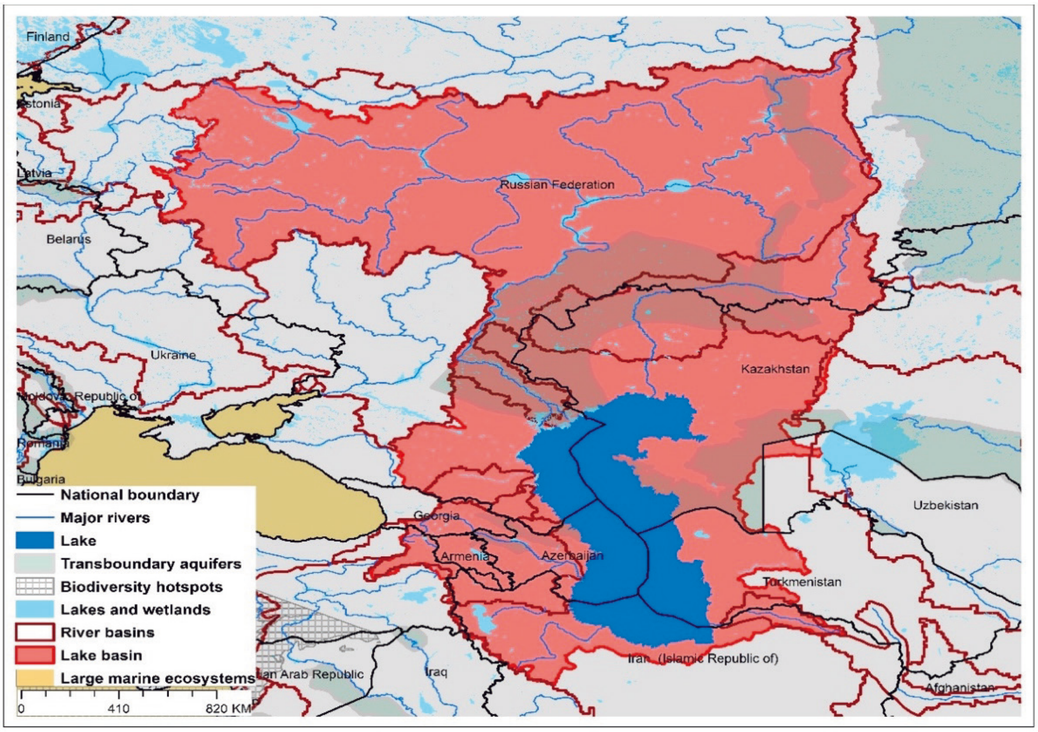
Caspian Sea — Geographic Information

The Caspian Sea, a terminal lake, is the world's largest single enclosed inland waterbody. It also is the largest salt lake in the world, containing about one-third of its inland surface waters, with a mean salinity about one-third of Earth's oceans. The Volga River contributes about 80% of its inflow. The lake has exhibited dramatic water level changes over the centuries synchronized largely with Volga River inflows, and more recently to climate change. The Volga River is thought to be the principal source of transboundary contaminants to the lake. The lake contains a heavily-exploited sturgeon population (caviar source), to the point banning sturgeon fishing has been advocated until the population recovers, although the high caviar prices constrain this goal. Another major environmental concern is oil and natural gas production activities along the lake edges. The lake has already received GEF funding, and consideration of further GEF-catalyzed management interventions requires a review of its GEF status.

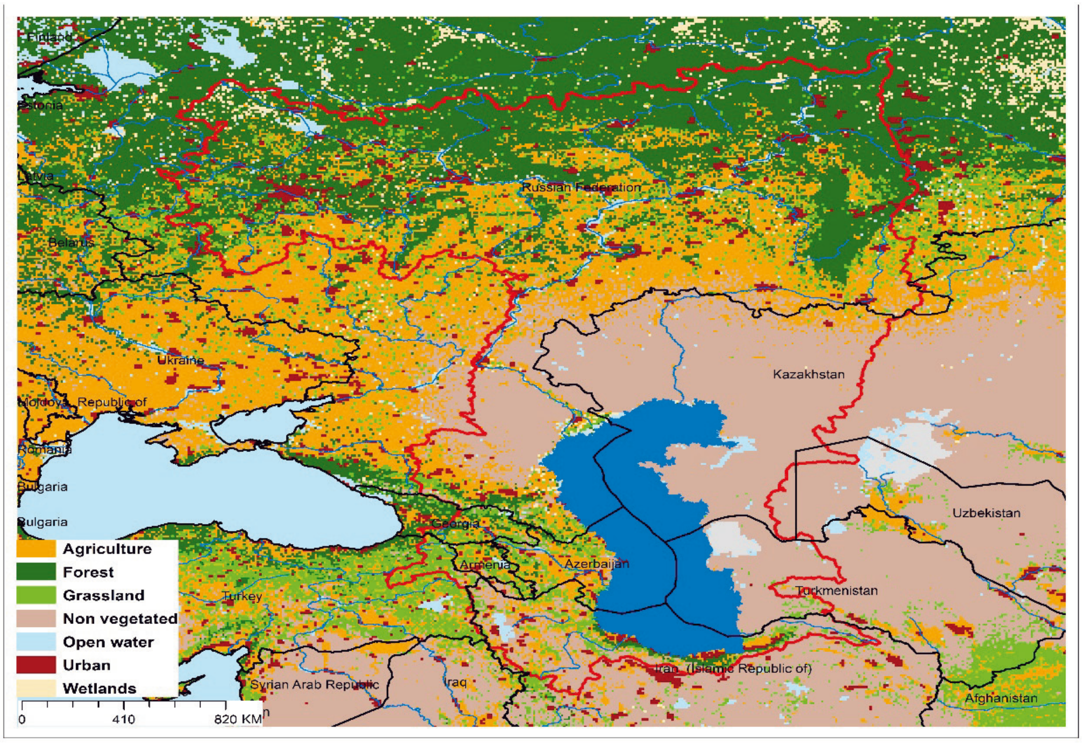


TWAP Regional Designation	Northern Africa & Western Asia; Eastern & Central Asia; Southern Asia; Eastern Europe	**Lake Basin Population (2010)**	105,000,000
River Basin	Caspian (endorheic)	**Lake Basin Population Density (2010; # km^{-2})**	20.1
Riparian Countries	Azerbaijan, Iran, Kazakhstan, Russia	**Average Basin Precipitation (mm yr^{-1})**	448.5
Basin Area (km^2)	3,412,322	**Shoreline Length (km)**	9,042
Lake Area (km^2)	377,543	**Human Development Index (HDI)**	0.77
Lake Area:Lake Basin Ratio	0.117	**International Treaties/Agreements Identifying Lake**	Yes

Caspian Sea Basin Characteristics



(a) Caspian Sea basin and associated transboundary water systems



(b) Caspian Sea basin land use

Caspian Sea Threat Ranking

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential threat risks be estimated on the basis of the characteristics of their drainage basins, rather than in-lake conditions. Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics.

The lake threat ranks were calculated with a spreadsheet-based interactive scenario analysis program, incorporating data and information about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services. These descriptive data for Caspian Sea and the other transboundary lakes included lake and basin areas, population numbers and densities, areal extent of basin stressors on the lake, data grid size, and other components considered important from the perspective of the user of the data results. The scenario analysis program also provides a means to define the appropriate context and preconditions for interpreting the ranking results.

The Caspian Sea threat ranks are expressed in terms of the Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and the Human Development Index (HDI) score, as well as combinations of these indices. However, it is emphasized that, being based on specific characteristics and assumptions regarding Caspian Sea and its basin characteristics, the calculated threat scores represent only one possible set of lake threat rankings. Defining the appropriate context and preconditions for interpreting the lake rankings remains an important responsibility of those using the threat ranking results, including lake managers and decision-makers.

Table 1. Caspian Sea Relative Threat Ranks, Based on Adjusted Human Water Security (Adj-HWS) and Reverse Biodiversity Threats, and Human Development Index (HDI) Score

(Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank		Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank		Human Development Index (HDI) Score	Relative HDI Rank
0.79	39		0.60	27		0.77	41

It is emphasized that the Caspian Sea rankings above are discussed here within the context of the management and decision-making process, rather than as strict numerical ranks. Based on its geographic, population and socioeconomic assumptions used in the scenario analysis program, the calculated Adj-HWS score for Caspian Sea indicates a moderately low threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Caspian Sea, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a medium threat rank, compared to the other transboundary lakes. Management interventions directed to improving the biodiversity status must be viewed with caution, however, since we lack sufficient knowledge and experience to accurately predict the ultimate impacts of biodiversity manipulations and preservation efforts. Further, the RvBD scores indicate the relative sensitivity of a lake basin to human activities, and high threat scores *per se* do not necessarily justify management interventions. Such interventions may actually increase biodiversity degradation, noting that many developed countries have already fundamentally degraded their biodiversity because of economic development activities. Thus, activities undertaken to address the Adj-HWS threats may actually degrade the biodiversity status and resources, even if the health and socioeconomic conditions of the lake basin stakeholders are improved as a result of better conditions, thereby increasing stakeholder resource consumption.

The relative Human Development Index (HDI) places the Caspian Sea basin in a moderately low threat rank in regard to its health, educational and economic conditions.

Table 2. Caspian Sea Threat Ranks, Based on Multiple Ranking Criteria

(Scores for Adj-HWS, RvBD and HDI ranks are presented in Table 1; the ranks may differ in some cases because of rounding of tied threat scores; Estimated risks: red – highest; orange – moderately high; yellow – medium;
green – moderately low; blue – low)

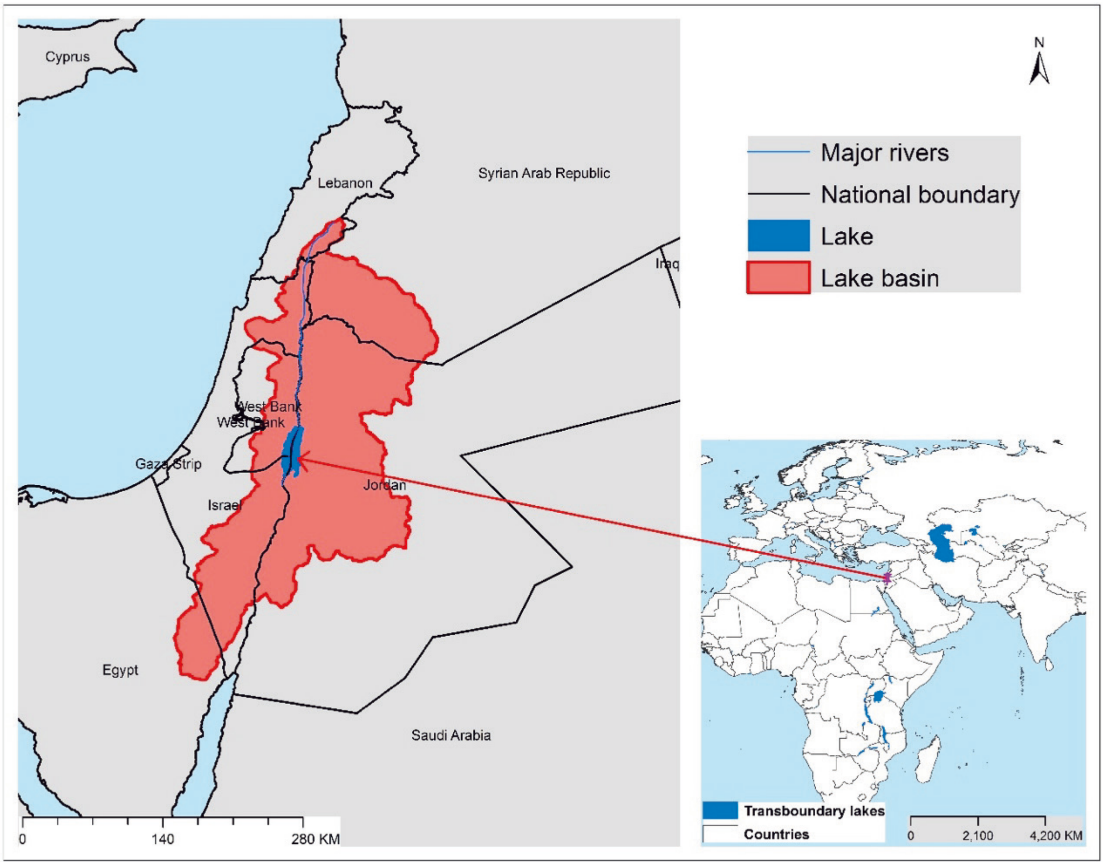
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
39	41	27		66	36		80	40		107	38

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Caspian Sea in the lower quarter of the threat ranks. The relative threat is somewhat increased when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Caspian Sea exhibits an overall moderately low threat ranking.

Interactions between the ranking parameters for Caspian Sea indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Caspian Sea must be considered on the basis of educated judgement and accurate representations of its situation. A fundamental question will be how can one decide a given management intervention will produce the greatest benefit(s) for the greatest number of people in the Caspian Sea basin? Accurate answers to such questions for Caspian Sea, and other transboundary lakes, will require a case-by-case assessment approach that considers the specific lake situation and the anticipated improvements from specific management interventions, as well as interactions with water systems to which the lake is linked.

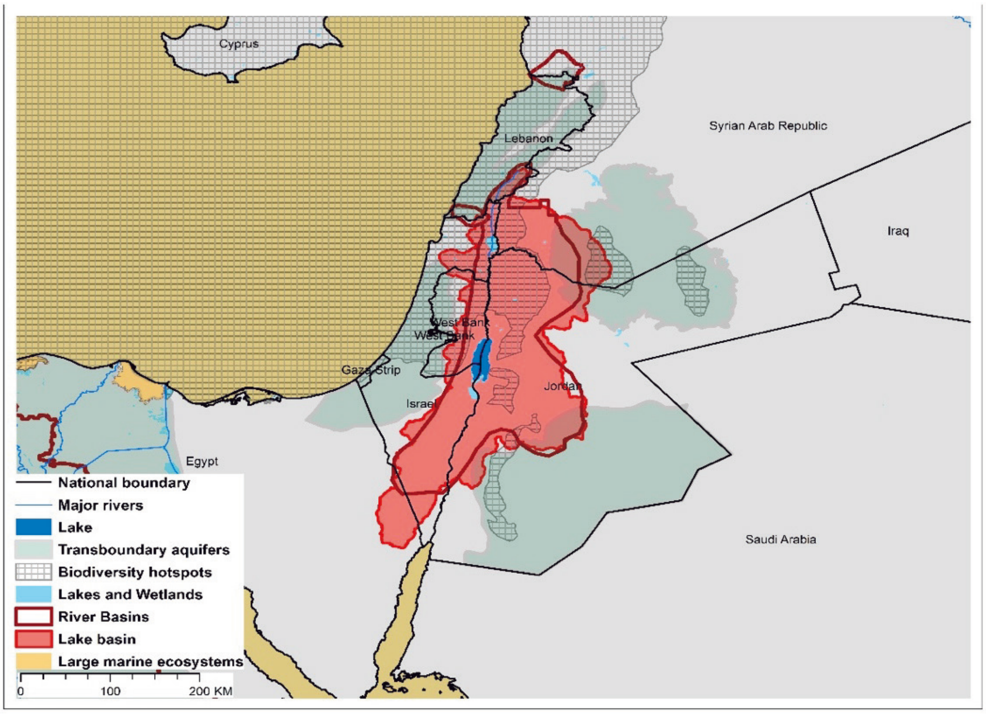
Dead Sea — Geographic Information

The Dead Sea is an endorheic salt lake located in the Jordan Rift Valley. It exhibits the lowest elevation and being the lowest body of water on Earth's surface. It is also the deepest hypersaline lake in the world, being about ten times as salty as the ocean. The salinity results in a harsh aquatic environment supporting little biodiversity. The major water inflow is the Jordan River to the north. The rainfall is irregular and scarce. The lake's water level began to decrease in the 1960s, when Israel and Jordan increased use of the lake water for commercial purposes. The lake has an enormous salt reserve, being sufficiently buoyant to support swimmers in the lake. The southern basin eventually was sub-divided into large evaporation ponds for salt extraction, resulting in the basin ceasing to be a natural body of water by the 21st Century, notably changing the physical appearance of the whole lake.

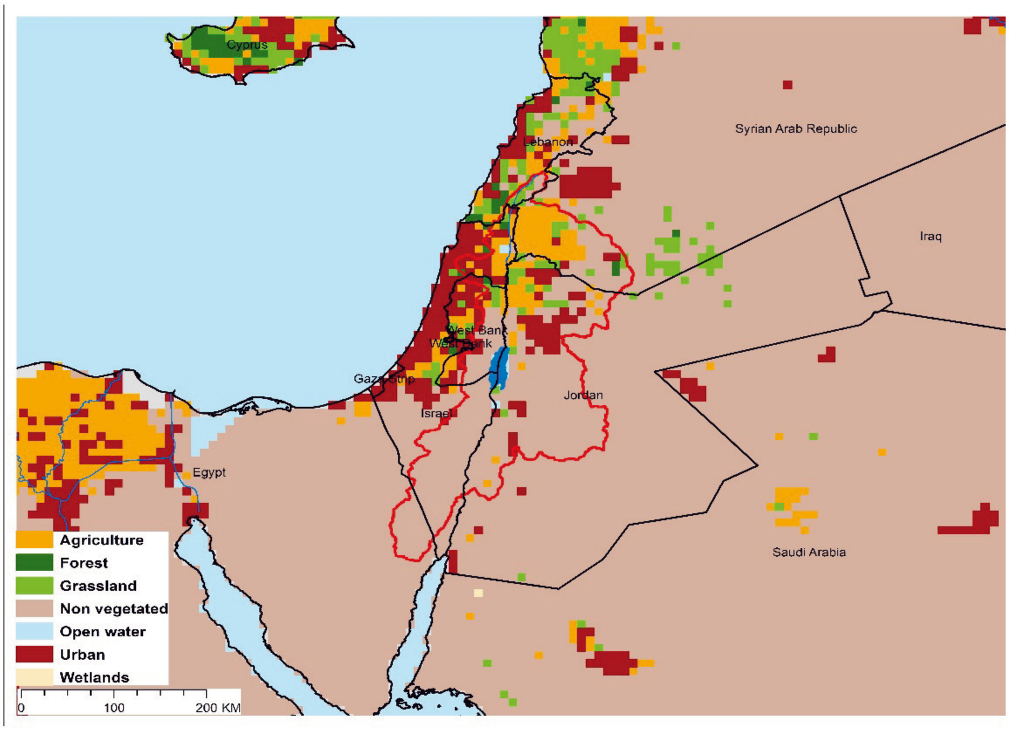


TWAP Regional Designation	Northern Africa & Western Asia	**Lake Basin Population (2010)**	9,454,130
River Basin	Jordan	**Lake Basin Population Density (2010; # km^{-2})**	161.0
Riparian Countries	Israel, Jordan, Palestine	**Average Basin Precipitation (mm yr^{-1})**	241.7
Basin Area (km^2)	40,013	**Shoreline Length (km)**	189.7
Lake Area (km^2)	642.7	**Human Development Index (HDI)**	0.72
Lake Area:Lake Basin Ratio	0.015	**International Treaties/Agreements Identifying Lake**	

Dead Sea Basin Characteristics



(a) Dead Sea basin and associated transboundary water systems



(b) Dead Sea basin land use

Dead Sea Threat Ranking

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential threat risks be estimated on the basis of the characteristics of their drainage basins, rather than in-lake conditions. Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics.

The lake threat ranks were calculated with a spreadsheet-based interactive scenario analysis program, incorporating data and information about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services. These descriptive data for Dead Sea and the other transboundary lakes included lake and basin areas, population numbers and densities, areal extent of basin stressors on the lake, data grid size, and other components considered important from the perspective of the user of the data results. The scenario analysis program also provides a means to define the appropriate context and preconditions for interpreting the ranking results.

The Dead Sea threat ranks are expressed in terms of the Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and the Human Development Index (HDI) score, as well as combinations of these indices. However, it is emphasized that, being based on specific characteristics and assumptions regarding Dead Sea and its basin characteristics, the calculated threat scores represent only one possible set of lake threat rankings. Defining the appropriate context and preconditions for interpreting the lake rankings remains an important responsibility of those using the threat ranking results, including lake managers and decision-makers.

Table 1. Dead Sea Relative Threat Ranks, Based on Adjusted Human Water Security (Adj-HWS) and Reverse Biodiversity Threats, and Human Development Index (HDI) Score

(Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank		Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank		Human Development Index (HDI) Score	Relative HDI Rank
0.90	13		0.51	41		0.72	34

It is emphasized that the Dead Sea rankings above are discussed here within the context of the management and decision-making process, rather than as strict numerical ranks. Based on its geographic, population and socioeconomic assumptions used in the scenario analysis program, the calculated Adj-HWS score for Dead Sea indicates a moderately high threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Dead Sea, which is meant to describe its biodiversity sensitivity to basin-derived degradation, decreases the lake to a moderately low threat rank, compared to the other transboundary lakes. Management interventions directed to improving the biodiversity status must be viewed with caution, however, since we lack sufficient knowledge and experience to accurately predict the ultimate impacts of biodiversity manipulations and preservation efforts. Further, the RvBD scores indicate the relative sensitivity of a lake basin to human activities, and high threat scores *per se* do not necessarily justify management interventions. Such interventions may actually increase biodiversity degradation, noting that many developed countries have already fundamentally degraded their biodiversity because of economic development activities. Thus, activities undertaken to address the Adj-HWS threats may actually degrade the biodiversity status and resources, even if the health and socioeconomic conditions of the lake basin stakeholders are improved as a result of better conditions, thereby increasing stakeholder resource consumption.

The relative Human Development Index (HDI) places the Dead Sea basin in a medium threat rank in regard to its health, educational and economic conditions.

Table 2. Dead Sea Threat Ranks, Based on Multiple Ranking Criteria

(Scores for Adj-HWS, RvBD and HDI ranks are presented in Table 1; the ranks may differ in some cases because of rounding of tied threat scores; Estimated risks: red – highest; orange – moderately high; yellow – medium;
green – moderately low; blue – low)

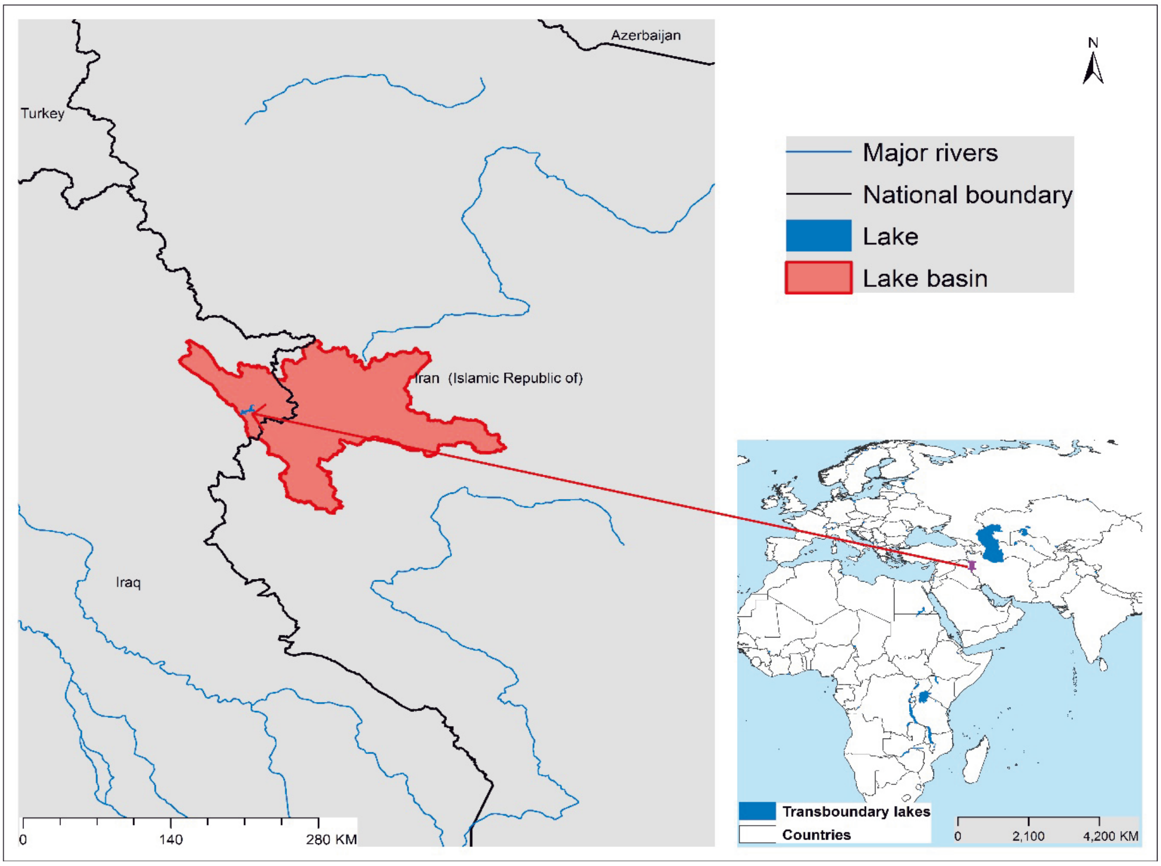
Adj-HWS Rank	HDI Rank	RvBD Rank	Sum Adj-HWS + RvBD	Relative Threat Rank	Sum Adj-HWS + HDI	Relative Threat Rank	Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
14	34	38	52	29	48	24	86	30

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Dead Sea in the upper half of the threat ranks. The relative threat is slightly lower when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Dead Sea exhibits a medium threat ranking.

Interactions between the ranking parameters for Dead Sea indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Dead Sea must be considered on the basis of educated judgement and accurate representations of its situation. A fundamental question will be how can one decide a given management intervention will produce the greatest benefit(s) for the greatest number of people in the Dead Sea basin? Accurate answers to such questions for Dead Sea, and other transboundary lakes, will require a case-by-case assessment approach that considers the specific lake situation and the anticipated improvements from specific management interventions, as well as interactions with water systems to which the lake is linked.

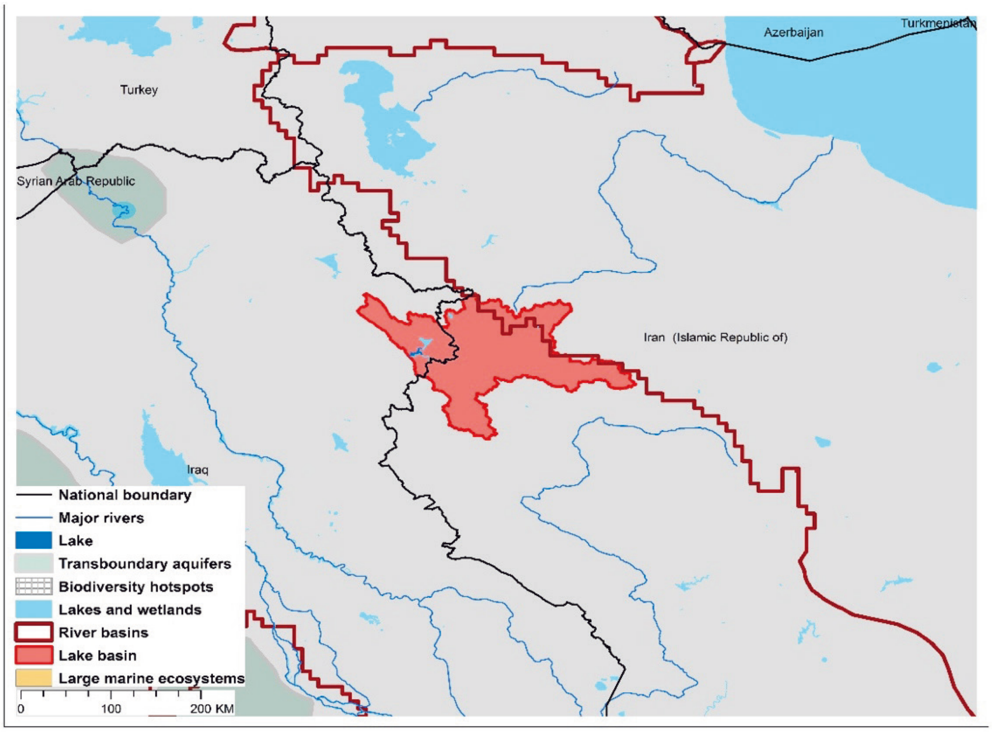
Lake Danbandikhan — Geographic Information

Lake Darbandikhan is a reservoir constructed for irrigation, flood control, hydropower production and recreation. Its dam has undergone several repairs since its construction between 1956 - 1961, attributed to poor construction and neglect. Several slope failures have occurred since its construction. The dam spillway and power station suffered damage during the Iran-Iraq war, with the power station recently rehabilitated. The area as a whole supports significant bird life, as well as recreational use and a fishery. Nevertheless, the lake is reported to be facing water quality degradation resulting in occasional fish kills. It is not clear that the riparian countries have any direct interest in addressing these issues through an international intervention facilitated by the GEF. Any consideration of a GEF-catalyzed management intervention should be preceded by an assessment of the current scientific and political situation.

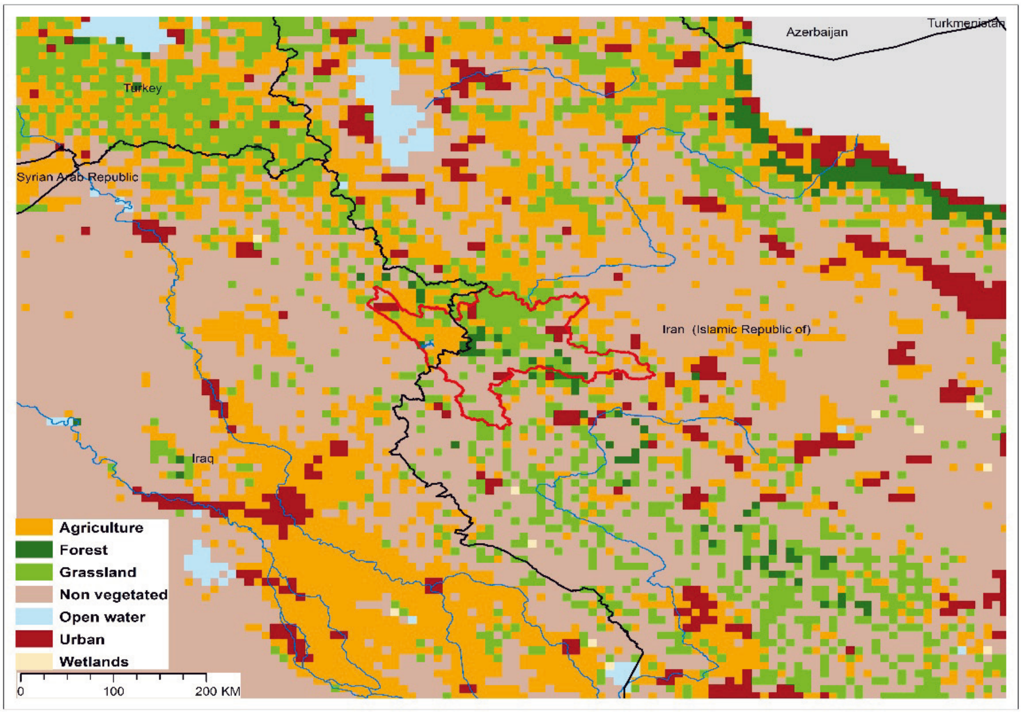


TWAP Regional Designation	Northern Africa & Western Asia; Southern Asia	**Lake Basin Population (2010)**	1,822,575
River Basin	Tigris/Euphrates	**Lake Basin Population Density (2010; # km^{-2})**	76.6
Riparian Countries	Iran, Iraq	**Average Basin Precipitation (mm yr^{-1})**	610.0
Basin Area (km^2)	15,725	**Shoreline Length (km)**	94.0
Lake Area (km^2)	114.3	**Human Development Index (HDI)**	0.68
Lake Area:Lake Basin Ratio	0.002	**International Treaties/Agreements Identifying Lake**	No

Lake Danbandikhan Basin Characteristics



(a) Lake Danbandikhan basin and associated transboundary water systems



(b) Lake Danbandikhan basin land use

Lake Danbandikhan Threat Ranking

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential threat risks be estimated on the basis of the characteristics of their drainage basins, rather than in-lake conditions. Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics.

The lake threat ranks were calculated with a spreadsheet-based interactive scenario analysis program, incorporating data and information about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services. These descriptive data for Lake Danbandikhan and the other transboundary lakes included lake and basin areas, population numbers and densities, areal extent of basin stressors on the lake, data grid size, and other components considered important from the perspective of the user of the data results. The scenario analysis program also provides a means to define the appropriate context and preconditions for interpreting the ranking results.

The Lake Danbandikhan threat ranks are expressed in terms of the Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and the Human Development Index (HDI) score, as well as combinations of these indices. However, it is emphasized that, being based on specific characteristics and assumptions regarding Lake Danbandikhan and its basin characteristics, the calculated threat scores represent only one possible set of lake threat rankings. Defining the appropriate context and preconditions for interpreting the lake rankings remains an important responsibility of those using the threat ranking results, including lake managers and decision-makers.

Table 1. Lake Danbandikhan Relative Threat Ranks, Based on Adjusted Human Water Security (Adj-HWS) and Reverse Biodiversity Threats, and Human Development Index (HDI) Score

(Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank		Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank		Human Development Index (HDI) Score	Relative HDI Rank
0.87	18		0.46	46		0.68	30

It is emphasized that the Lake Danbandikhan rankings above are discussed here within the context of the management and decision-making process, rather than as strict numerical ranks. Based on its geographic, population and socioeconomic assumptions used in the scenario analysis program, the calculated Adj-HWS score for Lake Danbandikhan indicates a moderately high threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lake Danbandikhan, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a low threat rank, compared to the other transboundary lakes. Management interventions directed to improving the biodiversity status must be viewed with caution, however, since we lack sufficient knowledge and experience to accurately predict the ultimate impacts of biodiversity manipulations and preservation efforts. Further, the RvBD scores indicate the relative sensitivity of a lake basin to human activities, and high threat scores *per se* do not necessarily justify management interventions. Such interventions may actually increase biodiversity degradation, noting that many developed countries have already fundamentally degraded their biodiversity because of economic development activities. Thus, activities undertaken to address the Adj-HWS threats may actually degrade the biodiversity status and resources, even if the health and socioeconomic conditions of the lake basin stakeholders are improved as a result of better conditions, thereby increasing stakeholder resource consumption.

The relative Human Development Index (HDI) places the Lake Danbandikhan basin in a medium threat rank in regard to its health, educational and economic conditions.

Table 2. Lake Danbandikhan Threat Ranks, Based on Multiple Ranking Criteria

(Scores for Adj-HWS, RvBD and HDI ranks are presented in Table 1; the ranks may differ in some cases because of rounding of tied threat scores; Estimated risks: red – highest; orange – moderately high; yellow – medium;
green – moderately low; blue – low)

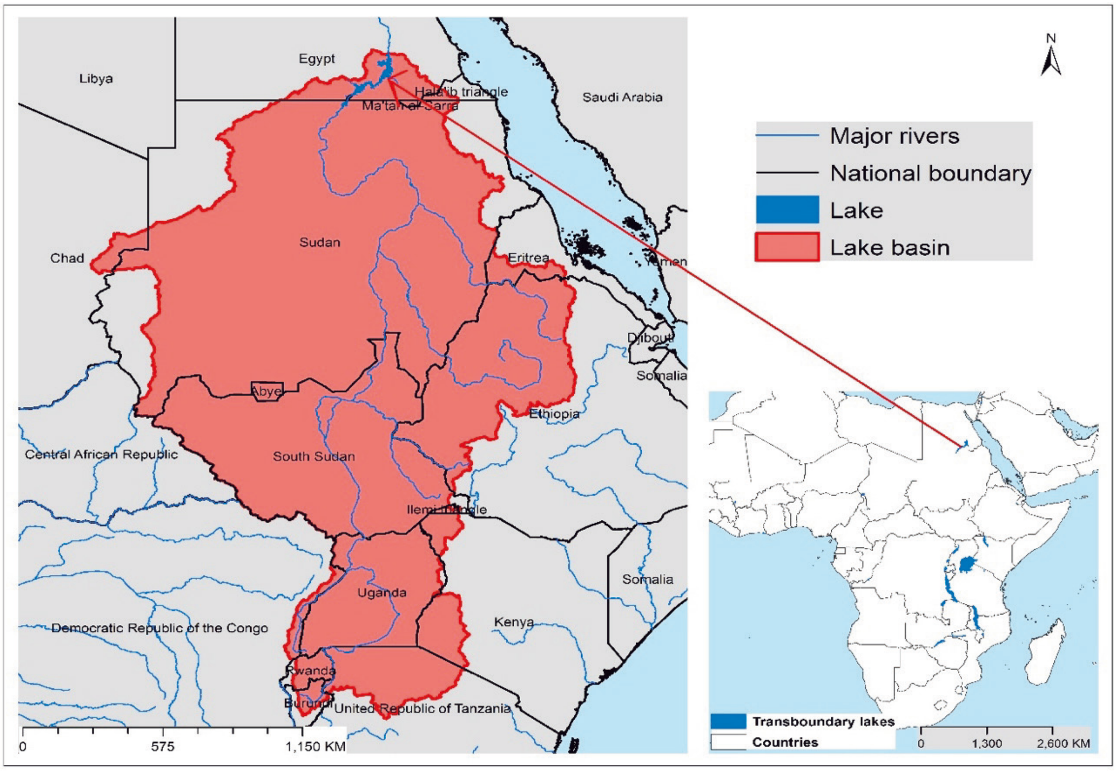
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
17	30	46		63	35		47	23		93	33

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Danbandikhan in the upper half of the threat ranks. The relative threat is somewhat reduced when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Lake Danbandikhan exhibits a medium threat ranking.

Interactions between the ranking parameters for Lake Danbandikhan indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Danbandikhan must be considered on the basis of educated judgement and accurate representations of its situation. A fundamental question will be how can one decide a given management intervention will produce the greatest benefit(s) for the greatest number of people in the Lake Danbandikhan basin? Accurate answers to such questions for Lake Danbandikhan, and other transboundary lakes, will require a case-by-case assessment approach that considers the specific lake situation and the anticipated improvements from specific management interventions, as well as interactions with water systems to which the lake is linked.

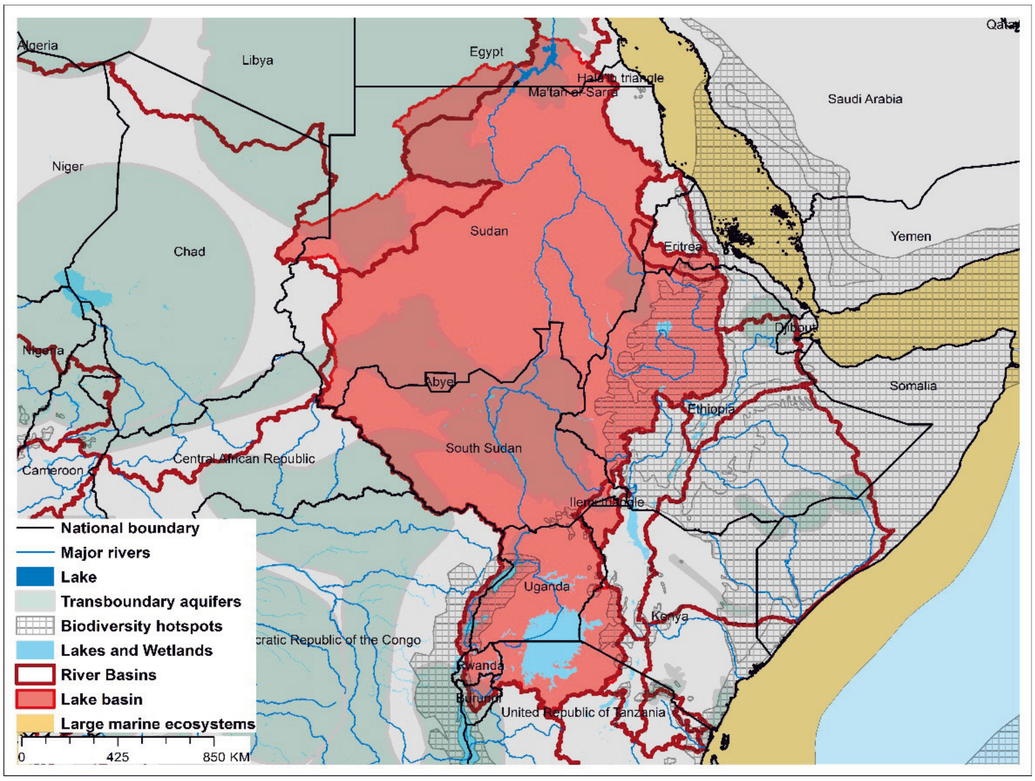
Lake Nasser/Aswan — Geographic Information

Lake Nasser, located in southern Egypt and northern Sudan (called Lake Nubia in Sudan), is one of the largest reservoirs in the world, with a water storage capacity of 132 km^3. Created by construction of the Aswan High Dam, it has a water storage capacity of 132 km^3, being constructed primarily to supply hydroelectric power and irrigation water. Creation of the lake threatened to submerge many significant historical tombs and temples, resulting in the Egyptian government appealing to UNESCO to assist in dismantling and relocating many monuments. The lake also has a major role in Egypt's fishing industry, annually producing around 15,000 to 25,000 tonnes of fish. The Blue Nile, originating at Lake Tana in Ethiopia, is one of the two major Nile tributaries, supplying approximately two-thirds of the Nile River flow during the June – September rainy season. This remains a sensitive subject between the riparian countries, noting the 1959 treaty discussions to allocate the downstream Nile River waters did not directly include upstream Ethiopia. Any GEF-catalyzed management intervention should be considered within the context of the overall Nile River trasnboundary system, noting the riparian country political concerns.

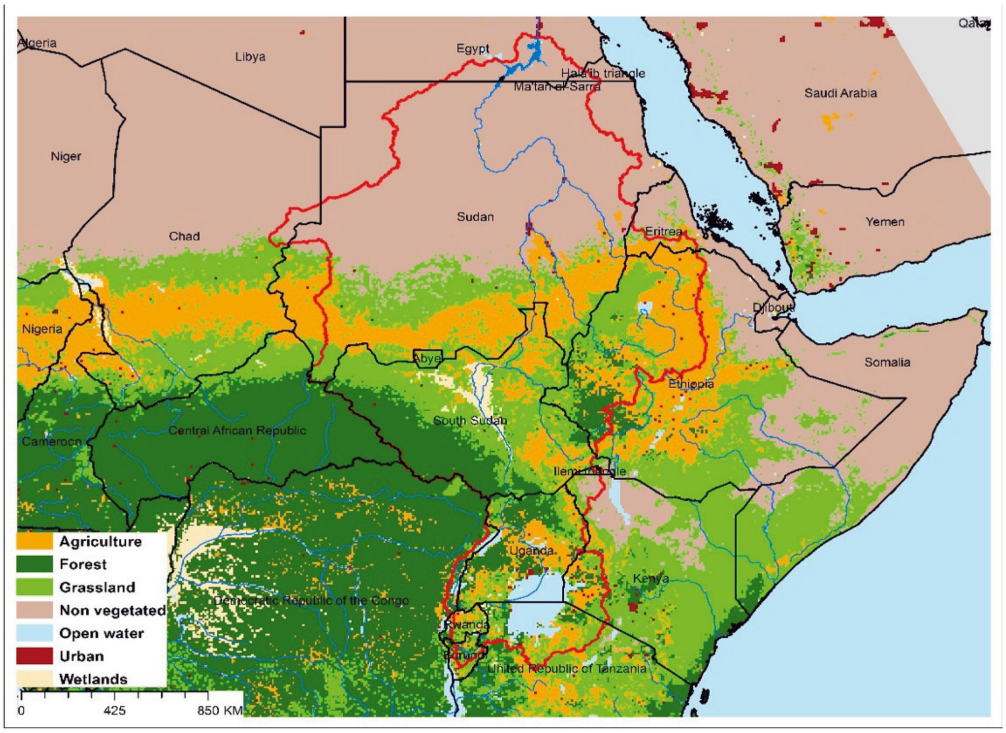


TWAP Regional Designation	Northern Africa & Western Asia	**Lake Basin Population (2010)**	149,000,000
River Basin	Nile	**Lake Basin Population Density (2010; # km^{-2})**	41.2
Riparian Countries	Egypt, Sudan	**Average Basin Precipitation (mm yr^{-1})**	633.2
Basin Area (km^2)	2,583,233	**Shoreline Length (km)**	3,783
Lake Area (km^2)	5,363	**Human Development Index (HDI)**	0.43
Lake Area:Lake Basin Ratio	0.002	**International Treaties/Agreements Identifying Lake**	Yes

Lake Nasser/Aswan Basin Characteristics



(a) Lake Nasser/Aswan basin and associated transboundary water systems



(b) Lake Nasser/Aswan basin land use

Lake Nasser/Aswan Threat Ranking

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential threat risks be estimated on the basis of the characteristics of their drainage basins, rather than in-lake conditions. Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics.

The lake threat ranks were calculated with a spreadsheet-based interactive scenario analysis program, incorporating data and information about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services. These descriptive data for Lake Nasser/Aswan and the other transboundary lakes included lake and basin areas, population numbers and densities, areal extent of basin stressors on the lake, data grid size, and other components considered important from the perspective of the user of the data results. The scenario analysis program also provides a means to define the appropriate context and preconditions for interpreting the ranking results.

The Lake Nasser/Aswan threat ranks are expressed in terms of the Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and the Human Development Index (HDI) score, as well as combinations of these indices. However, it is emphasized that, being based on specific characteristics and assumptions regarding Lake Nasser/Aswan and its basin characteristics, the calculated threat scores represent only one possible set of lake threat rankings. Defining the appropriate context and preconditions for interpreting the lake rankings remains an important responsibility of those using the threat ranking results, including lake managers and decision-makers.

Table 1. Lake Nasser/Aswan Relative Threat Ranks, Based on Adjusted Human Water Security (Adj-HWS) and Reverse Biodiversity Threats, and Human Development Index (HDI) Score

(Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank		Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank		Human Development Index (HDI) Score	Relative HDI Rank
0.86	21		0.68	15		0.43	14

It is emphasized that the Lake Nasser/Aswan rankings above are discussed here within the context of the management and decision-making process, rather than as strict numerical ranks. Based on its geographic, population and socioeconomic assumptions used in the scenario analysis program, the calculated Adj-HWS score for Lake Nasser/Aswan indicates a moderately high threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lake Nasser/Aswan, which is meant to describe its biodiversity sensitivity to basin-derived degradation, also places the lake in a moderately high threat rank, compared to the other transboundary lakes. Management interventions directed to improving the biodiversity status must be viewed with caution, however, since we lack sufficient knowledge and experience to accurately predict the ultimate impacts of biodiversity manipulations and preservation efforts. Further, the RvBD scores indicate the relative sensitivity of a lake basin to human activities, and high threat scores *per se* do not necessarily justify management interventions. Such interventions may actually increase biodiversity degradation, noting that many developed countries have already fundamentally degraded their biodiversity because of economic development activities. Thus, activities undertaken to address the Adj-HWS threats may actually degrade the biodiversity status and resources, even if the health and socioeconomic conditions of the lake basin stakeholders are improved as a result of better conditions, thereby increasing stakeholder resource consumption.

The relative Human Development Index (HDI) places the Lake Nasser/Aswan basin in a moderately high threat rank in regard to its health, educational and economic status.

Table 2. Lake Nasser/Aswan Threat Ranks, Based on Multiple Ranking Criteria

(Scores for Adj-HWS, RvBD and HDI ranks are presented in Table 1; the ranks may differ in some cases because of rounding of figures; Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

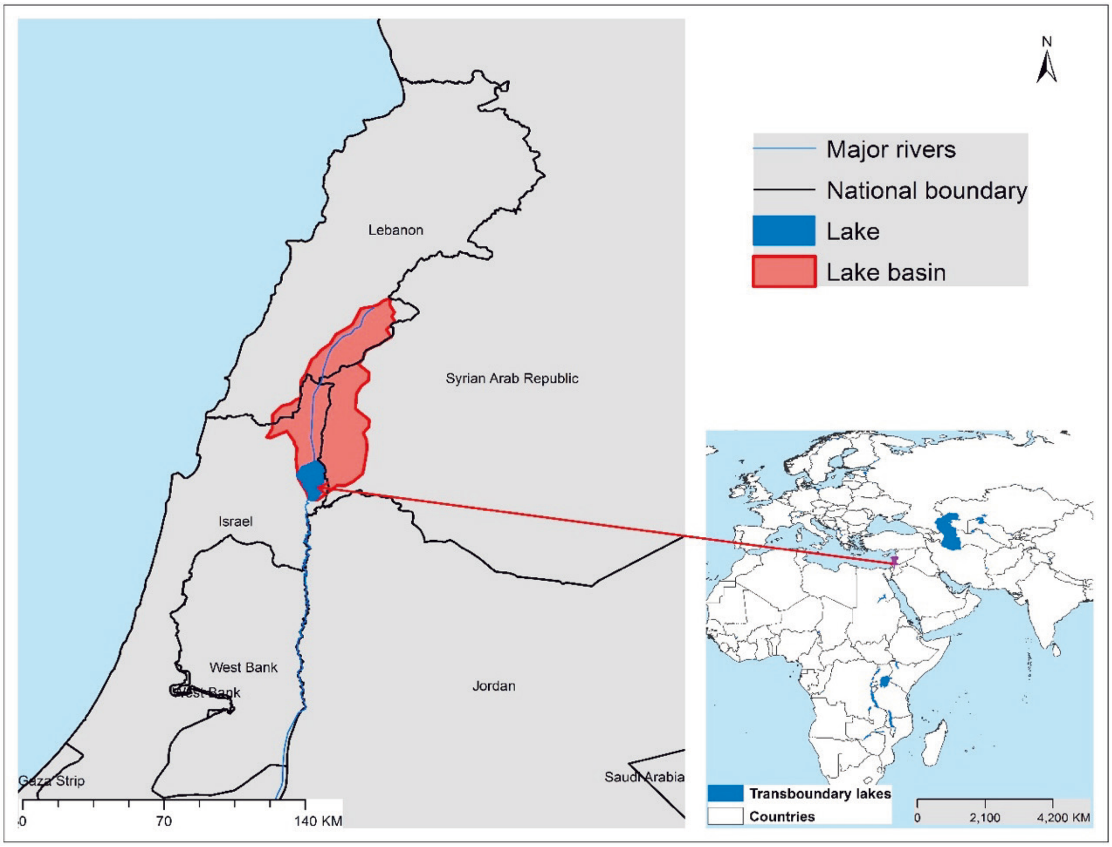
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
20	16	16		36	19		36	18		52	16

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Nasser/Aswan in the upper third of the threat ranks. The relative threat is similar when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Lake Nasser/Aswan exhibits an overall moderately high threat ranking.

Interactions between the ranking parameters for Lake Nasser/Aswan indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Nasser/Aswan must be considered on the basis of educated judgement and accurate representations of its situation. A fundamental question will be how can one decide a given management intervention will produce the greatest benefit(s) for the greatest number of people in the Lake Nasser/Aswan basin? Accurate answers to such questions for Lake Nasser/Aswan, and other transboundary lakes, will require a case-by-case assessment approach that considers the specific lake situation and the anticipated improvements from specific management interventions, as well as interactions with water systems to which the lake is linked. To this end, it is noted that the African transboundary lakes as a group merit special attention, with some lakes requiring more attention than others.

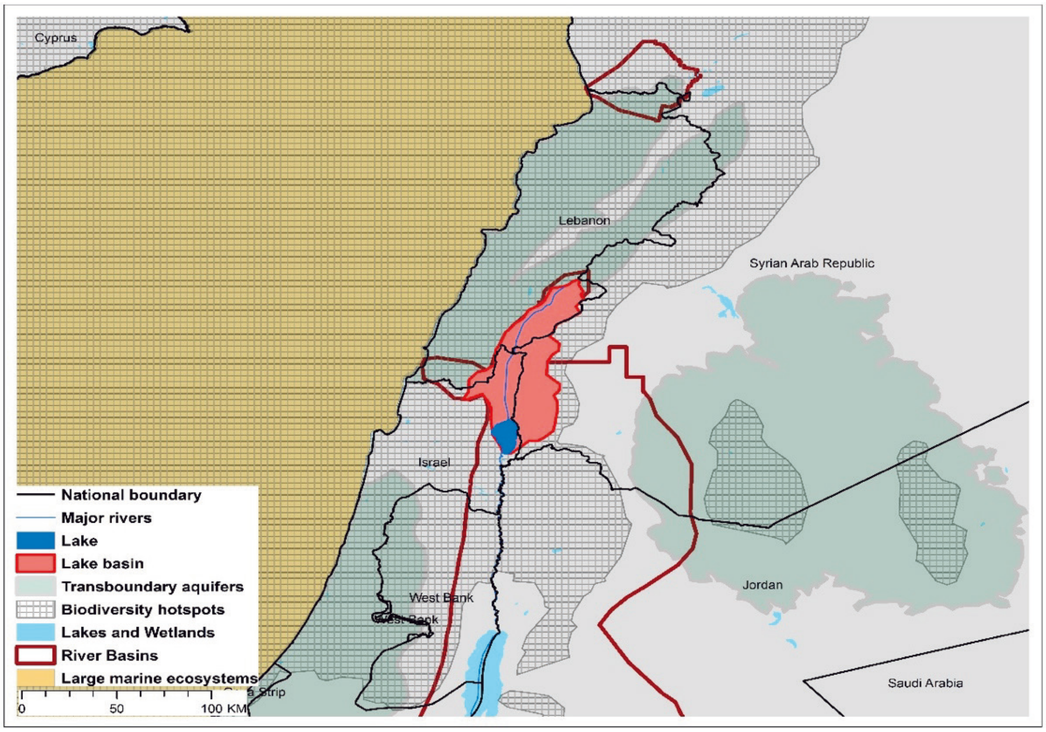
Sea of Galilee — Geographic Information

The Sea of Galilee, also known as Lake Kinneret or Lake Tiberias, is the largest freshwater lake in Israel, the lowest freshwater lake on Earth and the second-lowest lake overall behind the Dead Sea. The lake area has been populated from very early times, with much of the ministry of Jesus occurring on its shores which then exhibited continuous development of settlements, along with much boat ferrying and trade. The lake's warm waters have supported a significant commercial fishery for more than two millennia, with the fish life having an affinity with that of the East African lakes. Tourism also is an important economic activity, with historical and religious sites in the region drawing local and foreign tourists. Low water levels in recent years, however, have stressed the lake's ecology, attributed mainly to over-abstraction of its waters by the riparian countries, with the Sea of Galilee being threatened to become irreversibly salinized by salt water springs underlying the lake, which are held in check by the overlying freshwater.

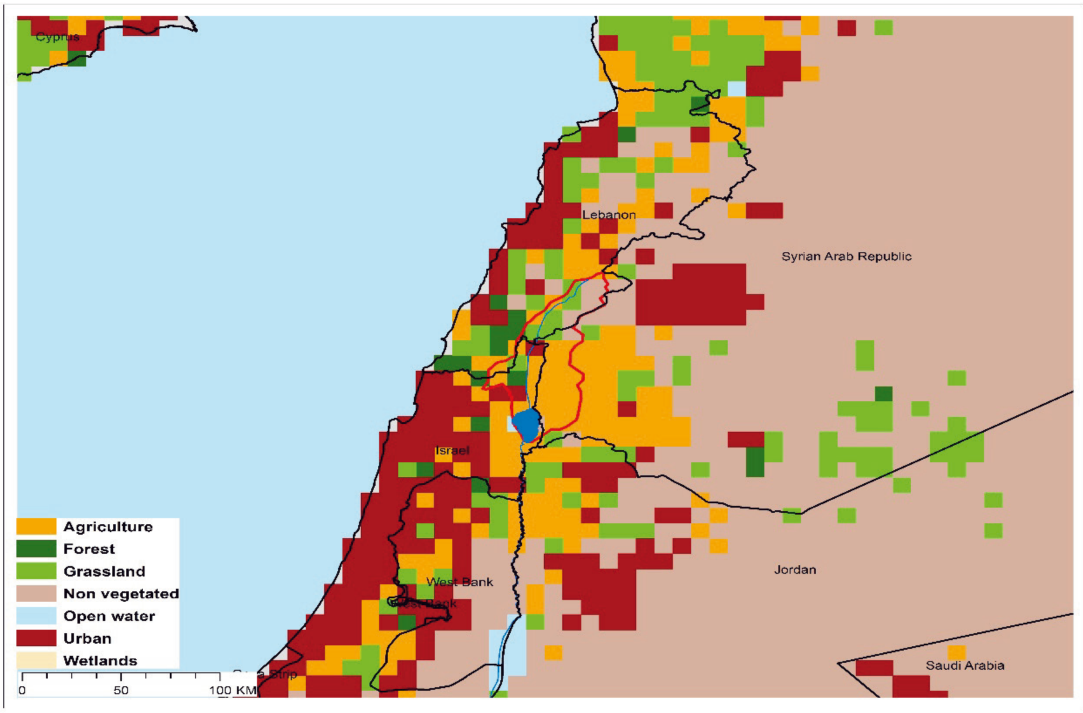


TWAP Regional Designation	Northern Africa & Western Asia	**Lake Basin Population (2010)**	545,267
River Basin	Jordan	**Lake Basin Population Density (2010; # km^{-2})**	170.0
Riparian Countries	Israel, Syria (Golan Heights)	**Average Basin Precipitation (mm yr^{-1})**	642.2
Basin Area (km^2)	162.0	**Shoreline Length (km)**	67.5
Lake Area (km^2)	2,250	**Human Development Index (HDI)**	0.88
Lake Area:Lake Basin Ratio	0.72	**International Treaties/Agreements Identifying Lake**	No

Sea of Galilee Basin Characteristics



(a) Sea of Galilee basin and associated transboundary water systems



(b) Sea of Galilee basin land use

Sea of Galilee Threat Ranking

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential threat risks be estimated on the basis of the characteristics of their drainage basins, rather than in-lake conditions. Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics.

The lake threat ranks were calculated with a spreadsheet-based interactive scenario analysis program, incorporating data and information about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services. These descriptive data for Sea of Galilee and the other transboundary lakes included lake and basin areas, population numbers and densities, areal extent of basin stressors on the lake, data grid size, and other components considered important from the perspective of the user of the data results. The scenario analysis program also provides a means to define the appropriate context and preconditions for interpreting the ranking results.

The Sea of Galilee threat ranks are expressed in terms of the Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and the Human Development Index (HDI) score, as well as combinations of these indices. However, it is emphasized that, being based on specific characteristics and assumptions regarding Sea of Galilee and its basin characteristics, the calculated threat scores represent only one possible set of lake threat rankings. Defining the appropriate context and preconditions for interpreting the lake rankings remains an important responsibility of those using the threat ranking results, including lake managers and decision-makers.

Table 1. Sea of Galilee Relative Threat Ranks, Based on Adjusted Human Water Security (Adj-HWS) and Reverse Biodiversity Threats, and Human Development Index (HDI) Score

(Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank		Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank		Human Development Index (HDI) Score	Relative HDI Rank
0.87	17		0.45	47		0.88	46

It is emphasized that the Sea of Galilee rankings above are discussed here within the context of the management and decision-making process, rather than as strict numerical ranks. Based on its geographic, population and socioeconomic assumptions used in the scenario analysis program, the calculated Adj-HWS score for Sea of Galilee indicates a moderately high threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Sea of Galilee, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a dramatically improved low threat rank, compared to the other transboundary lakes. Management interventions directed to improving the biodiversity status must be viewed with caution, however, since we lack sufficient knowledge and experience to accurately predict the ultimate impacts of biodiversity manipulations and preservation efforts. Further, the RvBD scores indicate the relative sensitivity of a lake basin to human activities, and high threat scores *per se* do not necessarily justify management interventions. Such interventions may actually increase biodiversity degradation, noting that many developed countries have already fundamentally degraded their biodiversity because of economic development activities. Thus, activities undertaken to address the Adj-HWS threats may actually degrade the biodiversity status and resources, even if the health and socioeconomic conditions of the lake basin stakeholders are improved as a result of better conditions, thereby increasing stakeholder resource consumption.

The relative Human Development Index (HDI) places the Sea of Galilee basin in a low threat rank in regard to its health, educational and economic conditions.

Table 2. Sea of Galilee Threat Ranks, Based on Multiple Ranking Criteria

(Scores for Adj-HWS, RvBD and HDI ranks are presented in Table 1; the ranks may differ in some cases because of rounding of tied threat scores; Estimated risks: red – highest; orange – moderately high; yellow – medium;
green – moderately low; blue – low)

Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
19	46	47		66	38		65	36		112	39

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Sea of Galilee in the lower third of the threat ranks. The relative threat is similar when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Sea of Galilee exhibits a moderately low threat ranking.

Interactions between the ranking parameters for Sea of Galilee indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Sea of Galilee must be considered on the basis of educated judgement and accurate representations of its situation. A fundamental question will be how can one decide a given management intervention will produce the greatest benefit(s) for the greatest number of people in the Sea of Galilee basin? Accurate answers to such questions for Sea of Galilee, and other transboundary lakes, will require a case-by-case assessment approach that considers the specific lake situation and the anticipated improvements from specific management interventions, as well as interactions with water systems to which the lake is linked.

METHODOLOGY AND CAVEATS REGARDING TRANSBOUNDARY LAKE THREAT RANKS

A serious lack of global-scale uniform data on the TWAP transboundary in-lake conditions required their potential risks be estimated on the basis of the characteristics of their drainage basins, rather than analysis of their in-lake conditions. The lake threat ranks were calculated with a scenario analysis program that allowed incorporation of specific assumptions and preconditions about the nature and magnitude of their basin-derived stresses, and their possible impacts on the sustainability of their ecosystem services, as defined by the user of the ranking results. Because the transboundary lake threat ranks are based on specific lake and basin assumptions, therefore, the calculated rankings represent only one possible set of lake rankings.

Using basin characteristics to rank transboundary lake threats precludes consideration of the unique features that can buffer their in-lake responses to basin-derived disturbances, including an integrating nature for all inputs, long water retention times, and complex, non-linear response dynamics. A global overview of river basin threats based on 23 basin-scale drivers under four thematic areas (catchment disturbance; pollution; water resource development; biotic factors) was modified for the transboundary lakes assessment. The driver weights were initially based on collective opinions of experts exhibiting a range of disciplinary expertise, subsequently being refined with inputs from lake scientists and managers participating in ILEC's 15th World Lake Conference.

A spreadsheet-based, interactive scenario analysis program was used to rank the transboundary lake threats. The lake basin characteristics were determined by superimposing the lake basins over the river basin grids, and scaling the driver data to lake basin scale. Selected basin drivers, weights and preconditions were used in the scenario analysis program to calculate the relative lake threat ranks, expressed in terms of the Incident (HWS) and Adjusted (Adj-HWS) Human Water Security and Incident Biodiversity (BD) threats.

The transboundary lake analyses incorporated several assumptions and preconditions. Small transboundary lakes (area <5 km^2), sparse basin populations (< 5 persons km^{-1}), or that were frozen over for major portions of the year (annual air temperature <5 ^{o}C), were eliminated from the analyses. The areal extent of the influences of the basin drivers was addressed with a sensitivity analysis that indicated an areal band of 100 km^2 around a lake, appropriately clipped for the surrounding basin, was a realistic upper boundary for the scenario analysis program. The river basin grid size was problematic in that some grids (30' grid [0.5^{o}]) were often larger than those of some transboundary lake basins, and about 10% of the transboundary lakes lacked driver data for some grids. Based on these considerations, a final list of 53 priority transboundary lakes was selected for the scenario analysis program calculations of relative threat scores.

Insights obtained from lake scientists and managers participating in the 15th World Lake Conference helped address some of these concerns. Region-specific lake questionnaires also were distributed in some cases, obtaining both quantitative and qualitative data regarding the transboundary lakes and their basins.

These various factors and concerns indicate the transboundary lake threat ranks must be considered within the context of the specific basin conditions and assumptions used to derive them, since they represent only one possible set of lake threat rankings. Other factors such as lake and basin area, basin population and density, regional location, per capita Gross National Income (GNI), and Human

Development Index (HDI) could produce markedly different ranking results. Defining the appropriate context and preconditions for interpreting the lake ranking results, a task beyond the scope of this analysis, remains an important responsibility of those using the results, including lake managers and decision-makers.

The calculated ranks of the priority transboundary lakes, based on the specific assumptions and preconditions regarding the lakes and their drainage basins, is expressed below in terms of Adjusted Human Water Security (Adj-HWS) threats, Reverse Biodiversity (RvBD) threats, and Human Development Index (HDI) status. The Incident Human Water Security (HWS) score would suggest the current threat ranks of the lakes. However, for identifying needed management interventions, the ability of the basin countries to undertake investments to reduce identified transboundary water threats (i.e., water supply stabilization, improved water services, etc.) is also a relevant factor. This ability is considered within the context of the Adj-HWS threat. Countries less able to make such investments, mainly developing countries, exhibited higher Adj-HWS threats. Thus, the Adj-HWS threat ranks provide a more realistic picture of the transboundary lakes most in need of catalytic funding for management interventions than those with lower Adj-HWS scores.

Our more limited knowledge and experience regarding the ultimate outcomes of ecosystem restoration and conservation activities precluded a BD metric identical to the Adj-HWS threat. The Adj-HWS threat rank is meant to identify the transboundary lakes in most need of management interventions from a water investment perspective. The native biodiversity of most developed countries, however, has already been largely degraded as a result of their economic development activities. Thus, the preservation of those ecosystems still exhibiting the most pristine or undisturbed conditions should be the major BD management intervention goal. To address this goal, a RvBD threat was developed as a BD surrogate to define relative BD threats. It was calculated as 1-BD score, with the resulting RvBD score indicating the relative 'pristineness' of a lake in regard to its biodiversity status. The higher RvBD scores calculated with this normalization procedure identify the transboundary lakes most likely to be sensitive to BD degradation and, therefore, the lakes most in need of management attention.

The Human Development Index (HDI) is a composite statistic used by the United Nations Development Programme (UNDP) to reflect the relative life expectancy, education level, and per capita income of a country. A country whose inhabitants exhibit longer life spans, higher education levels, and higher per capita GDPs typically exhibit higher HDI scores, suggesting a higher overall condition of its citizens. It is meant to indicate that economic growth alone is not the sole criteria to assessment of a country, but that the status of its citizens and their capabilities also are important defining factors, therefore being an indication of potential human development.

Along with the assumptions and preconditions defining specific lake basin characteristics, these three criteria were major indicators considered within the context of the scenario analysis program to calculate the relative threat ranks of the transboundary lakes, as presented in the transboundary lake profile sheets.

Transboundary Lakes Ranked on Basis of (a) Incident Human Water Security [HWS] Threats, (b) Adjusted Human Water Security [Adj-HWS] Threats, and (c) Incident Biodiversity [BD] Threats

(Cont., continent; Eur, Europe; N.Am, North America; Afr., Africa; S.Am, South America; Estimated risks: red – highest; orange – moderately high; yellow – medium; green – moderately low; blue – low)

(A) Lakes Ranked on Basis of Adjusted Human Water Security (Adj-HWS) Threats					(B) Lakes Ranked on Basis of Reverse Biodiversity (RvBD) Threats					(C) Lakes Ranked on Basis of Human Development Index (HDI) Scores				
Lake	Cont.	Surface Area (km^2)	Adj-HWS Threat Score	Rank	Lake	Cont.	Surface area (km^2)	RvBD Threat Score	Rank	Lake	Cont.	Surface area (km^2)	HDI Score	Rank
Sistan	Asia	488.2	0.98	1	Lake Congo River	Afr.	306.0	0.80	1	**Lake Congo River**	**Afr**	**306.0**	**0.34**	**1**
Ihema	Afr.	93.2	0.97	2	Sarygamysh	Asia	3777.7	0.75	2	**Selingue**	**Afr**	**334.4**	**0.36**	**2**
Azuei	S.Am	117.3	0.96	3	Chiuta	Afr.	143.3	0.74	3	**Rweru/Moero**	**Afr**	**125.6**	**0.36**	**3**
Rweru/Moero	Afr.	125.6	0.96	4	Mweru	Afr.	5021.5	0.72	4	**Cohoha**	**Afr**	**64.8**	**0.38**	**4**
Cohoha	Afr.	64.8	0.96	5	Aral Sea	Asia	23919.3	0.72	5	**Kivu**	**Afr**	**2371.1**	**0.38**	**5**
Edward	Afr.	2232.0	0.94	6	Tanganyika	Afr.	32685.5	0.71	6	**Mweru**	**Afr**	**5021.5**	**0.38**	**6**
Natron/Magadi	Afr.	560.4	0.93	7	Abbe/Abhe	Afr.	310.6	0.71	7	**Abbe/Abhe**	**Afr**	**310.6**	**0.40**	**7**
Abbe/Abhe	Afr.	310.6	0.93	8	Titicaca	S.Am	7480.0	0.71	8	**Tanganyika**	**Afr**	**32685.5**	**0.40**	**8**
Victoria	Afr.	66841.5	0.91	9	Chilwa	Afr.	1084.2	0.70	9	**Turkana**	**Afr**	**7439.2**	**0.41**	**9**
Albert	Afr.	5502.3	0.91	10	Salto Grande	S.Am	532.9	0.70	10	**Chiuta**	**Afr**	**143.3**	**0.41**	**10**
Kivu	Afr.	2371.1	0.91	11	Turkana	Afr.	7439.2	0.70	11	**Chilwa**	**Afr**	**1084.2**	**0.41**	**11**
Malawi/Nyasa	Afr.	29429.2	0.91	12	Cahora Bassa	Afr.	4347.4	0.69	12	**Malawi/Nyasa**	**Afr**	**29429.2**	**0.42**	**12**
Dead Sea	Eur	642.7	0.90	13	Chungarkkota	S.Am	52.6	0.69	13	**Edward**	**Afr**	**2232.0**	**0.43**	**13**
Turkana	Afr.	7439.2	0.90	14	Malawi/Nyasa	Afr.	29429.2	0.68	14	**Nasser/Aswan**	**Afr**	**5362.7**	**0.43**	**14**
Aras Su Qovsaginin Su Anbari	Asia	52.1	0.89	15	Nasser/Aswan	Afr.	5362.7	0.68	15	**Cahora Bassa**	**Afr**	**4347.4**	**0.43**	**15**
Mangla	Asia	85.4	0.87	16	Selingue	Afr.	334.4	0.68	16	**Chad**	**Afr**	**1294.6**	**0.43**	**16**
Galilee	Eur	162.0	0.87	17	Kivu	Afr.	2371.1	0.67	17	**Kariba**	**Afr**	**5358.6**	**0.43**	**17**
Darbandikhan	Asia	114.3	0.87	18	Natron/Magadi	Afr.	560.4	0.67	18	**Ihema**	**Afr**	**93.2**	**0.44**	**18**
Selingue	Afr.	334.4	0.87	19	Lago de Yacyreta	S.Am	1109.4	0.66	19	**Sistan**	**Asia**	**488.2**	**0.46**	**19**
Shardara/Kara-Kul	Asia	746.1	0.86	20	Kariba	Afr.	5258.6	0.66	20	**Albert**	**Afr**	**5502.3**	**0.46**	**20**
Nasser/Aswan	Afr.	5362.7	0.86	21	Edward	Afr.	2232.0	0.65	21	**Azuei**	**S.Am,**	**117.3**	**0.46**	**21**
Chilwa	Afr.	1084.2	0.86	22	Aby	Afr.	438.8	0.65	22	**Victoria**	**Afr**	**66841.5**	**0.47**	**22**
Josini/Pongola-poort Dam	Afr.	128.6	0.85	23	Chad	Afr.	1294.6	0.64	23	**Natron/Magadi**	**Afr**	**560.4**	**0.51**	**23**

	Afr.	143.3	0.85	24	Albert	Afr.	5502.3	0.63	24	**Aby**	**Afr**	**438.8**	**0.52**	**24**
Chad	Afr.	1294.6	0.84	25	Sistan	Asia	488.2	0.62	25	**Mangla**	**Asia**	**85.4**	**0.54**	**25**
Aral Sea	Asia	23919.3	0.84	26	Amistad	N.Am	131.3	0.61	26	**Aral Sea**		**23919.3**	**0.60**	**26**
Tanganyika	Afr.	32685.5	0.84	27	Caspian Sea	Asia	377543.2	0.60	27	**Josini/Pongola-poort Dam**	**Afr**	**128.6**	**0.61**	**27**
Aby	Afr.	438.8	0.83	28	Cohoha	Afr.	64.8	059	28	**Shardara/Kara-kul**	**Asia**	**746.1**	**0.65**	**28**
Cahul	Eur	89.0	0.82	29	Itaipu	S.Am	1154.1	0.58	29	**Sarygamysh**	**Asia**	**3777.7**	**0.67**	**29**
Chungarkkota	S.Am	52.6	0.82	30	Rweru/Moero	Afr.	125.6	0.58	30	**Darbandikhan**	**Asia**	**114.3**	**0.68**	**30**
Titicaca	S.Am	7480.0	0.82	31	Azuei	S.Am	117.3	0.57	31	**Cahul**	**Eur**	**89.0**	**0.69**	**31**
Sarygamysh	Asia	3777.7	0.82	32	Ihema	Afr.	93.2	0.56	32	**Titicaca**	**S.Am**	**7480.0**	**0.71**	**32**
Mweru	Afr.	5021.5	0.81	33	Victoria	Afr.	66841.5	0.56	33	**Chungarkkota**	**S.Am**	**52.6**	**0.71**	**33**
Cahora Bassa	Afr.	4347.4	0.78	34	Scutari/Skadar	Eur	381.5	0.55	34	**Dead Sea**	**Eur**	**642.7**	**0.72**	**34**
Itaipu	S.Am	1154.1	0.75	35	Shardara/Kara-Kul	Asia	746.1	0.54	35	**Lago de Yacyreta**	**S.Am**	**1109.4**	**0.73**	**35**
Kariba	Afr.	5258.6	0.75	36	Huron	N.Am	60565.2	0.53	36	**Aras Su Qovsaginin Su Anbari**	**Asia**	**52.1**	**0.73**	**36**
Lago de Yacyreta	S.Am	1109.4	0.75	37	Josini/Pongola-poort Dam	Afr.	128.6	0.52	37	**Itaipu**	**S.Am**	**1154.1**	**0.73**	**37**
Lake Congo River	Afr.	306.0	0.75	38	Champlain	N.Am	1098.9	0.51	38	**Salto Grande**	**S.Am**	**532.9**	**0.74**	**38**
Caspian Sea	Asia	377543.2	0.73	39	Ohrid	Eur	354.3	0.51	39	**Ohrid**	**Eur**	**354.3**	**0.74**	**39**
Salto Grande	S.Am	532.9	0.67	40	Macro Prespa	Eur	263.0	0.51	40	**Macro Prespa**	**Eur**	**263.0**	**0.75**	**40**
Scutari/Skadar	Eur	381.5	0.62	41	Dead Sea	Eur	642.7	0.51	41	**Caspian Sea**	**Asia**	**377543.2**	**0.77**	**41**
Neusiedler/Ferto	Eur	141.9	0.58	42	Maggiore	Eur	211.4	0.49	42	**Scutari/Skadar**	**Eur**	**381.5**	**0.78**	**42**
Szczecin Lagoon	Eur	822.4	0.53	43	Szczecin Lagoon	Eur	822.4	0.49	43	**Szczecin Lagoon**	**Eur**	**822.4**	**0.83**	**43**
Erie	N.Am	26560.8	0.51	44	Ontario	N.Am	19062.2	0.47	44	**Falcon**	**N.Am**	**120.6**	**0.85**	**44**
Macro Prespa)	Eur	263.0	0.51	45	Aras Su Qovsaginin Su Anbari	Asia	52.1	0.47	45	**Amistad**	**N.Am**	**131.3**	**0.86**	**45**
Falcon	N.Am	120.6	0.50	46	Darbandikhan	Asia	114.3	0.46	46	**Galilee**	**Eur**	**162.0**	**0.88**	**46**
Amistad	N.Am	131.3	0.49	47	Galilee	Eur	162.0	0.45	47	**Neusiedler/Ferto**	**Eur**	**141.9**	**0.88**	**47**
Ontario	N.Am	19062.2	0.48	48	Michigan	N.Am	58535.5	0.44	48	**Lake Maggiore**	**Eur**	**211.4**	**0.89**	**48**
Ohrid	Eur	354.3	0.47	49	Erie	N.Am	26560.8	0.43	49	**Ontario**	**N.Am**	**19062.2**	**0.92**	**49**
Michigan	N.Am	58535.5	0.44	50	Neusiedler/Ferto	Eur	141.9	0.39	50	**Huron**	**N.Am**	**60565.2**	**0.93**	**50**
Huron	N.Am	60565.2	0.42	51	Cahul	Eur	89.0	0.39	51	**Erie**	**N.Am**	**26560.8**	**0.93**	**51**
Maggiore	Eur	211.4	0.33	52	Mangla	Asia	85.4	0.38	52	**Champlain**	**N.Am**	**1098.9**	**0.94**	**52**
Champlain	N.Am	1098.9	0.29	53	Falcon	N.Am	120.6	0.38	53	**Michigan**	**N.Am**	**58535.5**	**0.94**	**53**

Transboundary Lake Threat Ranks by Multiple Ranking Criteria

(Cont., continent; Eur, Europe; N.Am, North America; Afr, Africa; S.Am, South America;
Adj-HWS, Adjusted Human Water Security threat; HWS, Incident Human Water Security threat; BD, Incident Biodiversity threat;
HDI, Human Development Index, RvBD, surrogate for 'Adjusted' Biodiversity threat;
Estimated risks: Red – highest; Orange – moderately high; Yellow – medium; Green – moderately low; Blue – low)

Cont.	Lake Name	Adj-HWS Threat	RvBD Threat	HDI	Adj-HWS Rank	HDI Rank	RvBD Rank	Sum Adj-HWS + RvBD	Relative Rank	Sum Adj-HWS + HDI	Relative Rank	Sum Adj-HWS + RvBD + HDI	Overall Rank
Afr	Abbe/Abhe	0.93	0.71	0.40	7	7	7	14	1	14	3	21	1
Afr	Turkana	0.90	0.70	0.41	13	10	9	22	2	23	10	32	2
Afr	Selingue	0.87	0.68	0.36	16	2	15	31	11	18	5	33	3
Afr	Malawi/Nyasa	0.91	0.68	0.42	9	12	14	23	3	21	9	35	4
Afr	Chiuta	0.85	0.74	0.41	23	9	3	26	5	32	15	35	4
Afr	Cohoha	0.96	0.59	0.38	3	4	28	31	2	7	1	35	4
Afr	Kivu	0.91	0.67	0.38	12	6	18	30	8	18	4	36	7
Afr	Rweru/Moero	0.96	0.58	0.36	4	3	30	34	16	7	2	37	8
Afr	Lake Congo River	0.75	0.78	0.34	35	1	1	36	18	36	19	37	8
Afr	Tanganyika	0.84	0.71	0.40	26	8	6	32	14	34	17	40	10
Afr	Edward	0.94	0.65	0.43	6	13	22	28	7	19	6	41	11
Afr	Chilwa	0.86	0.70	0.41	21	11	10	31	10	32	14	42	12
Afr	Mweru	0.81	0.72	0.38	33	5	4	37	21	38	20	42	12
Asia	Sistan	0.98	0.62	0.46	1	20	25	26	6	21	8	46	14
Afr	Natron/Magadi	0.93	0.67	0.51	8	23	17	25	4	31	13	48	15
Afr	Nasser/Aswan	0.86	0.68	0.43	20	16	16	36	19	36	18	52	16
Afr	Albert	0.91	0.63	0.46	10	19	24	34	15	29	12	53	17
Afr	Ihema	0.97	0.56	0.44	2	18	33	35	17	20	7	53	17
S.Am,	Azuei	0.96	0.57	0.46	5	21	31	36	20	26	11	57	19
Asia	Aral Sea	0.84	0.62	0.60	27	26	5	32	13	53	31	58	20
Asia	Sarygamysh	0.82	0.75	0.67	29	29	2	31	9	58	32	60	21
Afr	Cahora Bassa	0.78	0.69	0.43	34	15	13	47	25	49	25	62	22
Afr	Victoria	0.91	0.56	0.47	11	22	32	43	24	33	16	65	23
Afr	Chad	0.84	0.64	0.43	25	17	23	48	26	42	21	65	23
Afr	Kariba	0.75	0.66	0.43	36	14	19	55	30	50	28	69	25

S.Am	Titicaca	0.82	0.71	0.71	32	32	8	40	22	25	35	72	26
Afr	Aby	0.83	0.65	0.52	28	24	21	49	27	52	30	73	27
S.Am	Chungarkkota	0.82	0.69	0.71	31	33	12	43	23	64	34	76	28
Asia	Shardara/Kara-kul	0.86	0.54	0.65	22	28	35	57	31	50	27	85	29
Eur	Dead Sea	0.90	0.51	0.72	14	34	38	52	29	48	24	86	30
Afr	Josini/Pongola-poort Dam	0.85	0.52	0.61	24	27	37	61	34	51	29	88	31
S.Am	Salto Grande	0.67	0.70	0.74	40	38	11	51	28	78	39	89	32
Asia	Darbandikhan	0.87	0.46	0.68	17	30	46	63	35	47	23	93	33
S.Am	Lago de Yacyreta	0.75	0.66	0.73	38	36	20	58	32	74	38	94	34
Asia	Aras Su Qovsaginin Su Anbari	0.89	0.47	0.73	15	35	44	59	33	50	26	94	34
Asia	Mangla	0.87	0.38	0.54	18	25	53	71	39	43	22	96	36
S.Am	Itaipu	0.75	0.58	0.73	37	37	29	66	37	74	37	103	37
Asia	Caspian Sea	0.73	0.60	0.77	39	41	27	66	36	80	40	107	38
Eur	Galilee	0.87	0.45	0.88	19	46	47	66	38	65	36	112	39
Eur	Cahul	0.82	0.39	0.69	30	31	51	81	42	61	33	112	39
Eur	Scutari/Skadar	0.62	0.55	0.78	41	42	34	75	41	83	41	117	41
N.Am	Amistad	0.49	0.61	0.86	47	45	26	73	40	47	40	118	42
Eur	Macro Prespa (Large Prespa)	0.51	0.51	0.75	44	40	40	84	43	84	42	124	43
Eur	Ohrid	0.47	0.51	0.74	49	39	39	88	46	88	44	127	44
Eur	Szczecin Lagoon	0.53	0.49	0.83	43	43	43	86	44	86	43	129	45
N.Am	Huron	0.42	0.53	0.93	51	50	36	87	45	101	51	137	46
Eur	Neusiedler/Ferto	0.58	0.39	0.88	42	47	50	92	47	89	45	139	47
N.Am	Ontario	0.48	0.47	0.92	48	49	45	93	48	97	49	142	48
Eur	Lake Maggiore	0.33	0.50	0.89	52	48	42	94	50	100	50	142	48
N.Am	Falcon	0.50	0.38	0.85	46	44	52	98	53	90	46	142	48
N.Am	Erie	0.51	0.43	0.93	45	51	49	94	51	96	48	145	51
N.Am	Champlain	0.29	0.51	0.94	53	52	41	94	49	105	53	146	52
N.Am	Michigan	0.44	0.44	0.94	50	53	48	98	52	103	52	151	53

1. An Nahr Al Kabir
2. Asi/ Orontes
3. Astara Chay
4. Atui
5. Baraka
6. Congo/ Zaire
7. Coruh
8. Daoura
9. Dra
10. Gash
11. Guir
12. Jordan
13. Kura-Araks
14. Lake Chad
15. Maritsa
16. Medjerda
17. Nahr El Kebir
18. Niger
19. Nile
20. Oued Bon Naima
21. Psou
22. Rezvaya
23. Samur
24. Sulak
25. Tafna
26. Terek
27. Tigris-Euphrates/ Shatt al Arab
28. Velaka
29. Wadi Al Izziyah

Jacques Descloitres, MODIS Land Rapid Response Team at NASA GSFC

An Nahr Al Kabir Basin

Geography

Total drainage area (km^2)	1,032
No. of countries in basin	2
BCUs in basin	Lebanon (LBN), Syrian Arab Republic (SYR)
Population in basin (people)	204,269
Country at mouth	Lebanon, Syrian Arab Republic
Average rainfall (mm/year)	877

Governance

No. of treaties and agreements[1]	2
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
ANAK_LBN						
ANAK_SYR		647.61				
Total in Basin	0.67	647.61			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
ANAK_LBN								
ANAK_SYR	497.58	385.07	1.43	47.06	14	49.70	4,114.90	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	497.58	385.07	1.43	47.06	14.32	49.70	2,435.92	74.43

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
ANAK_LBN	0	0.29	83	280.81	0.85			0	9,928.04	0	0.00
ANAK_SYR	1	0.71	121	164.42	1.98			0	0.00	0	0.00
Total in Basin	1	1.00	204	197.88	1.56	0.00	0.00	0	4,050.89	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ANAK_LBN					5	4			4	2	2	3	1	2	1
ANAK_SYR	2	2	3		1	5	3		4	2	2		1	2	2
River Basin	2	2	3	5	3	5	3		4	2	2		1	2	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
ANAK_LBN									3
ANAK_SYR	2	3	3	4			2	3	2
River Basin	2	3	3	4	5	5	2	3	2

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

Disclaimer

The results and information of factsheet is produced and maintained by the River Basins Component of the GEF Transboundary Water Assessment Programme (GEF TWAP).

GEF TWAP is the first global-scale assessment of all transboundary water systems. The TWAP consists of five independent indicator-based water system assessments and the linkages between them, including their socioeconomic and governance-related features. The United Nations Environment Programme (UNEP) is the implementing agency of TWAP. Project Coordination Unit (PCU) in Nairobi, Kenya coordinates the work of UNESCO-IHP, ILEC, UNEP-DHI and the IOC of UNESCO on Transboundary Aquifers, Lake Basins, River Basins, Large Marine Ecosystems and Open Ocean respectively. Each executing partner engages a broad network of data and information rich partners with responsibilities either of a thematic or geographic nature. More on TWAP full size project at http://www.geftwap.org .

The TWAP River Basins component (TWAP RB) carried out a global comparison of 286 transboundary river basins, in order to enable the prioritisation of funds for basins at risk from a variety of issues, covering water quantity, water quality, ecosystems, governance and socio-economics. It also considered risks to deltas from threats of a transboundary nature, and considered the relative influence of lakes on these river basins. TWAP RB is an indicator–based assessment, allowing for an analysis of basins, based on risks to both societies and ecosystems. It also includes provisional outlook projections to 2030 and 2050 for a limited number of indicators.
Values given in the present fact-sheet represent an approximate guide only and should not replace recent local assessments.

Country Boundaries Under TWAP
TWAP RB assessment uses country delineations provided by FAO GAUL (Global Administrative Unit Layers) (FAO 2014). GAUL uses the International Boundary dataset of the UNCS (UN Cartographic Section) and inland boundaries are same for both datasets. Some differences occur in coastlines, where FAO GAUL dataset offers more detail.

Disputed areas
The GAUL project and original dataset maintains disputed areas in such a way to preserve national integrity for all disputing countries. The GAUL Set reports the international, first level and second level administrative boundaries delimiting, or falling within, the disputed areas in a way to enable the re-construction of the administrative units as they are specified by the individual disputing countries. Disputed areas are therefore shown as individual entities, not dependent from countries, with corresponding coding. Same approach has been taken by TWAP RB, reporting on disputed territories, as well as presentation of Basin Country Units.

Basin Delineation
TWAP RB assessment includes 286 transboundary river basins. Information on this layer and delineation methodology can be retrieved by downloading metadata sheet for the Basins layer from TWAP Rivers Data Portal at http://twap-rivers.org/indicators/ or by direct download from http://twap-rivers.org/assets/Basin%20and%20BCU%20Creation%20Documentation.pdf

For more information on data sources, indicator calculation methodologies, limitations and more consult indicator metadata sheets available on TWAP RB Data portal on http://twap-rivers.org . To view sources of data included in this Factsheet download the Factsheet Reference file at http://twap-rivers.org/assets/Factsheet_template_with_references.pdf.

For more information on data sources, indicator calculation methodologies, limitations and more consult indicator metadata sheets available on TWAP RB Data portal on http://twap-rivers.org .

Asi/Orontes Basin

Geography

Total drainage area (km^2)	23,830
No. of countries in basin	3
BCUs in basin	Lebanon (LBN), Syrian Arab Republic (SYR), Turkey (TUR)
Population in basin (people)	4,418,230
Country at mouth	Turkey
Average rainfall (mm/year)	609

Governance

No. of treaties and agreements[1]	2
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	2
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
ASIX_LBN		488.48				
ASIX_SYR		312.20				
ASIX_TUR		502.64			60.40	0.80
Total in Basin	8.99	377.18			60.40	0.80

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
ASIX_LBN	876.68	448.34	1.77	289.03	3	134.07	4,978.01	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

ASIX_SYR	5,351.10	3,711.09	11.16	1,257.57	77	294.47	1,727.01	
ASIX_TUR	2,193.79	1,876.85	5.34	137.48	52	121.97	1,918.24	
Total in Basin	8,421.58	6,036.27	18.27	1,684.09	132.45	550.50	1,906.10	93.70

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
ASIX_LBN	2	0.09	176	86.22	0.85	0.00	100.00	0	9,928.04	0	0.00
ASIX_SYR	16	0.67	3,098	192.68	1.98	0.00	100.00	2	0.00	1	62.19
ASIX_TUR	6	0.24	1,144	200.40	1.31	0.00	100.00	1	10,945.92	1	175.23
Total in Basin	24	1.00	4,418	185.41	1.75	0.00	100.00	3	3,229.06	2	83.93

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ASIX_LBN	5	3	3		5	1	5	3	4	3	2	3	3	2	2
ASIX_SYR	4	4	4		1	2	5	3	3	3	2		3	2	2
ASIX_TUR	5	4	4		3	2	5	3	3	5	3		1	3	3
River Basin	4	4	4	4	2	2	5	3	3	3	2		2	2	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
ASIX_LBN	5	5	4	5			1	1	3
ASIX_SYR	5	5	5	5			2	4	2
ASIX_TUR	5	5	4	5			1	2	4
River Basin	5	5	5	5	5	5	2	3	3

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Astara Chay Basin

Geography

Total drainage area (km^2)	402
No. of countries in basin	2
BCUs in basin	Azerbaijan (AZE), Iran (Islamic Republic of) (IRN)
Population in basin (people)	71,368
Country at mouth	Azerbaijan
Average rainfall (mm/year)	

Governance

No. of treaties and agreements[1]	1
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
ATCY_AZE						
ATCY_IRN						
Total in Basin					0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
ATCY_AZE								
ATCY_IRN								

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Total in Basin								

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
ATCY_AZE	0	0.40	23	144.14	1.35			0	7,811.79	0	0.00
ATCY_IRN	0	0.60	48	199.94	1.18	0.00	100.00	0	4,763.30	0	0.00
Total in Basin	0	1.00	71	177.40	1.32	0.00	67.17	0	5,764.08	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ATCY_AZE					5				3	3	3	3	1	2	1
ATCY_IRN					5				3	5	3	2	1	3	1
River Basin				3	5				3	4	3	2	1	3	1

Indicators

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Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
ATCY_AZE									3
ATCY_IRN									3
River Basin					4	4			3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin					

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Atui Basin

Geography

Total drainage area (km^2)	83,295
No. of countries in basin	2
BCUs in basin	Mauritania (MRT), Western Sahara (ESH)
Population in basin (people)	99,599
Country at mouth	Mauritania
Average rainfall (mm/year)	28

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems
(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
ATUI_ESH		8.65				
ATUI_MRT		6.39				
Total in Basin	0.61	7.37			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
ATUI_ESH	0.43	0.00	0.43	0.00	0	0.00	18.50	
ATUI_MRT	12.00	0.00	2.38	0.00	0	9.63	157.04	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	12.43	0.00	2.80	0.00	0.00	9.63	124.81	2.02

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
ATUI_ESH	40	0.48	23	0.58	3.72			0		0	0.00
ATUI_MRT	43	0.52	76	1.76	2.54	0.00	100.00	1	1,070.09	0	0.00
Total in Basin	83	1.00	100	1.20	1.87	0.00	76.73	1	821.13	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ATUI_ESH	3	5	1						3	5	3		1	3	5
ATUI_MRT	4	5	1		5				3	5	3		1	3	5
River Basin	4	5	1	3					2	5	3		1	3	5

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
ATUI_ESH	5	5	2	2			1	1	3
ATUI_MRT	5	5	4	4			2	5	4
River Basin	5	5	4	4	4	4	2	4	4

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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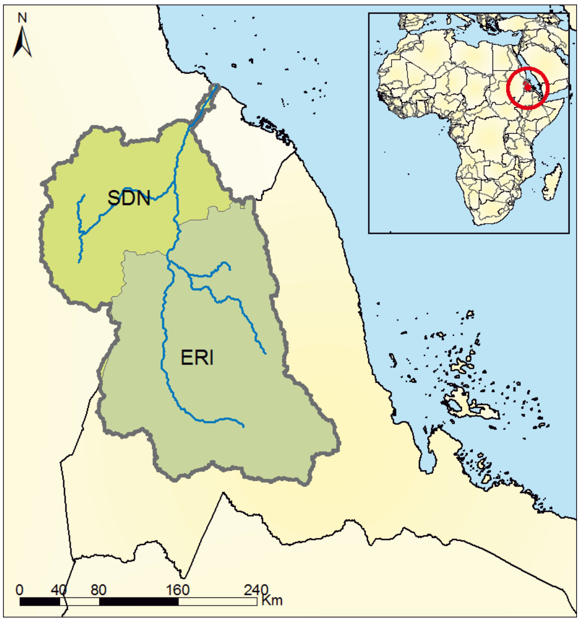
Baraka Basin



Geography

Total drainage area (km^2)	63,770
No. of countries in basin	2
BCUs in basin	Eritrea (ERI), Sudan (SDN)
Population in basin (people)	2,260,349
Country at mouth	Sudan
Average rainfall (mm/year)	270

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
BRKA_ERI		46.78				
BRKA_SDN		42.70				
Total in Basin	2.89	45.37			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
BRKA_ERI	104.49	36.16	10.00	12.24	0	45.76	54.66	
BRKA_SDN	230.47	213.03	2.40	0.00	4	11.07	661.11	

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Total in Basin	334.96	249.19	12.40	12.24	4.30	56.84	148.19	11.58

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
BRKA_ ERI	42	0.66	1,912	45.42	3.16	0.00	100.00	1	543.82	1	23.76
BRKA_ SDN	22	0.34	349	16.08	2.51			0	1,752.90	0	0.00
Total in Basin	64	1.00	2,260	35.45	3.06	0.00	84.58	1	730.30	1	15.68

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
BRKA_ERI	2	5	2		5	2	2	1	2	5	3	2	4	3	5
BRKA_SDN	3	5	3		5	2	2		2	5	3	3	1	4	5
River Basin	3	5	2	2	5	2	2	1	1	5	3	2	4	2	5

Indicators

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Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
BRKA_ERI	5	5	5	5			3	5	3
BRKA_SDN	5	5	5	5			3	5	3
River Basin	5	5	5	5	5	5	3	5	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

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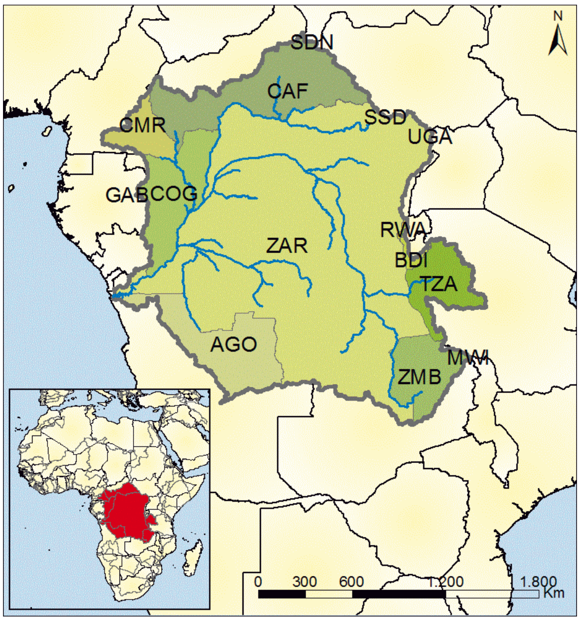
Congo/Zaire Basin



Geography

Total drainage area (km²)	3,688,878
No. of countries in basin	14
BCUs in basin	Angola (AGO), Burundi (BDI), Cameroon (CMR), Central African Republic (CAF), Congo (COG), Congo, The Democratic Republic Of The (ZAR), Gabon (GAB), Malawi (MWI), Rwanda (RWA), South Sudan (SSD), Sudan (SDN), Tanzania, United Republic Of (TZA), Uganda (UGA), Zambia (ZMB)
Population in basin (people)	90,605,235
Country at mouth	Angola, Congo, The Democratic Republic Of The
Average rainfall (mm/year)	1,537

Governance

No. of treaties and agreements[1]	2
No. of RBOs and Commissions[2]	2

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	20
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km³/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km³/year)	Av. Groundwater Discharge (km³/year)	Lake and Reservoir Surface Area (km²)	Lake and Reservoir Volume (km³)
CNGO_AGO		287.24				
CNGO_BDI		257.07			1,798.80	1,028.91
CNGO_CAF		442.08				
CNGO_CMR		397.20				
CNGO_COG		597.99			94.43	0.69
CNGO_GAB						

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

CNGO_MWI						
CNGO_RWA		309.57			1,037.45	248.99
CNGO_SDN						
CNGO_SSD						
CNGO_TZA		123.72			13,839.69	7,916.29
CNGO_UGA						
CNGO_ZAR		420.55			23,808.35	8,988.63
CNGO_ZMB		303.42			8,438.89	1,233.97
Total in Basin	1,478.47	400.79			49,017.60	19,417.48

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
CNGO_AGO	155.78	0.67	0.13	6.76	26	122.56	58.96	
CNGO_BDI	120.59	54.31	2.09	0.37	1	62.64	32.38	
CNGO_CAF	81.10	0.13	23.07	3.07	1	53.84	26.68	
CNGO_CMR	21.75	0.00	7.39	0.00	0	14.36	29.34	
CNGO_COG	91.73	0.17	1.81	1.90	28	59.54	38.78	
CNGO_GAB								
CNGO_MWI								
CNGO_RWA	50.41	0.02	1.70	0.00	4	44.60	31.63	
CNGO_SDN								
CNGO_SSD								
CNGO_TZA	236.34	58.18	31.13	12.63	2	132.58	37.81	
CNGO_UGA								
CNGO_ZAR	1,272.24	27.77	18.08	2.51	108	1,116.34	18.82	
CNGO_ZMB	90.23	26.86	1.39	0.51	11	50.11	34.44	
Total in Basin	2,120.16	168.10	86.79	27.74	180.98	1,656.54	23.40	0.14

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
CNGO_AGO	288	0.08	2,642	9.18	2.92	8.45	91.55	0	5,668.12	0	0.00
CNGO_BDI	14	0.00	3,724	272.63	2.90	0.00	100.00	1	267.48	0	0.00
CNGO_CAF	404	0.11	3,040	7.53	1.82	0.00	100.00	1	333.20	0	0.00

CNGO _CMR	95	0.03	741	7.80	2.20	2.30	97.70	1	1,315.49	0	0.00
CNGO _COG	247	0.07	2,365	9.56	2.70	1.88	98.12	1	3,172.06	0	0.00
CNGO _GAB	0	0.00	1	2.16	1.88			0	11,571.08	0	0.00
CNGO _MWI	0	0.00	2	26.01	3.00			0	226.46	0	0.00
CNGO _RWA	5	0.00	1,594	350.97	2.87	0.00	100.00	0	632.76	0	0.00
CNGO _SDN	0	0.00	0	3.71	2.51			0	1,752.90	0	0.00
CNGO _SSD	0	0.00	4	12.22				0	1,221.35	0	0.00
CNGO _TZA	162	0.04	6,251	38.65		0.00	100.00	2	694.77	0	0.00
CNGO _UGA	0	0.00	37	255.37	3.24			0	571.68	0	0.00
CNGO _ZAR	2,300	0.62	67,584	29.38	2.78	0.07	99.93	13	453.67	5	2.17
CNGO _ZMB	174	0.05	2,620	15.08	2.65	2.71	97.29	0	1,539.60	0	0.00
Total in Basin	3,689	1.00	90,605	24.56	2.75	0.44	99.51	19	723.40	5	1.36

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CNGO_AGO	1	1	1		5	2	2	3	3	3	4	5	1	4	2
CNGO_BDI	1	2	2		5	3	3	2	3	2	3	3	5	3	3
CNGO_CAF	1	1	1		5	2	1	3	2	5	4		5	4	2
CNGO_CMR	1	1	1		5	1	2	4	2	5	2	5	1	4	2
CNGO_COG	1	1	1		5	3	2	3	3	5	4	5	2	4	2
CNGO_GAB					5	1			1	5	3	5	1	3	1
CNGO_MWI					5	1			1	3	3	3	1	3	1
CNGO_RWA	1	1	1		5	1	3	3	2	5	2	3	1	4	2
CNGO_SDN					5				1	5	3	3	1	4	1
CNGO_SSD						1			1		3		1	4	1
CNGO_TZA	2	1	2		5	4	3	3	3	2	1	2	1	3	3
CNGO_UGA					5				1	5	3	3	1	3	1
CNGO_ZAR	1	1	1		5	3	2	3	4	2	3	5	5	4	3
CNGO_ZMB	1	1	2		5	4	2	3	3	2	4	3	1	4	3
River Basin	2	1	2	2	5	3	2	3	4	2	3	5	5	5	2

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
CNGO_AGO	2	2	1	1			4	5	4
CNGO_BDI	2	2	3	4			2	4	4
CNGO_CAF	2	2	1	1			2	4	4
CNGO_CMR	2	2	1	1			2	4	2
CNGO_COG	2	2	1	1			3	5	4
CNGO_GAB									3
CNGO_MWI									3
CNGO_RWA	2	3	3	4			3	5	3
CNGO_SDN									4
CNGO_SSD									4
CNGO_TZA	5	4	1	1			4	5	1
CNGO_UGA									4
CNGO_ZAR	2	2	1	1			3	5	4
CNGO_ZMB	2	2	1	1			4	5	4
River Basin	2	2	1	1	2	2	3	5	4

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	5	2	4	2	5

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Coruh Basin

Geography

Total drainage area (km^2)	22,039
No. of countries in basin	2
BCUs in basin	Georgia (GEO), Turkey (TUR)
Population in basin (people)	788,676
Country at mouth	Georgia, Turkey
Average rainfall (mm/year)	1,075

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	1

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
CRUH_GEO		1,297.06				
CRUH_TUR		539.57				
Total in Basin	13.07	592.95			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
CRUH_GEO	22.23	4.33	0.66	0.00	4	13.05	136.87	
CRUH_TUR	621.22	388.35	10.42	40.39	50	131.97	991.96	

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Total in Basin	643.45	392.68	11.08	40.39	54.27	145.02	815.86	4.92

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km²)
CRUH_GEO	2	0.08	162	88.99	-0.57			0	3,602.17	0	0.00
CRUH_TUR	20	0.92	626	30.98	1.31	0.00	100.00	0	10,945.92	0	0.00
Total in Basin	22	1.00	789	35.79	0.93	0.00	79.41	0	9,433.52	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CRUH_GEO	1	1	2		5	1	3	1	4	5	5	4	1	2	3
CRUH_TUR	2	1	2		3	2	4	3	3	5	3		1	3	3
River Basin	2	1	2	3	4	2	4	3	3	5	3		1	3	3

Indicators

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Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
CRUH_GEO	3	4	1	1			1	1	5
CRUH_TUR	4	5	1	1			1	2	3
River Basin	4	5	1	1	4	4	1	1	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Daoura Basin

Geography

Total drainage area (km^2)	49,690
No. of countries in basin	2
BCUs in basin	Algeria (DZA), Morocco (MAR)
Population in basin (people)	725,008
Country at mouth	Algeria
Average rainfall (mm/year)	130

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
DAUR_DZA		27.62				
DAUR_MAR		65.68				
Total in Basin	2.73	54.91			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
DAUR_DZA	2.52	0.00	0.38	0.00	0	2.14	139.24	
DAUR_MAR	534.30	506.45	2.75	0.00	0	25.10	755.80	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	536.81	506.45	3.13	0.00	0.00	27.24	740.42	19.67

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
DAUR_DZA	10	0.19	18	1.88	1.51			0	5,360.70	0	0.00
DAUR_MAR	40	0.81	707	17.63	1.00	0.00	100.00	0	3,108.65	1	24.94
Total in Basin	50	1.00	725	14.59	1.50	0.00	97.51	0	3,164.82	1	20.12

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
DAUR_DZA	3	5	1		4		4		2	5	3	2	1	3	3
DAUR_MAR	4	5	3		4	1	5	2	2	4	3	2	1	3	2
River Basin	4	5	3	3	4	1	5	2	2	4	3	2	1	4	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
DAUR_DZA	5	5	5	5			1	2	3
DAUR_MAR	5	5	5	5			1	2	3
River Basin	5	5	5	5	4	4	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Dra Basin

Geography

Total drainage area (km^2)	94,178
No. of countries in basin	2
BCUs in basin	Algeria (DZA), Morocco (MAR)
Population in basin (people)	1,183,624
Country at mouth	Morocco
Average rainfall (mm/year)	144

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	1
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
DRAX_DZA		32.90				
DRAX_MAR		83.60			42.90	0.27
Total in Basin	6.88	73.06			42.90	0.27

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
DRAX_DZA	1.85	0.00	0.53	0.00	0	1.32	313.33	
DRAX_MAR	2,180.66	1,900.05	6.07	195.73	2	76.53	1,851.60	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	2,182.51	1,900.05	6.60	195.73	2.27	77.86	1,843.92	31.72

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
DRAX_DZA	16	0.17	6	0.38	1.51			0	5,360.70	0	0.00
DRAX_MAR	79	0.83	1,178	14.98	1.00	0.00	100.00	0	3,108.65	2	25.44
Total in Basin	94	1.00	1,184	12.57	1.49	0.00	99.50	0	3,119.89	2	21.24

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
DRAX_DZA	2	4	1		4	1	4		2	5	3	2	1	3	3
DRAX_MAR	4	4	3		4	1	4	2	2	4	3	2	3	3	3
River Basin	3	4	3	3	4	1	4	2	2	4	3	2	3	4	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

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Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
DRAX_DZA	5	5	5	5			1	2	3
DRAX_MAR	5	5	5	5			1	1	3
River Basin	5	5	5	5	4	4	1	1	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Gash Basin

Geography

Total drainage area (km^2)	23,656
No. of countries in basin	3
BCUs in basin	Eritrea (ERI), Ethiopia (ETH), Sudan (SDN)
Population in basin (people)	1,906,237
Country at mouth	Sudan
Average rainfall (mm/year)	633

Governance

No. of treaties and agreements[1]	2
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
GASH_ERI		108.28				
GASH_ETH		230.96				
GASH_SDN						
Total in Basin	3.35	141.81			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
GASH_ERI	89.76	58.49	5.03	0.00	0	26.18	76.87	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

GASH_ETH	53.42	14.34	7.26	0.02	7	25.20	75.87	
GASH_SDN								
Total in Basin	143.19	72.83	12.29	0.02	6.67	51.38	75.11	4.27

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km²)
GASH_ ERI	17	0.71	1,168	69.33	3.16	0.00	100.00	0	543.82	0	0.00
GASH_ ETH	6	0.25	704	118.13	2.21	0.00	100.00	0	498.08	0	0.00
GASH_ SDN	1	0.04	34	40.27	2.51	0.00	100.00	1	1,752.90	0	0.00
Total in Basin	24	1.00	1,906	80.58	2.97	0.00	100.00	1	548.70	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
GASH_ERI	2	3	2		5	2	3	1	1	5	2	2	3	3	3
GASH_ETH	2	2	2		5		4	1	2	5	3	3	1	3	2
GASH_SDN					5	5			2	5	2	3	1	3	4
River Basin	2	3	2	1	5	2	4	1	1	5	2	2	3	2	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
GASH_ERI	5	5	3	4			3	5	3
GASH_ETH	5	5	3	3			2	3	4
GASH_SDN							3	5	3
River Basin	5	5	3	4	2	3	3	4	3

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Guir Basin

Geography

Total drainage area (km^2)	108,733
No. of countries in basin	2
BCUs in basin	Algeria (DZA), Morocco (MAR)
Population in basin (people)	347,709
Country at mouth	Algeria
Average rainfall (mm/year)	95

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	2
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
GUIR_DZA		26.63			305.70	2.24
GUIR_MAR		55.11				
Total in Basin	3.69	33.90			305.70	2.24

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
GUIR_DZA	130.33	74.90	2.03	40.67	0	12.73	754.93	
GUIR_MAR	120.29	110.69	1.83	0.00	0	7.78	687.08	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	250.62	185.59	3.85	40.67	0.00	20.51	720.77	6.80

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
GUIR_DZA	84	0.77	173	2.06	1.51	1.90	98.10	1	5,360.70	1	11.96
GUIR_MAR	25	0.23	175	6.97	1.00			0	3,108.65	1	39.81
Total in Basin	109	1.00	348	3.20	1.68	0.94	48.71	1	4,226.79	2	18.39

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
GUIR_DZA	2	5	2		4				3	5	3	2	1	3	5
GUIR_MAR	3	5	2		4		2	2	2	4	3	2	1	3	3
River Basin	2	5	2	4	4		2	2	2	4	3	2	1	3	4

Indicators

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Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
GUIR_DZA	5	5	5	5			2	2	3
GUIR_MAR	5	5	5	5			1	2	3
River Basin	5	5	5	5	4	5	2	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	2				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

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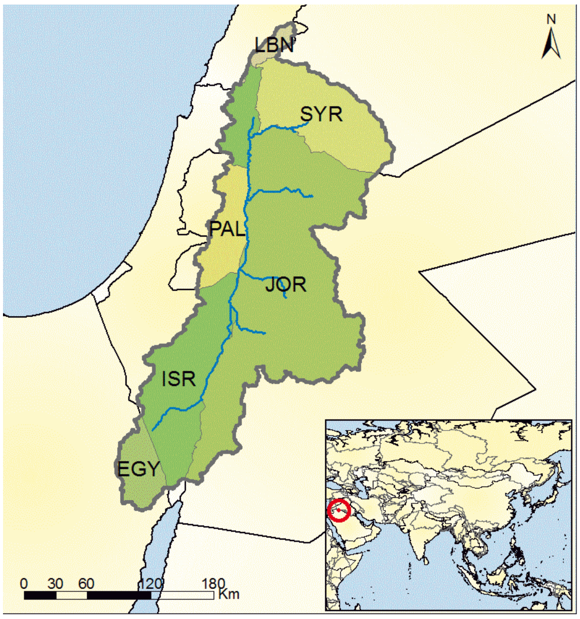
Jordan Basin



Geography

Total drainage area (km^2)	45,005
No. of countries in basin	6
BCUs in basin	Egypt (EGY), Israel (ISR), Jordan (JOR), Lebanon (LBN), Palestine, State Of (PAL), Syrian Arab Republic (SYR)
Population in basin (people)	9,584,341
Country at mouth	Jordan
Average rainfall (mm/year)	242

Governance

No. of treaties and agreements[1]	9
No. of RBOs and Commissions[2]	3

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	3
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
JORD_EGY		7.60				
JORD_ISR		137.09			365.85	20.93
JORD_JOR		63.08			396.76	47.61
JORD_LBN		505.37				
JORD_PAL		342.96			204.68	24.56
JORD_SYR		165.41			5.51	0.14
Total in Basin	5.28	117.39			972.80	93.24

Water Withdrawals

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

BCU	Total (km³/year)	Irrigation (km³/year)	Livestock (km³/year)	Electricity (km³/year)	Manufacture (km³/year)	Domestic (km³/year)	Per capita (m³/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
JORD_EGY	101.23	86.78	0.19	9.98	0	4.27	16,994.52	
JORD_ISR	639.33	484.37	3.15	25.45	12	114.31	456.98	
JORD_JOR	1,874.34	939.50	4.58	622.59	48	259.73	333.77	
JORD_LBN	999.80	381.30	1.99	361.25	7	247.81	14,630.01	
JORD_PAL	390.57	189.94	1.93	0.00	22	176.57	321.54	
JORD_SYR	2,180.34	1,531.58	4.35	408.86	51	184.57	1,702.41	
Total in Basin	6,185.61	3,613.47	16.18	1,428.14	140.56	987.26	645.39	117.08

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km²)
JORD_EGY	2	0.05	6	2.62	1.78			0	3,314.46	0	0.00
JORD_ISR	10	0.21	1,399	145.34	2.32	0.00	100.00	1	36,151.21	0	0.00
JORD_JOR	23	0.50	5,616	247.99	2.94	0.00	100.00	5	5,214.19	0	0.00
JORD_LBN	1	0.01	68	102.36	0.85	0.00	100.00	0	9,928.04	0	0.00
JORD_PAL	3	0.07	1,215	404.76		13.49	86.51	1	0.00	0	0.00
JORD_SYR	7	0.15	1,281	188.60	1.98	0.00	100.00	0	0.00	0	0.00
Total in Basin	45	1.00	9,584	212.96	2.22	1.71	98.23	7	8,404.89	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
JORD_EGY	5	5	5		3				3	5	3	2	1	2	5
JORD_ISR	4	5	3		1	2	5	3	3	2	1	1	4	2	2
JORD_JOR	5	5	4		3		5	3	3	1	1	2	5	2	4
JORD_LBN	5		3		5	4			3	1	1	3	2	2	1
JORD_PAL	4	5	3				3	4	3	4	3		5	2	2
JORD_SYR	5	5	5		1	3	5	3	3	1	1		1	2	3
River Basin	5	5	4	5	2	2	5	4	3	2	1		5	2	4

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
JORD_EGY	5	5	5	5					4
JORD_ISR	5	5	5	5			2	4	2
JORD_JOR	5	5	5	5			3	4	1
JORD_LBN	5	5							2
JORD_PAL	4	5	5	5					4
JORD_SYR	5	5	5	5			2	4	1
River Basin	5	5	5	5	5	5	2	4	2

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	5				

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Kura-Araks Basin

Geography

Total drainage area (km^2)	190,033
No. of countries in basin	6
BCUs in basin	Armenia (ARM), Azerbaijan (AZE), Georgia (GEO), Iran (Islamic Republic of) (IRN), Russian Federation (RUS), Turkey (TUR)
Population in basin (people)	14,462,042
Country at mouth	Azerbaijan
Average rainfall (mm/year)	519

Governance

No. of treaties and agreements[1]	5
No. of RBOs and Commissions[2]	1

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	6
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
KURA_ARM		128.01			1,249.90	11.25
KURA_AZE		108.83			604.70	8.26
KURA_GEO		254.40				
KURA_IRN		92.76			106.80	0.70
KURA_RUS						
KURA_TUR		95.16			121.20	2.55
Total in Basin	25.28	133.02			2,082.60	22.76

Water Withdrawals

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

BCU	Total (km³/year)	Irrigation (km³/year)	Livestock (km³/year)	Electricity (km³/year)	Manufacture (km³/year)	Domestic (km³/year)	Per capita (m³/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
KURA_ARM	2,634.36	1,814.64	10.29	448.32	108	253.06	696.90	
KURA_AZE	12,076.35	9,493.69	35.09	1,817.57	103	627.13	2,733.08	
KURA_GEO	1,762.26	1,077.83	17.16	162.42	175	329.97	622.44	
KURA_IRN	8,470.13	7,015.19	22.92	860.06	108	464.24	3,531.53	
KURA_RUS								
KURA_TUR	1,335.29	1,242.64	7.16	3.84	11	71.15	1,297.94	
Total in Basin	26,278.39	20,643.98	92.63	3,292.21	504.03	1,745.54	1,817.06	103.95

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km²)
KURA_ARM	30	0.16	3,780	127.61	0.17	0.36	99.64	2	3,504.77	4	135.03
KURA_AZE	60	0.31	4,419	73.93	1.35	0.00	100.00	1	7,811.79	2	33.46
KURA_GEO	35	0.18	2,831	82.03	-0.57	0.41	99.59	2	3,602.17	4	115.89
KURA_IRN	37	0.20	2,398	64.63	1.18	0.00	100.00	3	4,763.30	2	53.90
KURA_RUS	0	0.00	5	30.52	-0.12			0	14,611.70	0	0.00
KURA_TUR	29	0.15	1,029	35.65	1.31	0.00	100.00	0	10,945.92	1	34.65
Total in Basin	190	1.00	14,462	76.10	0.71	0.17	99.79	8	5,581.58	13	68.41

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
KURA_ARM	4	4	4		4	1	5	2	3	3	2	5	5	1	2
KURA_AZE	4	5	5		5	2	4	2	3	3	2	3	5	2	2
KURA_GEO	2	3	3		5	1	5	1	3	3	3	4	5	2	3
KURA_IRN	5	5	5		5	1	4	2	3	2	2	2	1	3	3
KURA_RUS					4	3			3	2	3	2	1	2	1
KURA_TUR	5	3	5		3	1	5	2	3	5	3		1	3	5
River Basin	4	5	5	3	5	1	5	2	3	3	2	4	4	3	3

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Very low	Low	Medium	High	Very high

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Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
KURA_ARM	5	5	5	5			1	1	3
KURA_AZE	5	5	5	5			1	1	3
KURA_GEO	3	4	3	3			1	1	4
KURA_IRN	5	5	5	5			1	2	2
KURA_RUS									4
KURA_TUR	5	5	4	4			1	2	3
River Basin	5	5	5	5	3	4	1	1	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	3				

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Lake Chad Basin

Geography

Total drainage area (km^2)	2,596,852
No. of countries in basin	8
BCUs in basin	Algeria (DZA), Cameroon (CMR), Central African Republic (CAF), Chad (TCD), Libya (LBY), Niger (NER), Nigeria (NGA), Sudan (SDN)
Population in basin (people)	44,036,304
Country at mouth	Cameroon, Chad, Niger, Nigeria
Average rainfall (mm/year)	341

Governance

No. of treaties and agreements[1]	3
No. of RBOs and Commissions[2]	1

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	4
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
LKCH_CAF		245.76				
LKCH_CMR		279.11			1,828.57	7.31
LKCH_DZA		1.36				
LKCH_LBY		0.45				
LKCH_NER		17.58			2,472.04	9.89
LKCH_NGA		147.38			5,715.48	25.93
LKCH_SDN		35.32				
LKCH_TCD		76.88			9,956.71	41.04
Total in Basin	191.79	73.86			19,972.80	84.18

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
LKCH_CAF	40.39	0.02	14.80	0.02	0	25.13	32.84	
LKCH_CMR	160.52	85.91	12.19	0.00	13	49.89	60.72	
LKCH_DZA	3.83	0.00	1.96	0.00	0	1.87	129.09	
LKCH_LBY	66.69	54.92	0.94	7.36	0	3.47	3,824.93	
LKCH_NER	166.94	100.84	17.54	0.00	2	46.15	55.94	
LKCH_NGA	2,052.10	1,334.33	67.36	5.42	159	485.63	81.67	
LKCH_SDN	161.27	13.17	33.41	0.00	42	72.79	61.05	
LKCH_TCD	610.47	347.57	72.77	11.19	2	177.19	65.20	
Total in Basin	3,262.19	1,936.76	220.96	23.99	218.36	862.12	74.08	1.70

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
LKCH_CAF	215	0.08	1,230	5.73	1.82	0.00	100.00	0	333.20	0	0.00
LKCH_CMR	48	0.02	2,644	55.04	2.20	4.56	95.44	2	1,315.49	1	20.82
LKCH_DZA	106	0.04	30	0.28	1.51	0.00	100.00	0	5,360.70	0	0.00
LKCH_LBY	57	0.02	17	0.30	1.93			0	12,167.40	0	0.00
LKCH_NER	694	0.27	2,984	4.30	3.54	0.82	99.18	1	412.52	0	0.00
LKCH_NGA	179	0.07	25,127	140.41	2.50	0.00	100.00	9	3,005.51	15	83.82
LKCH_SDN	164	0.06	2,641	16.14	2.51	0.00	100.00	1	1,752.90	0	0.00
LKCH_TCD	1,133	0.44	9,363	8.26	2.75	3.46	96.54	3	1,045.89	0	0.00
Total in Basin	2,597	1.00	44,036	16.96	2.82	1.07	98.89	16	2,167.14	16	6.16

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LKCH_CAF	1	1	1		5	3	2	2	2	5	4		1	5	2
LKCH_CMR	1	1	2		5	3	4	2	2	3	4	5	4	3	3

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LKCH_DZA	4	5	1		4				2	5	3	2	1	3	5
LKCH_LBY	4	5	5		5				2	4	2	2	4	2	5
LKCH_NER	2	2	2		5	5	3	2	2	3	4		2	4	4
LKCH_NGA	2	3	2		5	5	4	2	2	3	4	4	3	4	4
LKCH_SDN	3	2	2		5	1	3	1	1	5	3	3	1	4	4
LKCH_TCD	3	1	2		5	4	2	2	2	3	4	3	5	5	3
River Basin	3	1	2	3	5	4	3	2	2	3	4		4	5	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	**1.Environmental water stress**		**2.Human water stress**		**4.Nutrient pollution**		**16.Change in population density**		**11.Hydropolitical tension**
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
LKCH_CAF	2	2	1	1			2	4	4
LKCH_CMR	2	2	1	1			2	5	4
LKCH_DZA	4	5	5	4			2	3	3
LKCH_LBY	5	4	5	5			2	4	2
LKCH_NER	5	5	1	1			4	5	5
LKCH_NGA	5	5	3	4			3	5	4
LKCH_SDN	5	5	2	3			3	5	4
LKCH_TCD	5	5	1	1			3	5	5
River Basin	5	5	1	1	3	3	3	5	4

TWAP RB Assessment results: Water System Linkages

Thematic group	**Lake Influence Indicator**	**Delta Vulnerability Index**			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	2				

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Maritsa Basin

Geography

Total drainage area (km^2)	52,590
No. of countries in basin	3
BCUs in basin	Bulgaria (BGR), Greece (GRC), Turkey (TUR)
Population in basin (people)	3,476,248
Country at mouth	Greece, Turkey
Average rainfall (mm/year)	629

Governance

No. of treaties and agreements[1]	2
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
MRSA_BGR		194.24				
MRSA_GRC		307.47				
MRSA_TUR		275.60				
Total in Basin	11.97	227.61			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
MRSA_BGR	4,070.42	1,794.50	9.40	1,650.39	332	284.56	1,906.20	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

MRSA_GRC	404.85	389.27	1.26	0.00	0	14.32	4,888.30	
MRSA_TUR	1,928.52	1,162.59	10.26	214.94	169	372.12	1,532.92	
Total in Basin	6,403.79	3,346.36	20.92	1,865.33	500.19	671.00	1,842.16	53.50

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
MRSA_BGR	35	0.67	2,135	60.94	-0.64	0.00	100.00	3	7,296.49	19	542.22
MRSA_GRC	3	0.06	83	26.96	0.31	66.75	33.25	0	21,910.22	0	0.00
MRSA_TUR	14	0.28	1,258	86.90	1.31	0.00	100.00	1	10,945.92	7	483.52
Total in Basin	53	1.00	3,476	66.10	0.10	1.59	98.41	4	8,965.40	26	494.39

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
MRSA_BGR	2	5	3		4	1	5	3	3	1	4	1	4	1	3
MRSA_GRC	2	4	3		1	1	5	4	3	4	5	3	1	1	3
MRSA_TUR	3	4	3		3	1	5	3	3	2	4		1	2	2
River Basin	2	4	3	4	4	1	5	3	3	2	4		3	2	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	**1.Environmental water stress**		**2.Human water stress**		**4.Nutrient pollution**		**16.Change in population density**		**11.Hydropolitical tension**
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
MRSA_BGR	3	4	5	5			1	1	4
MRSA_GRC	3	4	5	5			1	1	5
MRSA_TUR	3	4	4	5			1	2	4
River Basin	3	4	5	5	4	4	1	1	4

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Medjerda Basin

Geography

Total drainage area (km^2)	23,175
No. of countries in basin	2
BCUs in basin	Algeria (DZA), Tunisia (TUN)
Population in basin (people)	2,554,202
Country at mouth	Tunisia
Average rainfall (mm/year)	531

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
MDJD_DZA		66.30				
MDJD_TUN		127.52				
Total in Basin	2.46	106.02			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
MDJD_DZA	387.71	203.47	2.82	84.91	18	78.13	577.44	
MDJD_TUN	2,683.80	1,623.54	13.79	744.29	35	267.34	1,425.46	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	3,071.51	1,827.01	16.61	829.20	53.23	345.47	1,202.53	125.01

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km²)
MDJD_DZA	8	0.34	671	86.02	1.51	0.00	100.00	2	5,360.70	1	128.11
MDJD_TUN	15	0.66	1,883	122.50	1.12	0.00	100.00	0	4,329.10	9	585.57
Total in Basin	23	1.00	2,554	110.21	1.23	0.00	100.00	2	4,600.28	10	431.49

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MDJD_DZA	4	4	3		4	1	5	1	3	5	3	2	2	3	3
MDJD_TUN	5	4	4		4	3	5	2	3	4	3	2	4	2	4
River Basin	5	4	4	4	4	2	5	2	3	4	3	2	4	3	4

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
MDJD_DZA	5	5	5	5			2	2	3
MDJD_TUN	5	5	5	5			1	2	3
River Basin	5	5	5	5	5	5	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

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17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Nahr El Kebir Basin

Geography

Total drainage area (km^2)	1,598
No. of countries in basin	2
BCUs in basin	Syrian Arab Republic (SYR), Turkey (TUR)
Population in basin (people)	772,647
Country at mouth	Syrian Arab Republic
Average rainfall (mm/year)	

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
NHRK_SYR						
NHRK_TUR						
Total in Basin					0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
NHRK_SYR								
NHRK_TUR								

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Total in Basin								

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km²)
NHRK_SYR	1	0.84	710	531.12	1.98	0.00	100.00	1	0.00	0	0.00
NHRK_TUR	0	0.16	63	240.58	1.31			0	10,945.92	0	0.00
Total in Basin	2	1.00	773	483.46	1.91	0.00	91.84	1	893.40	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
NHRK_SYR		3			1		5		4	4	3		1	2	2
NHRK_TUR					3				4	5	3		1	2	1
River Basin		3		5	2		5		3	4	3		1	3	2

Indicators

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Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
NHRK_SYR			4	5					3
NHRK_TUR									3
River Basin			4	5	5	5			3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin					

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

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Niger Basin

Geography

Total drainage area (km^2)	2,111,475
No. of countries in basin	12
BCUs in basin	Algeria (DZA), Benin (BEN), Burkina Faso (BFA), Cameroon (CMR), Chad (TCD), Côte D'Ivoire (CIV), Guinea (GIN), Mali (MLI), Mauritania (MRT), Niger (NER), Nigeria (NGA), Sierra Leone (SLE)
Population in basin (people)	93,617,850
Country at mouth	Nigeria
Average rainfall (mm/year)	656

Governance

No. of treaties and agreements[1]	14
No. of RBOs and Commissions[2]	3

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	22
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
NGER_BEN		181.29				
NGER_BFA		35.88			19.13	0.11
NGER_CIV		317.90				
NGER_CMR		391.90			585.90	6.83
NGER_DZA		1.42				
NGER_GIN		477.00			71.50	0.42
NGER_MLI		67.10			2,463.27	15.74
NGER_MRT		3.47				

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

NGER_NER		18.36					
NGER_NGA		331.16				2,086.00	13.35
NGER_SLE		1,237.41					
NGER_TCD		378.98					
Total in Basin	335.43	158.86				5,225.80	36.46

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
NGER_BEN	40.52	9.22	8.82	0.00	0	22.48	36.16	
NGER_BFA	116.53	11.17	17.18	12.74	9	66.24	38.55	
NGER_CIV	18.90	4.54	5.79	0.00	0	8.57	45.07	
NGER_CMR	121.28	14.18	19.93	0.00	16	71.10	33.41	
NGER_DZA	12.70	0.00	2.82	6.62	0	3.26	248.89	
NGER_GIN	98.85	44.97	7.67	3.53	0	42.29	44.96	
NGER_MLI	3,610.61	3,044.33	61.94	14.51	299	190.89	319.20	
NGER_MRT	1.27	0.07	0.23	0.00	0	0.96	127.18	
NGER_NER	1,124.83	821.41	29.74	21.37	16	236.10	89.62	
NGER_NGA	3,151.05	723.72	180.46	472.02	367	1,407.75	54.26	
NGER_SLE	1.23	0.04	0.20	0.00	0	1.00	3,922.92	
NGER_TCD	28.41	0.00	2.41	0.00	1	25.22	23.01	
Total in Basin	8,326.20	4,673.65	337.19	530.79	708.72	2,075.85	88.94	2.48

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Populati on ('000 people)	Populati on density (people/ km^2)	Annual pop. growth (%)	Rural populati on ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
NGER_BEN	45	0.02	1,120	25.04	2.96	0.93	99.07	0	804.67	0	0.00
NGER_BFA	83	0.04	3,023	36.24	2.97	0.00	100.00	0	683.95	19	227.78
NGER_CIV	24	0.01	419	17.80	1.82	0.00	100.00	0	1,521.22	3	127.30
NGER_CMR	87	0.04	3,631	41.82	2.20	4.38	95.62	2	1,315.49	1	11.52
NGER_DZA	161	0.08	51	0.32	1.51			0	5,360.70	0	0.00
NGER_GIN	96	0.05	2,198	22.95	1.98	0.00	100.00	1	527.26	0	0.00
NGER_MLI	556	0.26	11,311	20.36	3.08	6.15	93.85	3	715.13	2	3.60
NGER_MRT	3	0.00	10	3.68				0	1,070.09	0	0.00

NGER_NER	488	0.23	12,551	25.72	3.54	0.00	100.00	2	412.52	0	0.00
NGER_NGA	550	0.26	58,068	105.52	2.50	0.00	100.00	25	3,005.51	31	56.33
NGER_SLE	0	0.00	0	18.85				0	809.12	0	0.00
NGER_TCD	19	0.01	1,235	63.44	2.75	0.00	100.00	0	1,045.89	0	0.00
Total in Basin	2,111	1.00	93,618	44.34	2.94	0.92	99.01	33	2,124.69	56	26.52

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	**Water Quantity**			**Water Quality**			**Ecosystems**			**Governance**			**Socioeconomics**		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
NGER_BEN	2	1	2		5	1	4	3	1	2	3	3	2	4	2
NGER_BFA	2	2	2		5	3	5	2	1	2	1	1	1	4	3
NGER_CIV	1	1	2		5	3	4	2	1	2	1	5	1	3	2
NGER_CMR	2	1	2		5	3	4	2	3	2	3	5	1	3	4
NGER_DZA	4	5	1		4				2	5	2	2	1	3	5
NGER_GIN	1	1	2		5	2	3	2	2	2	3	4	4	5	2
NGER_MLI	2	3	2		5	4	4	2	1	2	3		5	4	2
NGER_MRT	1	4	2		5		4	1	2	5	3		1	4	2
NGER_NER	3	4	2		5	4	3	2	2	2	3		5	3	3
NGER_NGA	2	1	2		5	3	4	2	3	2	3	4	3	4	3
NGER_SLE	1		1		5				1	5	2	5	1	5	1
NGER_TCD	1	1	1		5	3	3	2	2	2	1	3	1	5	3
River Basin	2	1	2	3	5	4	4	2	3	2	3		4	5	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	**1.Environmental water stress**		**2.Human water stress**		**4.Nutrient pollution**		**16.Change in population density**		**11.Hydropolitical tension**
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

NGER_BEN	3	4	1	1			3	5	3
NGER_BFA	5	5	2	3			4	5	1
NGER_CIV	3	3	1	1			3	5	1
NGER_CMR	2	2	1	1			2	4	3
NGER_DZA	5	5	1	1			2	3	2
NGER_GIN	2	3	1	1			3	5	3
NGER_MLI	5	5	2	2			3	5	3
NGER_MRT	5	5	1	1					4
NGER_NER	5	5	4	4			4	5	4
NGER_NGA	4	3	1	3			3	5	3
NGER_SLE	2	2							2
NGER_TCD	2	2	1	1			3	5	2
River Basin	5	5	1	1	3	3	3	5	3

TWAP RB Assessment results: Water System Linkages

Thematic group	**Lake Influence Indicator**	**Delta Vulnerability Index**			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	1	5	3	4	4

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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The TWAP River Basins component (TWAP RB) carried out a global comparison of 286 transboundary river basins, in order to enable the prioritisation of funds for basins at risk from a variety of issues, covering water quantity, water quality, ecosystems, governance and socio-economics. It also considered risks to deltas from threats of a transboundary nature, and considered the relative influence of lakes on these river basins. TWAP RB is an indicator–based assessment, allowing for an analysis of basins, based on risks to both societies and ecosystems. It also includes provisional outlook projections to 2030 and 2050 for a limited number of indicators.
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Nile Basin

Geography

Total drainage area (km^2)	2,932,702
No. of countries in basin	14
BCUs in basin	Abyei (SDN/SSD), Burundi (BDI), Central African Republic (CAF), Congo, The Democratic Republic Of The (ZAR), Egypt (EGY), Eritrea (ERI), Ethiopia (ETH), Hala'ib triangle (EGY/SDN), Kenya (KEN), Rwanda (RWA), South Sudan (SSD), Sudan (SDN), Tanzania, United Republic Of (TZA), Uganda (UGA)
Population in basin (people)	174,365,405
Country at mouth	Egypt
Average rainfall (mm/year)	622

Governance

No. of treaties and agreements[1]	22
No. of RBOs and Commissions[2]	5

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	26
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
NILE_BDI		311.55			146.58	1.34
NILE_CAF						
NILE_EGY		0.51			3,435.46	86.57
NILE_EGY/SDN		2.71				
NILE_ERI		57.57				
NILE_ETH		391.34			3,337.20	30.80

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NILE_KEN		357.95			3,801.62	152.07
NILE_RWA		174.41			167.22	1.06
NILE_SDN		24.54			1,545.84	18.68
NILE_SDN/SSD		73.63				
NILE_SSD		117.49			204.40	1.30
NILE_TZA		73.16			34,736.31	1,386.83
NILE_UGA		468.99			35,391.77	1,253.85
NILE_ZAR		194.32			3,802.50	81.63
Total in Basin	379.34	129.35			86,568.90	3,014.13

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
NILE_BDI	64.67	1.27	2.86	0.02	0	60.23	13.29	
NILE_CAF								
NILE_EGY	54,067.97	39,685.32	75.00	3,792.84	6,249	4,266.20	1,455.78	
NILE_EGY/SDN	0.95	0.00	0.74	0.00	0	0.21	183.04	
NILE_ERI	23.79	20.99	0.52	0.00	0	2.28	157.75	
NILE_ETH	1,308.59	151.21	163.32	0.35	338	655.35	41.18	
NILE_KEN	581.93	23.98	38.11	34.39	11	474.83	40.78	
NILE_RWA	241.42	14.57	12.00	0.77	20	193.61	30.81	
NILE_SDN	20,199.78	18,141.05	241.44	356.65	719	741.47	764.16	
NILE_SDN/SSD	3.81	0.00	2.24	0.00	0	1.58	33.68	
NILE_SSD	495.06	31.64	196.71	22.70	52	191.87	65.79	
NILE_TZA	359.82	51.90	52.27	62.18	11	182.15	39.63	
NILE_UGA	981.13	13.32	72.57	0.38	126	768.54	30.31	
NILE_ZAR	71.04	0.04	1.53	0.00	13	56.28	25.43	
Total in Basin	78,399.96	58,135.28	859.32	4,270.27	7,540.50	7,594.59	449.63	20.67

Socioeconomic Geography

BCU	Area (‘000 km^2)	BCU area in basin (%)	Population (‘000 people)	Population density (people/km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
NILE_BDI	13	0.00	4,867	368.77	2.90	4.34	95.66	0	267.48	4	303.06
NILE_CAF	0	0.00	1	3.38	1.82			0	333.20	0	0.00
NILE_E	208	0.07	37,140	178.34	1.78	0.00	100.00	15	3,314.46	4	19.21

GY											
NILE_EGY/SDN	6	0.00	5	0.86				0		0	0.00
NILE_ERI	8	0.00	151	19.70	3.16			0	543.82	0	0.00
NILE_ETH	357	0.12	31,775	88.92	2.21	3.55	96.45	3	498.08	2	5.60
NILE_KEN	50	0.02	14,272	288.11	2.58	0.00	100.00	2	994.31	0	0.00
NILE_RWA	21	0.01	7,835	375.85	2.87	0.00	100.00	1	632.76	0	0.00
NILE_SDN	1,265	0.43	26,434	20.89	2.51	0.00	100.00	17	1,752.90	4	3.16
NILE_SDN/SSD	10	0.00	113	11.39				0		0	0.00
NILE_SSD	617	0.21	7,525	12.19		0.00	100.00	4	1,221.35	0	0.00
NILE_TZA	120	0.04	9,080	75.84		0.00	100.00	3	694.77	0	0.00
NILE_UGA	237	0.08	32,374	136.66	3.24	0.03	99.97	1	571.68	1	4.22
NILE_ZAR	20	0.01	2,793	136.34	2.78	0.00	100.00	0	453.67	0	0.00
Total in Basin	2,933	1.00	174,365	59.46	2.56	0.77	99.07	46	1,382.55	15	5.11

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NILE_BDI	1	3	2		5	3	3	3	2	2	3	3	1	3	2
NILE_CAF					5	1			2	5	2		1	5	1
NILE_EGY	4	5	5		3	5	5	3	2	2	3	2	5	2	4
NILE_EGY/SDN	5	5	1						2	5	3		1	5	1
NILE_ERI	2	1	2		5	1	4	2	1	5	4	2	1	4	4
NILE_ETH	2	1	2		5	1	4	2	3	3	3	3	1	3	2
NILE_KEN	1	2	2		5	3	4	2	4	2	1	3	1	4	3
NILE_RWA	1	4	2		5	5	3	3	3	2	3	3	5	4	2
NILE_SDN	3	5	5		5	2	3	1	2	4	3	3	5	4	4
NILE_SDN/SSD	1	1	1			1	3	2	1	5	3		5	5	3
NILE_SSD	2	1	2			3	3	2	2		5		5	5	3
NILE_TZA	2	1	2		5	3	3	2	4	2	3	2	1	3	3
NILE_UGA	2	1	2		5	4	3	2	4	2	3	3	5	3	2
NILE_ZAR	1	1	1		5	3	4	2	3	2	2	5	1	4	2
River Basin	2	1	3	1	5	3	3	2	4	3	3	3	5	4	3

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	**1.Environmental water stress**		**2.Human water stress**		**4.Nutrient pollution**		**16.Change in population density**		**11.Hydropolitical tension**
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
NILE_BDI	2	2	4	4			2	3	4
NILE_CAF							3	5	2
NILE_EGY	4	4	5	5			2	2	4
NILE_EGY/SDN	5	5	5	5					3
NILE_ERI	5	5	1	1					5
NILE_ETH	4	4	1	1			2	3	4
NILE_KEN	5	5	2	4			3	5	2
NILE_RWA	3	3	4	5			3	5	4
NILE_SDN	5	5	5	5			3	5	4
NILE_SDN/SSD	3	3	1	1					3
NILE_SSD	3	3	1	1					5
NILE_TZA	5	5	1	1			4	5	3
NILE_UGA	3	5	2	3			4	5	4
NILE_ZAR	2	3	3	4			3	5	3
River Basin	5	5	2	3	1	1	3	5	4

TWAP RB Assessment results: Water System Linkages

Thematic group	**Lake Influence Indicator**	**Delta Vulnerability Index**			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	5	4	2	5	4

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Oued Bon Naima Basin

Geography

Total drainage area (km^2)	369
No. of countries in basin	2
BCUs in basin	Algeria (DZA), Morocco (MAR)
Population in basin (people)	52,447
Country at mouth	Algeria, Morocco
Average rainfall (mm/year)	

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
ODBN_DZA						
ODBN_MAR						
Total in Basin					0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
ODBN_DZA								
ODBN_MAR								

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Total in Basin								

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km²)
ODBN_DZA	0	0.27	12	119.33	1.51	100.00	0.00	0	5,360.70	0	0.00
ODBN_MAR	0	0.73	40	150.71	1.00	0.00	100.00	0	3,108.65	0	0.00
Total in Basin	0	1.00	52	142.16	1.57	22.87	77.13	0	3,623.72	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ODBN_DZA					4				3	5	3	2	1	3	1
ODBN_MAR					4				3	4	3	2	1	3	1
River Basin				5	4				3	4	3	2	1	3	1

Indicators

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Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
ODBN_DZA									3
ODBN_MAR									3
River Basin					5	5			3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin					

3 Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Psou Basin

Geography

Total drainage area (km^2)	423
No. of countries in basin	2
BCUs in basin	Georgia (GEO), Russian Federation (RUS)
Population in basin (people)	24,577
Country at mouth	Georgia/ Russian Federation
Average rainfall (mm/year)	1,719

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
PSOU_GEO						
PSOU_RUS		1,363.76				
Total in Basin	0.58	1,363.76			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
PSOU_GEO								
PSOU_RUS	31.35	0.00	1.37	0.00	14	16.13	1,732.68	

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[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Total in Basin	31.35	0.00	1.37	0.00	13.84	16.13	1,275.38	5.43

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
PSOU_GEO	0	0.52	6	29.38				0	3,602.17	0	0.00
PSOU_RUS	0	0.48	18	89.25				0	14,611.70	0	0.00
Total in Basin	0	1.00	25	58.04	0.08	0.00	0.00	0	11,706.01	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PSOU_GEO					5				4	3	3	4	1	2	1
PSOU_RUS	1		1		4				4	3	3	2	1	2	3
River Basin	1		1	4	5				3	3	3	3	1	3	3

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
PSOU_GEO									3
PSOU_RUS	5	5							3
River Basin	5	5			4	4			3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Rezvaya Basin

Geography

Total drainage area (km^2)	771
No. of countries in basin	2
BCUs in basin	Bulgaria (BGR), Turkey (TUR)
Population in basin (people)	30,582
Country at mouth	Bulgaria, Turkey
Average rainfall (mm/year)	

Governance

No. of treaties and agreements[1]	1
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
REZV_BGR						
REZV_TUR						
Total in Basin					0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
REZV_BGR								
REZV_TUR								
Total in Basin								

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Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
REZV_BGR	0	0.20	3	20.00	-0.64			0	7,296.49	0	0.00
REZV_TUR	1	0.80	28	44.49	1.31			0	10,945.92	1	1,615.41
Total in Basin	1	1.00	31	39.67	1.08	0.00	0.00	0	10,583.19	1	1,297.02

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
REZV_BGR					4				3	4	2	1	1	1	1
REZV_TUR					3				3	4	2		1	2	1
River Basin				4	3				3	4	2		1	3	1

Indicators

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Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
REZV_BGR									2
REZV_TUR									2
River Basin					4	4			2

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin					

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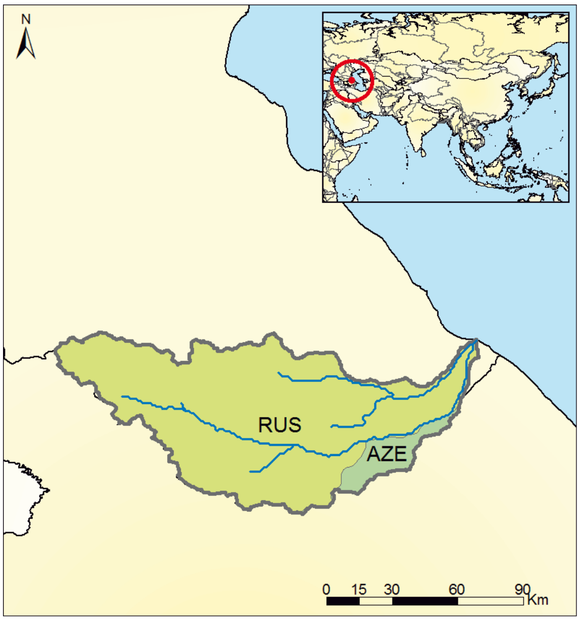
Samur Basin



Geography

Total drainage area (km^2)	6,787
No. of countries in basin	2
BCUs in basin	Azerbaijan (AZE), Russian Federation (RUS)
Population in basin (people)	209,885
Country at mouth	Russian Federation
Average rainfall (mm/year)	550

Governance

No. of treaties and agreements[1]	1
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
SAMR_AZE						
SAMR_RUS		288.79				
Total in Basin	1.96	288.79			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
SAMR_AZE								
SAMR_RUS	212.51	108.19	4.71	0.00	38	61.45	1,155.33	
Total in Basin	212.51	108.19	4.71	0.00	38.17	61.45	1,012.52	10.84

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Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km²)
SAMR _AZE	0	0.07	26	52.88	1.35			0	7,811.79	0	0.00
SAMR _RUS	6	0.93	184	29.22	-0.12			0	14,611.70	0	0.00
Total in Basin	7	1.00	210	30.93	0.36	0.00	0.00	0	13,771.17	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
SAMR_AZE					5	1			3	3	3	3	1	2	2
SAMR_RUS	2	2	2		4	2	2	1	3	3	3	2	1	2	3
River Basin	2	2	2	3	4	2	2	2	3	3	3	2	1	2	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
SAMR_AZE									3
SAMR_RUS	4	5	2	2			1	1	3
River Basin	4	5	2	2	3	4	1	1	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Sulak Basin

Geography

Total drainage area (km^2)	14,108
No. of countries in basin	3
BCUs in basin	Azerbaijan (AZE), Georgia (GEO), Russian Federation (RUS)
Population in basin (people)	425,005
Country at mouth	Russian Federation
Average rainfall (mm/year)	641

Governance

No. of treaties and agreements[1]	1
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
SULK_AZE						
SULK_GEO						
SULK_RUS		231.53				
Total in Basin	3.27	231.53			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
SULK_AZE								

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[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

SULK_GEO								
SULK_RUS	358.67	170.66	8.27	0.00	79	100.90	888.41	
Total in Basin	358.67	170.66	8.27	0.00	78.84	100.90	843.91	10.98

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
SULK_AZE	0	0.00	0	50.94	1.35			0	7,811.79	0	0.00
SULK_GEO	1	0.07	21	21.88	-0.57			0	3,602.17	0	0.00
SULK_RUS	13	0.93	404	30.73	-0.12	0.00	100.00	0	14,611.70	2	152.21
Total in Basin	14	1.00	425	30.12	0.20	0.00	94.99	0	14,061.89	2	141.76

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
SULK_AZE					5	4			3	3	3	3	1	2	1
SULK_GEO					5	2			3	3	3	4	1	2	2
SULK_RUS	2	1	2		4	3	4	1	3	2	3	2	1	2	3
River Basin	2	1	2	4	4	3	4	2	3	2	3	2	1	3	2

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
SULK_AZE									3
SULK_GEO									3
SULK_RUS	3	5	1	2			1	1	3
River Basin	3	5	1	1	4	4	1	1	3

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TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Tafna Basin

Geography

Total drainage area (km^2)	7,264
No. of countries in basin	2
BCUs in basin	Algeria (DZA), Morocco (MAR)
Population in basin (people)	995,141
Country at mouth	Algeria
Average rainfall (mm/year)	341

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
TAFN_DZA		44.41				
TAFN_MAR		37.63				
Total in Basin	0.30	41.86			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
TAFN_DZA	459.67	350.85	2.83	0.00	24	82.36	825.47	
TAFN_MAR	676.28	411.40	0.87	238.69	4	21.12	1,542.99	
Total in Basin	1,135.94	762.24	3.70	238.69	27.82	103.48	1,141.49	373.59

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km²)
TAFN_DZA	5	0.74	557	104.08	1.51	3.22	96.78	1	5,360.70	3	560.70
TAFN_MAR	2	0.26	438	229.06	1.00	0.00	100.00	1	3,108.65	0	0.00
Total in Basin	7	1.00	995	137.00	1.70	1.80	98.20	2	4,368.83	3	413.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
TAFN_DZA	5	4	5		4	2	3		3	5	3	2	3	3	5
TAFN_MAR	3		5		4				3	4	3	2	1	3	5
River Basin	5	5	5	5	4	2	3		3	4	3	2	3	3	5

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**P-2030**	**P-2050**	**Projected**
TAFN_DZA	5	5	5	5			2	2	3
TAFN_MAR	5	5					1	2	3
River Basin	5	5	5	5	5	5	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

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17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Terek Basin

Geography

Total drainage area (km^2)	43,006
No. of countries in basin	2
BCUs in basin	Georgia (GEO), Russian Federation (RUS)
Population in basin (people)	3,939,188
Country at mouth	Russian Federation
Average rainfall (mm/year)	752

Governance

No. of treaties and agreements[1]	1
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
TERK_GEO						
TERK_RUS		363.34				
Total in Basin	15.63	363.34			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
TERK_GEO								
TERK_RUS	3,063.34	1,766.68	35.78	240.09	481	539.75	782.81	
Total in Basin	3,063.34	1,766.68	35.78	240.09	481.04	539.75	777.66	19.60

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Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km²)
TERK_GEO	2	0.04	26	14.76	-0.57			0	3,602.17	0	0.00
TERK_RUS	41	0.96	3,913	94.87	-0.12	0.00	100.00	4	14,611.70	0	0.00
Total in Basin	43	1.00	3,939	91.60	0.22	0.00	99.34	4	14,539.17	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TERK_GEO					5	5			4	3	3	4	1	2	2
TERK_RUS	2	3	2		4	3	3	2	3	2	3	2	2	2	2
River Basin	2	3	2	4	4	4	3	2	3	2	3	2	2	3	2

Indicators

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Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
TERK_GEO									3
TERK_RUS	3	4	3	3			1	1	3
River Basin	3	5	3	3	4	4	1	1	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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Tigris-Euphrates/Shatt al Arab Basin

Geography

Total drainage area (km^2)	868,060
No. of countries in basin	6
BCUs in basin	Iran (Islamic Republic of) (IRN), Iraq (IRQ), Jordan (JOR), Saudi Arabia (SAU), Syrian Arab Republic (SYR), Turkey (TUR)
Population in basin (people)	65,437,198
Country at mouth	Iraq
Average rainfall (mm/year)	357

Governance

No. of treaties and agreements[1]	7
No. of RBOs and Commissions[2]	1

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	27
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
TIGR_IRN		298.74			404.61	2.92
TIGR_IRQ		89.08			5,376.79	131.98
TIGR_JOR		0.40				
TIGR_SAU		23.86				
TIGR_SYR		83.66			638.60	9.39
TIGR_TUR		278.37			1,864.30	28.05
Total in Basin	147.67	170.12			8,284.30	172.34

Water Withdrawals

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
[2] For details on River Basin Organisations (RBOs) and Commissions please visit http://www.transboundarywaters.orst.edu/

BCU	Total (km³/year)	Irrigation (km³/year)	Livestock (km³/year)	Electricity (km³/year)	Manufacture (km³/year)	Domestic (km³/year)	Per capita (m³/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
TIGR_IRN	27,566.02	24,603.83	43.33	636.32	472	1,810.17	2,142.50	
TIGR_IRQ	50,923.51	44,463.97	35.62	4,524.60	347	1,552.22	1,765.88	
TIGR_JOR	1.44	0.00	0.10	0.00	0	1.34	1,085.14	
TIGR_SAU	5.28	0.00	0.39	0.84	0	4.00	142.66	
TIGR_SYR	13,644.50	12,518.08	21.58	311.18	129	664.20	1,155.71	
TIGR_TUR	19,567.23	17,779.30	62.61	310.42	323	1,092.06	1,645.84	
Total in Basin	111,707.97	99,365.18	163.63	5,783.37	1,271.81	5,123.99	1,707.10	75.65

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/km²)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km²)
TIGR_IRN	164	0.19	12,866	78.58	1.18	0.00	100.00	12	4,763.30	6	36.64
TIGR_IRQ	398	0.46	28,838	72.54	2.93	0.00	100.00	19	6,669.54	7	17.61
TIGR_JOR	0	0.00	1	5.98	2.94			0	5,214.19	0	0.00
TIGR_SAU	17	0.02	37	2.21	2.65			0	25,851.60	0	0.00
TIGR_SYR	114	0.13	11,806	103.55	1.98	0.00	100.00	5	0.00	1	8.77
TIGR_TUR	176	0.20	11,889	67.63	1.31	0.00	100.00	13	10,945.92	19	108.08
Total in Basin	868	1.00	65,437	75.38	1.97	0.00	99.94	49	5,879.19	33	38.02

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
TIGR_IRN	4	4	4		5	1	4	4	3	3	2	2	3	3	2
TIGR_IRQ	4	5	5		5	4	5	3	3	2	3	3	5	2	3
TIGR_JOR	5		1		3					4	3	2	1	2	5
TIGR_SAU	4	5	1		4				4	5	3	3	1	2	5
TIGR_SYR	4	5	5		1	2	5	3	3	4	4		4	2	3
TIGR_TUR	3	2	3		3	1	5	4	3	3	3		4	3	2
River Basin	4	5	5	3	4	2	5	4	3	3	3		5	3	2

[3] Lined (or dotted) cells indicate a lower degree of confidence in results due to global modelling limitations and other gap-filling methods.

Indicators

1 - Environmental water stress **2** – Human water stress **3** – Agricultural water stress **4** – Nutrient pollution **5** – Wastewater pollution **6** – Wetland disconnectivity **7** – Ecosystem impacts from dams **8** – Threat to fish **9** – Extinction risk **10** – Legal framework **11** – Hydropolitical tension **12** – Enabling environment **13** – Economic dependence on water resources **14** – Societal well-being **15** – Exposure to floods and droughts

Very low	Low	Medium	High	Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
TIGR_IRN	5	5	4	4			1	2	3
TIGR_IRQ	5	5	5	5			3	5	4
TIGR_JOR	5	5					3	4	3
TIGR_SAU	5	5	5	5					3
TIGR_SYR	5	5	5	5			2	4	4
TIGR_TUR	5	5	3	4			1	2	4
River Basin	5	5	5	5	3	4	2	4	4

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	5	4	2	3	5

Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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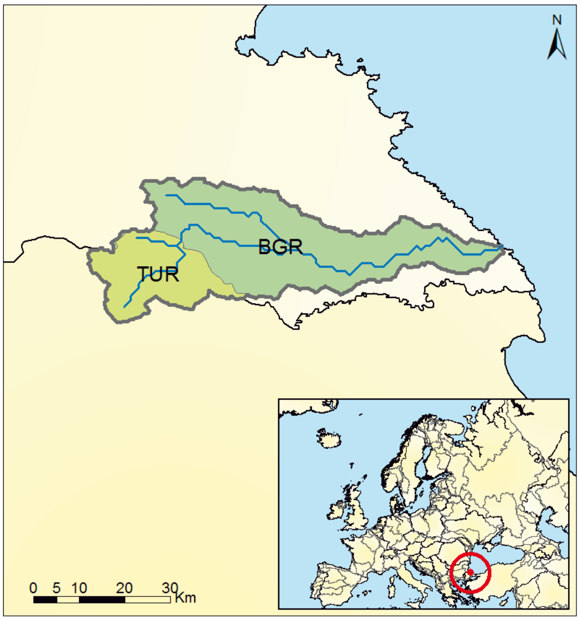
Velaka Basin



Geography

Total drainage area (km^2)	1,075
No. of countries in basin	2
BCUs in basin	Bulgaria (BGR), Turkey (TUR)
Population in basin (people)	20,475
Country at mouth	Bulgaria
Average rainfall (mm/year)	665

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
VLKA_BGR		211.33				
VLKA_TUR		193.80				
Total in Basin	0.22	205.50			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
VLKA_BGR	68.09	46.26	0.96	6.78	3	11.07	8,722.98	
VLKA_TUR	76.21	57.90	0.48	0.00	8	9.54	6,015.19	
Total in Basin	144.30	104.16	1.44	6.78	11.32	20.60	7,047.41	65.30

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Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
VLKA_BGR	1	0.73	8	9.94	-0.64			0	7,296.49	0	0.00
VLKA_TUR	0	0.27	13	43.69	1.31			0	10,945.92	0	0.00
Total in Basin	1	1.00	20	19.04	0.56	0.00	0.00	0	9,554.74	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
VLKA_BGR	2		2		4				3	4	3	1	1	1	2
VLKA_TUR	2		3		3				3	5	3		1	2	2
River Basin	2		2	3	3				3	4	3		1	2	2

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Very low | Low | Medium | High | Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
VLKA_BGR	3	4					1	1	3
VLKA_TUR	3	4							3
River Basin	3	4			3	4	1	1	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

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Indicators

17 – Lake influence indicator **18** – Relative sea level rise (RSLR) **19** – Wetland ecological threat **20** – Population pressure **21** – Delta governance

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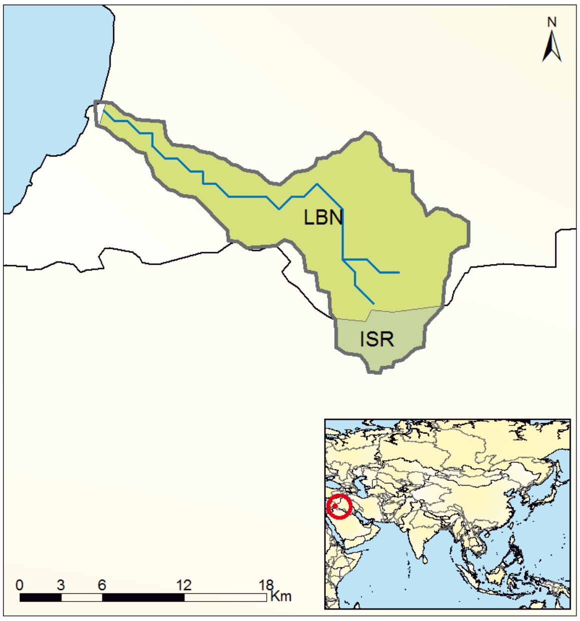
Wadi Al Izziyah Basin



Geography

Total drainage area (km^2)	162
No. of countries in basin	2
BCUs in basin	Israel (ISR), Lebanon (LBN)
Population in basin (people)	48,855
Country at mouth	Lebanon
Average rainfall (mm/year)	698

Governance

No. of treaties and agreements[1]	0
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

A BCU (Basin Country Unit) is defined as the portion of a country within a particular river basin.
All BCUs have a BCU code which includes a Basin Code of four letters and a Country Code of three letters: XXXX-XXX

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
WADI_ISR						
WADI_LBN		294.61				
Total in Basin	0.05	294.61			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
WADI_ISR								
WADI_LBN	397.10	194.30	0.65	123.67	2	76.34	9,468.82	
Total in Basin	397.10	194.30	0.65	123.67	2.14	76.34	8,128.18	830.40

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Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500 ,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000 .000 km^2)
WADI_ISR	0	0.12	7	369.19	2.32			0	36,151.21	0	0.00
WADI_LBN	0	0.88	42	292.08	0.85			0	9,928.04	0	0.00
Total in Basin	0	1.00	49	300.98	1.08	0.00	0.00	0	13,640.86	0	0.00

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Indicator[3]

Thematic group	Water Quantity			Water Quality			Ecosystems			Governance			Socioeconomics		
BCU	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
WADI_ISR					1					5	3	1	1	2	1
WADI_LBN	5		3		5					4	3	3	1	2	1
River Basin	5		3	5	4					4	3	3	1	2	1

Indicators

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Very low Low Medium High Very high

TWAP RB Assessment Results: BCU and Basin Relative Risk Category per Projected Indicator

Projected Indicator	1.Environmental water stress		2.Human water stress		4.Nutrient pollution		16.Change in population density		11.Hydropolitical tension
Basin BCU	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	P-2030	P-2050	Projected
WADI_ISR									4
WADI_LBN	5	5							4
River Basin	5	5			5	5			4

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1				

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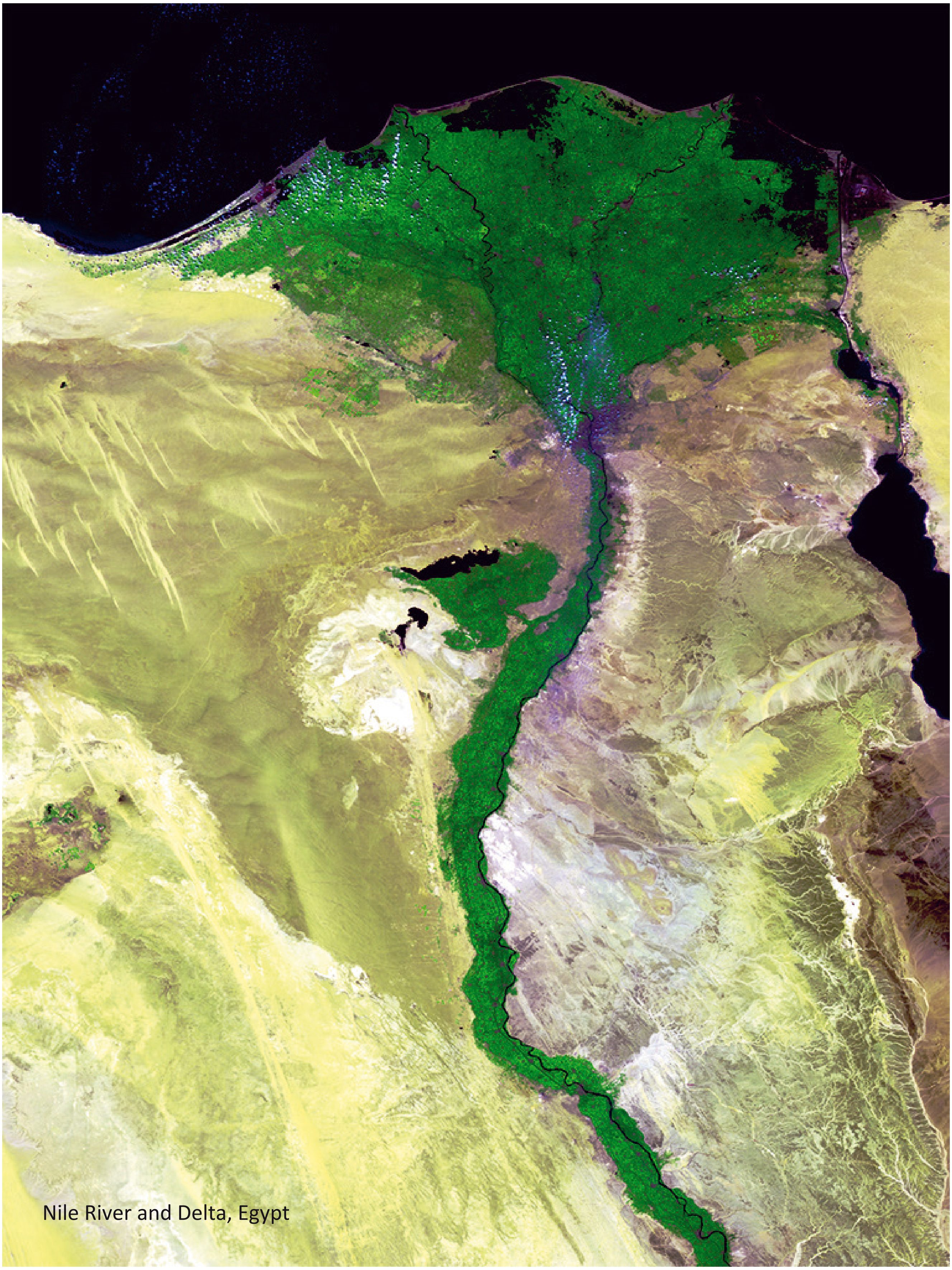
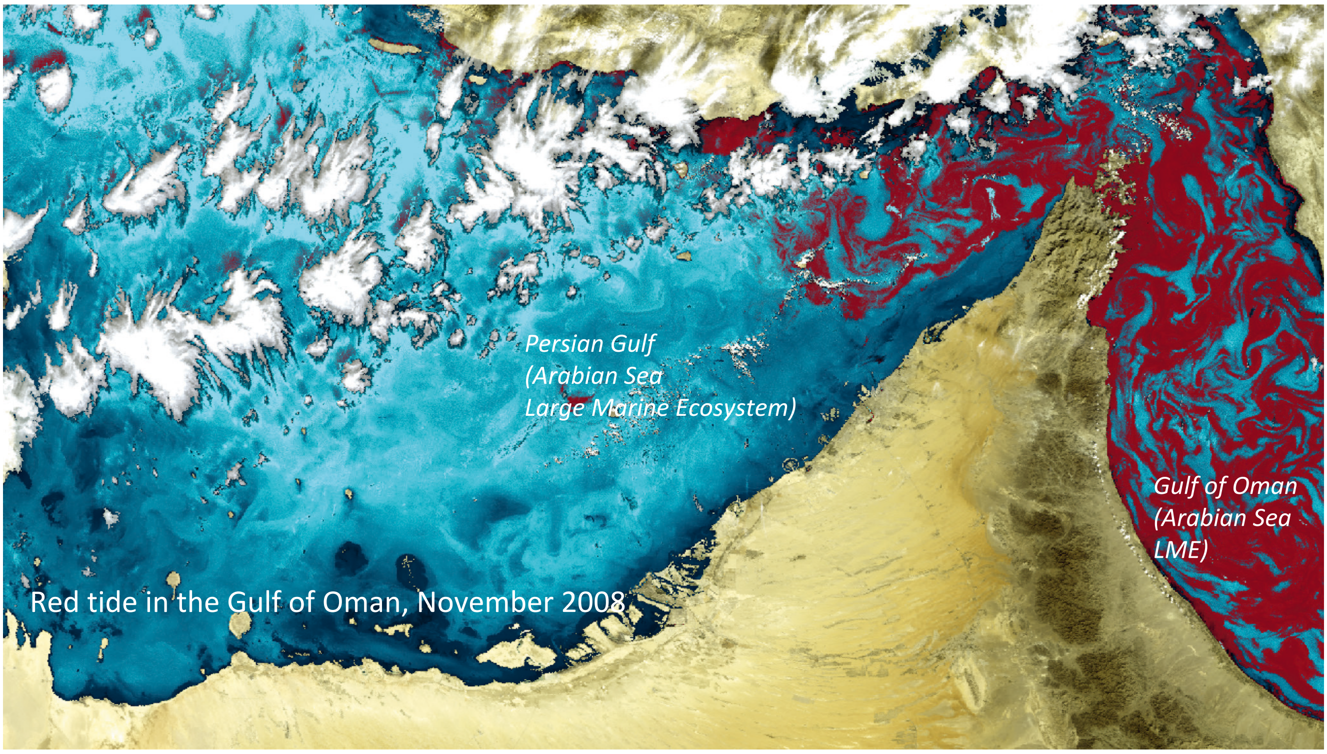


ESA/ VITO

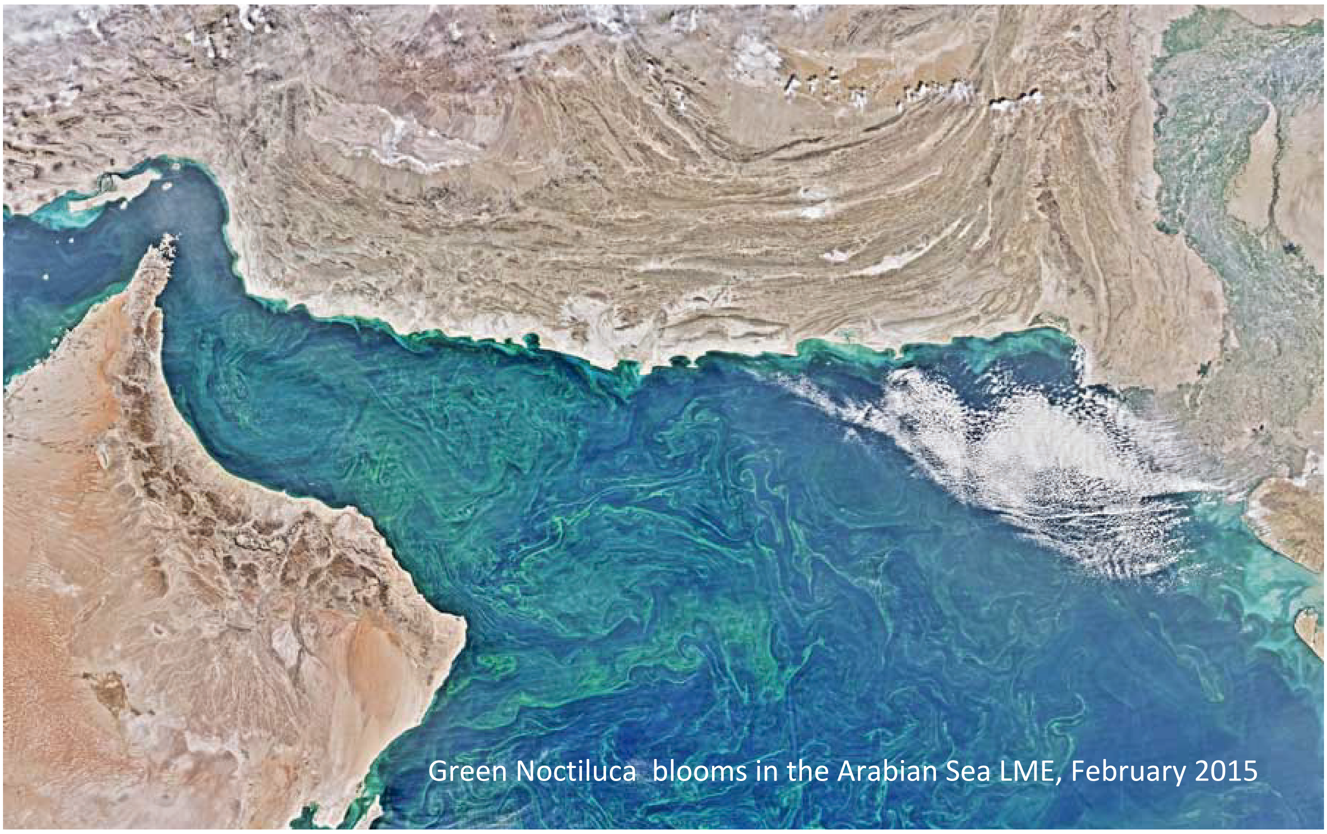
Large Marine Ecosystems

1. LME 26 – Mediterranean Sea
2. LME 27 – Canary Current
3. LME 32 – Arabian Sea
4. LME 33 – Red Sea
5. LME 62 – Black Sea



Red tide in the Gulf of Oman, November 2008

C-wams Project, Planetek Hellas/ ESA



Green Noctiluca blooms in the Arabian Sea LME, February 2015

N. Kuring/ NASA Ocean Color Web

LME 26 – Mediterranean Sea

Bordering countries: Albania, Algeria, Bosnia-Herzegovina, Croatia, Cyprus, Egypt, France, Gibraltar, Greece, Holy See (Vatican), Israel, Italy, Lebanon, Libyan Arab Jamahiriya, Malta, Monaco, Morocco, Occupied Palestinian Territory, San Marino, Serbia and Montenegro, Slovenia, Spain, Syrian Arab Republic, Tunisia, Turkey.

LME Total area: 2,528,398 km^2

List of indicators

LME overall risk

This LME falls in the cluster of LMEs that exhibit medium to high numbers of collapsed and overexploited fish stocks, high levels of demersal non-destructive low bycatch fishing, as well as very high shipping pressure.

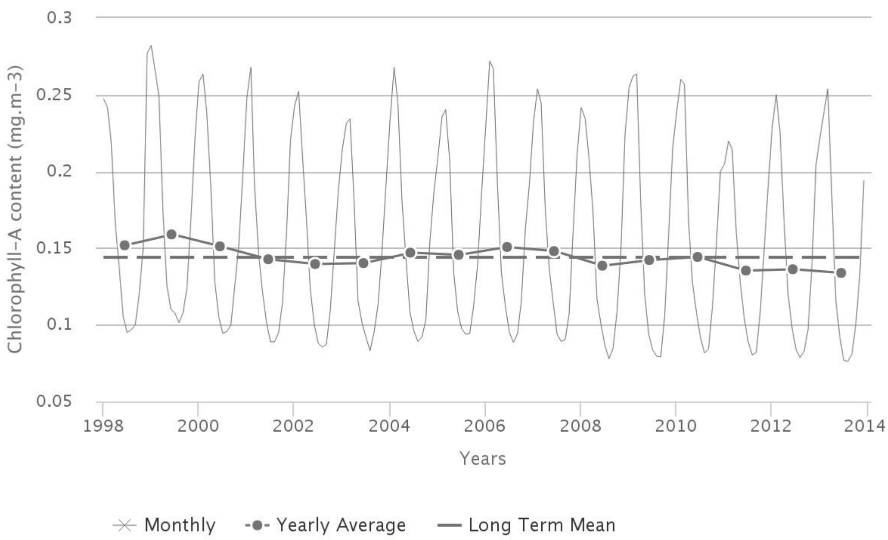
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is high.

Productivity

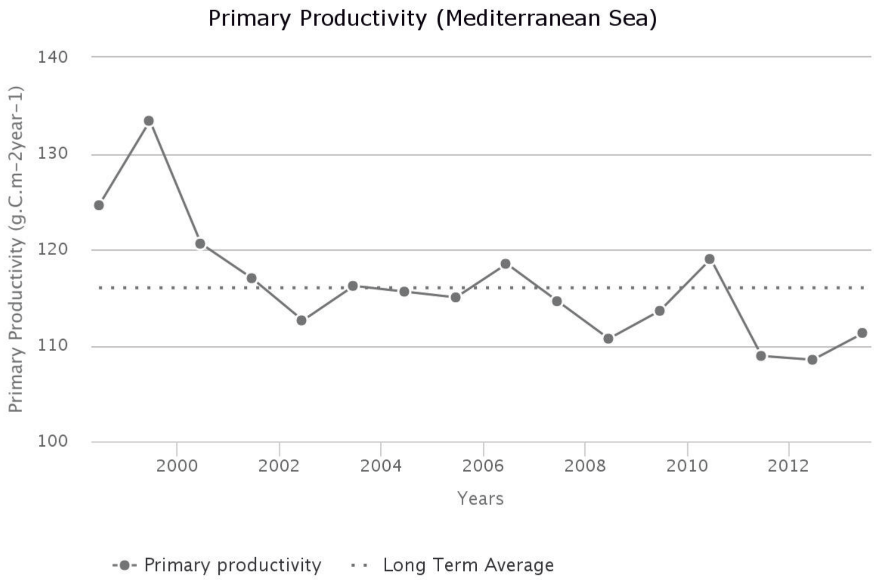
Chlorophyll-A

The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.249 mg.m^{-3}) in February and a minimum (0.0866 mg.m^{-3}) during August. The average CHL is 0.144 mg.m^{-3}. Maximum primary productivity (133 g.C.m^{-2}.y^{-1}) occurred during 1999 and minimum primary productivity (108 g.C.m^{-2}.y^{-1}) during 2012. There is a statistically insignificant increasing trend in Chlorophyll of 2.72 % from 2003 through 2013. The average primary productivity is 116 g.C.m^{-2}.y^{-1}, which places this LME in Group 1 of 5 categories (with 1 = lowest and 5= highest).

Chlorophyll-A (Mediterranean Sea)

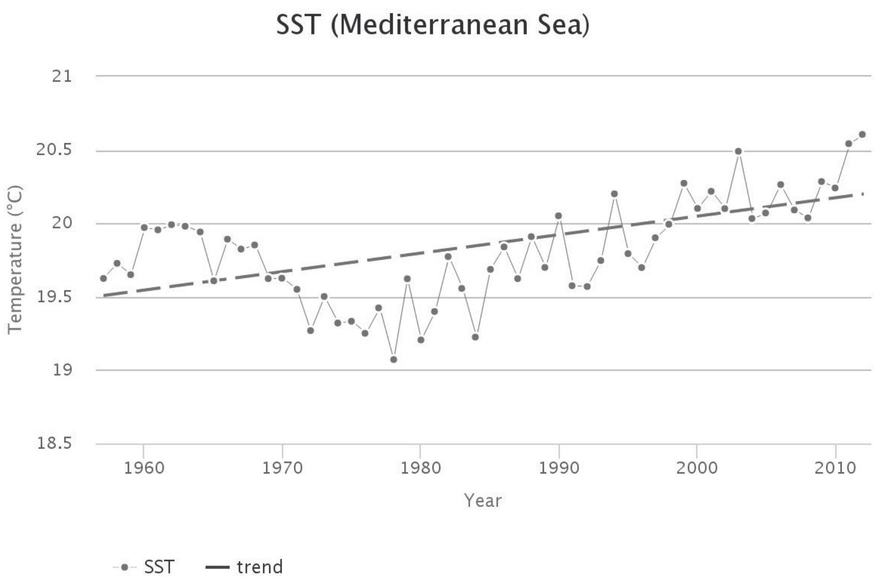


Primary productivity



Sea Surface Temperature

From 1957 to 2012, the Mediterranean Sea LME #26 has warmed by 0.66°C, thus belonging to Category 3 (moderate warming LME). The thermal history of this LME between 1957 and 2012 consists of two regimes. During the first (mostly cooling) epoch, after peaking at 20°C in the early 1960s, SST cooled down to 19.1°C in 1978. This year has marked a sharp transition from cooling to warming. During the second (warming) regime (still on), SST rose to 20.6°C in 2012. From the absolute minimum of 19.1°C in 1978 to the absolute maximum of 20.6°C in 2012, the SST warming rate was 1.5°C in 34 years. This LME consists of two parts, Western and Eastern Mediterranean, whose circulation patterns are rather independent from one another. The 1982-2003 warming magnitude increased eastward, from 0.5-1.0°C in the Gulf of Lions and Ligurian Sea up to 2-3°C in the Levantine Basin (EEA, 2007, p.236, Map 5.9).

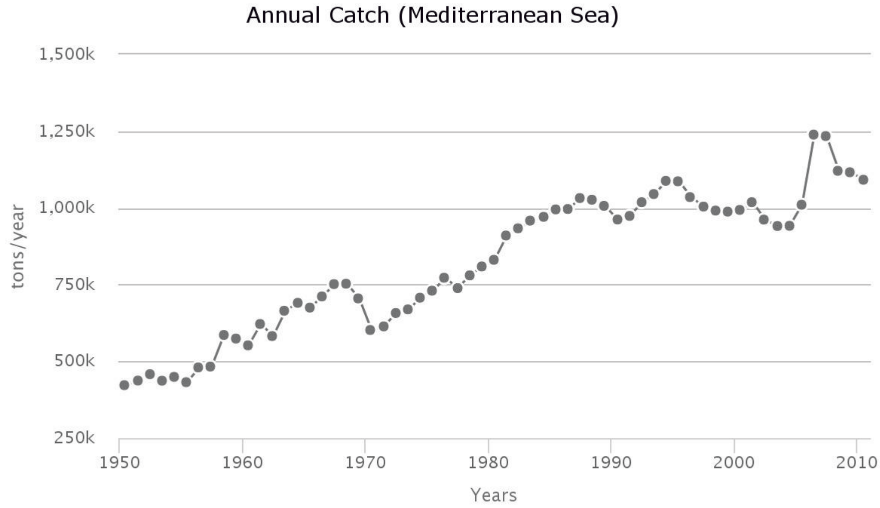


Fish and Fisheries

The Mediterranean Sea LME is one of the most diverse and stable LMEs in terms of species groupings and their share in the total catch. Total reported landings in the LME, consisting largely of clupeoids (pilchard, anchovy and sardinella), increased from 1950 to the mid-1980s, levelling off at around 900,000 t in the 1990s, with landings over 1 million t recorded in 1994 and 1995.

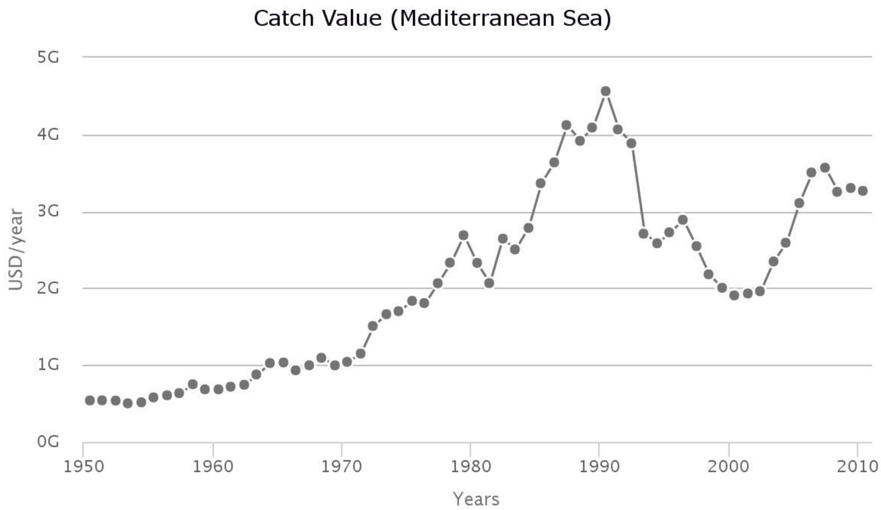
Annual Catch

The landings peaked at about 1.2 million t in 2006.



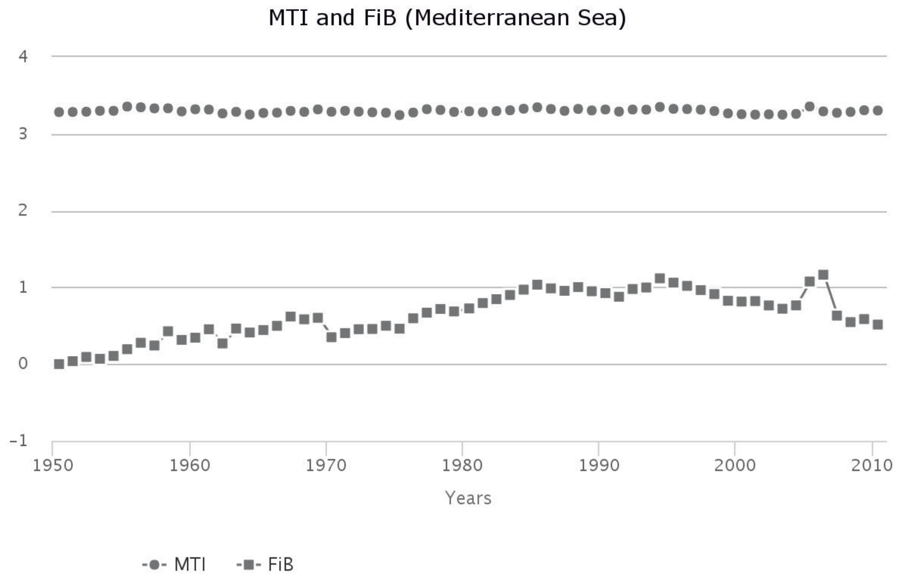
Catch value

The value of the reported landings peaked at about 4.6 billion US$ (in 2005 real US$) in 1990.



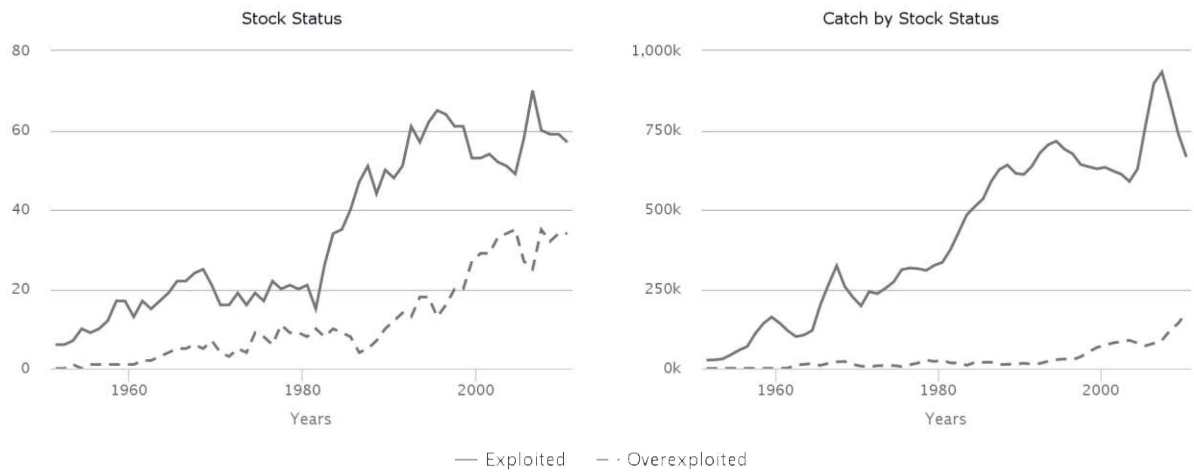
Marine Trophic Index and Fishing-in-Balance index

The MTI increased until the mid-1980s and has declined since the mid-1990s, when the expansion of the fisheries, particularly offshore, ceased, as suggested by the increase of the FiB index from 1950 to the mid-1980s. Since the mid-1980s, the FiB has stabilized and began to decline in the late 1990s, an indication of decline in both the MTI and catch, and a confirmation that substantial ‘fishing down’ has occurred in the Mediterranean. The FiB index increased in the mid-2000 and then further declined since 2006. This indicates ‘fishing down’ of the food web in LME.



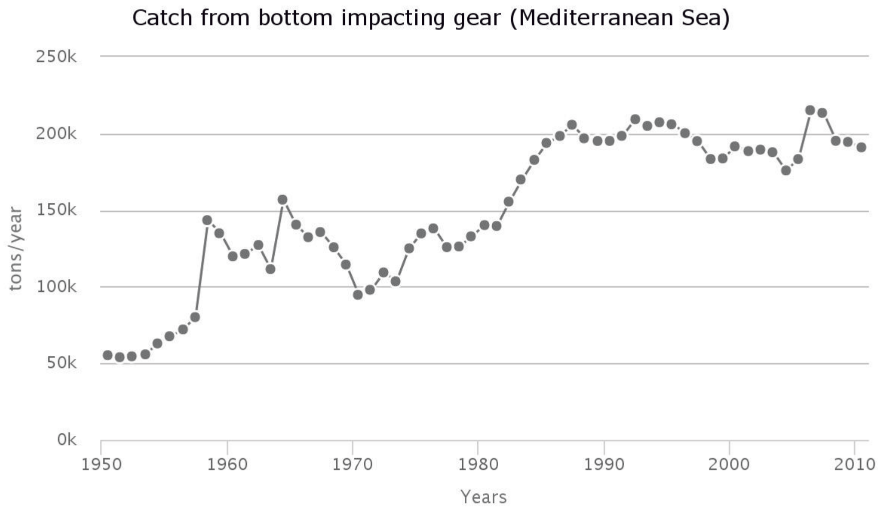
Stock status

The Stock-Catch Status Plots suggest that, based on reported landings statistics, very few stocks have collapsed (less than 15%), and that over 86 % of the reported landings originate from overexploited and fully exploited stocks.



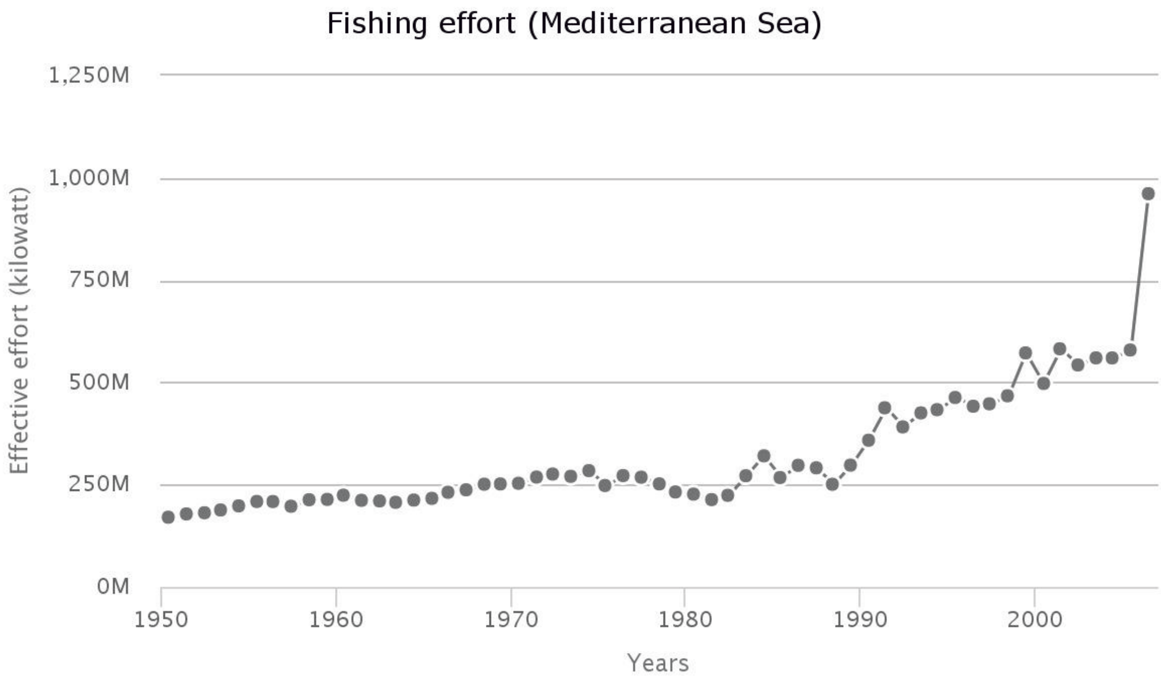
Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch fluctuated between 12 and 25% from 1950 to 2010. This percentage reached its peak at 25% in 1957. In the recent decade, this percentage fluctuated around 18%.



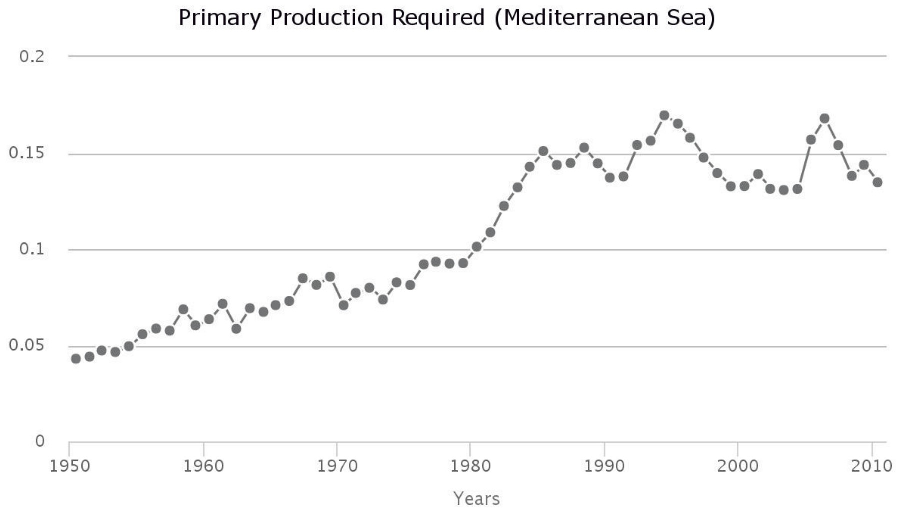
Fishing effort

The total effective effort continuously increased from around 200 million kW in the 1950s to its peak at 960 million kW in the mid-2000s.



Primary Production Required

The primary production required (PPR) to sustain the reported landings in this LME reached 20% of the observed primary production in 1994, but has since declined to 15%..



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular *nitrogen load*) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the *ratio of nutrients* entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans. An overall nutrient indicator (*Merged Nutrient Indicator*) based on 2 sub-indicators: *Nitrogen Load* and *Nutrient Ratio* (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was moderate (level 3 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a “current trends” scenario (Global Orchestration), this remained the same in 2030 and 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was moderate (3). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was moderate (3). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

2000			2030			2050		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
3	3	3	3	3	3	3	3	3

Legend:
Very low Low Medium High Very high

POPs

Data are available from 15 samples at 15 locations on the European side and Israel. They show moderate average concentrations (ng.g^{-1} of pellets) of 112 (range 5-264 ng.g^{-1}) for PCBs and 125 (range 1- 1,061 ng.g^{-1}) for DDTs, corresponding to risk category 3 and category 4, respectively, of the five risk categories (1 = lowest risk; 5 = highest risk). On the other hand, HCHs show a minimal average concentration of 1.1 (range 0-2.2 ng.g^{-1}), corresponding to risk category 1. PCBs seem to be widely distributed in this LME. High concentrations of PCBs (225 – 264 ng.g^{-1}) were observed at industrial centers in Greece, and are due to legacy pollution. Extremely high concentrations of DDTs (1,061 ng.g^{-1} and 262 ng.g^{-1}) were observed in Durres (Albania) and Athens (Greece), respectively. The sources of DDTs should be investigated. Pellets from the North African coast are also necessary to improve the understanding of the pollution status of this LME.

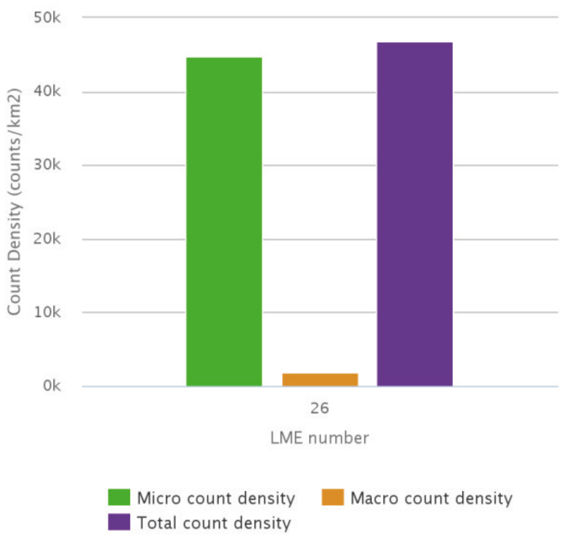
	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk
15	112	**3**	125	**4**	1.1	**1**

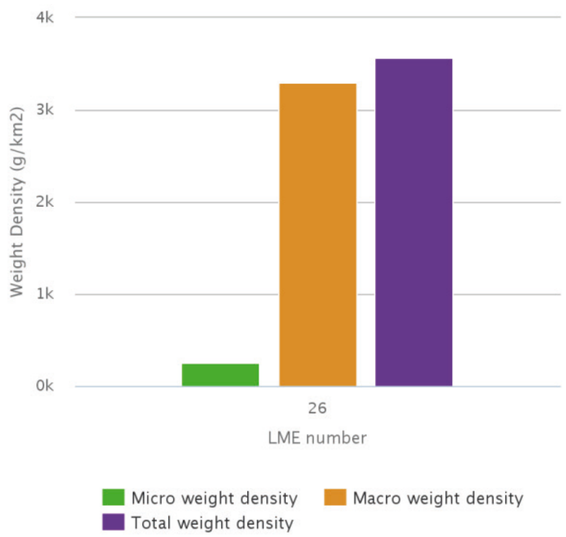
Legend:

Very low Low Medium High Very high

Plastic debris

x Modelled estimates of floating plastic abundance (items km^{-2}), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with the highest plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The high values are due to relative importance of these sources in this LME. The abundance of floating plastic in this category is estimated to be on average over 400 times higher that those LMEs with lowest values. There is good evidence from sea-based direct observations and towed nets to support this conclusion.





Ecosystem Health

Mangrove and coral cover

Not applicable.

Reefs at risk

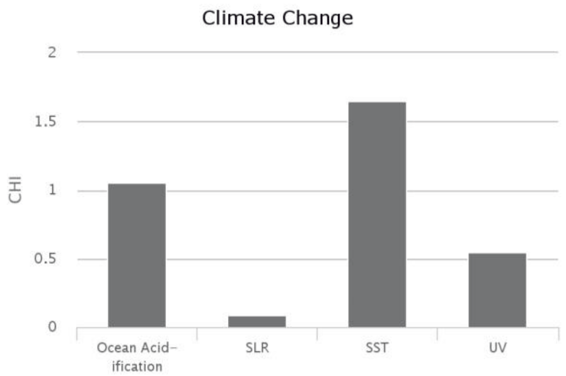
Not applicable.

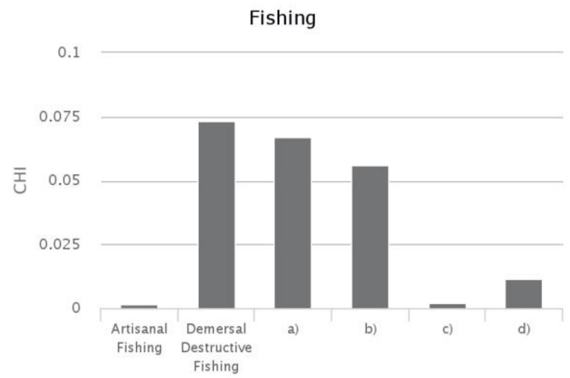
Marine Protected Area change

The Mediterranean Sea LME experienced an increase in MPA coverage from 1,357 km^2 prior to 1983 to 106,325 km^2 by 2014. This represents an increase of 7,733%, within the medium category of MPA change.

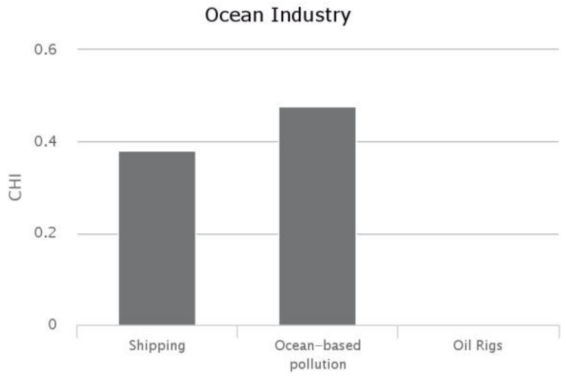
Cumulative Human Impact

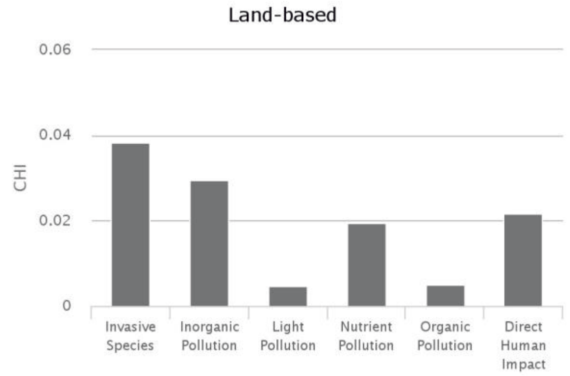
The Mediterranean Sea LME experiences an above average overall cumulative human impact (score 4.52; maximum LME score 5.22), which is also well above the LME with the least cumulative impact. It falls in risk category 5 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, three connected to climate change have the highest average impact on the LME: ocean acidification (1.06; maximum in other LMEs was 1.20), UV radiation (0.54; maximum in other LMEs was 0.76), and sea surface temperature (1.65; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, sea level rise, ocean based pollution, and all three types of demersal commercial fishing (demersal destructive, non-destructive low-bycatch, and non-destructive high-bycatch).





a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing

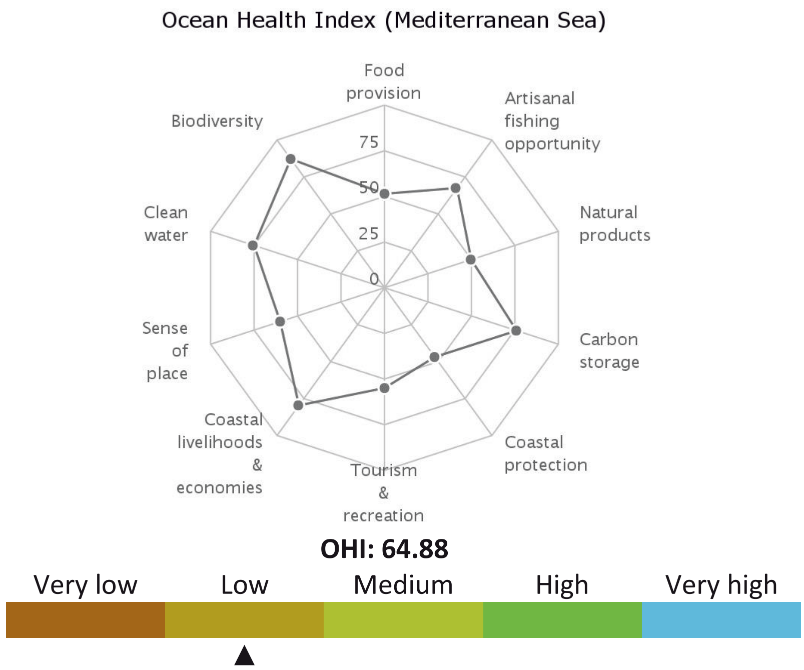




CHI: 4.52

Ocean Health Index

The Mediterranean Sea LME scores below average on the Ocean Health Index compared to other LMEs (score 69 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is well below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 decreased 1 point compared to the previous year, due in large part to changes in the scores for clean waters. This LME scores lowest on mariculture, natural products, coastal protection, and iconic species goals and highest on artisanal fishing opportunities, coastal economies, and habitat biodiversity goals. It falls in risk category 3 of the five risk categories, which is an average level of risk (1 = lowest risk; 5 = highest risk).



Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for this LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The coastal area stretches over 1 427 730 km^2. A current population of 236 678 thousand in 2010 is projected to increase to 353 578 thousand in 2100, with a density of 166 persons per km^2 in 2010 increasing to 248 per km^2 by 2100. About 35% of coastal population lives in rural areas, and is projected to increase in share to 36% in 2100.

Total population		**Rural population**	
2010	**2100**	**2010**	**2100**
236,677,556	353,577,642	83,755,361	128,562,772

Legend: Very low | Low | Medium | High | Very high

Coastal poor

The indigent population makes up 15% of the LME's coastal dwellers. This LME places in the medium-risk category based on percentage and in the very high-risk category using absolute number of coastal poor (present day estimate).

Coastal poor
35,405,357

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. This LME ranks in the very high-revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $3 431 million for the period 2001-2010. Fish protein accounts for 12% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013 $478 729 million places it in the very high-revenue category. On average, LME-based tourism income contributes 13% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for this LME falls in the category with medium risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
3,430,991,381	12.2	478,729,000,000	13.1	0.7301

Legend:
Very low   Low   Medium   High   Very high

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day LME HDI belongs to the high HDI and low risk category. Based on an HDI of 0.780, this LME has an HDI Gap of 0.220, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.

HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). This LME is projected to assume a place in the very low risk category (very high HDI) in 2100 under a sustainable development pathway. Under a fragmented world scenario, the LME is estimated to place in a very high-risk category (very low HDI) because of reduced income levels and increased population values from those estimated in a sustainable development scenario.

	HDI 2100	
HDI	SSP1	SSP3
0.7804	0.9058	0.5554

Legend:
Very low   Low   Medium   High   Very high

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (*e.g.* overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m^2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index of this LME is within the very high-risk (very high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is high. In a sustainable development scenario, the risk index from sea level rise in 2100 is very low, and increases to very high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	**Contemporary Threat**	**SSP1**	**SSP3**
0.7779	0.4400	0.3957	0.6605

Legend:

Very low · Low · Medium · High · Very high

Governance

Governance architecture

Given the semi-enclosed nature of this LME, the fit of arrangements to the LME is very close, with two extending also to the Black Sea, and one (ICCAT) extending an Atlantic ocean-wide. The fact that decisions taken in ICCAT are not binding, seriously weakens this arrangement. However, the uptake of recommendations by the GFCM strengthens them in the Mediterranean. The Barcelona Convention and its protocols provide a strong framework for addressing land and marine-based sources of pollution as well as biodiversity issues. A strength of the Specially Protected Areas and Biodiversity Protocol is that it applies to areas beyond national jurisdiction. The need for an integrating mechanism is recognized by the countries in the establishment of the Mediterranean Commission on Sustainable Development. However, it appears to be a consultative body that is largely advisory in nature rather than having any formal coordination mandate.

The overall scores for ranking of risk were:

Engagement	Completeness	Integration
85	**78**	**1**

Legend:

Very low · Low · Medium · High · Very high

LME 27 – Canary Current

Bordering countries: Spain, Morocco, Western Sahara, Mauritania, Senegal, Gambia, Guinea-Bissau.
LME Total area: 1,120,439 km^2

List of indicators

LME overall risk

This LME falls in the cluster of LMEs that exhibit low to medium levels of economic development (based on the night light development index) and medium levels of collapsed and overexploited fish stocks.

Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is very high.

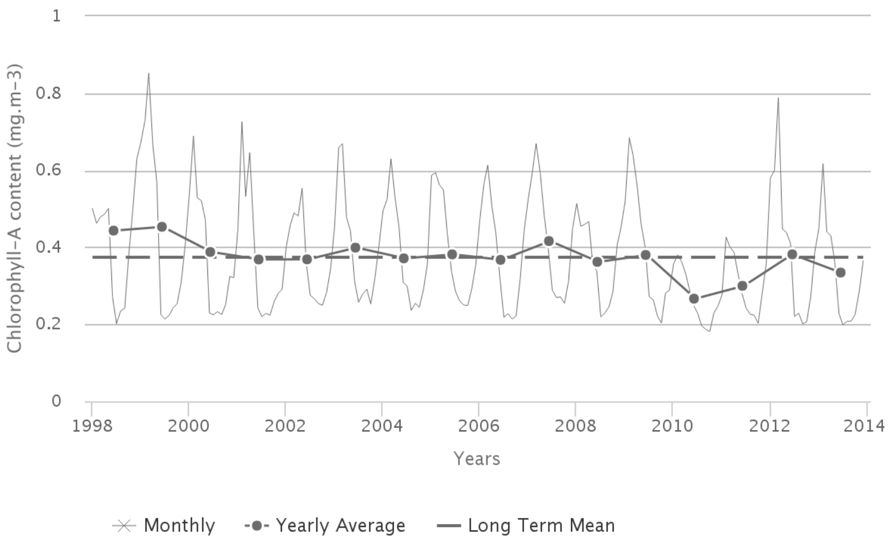
Very low	Low	Medium	High	Very high
				▲

Productivity

Chlorophyll-A

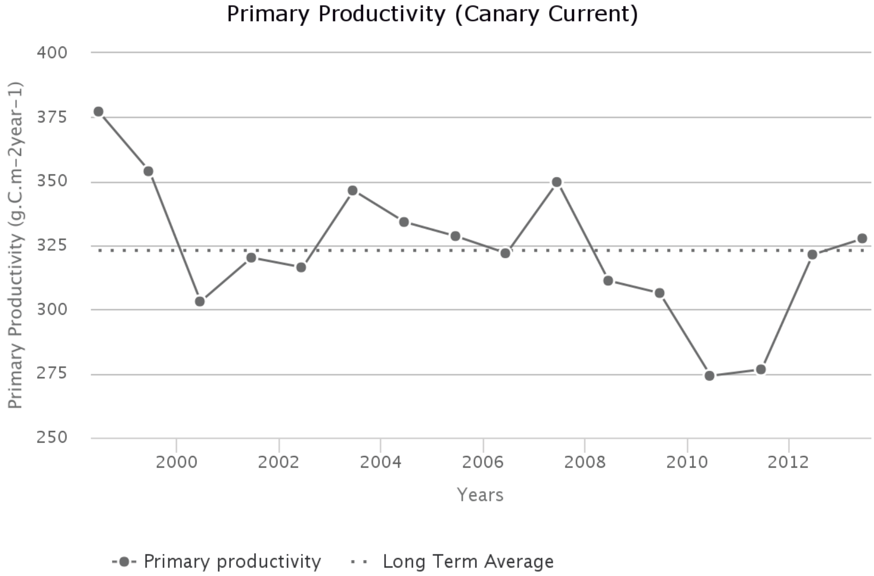
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.570 $mg.m^{-3}$) in February and a minimum (0.241 $mg.m^{-3}$) during September. The average CHL is 0.374 $mg.m^{-3}$. Maximum primary productivity (377 $g.C.m^{-2}.y^{-1}$) occurred during 1998 and minimum primary productivity (274 $g.C.m^{-2}.y^{-1}$) during 2010. There is a statistically insignificant decreasing trend in Chlorophyll of -11.8 % from 2003 through 2013. The average primary productivity is 323 $g.C.m^{-2}.y^{-1}$, which places this LME in Group 3 of 5 categories (with 1 = lowest and 5= highest).

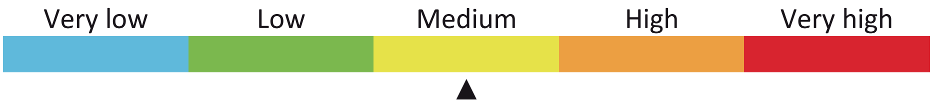
Chlorophyll-A (Canary Current)



Very low	Low	Medium	High	Very high
		▲		

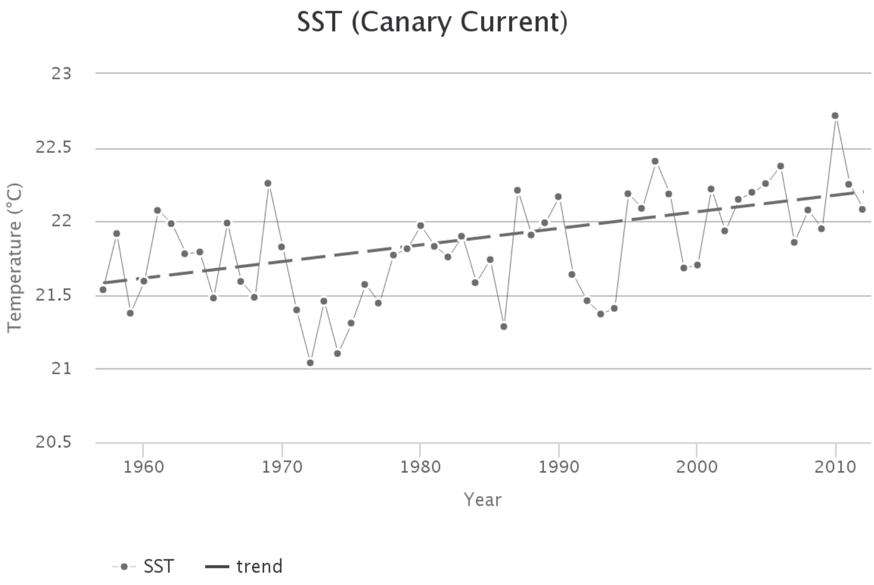
Primary productivity





Sea Surface Temperature

From 1957 to 2012, the Canary Current LME #27 has warmed by 0.59°C, thus belonging to Category 3 (moderate warming LME). The long-term warming since 1957 has been interrupted by a few reversals. The most significant cold spell occurred after the warm event of 1969 and lasted a decade. The near-all-time maximum of 1969 was concurrent with the all-time maximum in the Caribbean Sea LME #11. This simultaneity likely was not coincidental since both LMEs are strongly affected – and connected – by trade winds blowing westward across the North Atlantic. The Canary Current is one of four major areas of coastal upwelling in the World Ocean. While over the last 25 years two major upwelling areas - the California Current LME #3 and Humboldt Current LME #13 – cooled, the Canary Current LME #27 and the Benguela Current LME #29 warmed. The recent warming of the Canary Current LME is especially striking since the 20th century intensification of coastal upwelling off Northwest Africa is well-documented (McGregor et al., 2007). The upwelling intensification should have resulted in cooling, not warming.

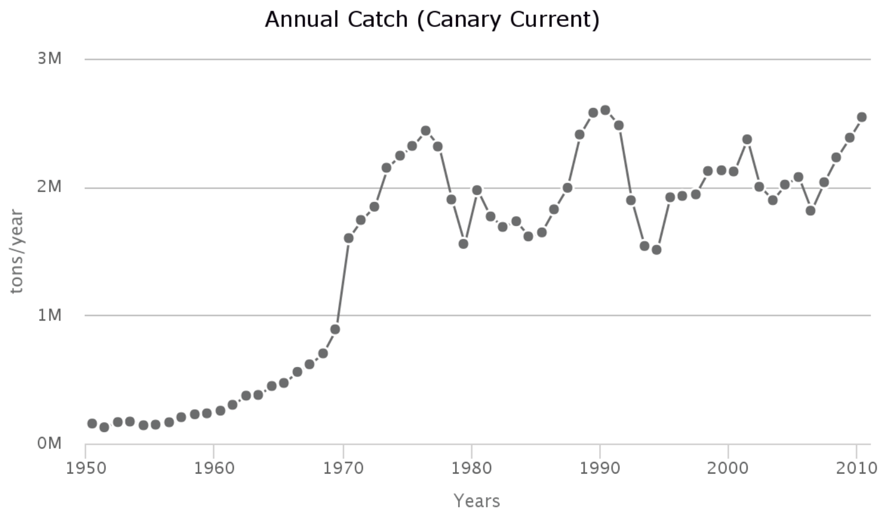


Fish and Fisheries

The Canary Current LME is rich in fisheries resources among which are small pelagic sardine and anchovy (e.g., *Sardina pilchardus*, *Sardinella aurita*, *S. maderensis*, *Engraulis encrasicolus*) that constitute more than 60% of the catch in the LME. Other species caught in the LME include mackerel (*Scomber japonicus* and *Trachurus spp.*), tuna (e.g., *Katsuwonus pelamis*), coastal migratory pelagic finfish, a wide range of demersal finfish and cephalopods (*Octopus vulgaris*, *Sepia spp.*, and *Loligo vulgaris*) and shrimps (*Parapenaeus longirostris* and *Penaeus notialis*). In addition to small national fleets, the EEZs of Mauritania, Senegal, Gambia and Guinea Bissau all accommodate large distant water fleets from the European Union and Asia.

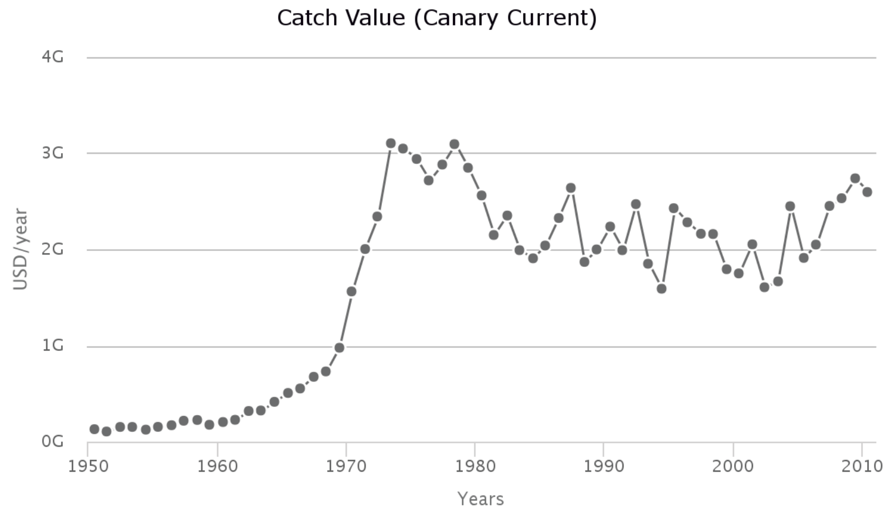
Annual Catch

Total reported landings in the LME increased steadily to about 2.4 million t in 1976, followed by a series of large fluctuations between 1.5 and 2.5 million t until the total reported landings reached a peak of 2.6 million t in 1990.



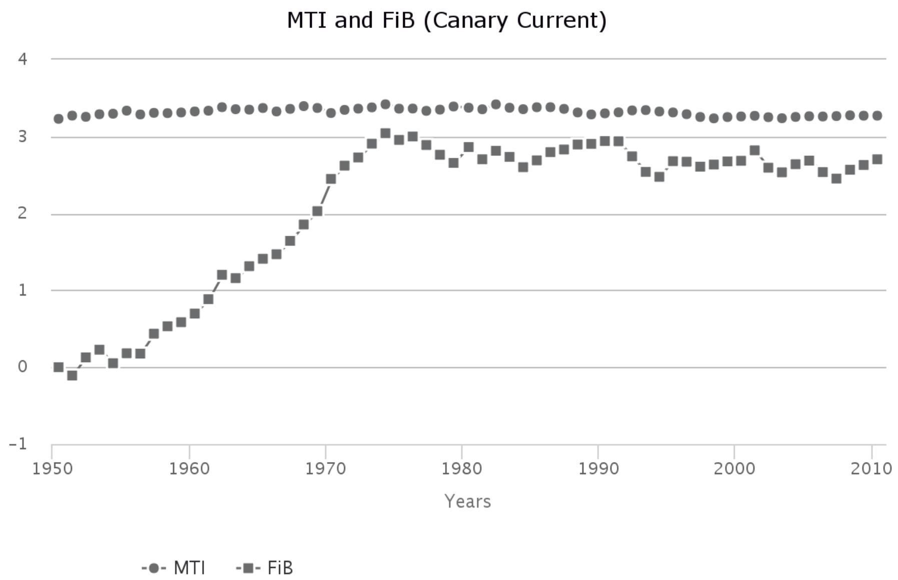
Catch value

The fluctuations in the total landings are also reflected in their value, which varies between 1.8 and around 3 billion US$ (in 2005 real US$).



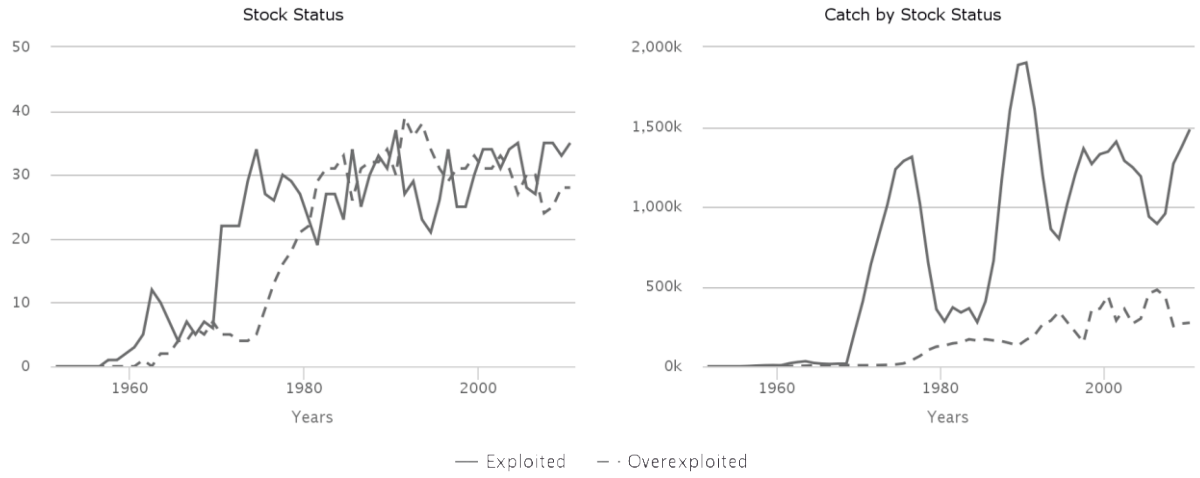
Marine Trophic Index and Fishing-in-Balance index

The MTI declined since the mid-1970, an indication of 'fishing down'. The FiB index indicates a possible slight decline during this period suggesting a situation where catches, which should increase when trophic levels decrease, were in fact decreasing.



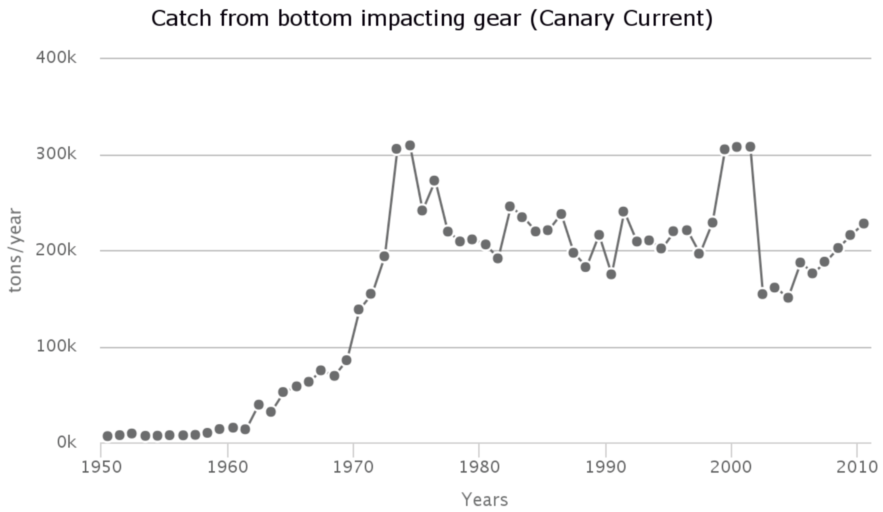
Stock status

The Stock-Catch Status Plots show that about 30% of exploited stocks can be considered collapsed, and another 20% are overexploited in the LME. Still, over 60% of the catch originates from stocks that are classified as "fully exploited".



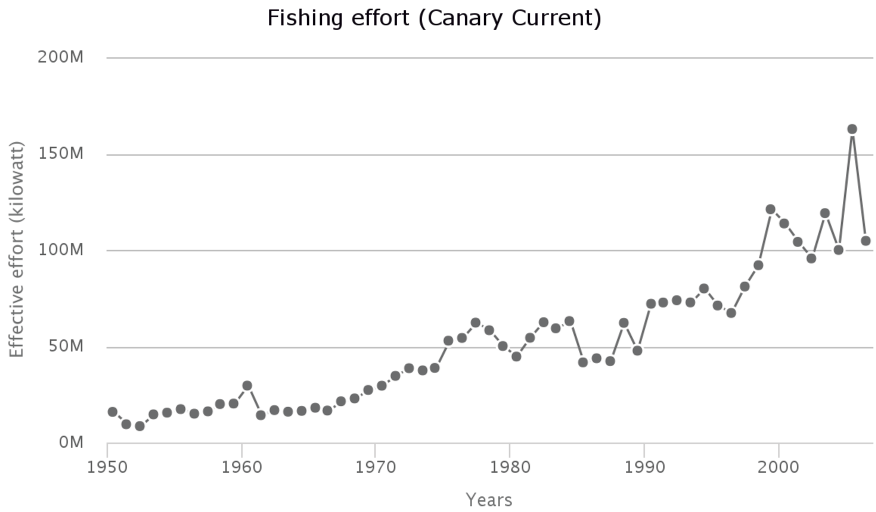
Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch fluctuated between 3 and 15% from 1950 to 2010. This percentage fluctuated around 9% in the recent decade.



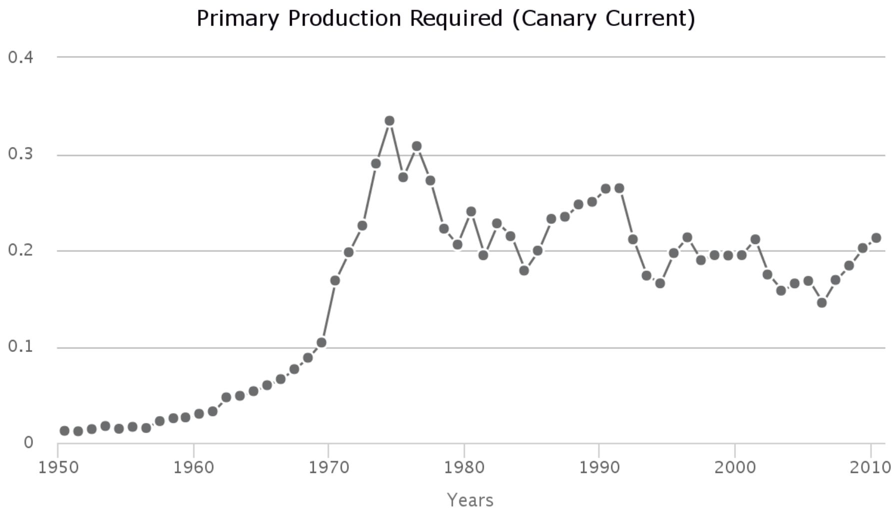
Fishing effort

The total effective effort continuously increased from around 10 million kW in the early 1950s to its peak at 160 million kW in the mid-2000s.



Primary Production Required

The primary production required (PPR) to sustain the reported landing in the LME reached 25% of the observed primary production in the early 1970s, but has since fluctuated to about 15%.



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular *nitrogen load*) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the *ratio of nutrients* entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans. An overall nutrient indicator (*Merged Nutrient Indicator*) based on 2 sub-indicators: *Nitrogen Load* and *Nutrient Ratio* (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was very low (level 1 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a "current trends" scenario (Global Orchestration), this remained the same in 2030 and 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was moderate (3). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was very low (1). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

2000			2030			2050		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
1	3	1	1	3	1	1	3	1

Legend: Very low, Low, Medium, High, Very high

POPs

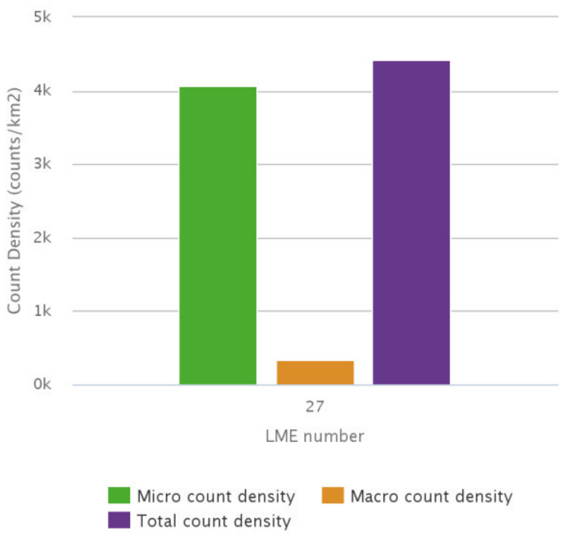
Data are available only for one sample at one location in the Canary Islands. This location shows minimal concentrations (ng.g-1 of pellets) for all the indicators (10 for PCBs, 4 for DDTs, and not detected for HCHs). This is probably due to remoteness from anthropogenic activities involving the use of POPs (industrial activities using PCBs and agricultural activities using DDT and HCH pesticides). On the African coast, PCB pollution was suspected in another study (Gioia et al., 2008). Pellets from the African coast are needed to properly evaluate the pollution status of this LME.

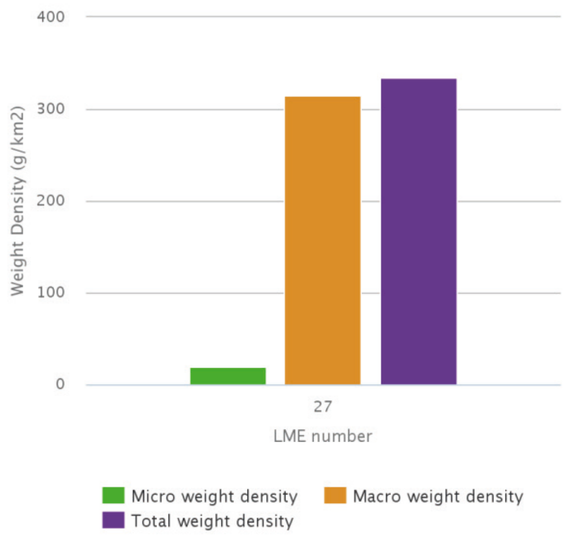
	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk
1	10	**1**	4	**1**	0.0	**1**

Legend: Very low, Low, Medium, High, Very high

Plastic debris

Modelled estimates of floating plastic abundance (items km^{-2}), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with relatively moderate levels of plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The high values are due to the relative importance of these sources in this LME. The abundance of floating plastic in this category is estimated to be on average over 12 times lower that those LMEs with lowest values. There is very limited evidence from sea-based direct observations and towed nets to support this conclusion.





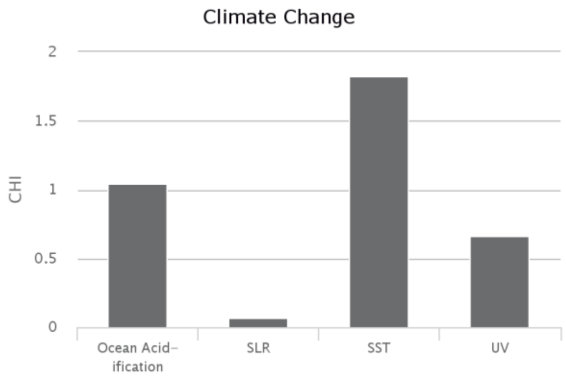
Ecosystem Health

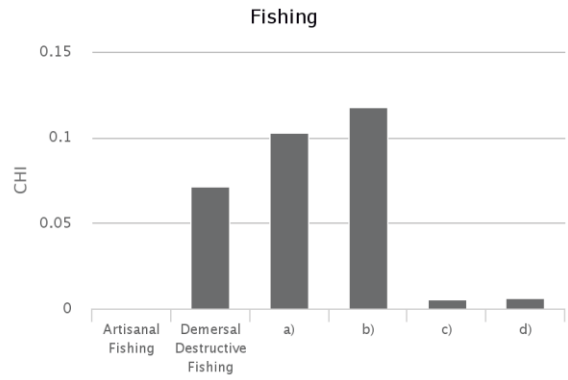
Mangrove and coral cover
0.28% of this LME is covered by mangroves.

Reefs at risk
Not applicable.

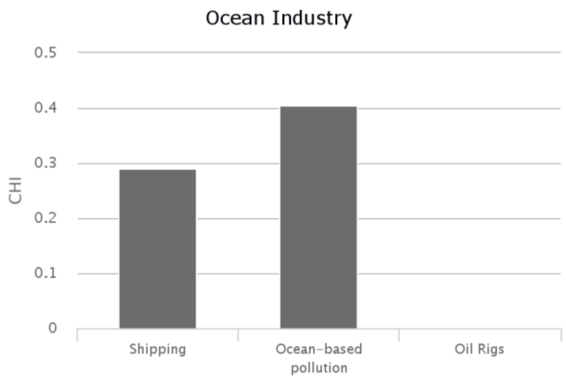
Marine Protected Area change
The Canary Current LME experienced an increase in MPA coverage from 7,366 km2 prior to 1983 to 13,425 km2 by 2014. This represents an increase of 82%, within the lowest category of MPA change.

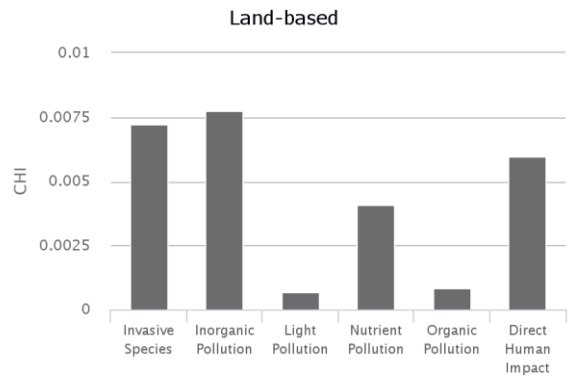
Cumulative Human Impact
The Canary Current LME experiences well above average overall cumulative human impact (score 4.63; maximum LME score 5.22). It falls in risk category 5 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, three connected to climate change have the highest average impact on the LME: ocean acidification (1.05; maximum in other LMEs was 1.20), UV radiation (0.66; maximum in other LMEs was 0.76), and sea surface temperature (1.82; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, sea level rise, ocean based pollution, and all three types of demersal commercial fishing (demersal destructive, non-destructive low-bycatch, and non-destructive high-bycatch).





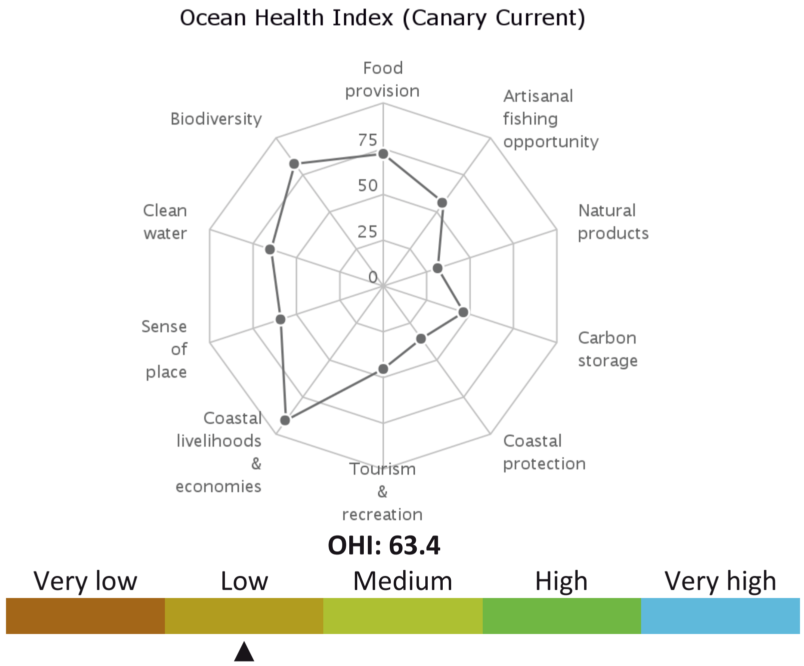
a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing





Ocean Health Index

The Canary Current LME scores above average on the Ocean Health Index compared to other LMEs (score 72 out of 100; range for other LMEs was 57 to 82) but still relatively low. This score indicates that the LME is well below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 decreased 1 point compared to the previous year, due in large part to changes in the score for natural products. This LME scores lowest on mariculture, coastal protection, carbon storage, tourism & recreation and iconic species goals and highest on artisanal fishing opportunities and coastal livelihoods goals. It falls in risk category 2 of the five risk categories, which is a moderate level of risk (1 = lowest risk; 5 = highest risk).



Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for this LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The coastal area stretches over 352 345 km^2. A current population of 33 735 thousand in 2010 is projected to increase to 71 914 thousand in 2100, with a density of 96 persons per km^2 in 2010 increasing to 204 per km^2 by 2100. About 45% of coastal population lives in rural areas, and is projected to increase in share to 56% in 2100.

Total population		Rural population	
2010	2100	2010	2100
33,734,742	71,913,903	15,118,657	39,951,644

Legend: Very low, Low, Medium, High, Very high

Coastal poor

The indigent population makes up 26% of the LME's coastal dwellers. This LME places in the very high-risk category based on percentage and in the high-risk category using absolute number of coastal poor (present day estimate).

Coastal poor
8,801,511

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. This LME ranks in the very high-revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $2 624 million for the period 2001-2010. Fish protein accounts for 25% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013

$39 268 million places it in the high-revenue category. On average, LME-based tourism income contributes 16% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for this LME falls in the category with high risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
2,624,422,433	25.1	39,267,538,357	16.2	0.8157

Legend:

Very low | Low | Medium | High | Very high

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day LME HDI belongs to the very low HDI and very high-risk category. Based on an HDI of 0.583, this LME has an HDI Gap of 0.417, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.

HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). This LME is projected to assume a place in the very low risk category (very high HDI) in 2100 under a sustainable development pathway. Under a fragmented world scenario, the LME is estimated to place in a very high-risk category (very low HDI) because of reduced income levels and increased population values from those estimated in a sustainable development scenario.

	HDI 2100	
HDI	SSP1	SSP3
0.5834	0.8359	0.3591

Legend:

Very low | Low | Medium | High | Very high

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (e.g. overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index of this LME is within the very high-risk (very high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is very high. In a sustainable development scenario, the risk index from sea level rise in 2100 is very low, and increases to very high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	Contemporary Threat	SSP1	SSP3
0.8193	0.5439	0.4657	0.7379

Legend:

Very low | Low | Medium | High | Very high

Governance

Governance architecture

In this LME, the two transboundary arrangements for fisheries (SRFC and CECAF) in the areas within national jurisdiction are closely connected. So are the two arrangements for pollution and biodiversity that fall under the Abidjan Convention. However neither of these pairs appears to be integrated with each other or with the tuna arrangement. No integrating mechanisms, such as an overall policy coordinating organisation for the LME, could be found. There may be interaction amongst the arrangements through participation in each other's meetings, but this appears to be informal.

The overall scores for ranking of risk were:

Engagement	Completeness	Integration
69	46	0.2

Legend:

Very low | Low | Medium | High | Very high

LME 32 – Arabian Sea

Bordering countries: Bahrain, Djibouti, India, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, Somalia, United Arab Emirates, Yemen.

LME Total area: 3,950,421 km^2

List of indicators

LME overall risk

This LME falls in the cluster of LMEs that exhibit low to medium levels of economic development (based on the night light development index) and medium levels of collapsed and overexploited fish stocks.

Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is very high.

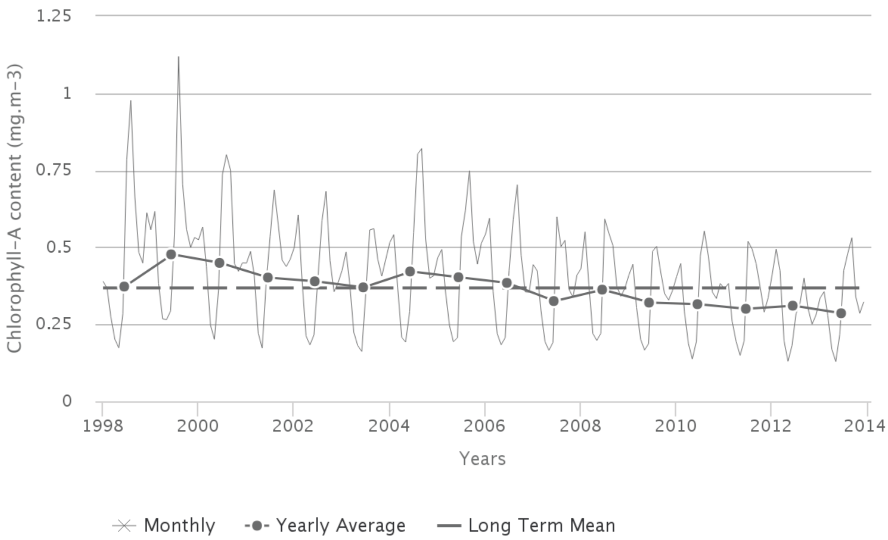
Very low	Low	Medium	High	Very high
				▲

Productivity

Chlorophyll-A

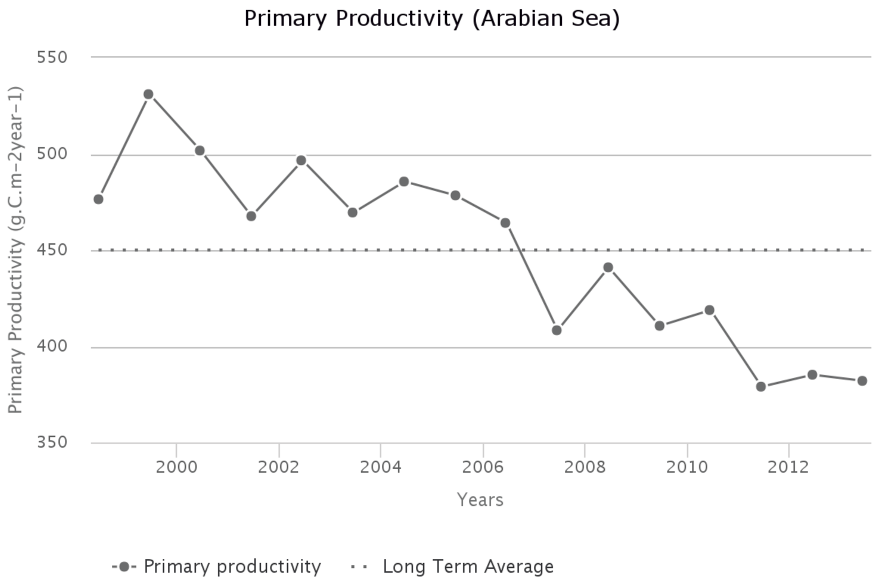
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.674 $mg.m^{-3}$) in August and a minimum (0.176 $mg.m^{-3}$) during May. The average CHL is 0.368 $mg.m^{-3}$. Maximum primary productivity (531 $g.C.m^{-2}.y^{-1}$) occurred during 1999 and minimum primary productivity (379 $g.C.m^{-2}.y^{-1}$) during 2011. There is a statistically insignificant decreasing trend in Chlorophyll of -18.2 % from 2003 through 2013. The average primary productivity is 450 $g.C.m^{-2}.y^{-1}$, which places this LME in Group 5 of 5 categories (with 1 = lowest and 5= highest).

Chlorophyll-A (Arabian Sea)



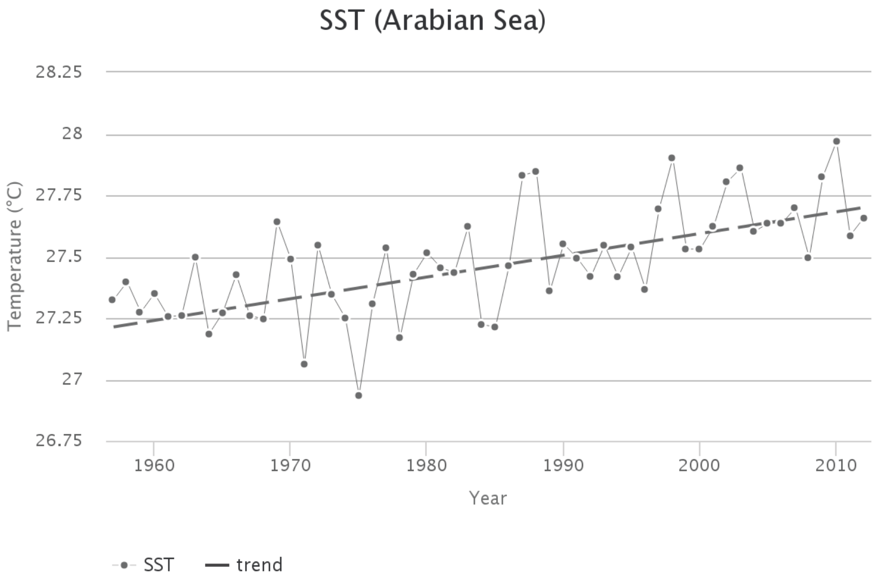
Very low	Low	Medium	High	Very high
				▲

Primary productivity



Sea Surface Temperature

From 1957 to 2012, the Arabian Sea LME #32 has warmed by 0.48°C, thus belonging to Category 3 (moderate warming LME). Like all Indian Ocean LMEs, the Arabian Sea warmed slowly and steadily, except for a sharp drop below 27°C in 1975. Interannual variability of SST in this LME is relative small, with a magnitude of ~0.5°C. The most pronounced event, the all-time minimum of 1975, was likely caused by large-scale forcing since it occurred simultaneously across the entire northern Indian Ocean, including the Red Sea LME #33 and the Bay of Bengal LME #34. The near-all-time maximum of 1998 occurred simultaneously with most Indian Ocean LMEs and only one year before a near-all-time maximum of 1999 in the Red Sea. The rapid warming between 1985 and 1987 ushered in the modern warm epoch in the Arabian Sea. This warming occurred nearly synchronously with a similar warming in the Somali Coastal Current LME #31.

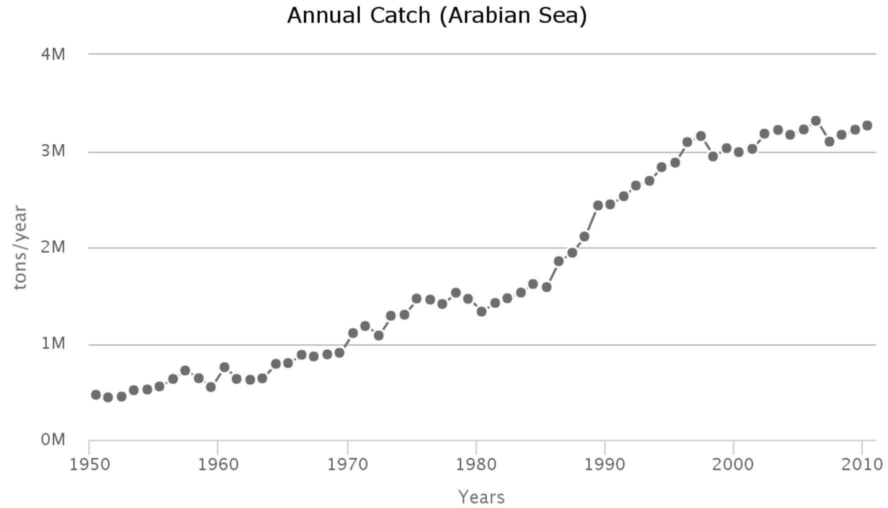


Fish and Fisheries

The fisheries of the Arabian Sea LME are multi-gear and multi-species and include both artisanal and commercial sectors, with the former being dominant. Among the major exploited groups are Indian oil sardine (*Sardinella longiceps*), caught mainly off India's west coast. However, nearly half of the reported landings in the LME are identified only as 'marine fish'.

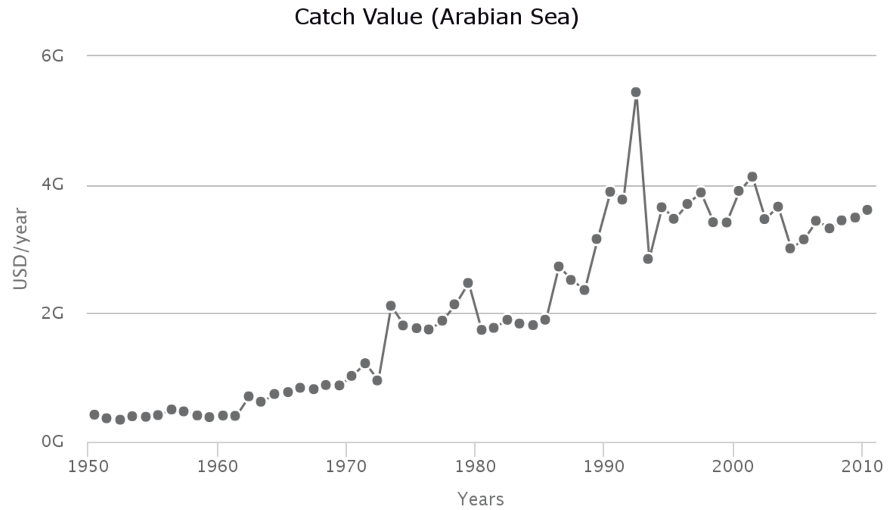
Annual Catch

Total reported landings increased steadily, reaching 3.3 million t in 2006.



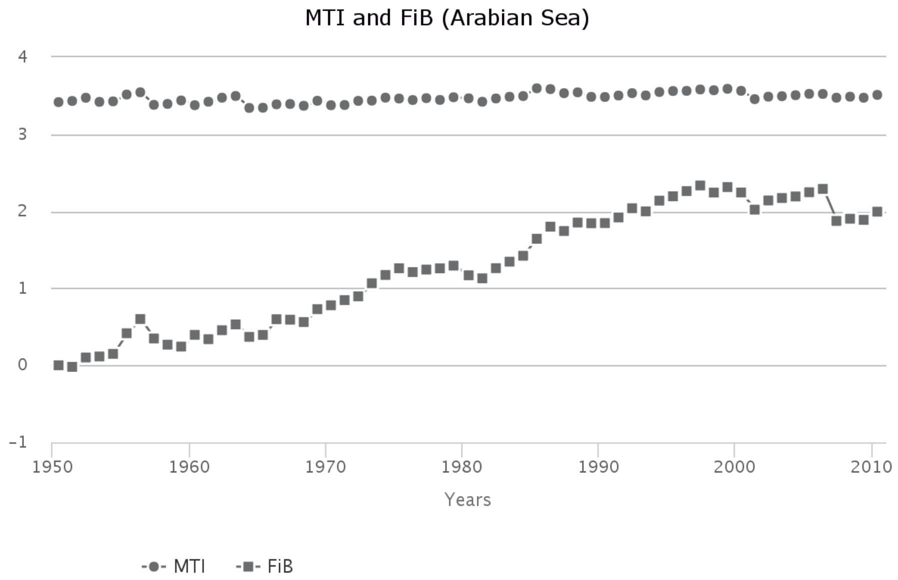
Catch value

The value of the reported landings reached around 5.5 billion US$ (in 2005 value) in 1992.



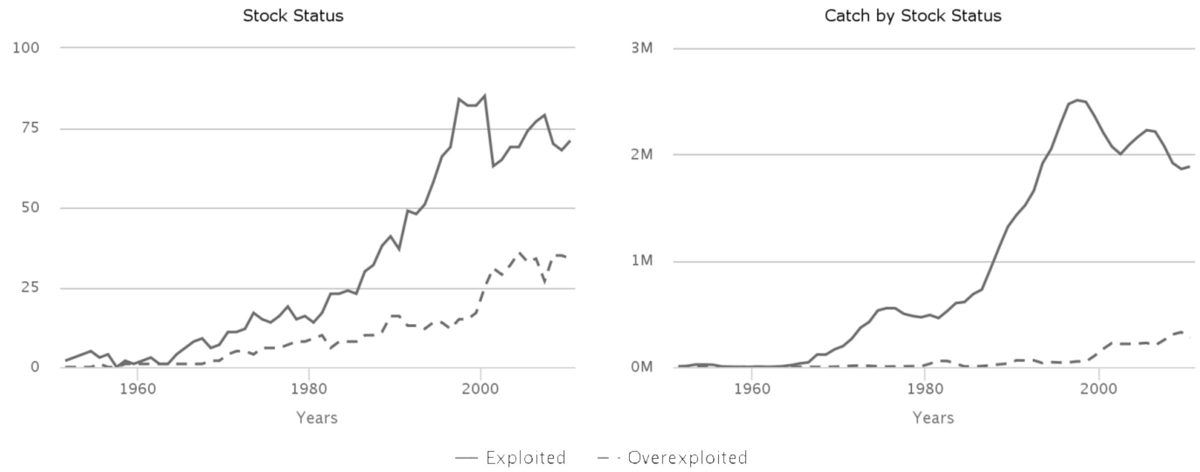
Marine Trophic Index and Fishing-in-Balance index

From the early 1980s to the late 1990s, both the MTI and the FiB index showed an increase, consistent with a spatial (offshore) expansion of fisheries targeting high trophic level large pelagic fishes in the region. However, MTI computed without the landings of tuna and other large pelagic species shows a steady decline since 1975, suggesting the occurrence of a strong 'fishing down' effect.



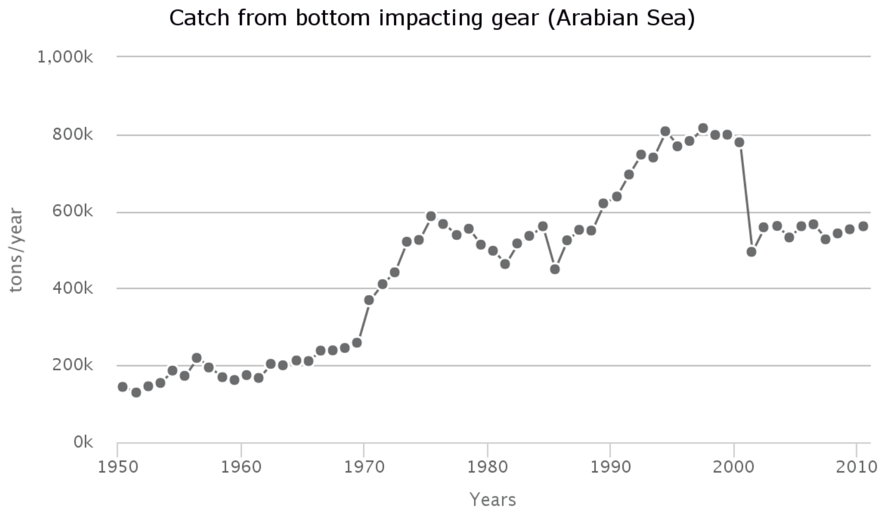
Stock status

The Stock-Catch Status Plots indicate that the number of collapsed and overexploited stocks in the LME have been rapidly increasing, to more than 30% in recent years, but that over 80 % of the catch is still taken from fully exploited stocks.



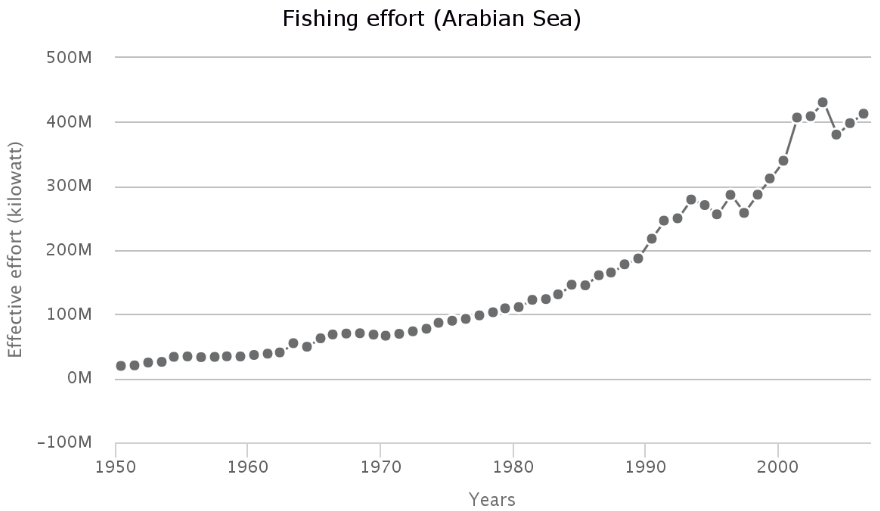
Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch increased from 30% in the 1950s to its first peak at around 40% in 1971. Then, this percentage kept decreasing and fluctuated around 17% in recent decade.



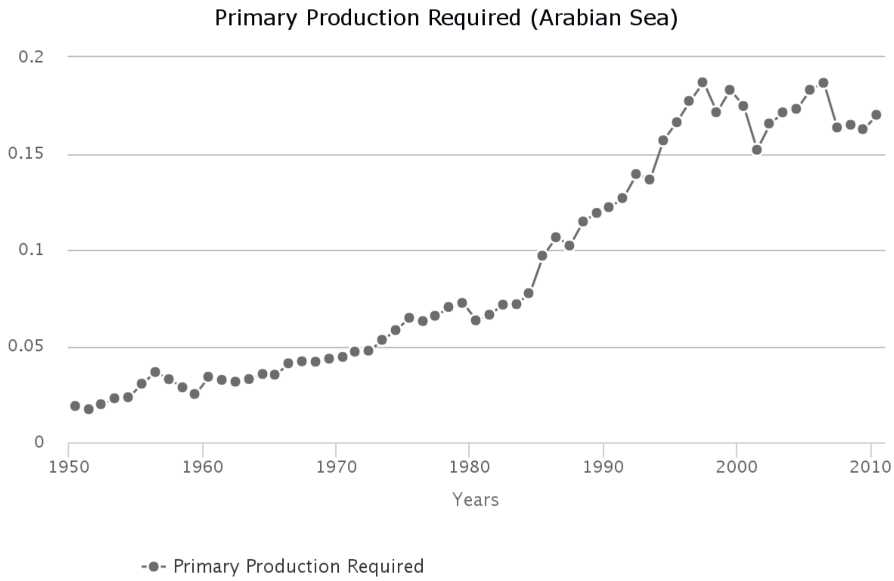
Fishing effort

The total effective effort continuously increased from around 20 million kW in 1950 to its peak around 430 million kW in the mid-2000s.



Primary Production Required

The primary production required (PPR) to sustain the reported landings in this LME reached 20% of the observed primary production in the mid-1990s, but has since declined.



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular *nitrogen load*) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the *ratio of nutrients* entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans. An overall nutrient indicator (*Merged Nutrient Indicator*) based on 2 sub-indicators: *Nitrogen Load* and *Nutrient Ratio* (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated..

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was moderate (level 3 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a “current trends” scenario (Global Orchestration), this remained the same in 2030 and 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was moderate (3). According to the Global Orchestration scenario, this remained the same in 2030 and increased to high in 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was moderate (3). According to the Global Orchestration scenario, this remained the same in 2030 and increased to high in 2050.

2000			2030			2050		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
3	3	3	3	3	3	3	4	4

Legend: Very low, Low, Medium, High, Very high

POPs

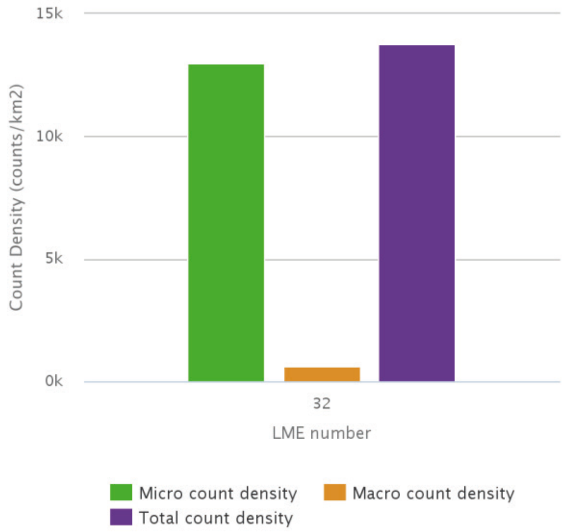
Data are available for only one sample at one location in Mumbai, India. This location shows moderate concentration for PCBs (53 ng.g^{-1} of pellets), corresponding to risk category 3, and low concentration for DDTs (10 ng.g^{-1}) and minimal concentration for HCHs (1.8 ng.g^{-1}), corresponding to risk category 2 of the five risk categories (1 = lowest risk; 5 = highest risk). Moderate concentration of PCBs could be derived from old electronic instruments. Due to the rapid economic growth and associated pollution concerns, extensive monitoring is necessary in this LME.

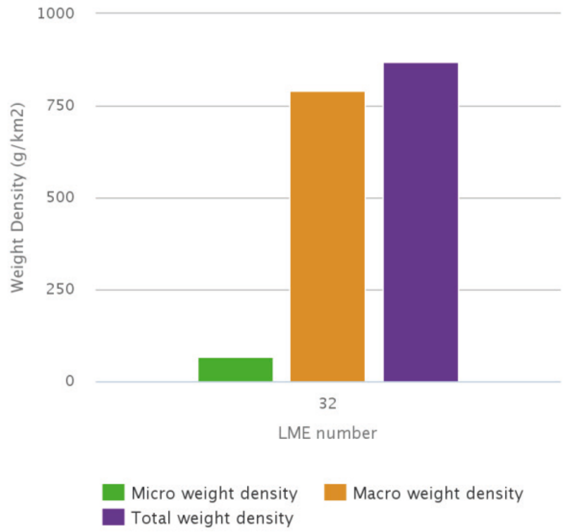
	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk
1	53	**3**	10	**2**	1.8	**1**

Legend: Very low, Low, Medium, High, Very high

Plastic debris

Modelled estimates of floating plastic abundance (items km^{-2}), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with relatively high levels of plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The high values are due to the relative importance of these sources in this LME. The abundance of floating plastic in this category is estimated to be on average over 100 times higher that those LMEs with lowest values. There is limited evidence from sea-based direct observations and towed nets to support this conclusion.





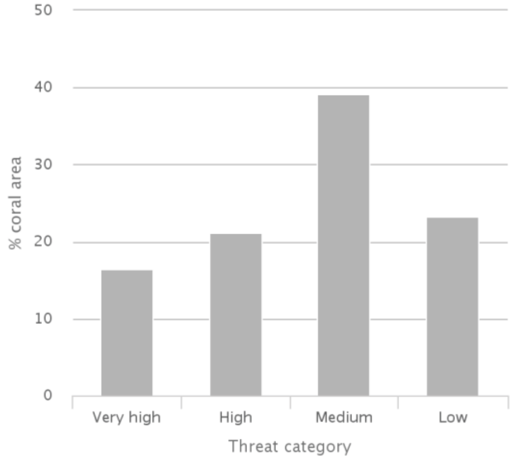
Ecosystem Health

Mangrove and coral cover

0.03% of this LME is covered by mangroves (US Geological Survey, 2011) and 0.1% by coral reefs (Global Distribution of Coral Reefs, 2010).

Reefs at risk

This LME has a present (2011) integrated threat index (combining threat from overfishing and destructive fishing, watershed-based and marine-based pollution and damage) of 231. 22% of coral reefs cover is under very high threat, and 15% under high threat (of the 5 possible threat categories, from low to critical). When combined with past thermal stress (between 1998 and 2007), these values increase to 24% and 25% for very high and high threat categories respectively. By year 2030, 23% of coral cover in this LME is predicted to be under very high to critical level of threat from warming and acidification; this proportion increases to 37% by 2050.

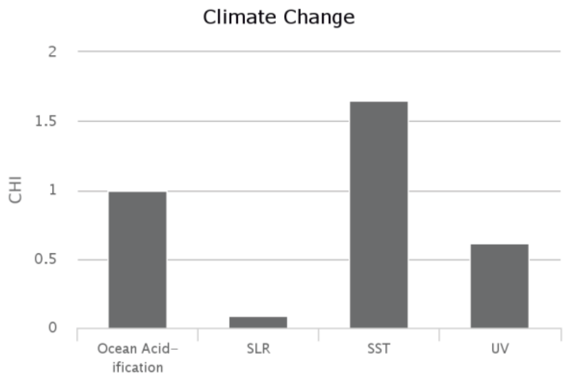


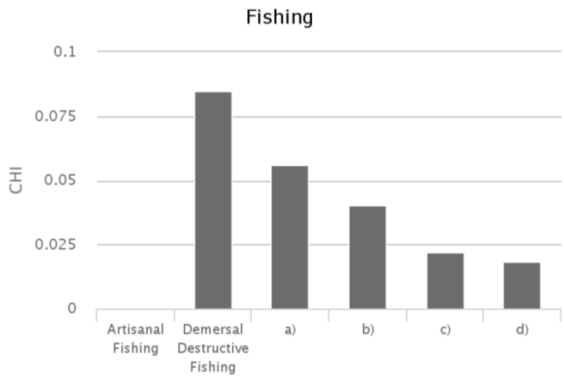
Marine Protected Area change

The Arabian Sea LME experienced an increase in MPA coverage from 2,071 km^2 prior to 1983 to 12,449 km^2 by 2014. This represents an increase of 501%, within the low category of MPA change.

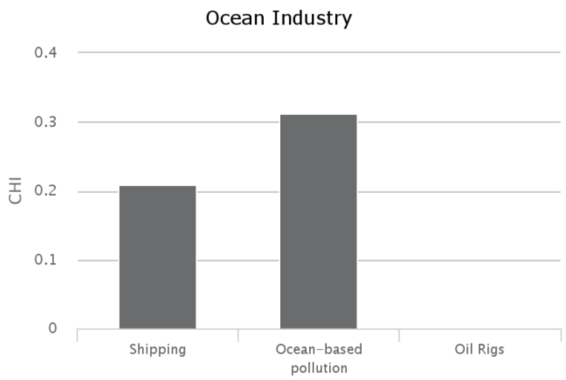
Cumulative Human Impact

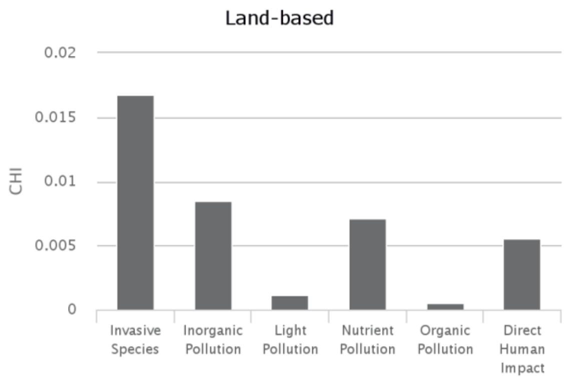
The Arabian Sea LME experiences an above average overall cumulative human impact (score 4.12; maximum LME score 5.22), which is also well above the LME with the least cumulative impact. It falls in risk category 4 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, three connected to climate change have the highest average impact on the LME: ocean acidification (1.00; maximum in other LMEs was 1.20), UV radiation (0.61; maximum in other LMEs was 0.76), and sea surface temperature (1.65; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, sea level rise, ocean based pollution, demersal destructive commercial fishing, and demersal non-destructive low-bycatch commercial fishing.





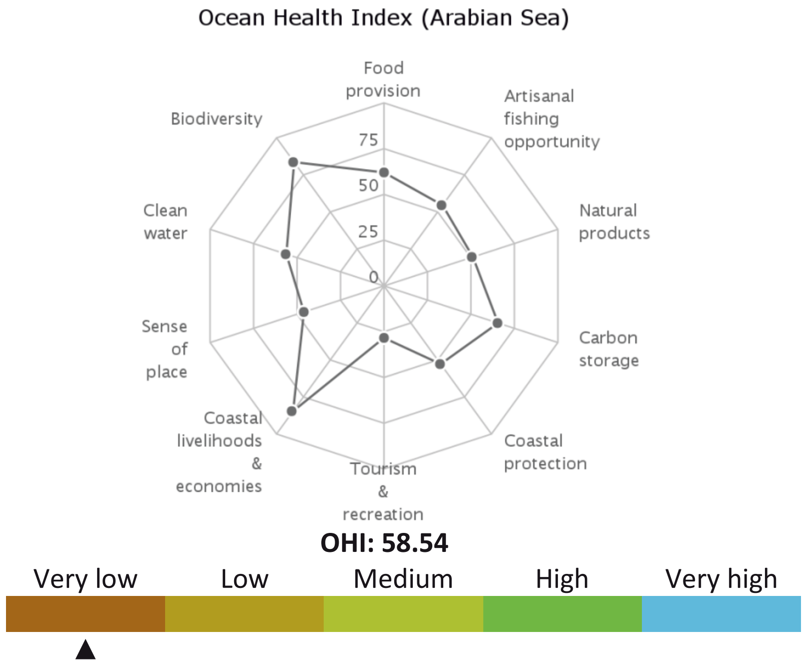
a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing





Ocean Health Index

The Arabian Sea LME scores below average on the Ocean Health Index compared to other LMEs (score 66 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is well below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 remained unchanged compared to the previous year. This LME scores lowest on mariculture, coastal protection, tourism & recreation, and sense of place goals and highest on artisanal fishing opportunities and coastal economies goals. It falls in risk category 5 of the five risk categories, which is the highest level of risk (1 = lowest risk; 5 = highest risk).



Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for this LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The coastal area stretches over 513 873 km^2. A current population of 27 950 thousand in 2010 is projected to increase to 108 998 thousand in 2100, with a density of 54 persons per km^2 in 2010 reaching 202 per km^2 by 2100. About 58% of coastal population lives in rural areas, and is projected to increase in share to 68% in 2100.

Total population		Rural population	
2010	2100	2010	2100
192,379,489	316,830,284	94,565,089	164,612,205

Legend: Very low, Low, Medium, High, Very high

Coastal poor

The indigent population makes up 24% of the LME's coastal dwellers. This LME places in the very high-risk category based on percentage and in the high-risk category using absolute number of coastal poor (present day estimate).

Coastal poor
43,095,719

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. This LME ranks in the low-revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $230 million for the period 2001-2010. Fish protein accounts for 9% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013 $12 134 million places it in the low-revenue category. On average, LME-based tourism income contributes 7% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for this LME falls in the category with high risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
4,130,753,748	11.7	53,384,607,318	7.2	0.7750

Legend: Very low, Low, Medium, High, Very high

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day LME HDI belongs to the low HDI and high-risk category. Based on an HDI of 0.648, this LME has an HDI Gap of 0.352, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.

HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). This LME is projected to assume a place in the very low risk category (very high HDI) in 2100 under a sustainable development pathway. Under a fragmented world scenario, the LME is estimated to place in a very high-risk category (very low HDI) because of reduced income levels and increased population values from those in a sustainable development pathway.

	HDI 2100	
HDI	SSP1	SSP3
0.6184	0.8529	0.4432

Legend: Very low, Low, Medium, High, Very high

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (e.g. overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m^2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index of this LME is within the high-risk (high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is high. In a sustainable development scenario, the risk index from sea level rise in 2100 is very low, and increases to very high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	**Contemporary Threat**	**SSP1**	**SSP3**
0.9389	0.4828	0.4650	0.7248

Legend: Very low, Low, Medium, High, Very high

Governance

Governance architecture

While this LME has two separate regional seas agreements (in place covering pollution (LBS and MBS) and biodiversity (Kuwait and Jeddah Conventions and protocols), no overarching integrating mechanisms, such as an overall policy coordinating organisation for the LME, could be found. There may be interaction amongst the arrangements through participation in each other's meetings, but this appears to be informal. In terms of transboundary fisheries arrangements, these are also not formally integrated although informal linkages may be present at some level.

The overall scores for ranking of risk were:

Engagement	Completeness	Integration
86	**45**	**0.1**

Legend: Very low, Low, Medium, High, Very high

LME 33 – Red Sea

Bordering countries: Djibouti, Egypt, Eritrea, Israel, Jordan, Saudi Arabia, Sudan, Yemen.
LME Total area: 480,385 km^2

List of indicators

LME overall risk

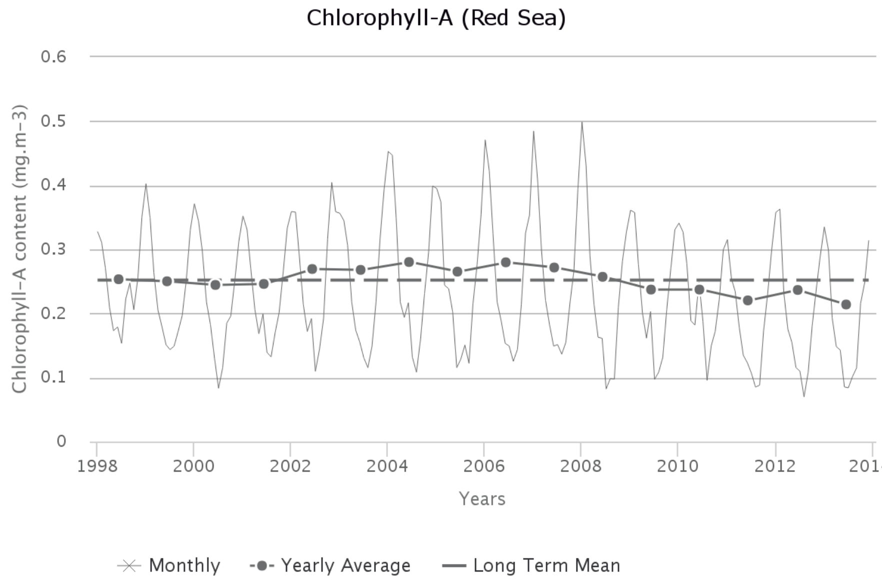
This LME falls in the cluster of LMEs that exhibit high rates of increase in MPA coverage.
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is high.

Very low | Low | Medium | High | Very high

Productivity

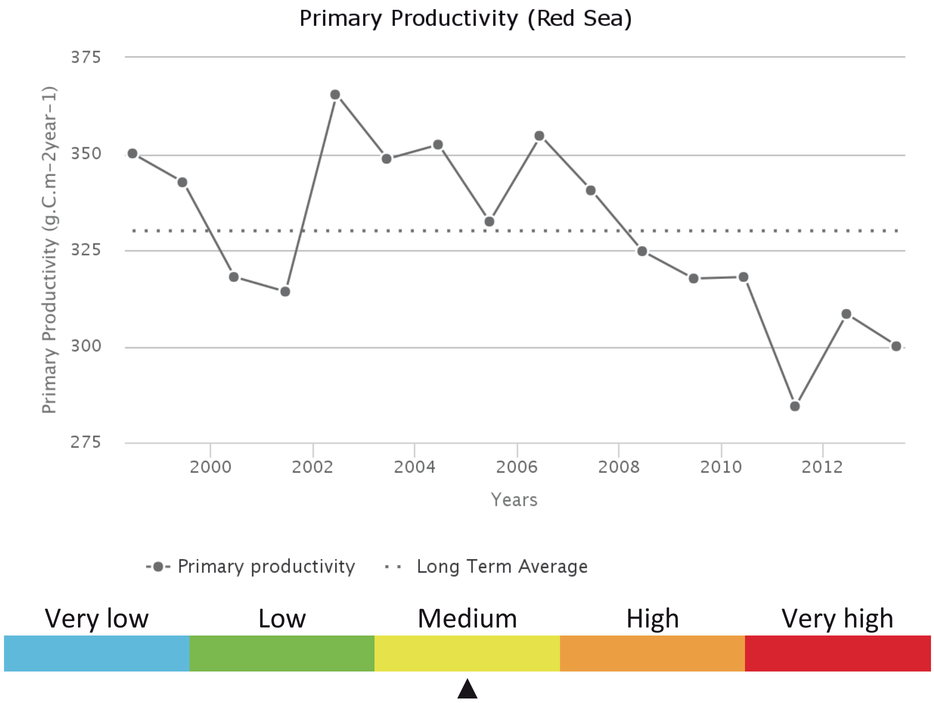
Chlorophyll-A 2

The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.390 mg.m^{-3}) in January and a minimum (0.183 mg.m^{-3}) during September. The average CHL is 0.252 mg.m^{-3}. Maximum primary productivity (365 g.C.m^{-2}.y^{-1}) occurred during 2002 and minimum primary productivity (284 g.C.m^{-2}.y^{-1}) during 2011. There is a statistically insignificant decreasing trend in Chlorophyll of -22.1 % from 2003 through 2013. The average primary productivity is 330 g.C.m^{-2}.y^{-1}, which places this LME in Group 3 of 5 categories (with 1 = lowest and 5= highest).



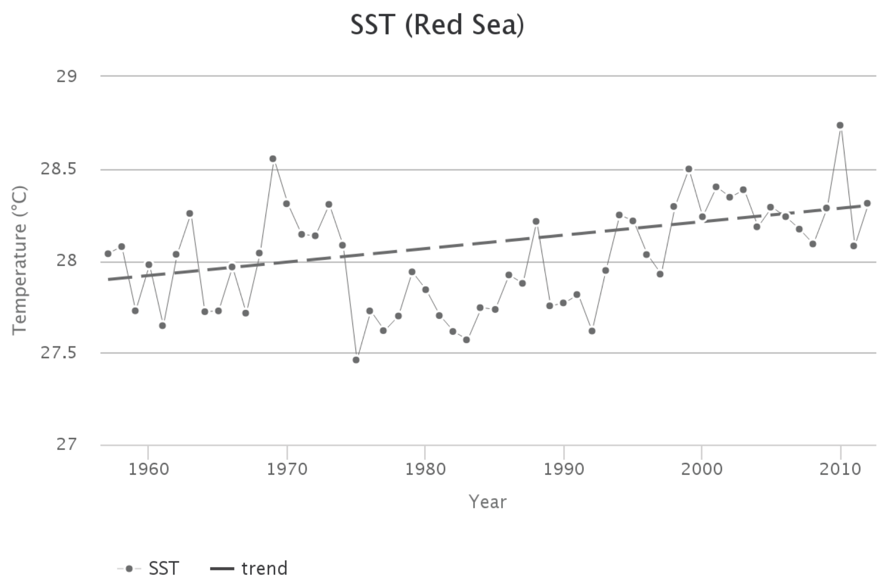
Very low | Low | Medium | High | Very high

Primary productivity



Sea Surface Temperature

From 1957 to 2012, the Red Sea LME #33 has warmed by 0.40°C, thus being on a threshold between Categories 3 and 4 (moderate-to-slow warming LME). The Red Sea saw its SST rising rather gradually except for a sharp drop in the mid-1970s. The most recent peak SST of 28.7°C in 2010 marked the all-time maximum. Using the all-time minimum of 27.4°C in 1975 as a reference point, SST rose by 1.4°C to 28.8°C in 2012. As a relatively small land-locked water body, the Red Sea and its thermal regime, especially of the surface layer, are heavily influenced by the terrestrial climates of adjacent landmasses of Africa and the Arabian Peninsula.



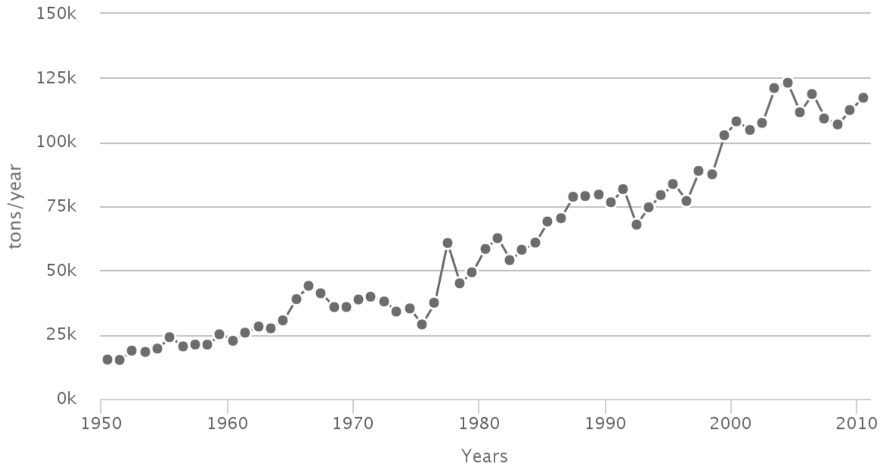
Fish and Fisheries

About 1,200 species of fish are known to occur in the Red Sea LME, and marked differences occur in fish species richness, assemblage compositions and species abundance in different parts of the Red Sea, reflecting the heterogeneous nature of its environment. Fishing occurs mainly at the subsistence or artisanal levels, although commercial trawling and purse seining are also carried out in Egypt, Saudi Arabia and Yemen

Annual Catch

Total reported landings from this LME have increased steadily, recording over 130,000 t in 2004, most of it in the "mixed group".

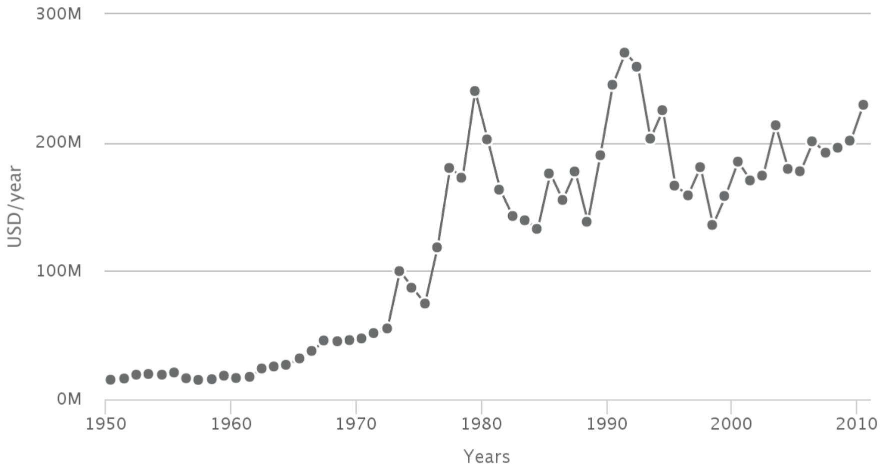
Annual Catch (Red Sea)



Catch value

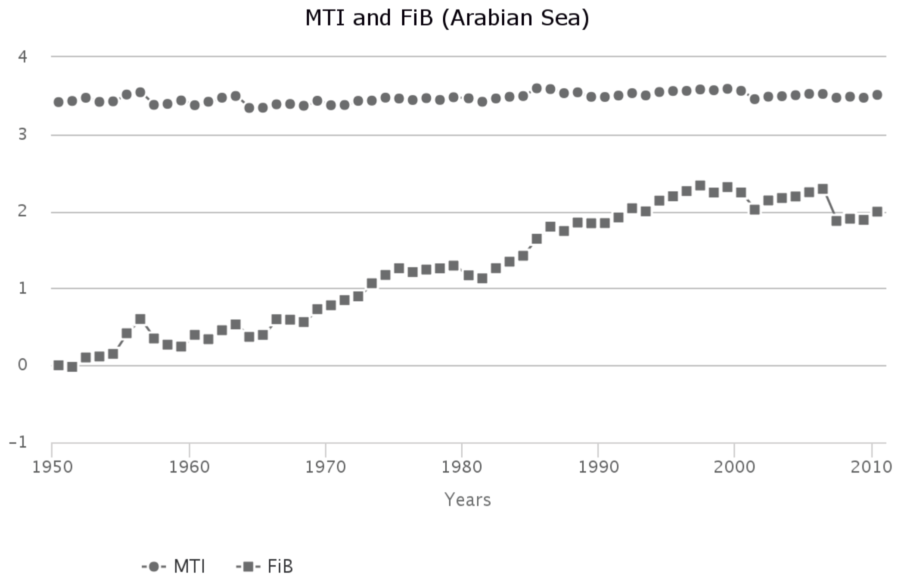
The value of the reported landings also increased to about 270 million US$ in 1991 (in 2005 real US$).

Catch Value (Red Sea)



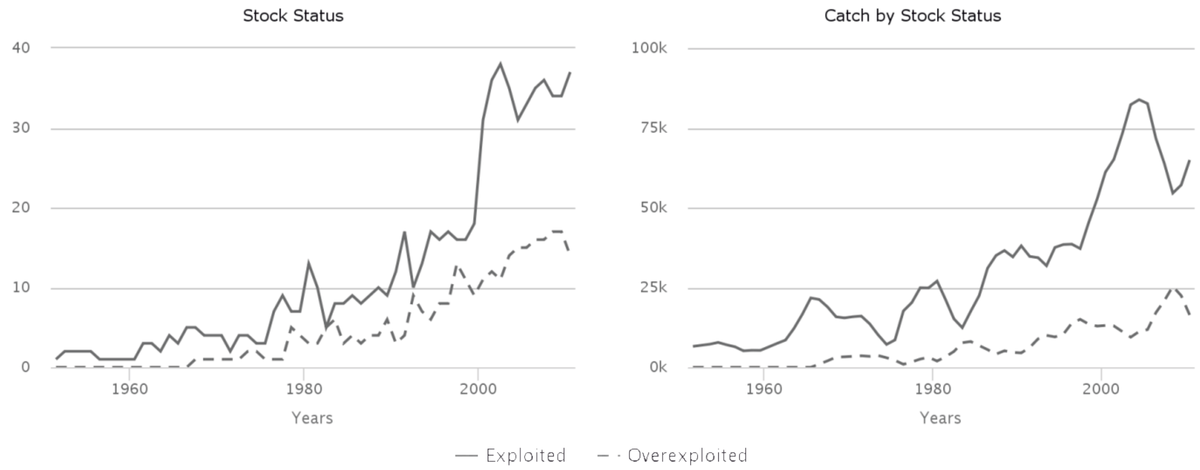
Marine Trophic Index and Fishing-in-Balance index

The fisheries of the Red Sea LME are still expanding, and therefore, they show high and stable MTI values, with an increase in the FiB index.



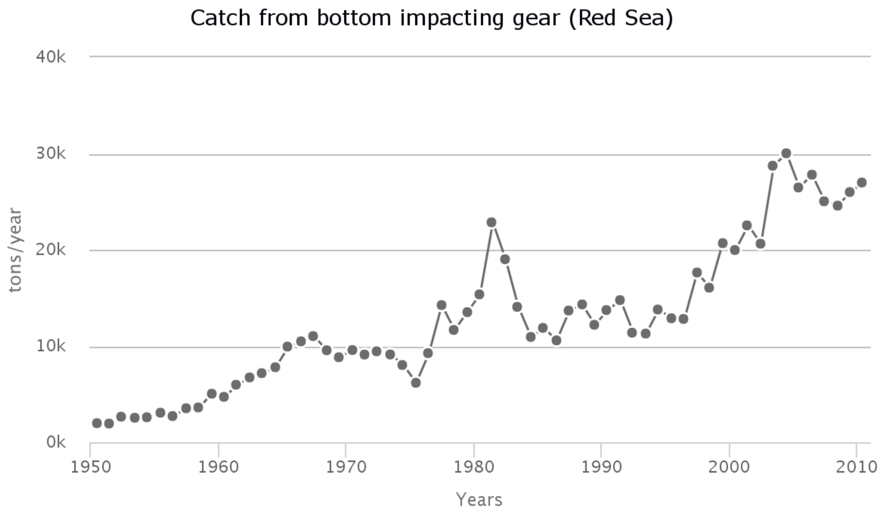
Stock status

The Stock-Catch Status Plots indicate that the number of collapsed stocks is similar to that of overexploited stocks (16 – 17%), but the collapsed stocks only contribute a very small amount of the total catch. About 85% of the catch originates from overexploited and fully exploited stocks.



Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch increased from 13% in the 1950s to its first peak at around 35% in 1981. Then, this percentage kept decreasing and fluctuated around 23% in recent decade.

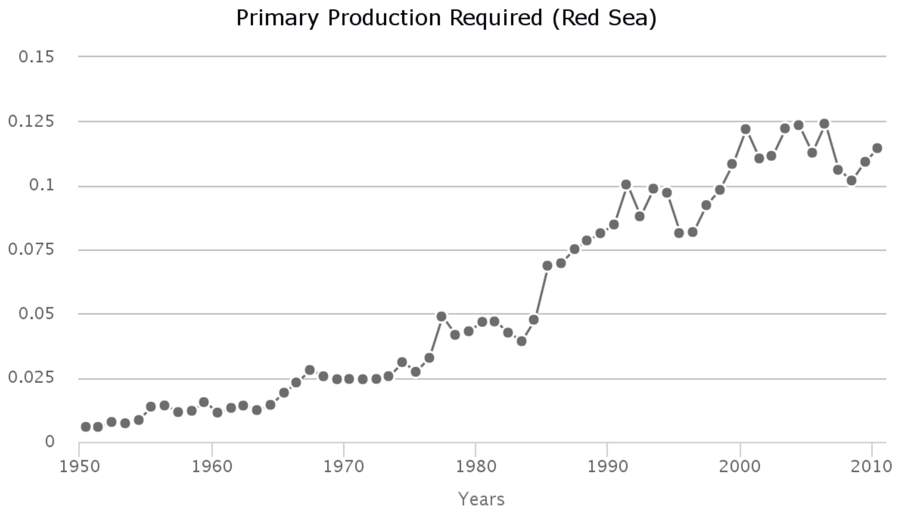


Fishing effort

The total effective effort continuously increased from around 7 million kW in the 1950s to its peak around 70 million kW in the mid-2000s.

Primary Production Required

The primary production required (PPR) to sustain the reported landing in this LME is increasing in recent years, but has yet to reach 10% of the observed primary production.



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular *nitrogen load*) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the *ratio of nutrients* entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans. An overall nutrient indicator (*Merged Nutrient Indicator*) based on 2 sub-indicators: *Nitrogen Load* and *Nutrient Ratio* (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was very low (level 1 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a “current trends” scenario (Global Orchestration), this remained the same in 2030 and 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was high (4). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was very low (1). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

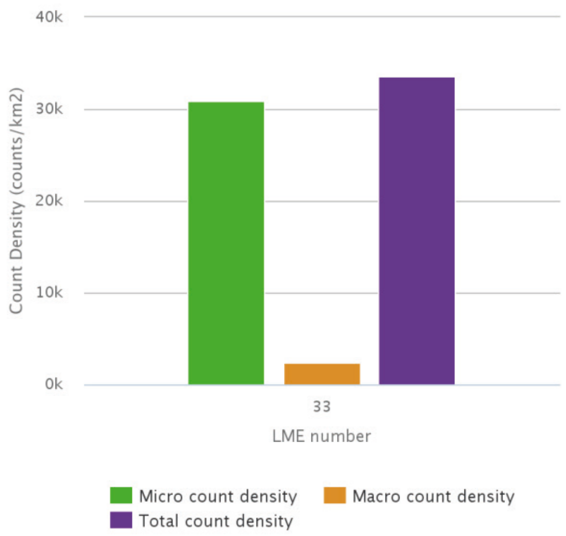
2000			2030			2050		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
1	4	1	1	4	1	1	4	1

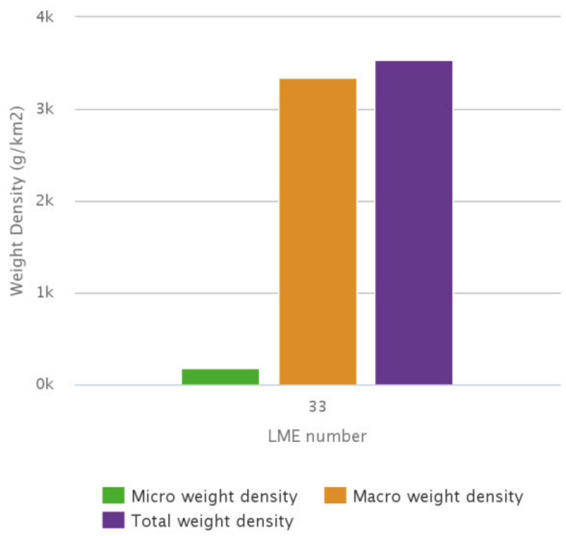
Legend:

Very low Low Medium High Very high

POPs
No pellet samples were obtained from this LME.

Plastic debris
Modelled estimates of floating plastic abundance (items km^{-2}), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with the highest plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The high values are due to relative importance of these sources in this LME. The abundance of floating plastic in this category is estimated to be on average over 400 times higher that those LMEs with lowest values. There is limited evidence from sea-based direct observations and towed nets to support this conclusion.

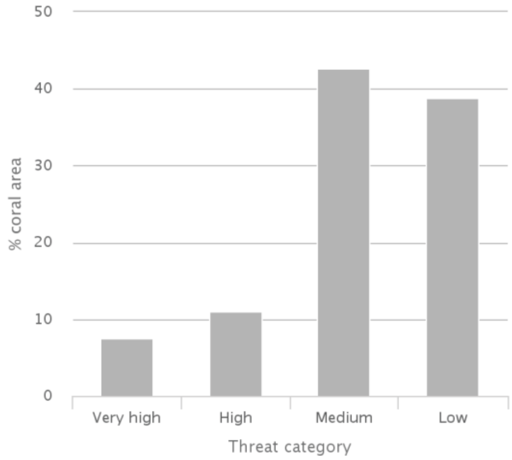




Ecosystem Health

Mangrove and coral cover
0.02% of this LME is covered by mangroves (US Geological Survey, 2011) and 2.7% by coral reefs (Global Distribution of Coral Reefs, 2010).

Reefs at risk
This LME has a present (2011) integrated threat index (combining threat from overfishing and destructive fishing, watershed-based and marine-based pollution and damage) of 187. This is the highest integrated threat score of any LME. 11% of coral reefs cover is under very high threat, and 7% under high threat (of the 5 possible threat categories, from low to critical). When combined with past thermal stress (between 1998 and 2007), these values increase to 11% and 23% for very high and high threat categories respectively. By year 2030, 12% of coral cover in this LME is predicted to be under very high to critical level of threat from warming and acidification; this proportion increases to 18% by 2050.

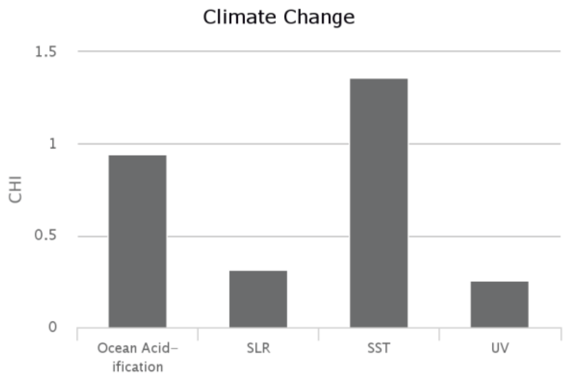


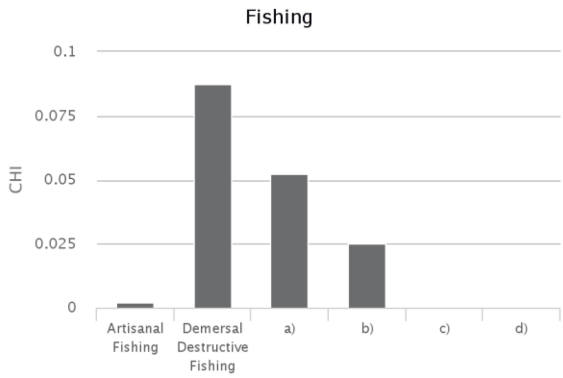
Marine Protected Area change

The Red Sea LME experienced an increase in MPA coverage from 1.7 km^2 prior to 1983 to 16,630 km^2 by 2014. This represents an increase of 50,000%, within the highest category of MPA change.

Cumulative Human Impact

The Red Sea LME experiences an above average overall cumulative human impact (score 3.61; maximum LME score 5.22), which is also well above the LME with the least cumulative impact. It falls in risk category 3 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, all four connected to climate change have the highest average impact on the LME: ocean acidification (0.94; maximum in other LMEs was 1.20), UV radiation (0.26; maximum in other LMEs was 0.76), sea level rise (0.31; maximum in other LMEs was 0.71), and sea surface temperature (1.36; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, ocean based pollution, invasive species, demersal destructive commercial fishing, and demersal non-destructive low-bycatch commercial fishing.





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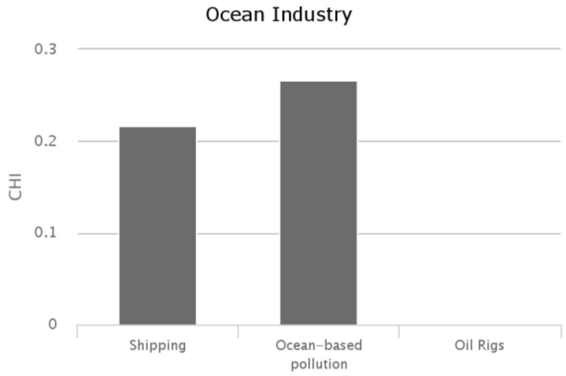
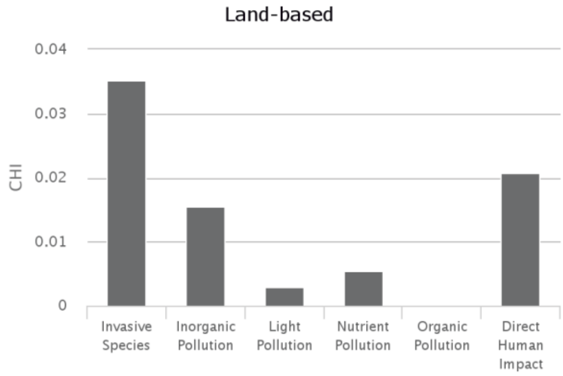
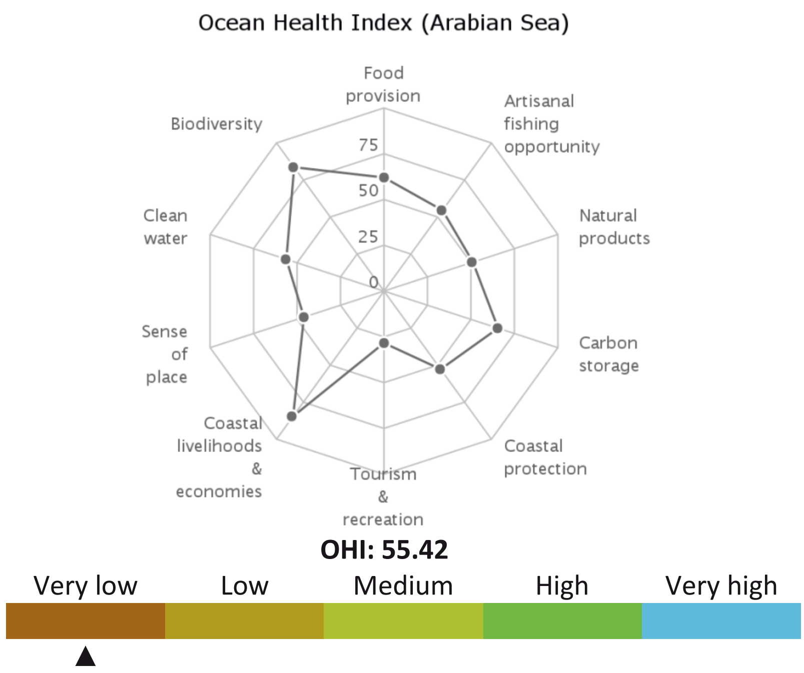




Ocean Health Index

The Red Sea LME has one of the lowest scores on the Ocean Health Index (score 60 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is well below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 decreased 2 points compared to the previous year, due in large part to changes in the scores for natural products and clean waters. This LME scores lowest on mariculture, natural products, coastal protection, tourism & recreation, and sense of place goals and highest on artisanal fishing opportunities and habitat biodiversity goals. It falls in risk category 5 of the five risk categories, which is the highest level of risk (1 = lowest risk; 5 = highest risk).



Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for the this LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The coastal area stretches over 513 873 km^2. A current population of 27 950 thousand in 2010 is projected to increase to 108 998 thousand in 2100, with a density of 54 persons per km^2 in 2010 reaching 202 per km^2 by 2100. About 58% of coastal population lives in rural areas, and is projected to increase in share to 68% in 2100.

Total population		Rural population	
2010	2100	2010	2100
27,949,857	103,998,449	16,155,251	70,332,905

Legend: Very low, Low, Medium, High, Very high

Coastal poor

The indigent population makes up 24% of the LME's coastal dwellers. This LME places in the very high-risk category based on percentage and in the high-risk category using absolute number of coastal poor (present day estimate).

Coastal poor
6,778,119

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. This LME ranks in the medium-revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $230 million for the period 2001-2010. Fish protein accounts for 9% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013

$12 134 million places it in the medium-revenue category. On average, LME-based tourism income contributes 7% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for this LME falls in the category with high risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
230,291,568	9.2	12,133,838,451	6.9	0.8135

Legend: Very low, Low, Medium, High, Very high

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day LME HDI belongs to the low HDI and high risk category. Based on an HDI of 0.648, this LME has an HDI Gap of 0.352, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.

HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). This LME is projected to assume a place in the very low risk category (very high HDI) in 2100 under a sustainable development pathway. Under a fragmented world scenario, the LME is estimated to place in a very high-risk category (low HDI) because of reduced income levels and increased population values from those in a sustainable development pathway.

	HDI 2100	
HDI	SSP1	SSP3
0.6480	0.8163	0.4606

Legend: Very low, Low, Medium, High, Very high

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (e.g. overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index of this LME is within the very high-risk (very high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is high. In a sustainable development scenario, the risk index from sea level rise in 2100 is very low, and increases to very high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	**Contemporary Threat**	**SSP1**	**SSP3**
0.6870	0.3934	0.4606	0.6622

Legend:

Very low Low Medium High Very high

Governance

Governance architecture

The two arrangements for pollution and for biodiversity fall under the Jeddah Convention. However, there does not appear to be any specific regional arrangements for fishing in general nor habitat degradation and its effect on biodiversity within the Red Sea and Gulf of Aden. The transboundary arrangement for turtles and their habitat in the Indian Ocean does not appear to be integrated formally with the other arrangements. No integrating mechanisms, such as an overall policy coordinating organisation for the LME, could be found. There may be interaction amongst the arrangements through participation in each other's meetings, but this appears to be informal.

The overall scores for ranking of risk were:

Engagement	Completeness	Integration
65	**52**	**0.2**

Legend:

Very low Low Medium High Very high

LME 62 – Black Sea

Bordering countries: Turkey, Bulgaria, Romania, Ukraine, Russian Federation, Georgia.
LME Total area: 461398 km^2

List of indicators

LME overall risk

This LME falls in the cluster of LMEs that exhibit low to medium levels of economic development (based on the night light development index) and medium levels of collapsed and overexploited fish stocks.

Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is high..

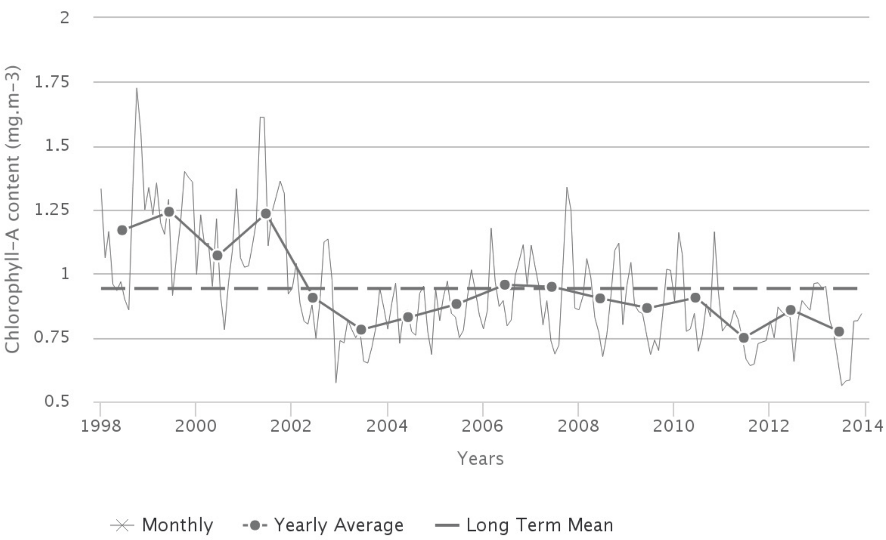
Very low | Low | Medium | High | Very high

Productivity

Chlorophyll-A 2

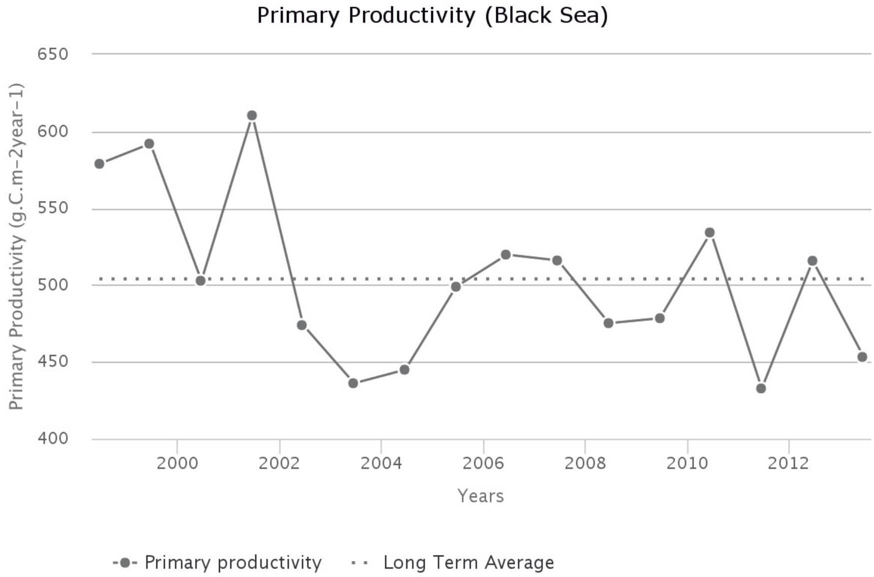
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (1.10 $mg.m^{-3}$) in November and a minimum (0.757 $mg.m^{-3}$) during July. The average CHL is 0.942 $mg.m^{-3}$. Maximum primary productivity (610 $g.C.m^{-2}.y^{-1}$) occurred during 2001 and minimum primary productivity (433 $g.C.m^{-2}.y^{-1}$) during 2011. There is a statistically insignificant decreasing trend in Chlorophyll of -5.30 % from 2003 through 2013. The average primary productivity is 504 $g.C.m^{-2}.y^{-1}$, which places this LME in Group 5 of 5 categories (with 1 = lowest and 5= highest).

Chlorophyll-A (Black Sea)



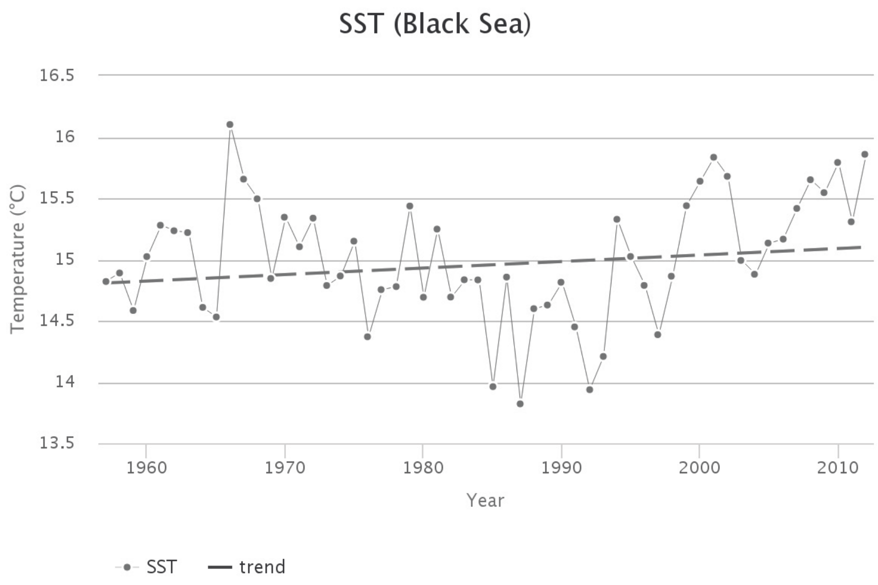
Very low | Low | Medium | High | Very high

Primary productivity



Sea Surface Temperature

From 1957 to 2012, the Black Sea LME #62 has warmed by 0.31°C, thus belonging to Category 4 (slow warming LME). After peaking in 1966 at 16.1°C, SST dropped down to 14.0°C in 1987, an exceptionally cold year in this region. Thus, SST decreased by 2.1°C in 21 years between 1966 and 1987, after which SST rose to 15.8°C in 2001 and remained relatively high through 2012. Yet the long-term linear trend-based warming between 1957 and 2012 was just 0.31°C due to the pronounced cooling of the 1980s-1990s. These numbers compare favorably with those by Ginzburg et al. (2008) who studied seasonal and interannual variability from satellite SST in 1982-2002 and reported the same cold events of 1985, 1987, and 1992-1993 that are evident above; they also found out that winter SST has bottomed out in early 1993 and reported a 3°C increase in summer SST (from 23°C to 26°C) in 1982-2002, with the summertime SST trend being mostly decoupled from the wintertime SST trends except for the last few years. The extreme magnitude of the 1982-2002 trend reported by Ginzburg et al. (2008) is not corroborated by our data.

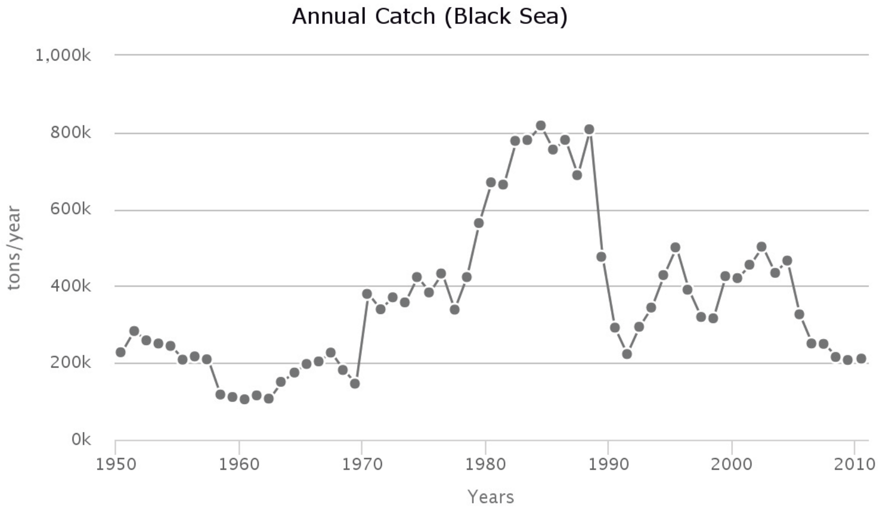


Fish and Fisheries

Marine fisheries are an important economic sector in the countries bordering the Black Sea LME, and virtually all its commercial fish stocks are shared among the bordering countries. In addition to capture fisheries, there is a long history of sturgeon aquaculture in the Azov Sea and more recently, the cultivation of mussels, oysters, shrimp and some finfish. Prior to the 1970s, there were abundant stocks of several valuable species in the LME.

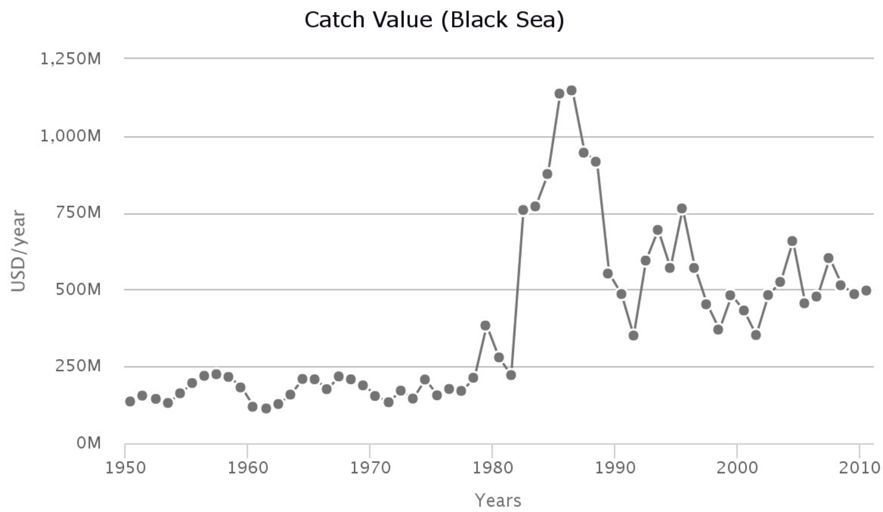
Annual Catch

Total reported landings in this LME showed several peaks and troughs, driven primarily by the fluctuation in the landings of European anchovy, with a peak landing of 820,000 t recorded in 1984. The landings have increased following a precipitous decline from 1989 to 1991, however, they have not returned to the level achieved in the mid-1980s.



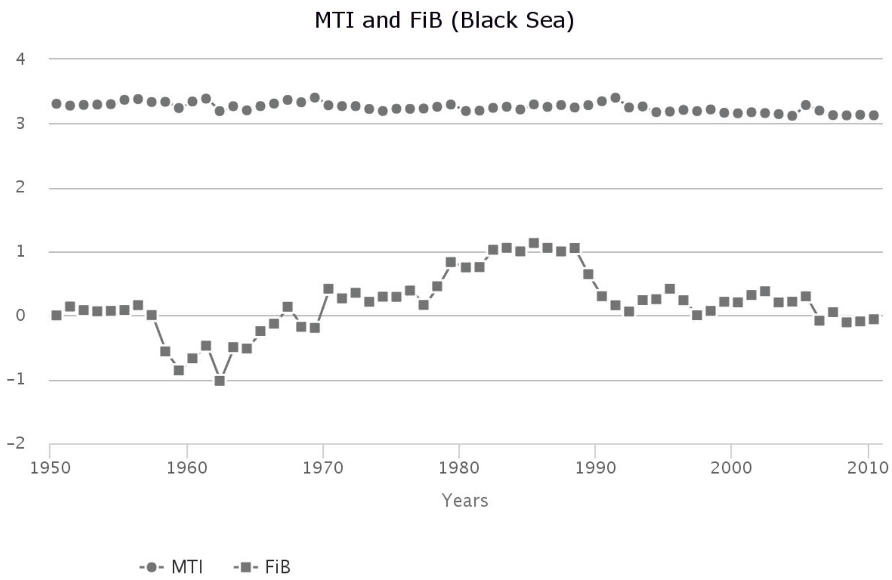
Catch value

The value of the reported landings reflected the trend in the landings, peaking in 1986 at about 1.1 billion US$ (in 2005 real US$).



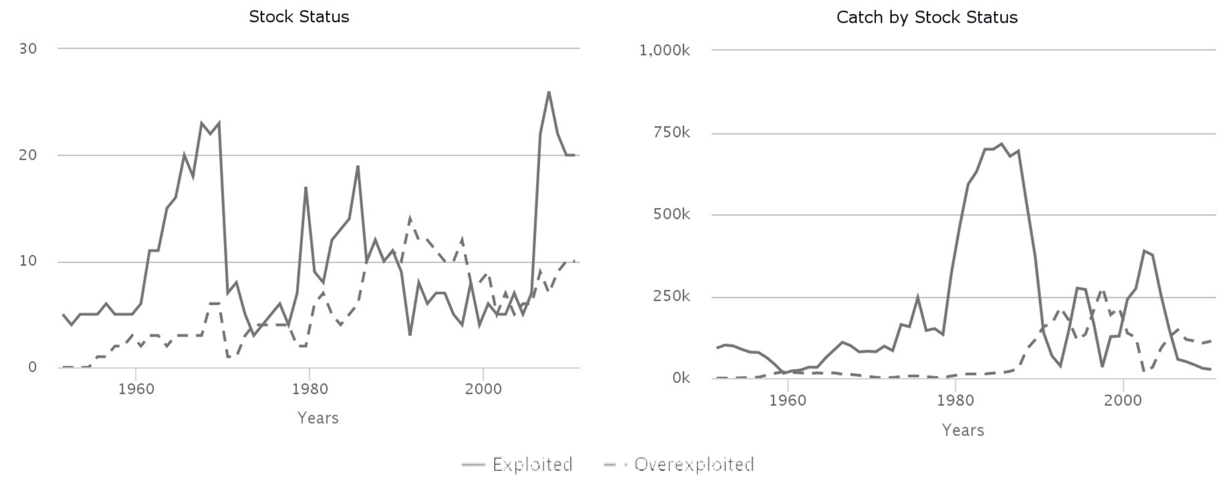
Marine Trophic Index and Fishing-in-Balance index

The MTI has been on a decline since the 1950s, with very low values being observed in the 1990s. The increase in the FiB index from the 1970s to the mid-1980s is driven by the increased reported landings of anchovy during this period. The FiB index declined in the early 1990s, an indication of 'fishing down' of the food web in this LME.



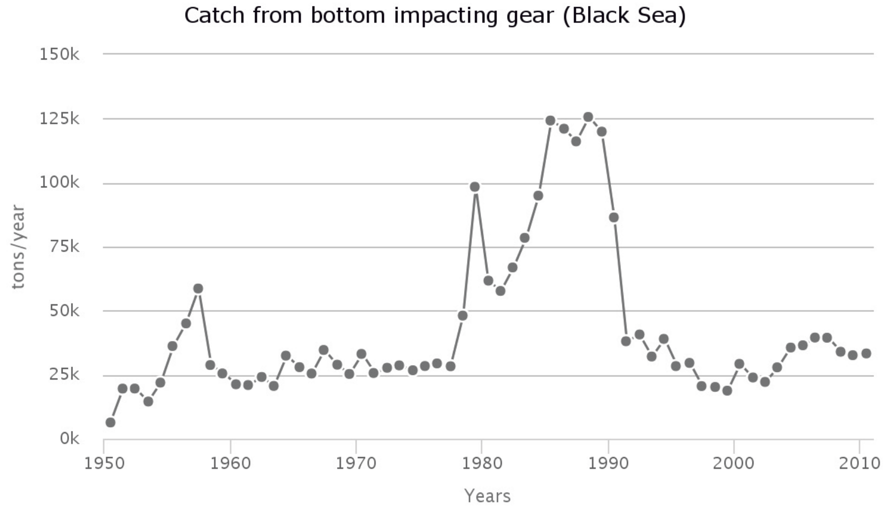
Stock status

The Stock-Catch Status Plots indicate a high level of collapsed stocks (about 30%) which contribute less than 10% of the total catch, with close to 60% of the reported landings coming from overexploited stocks.



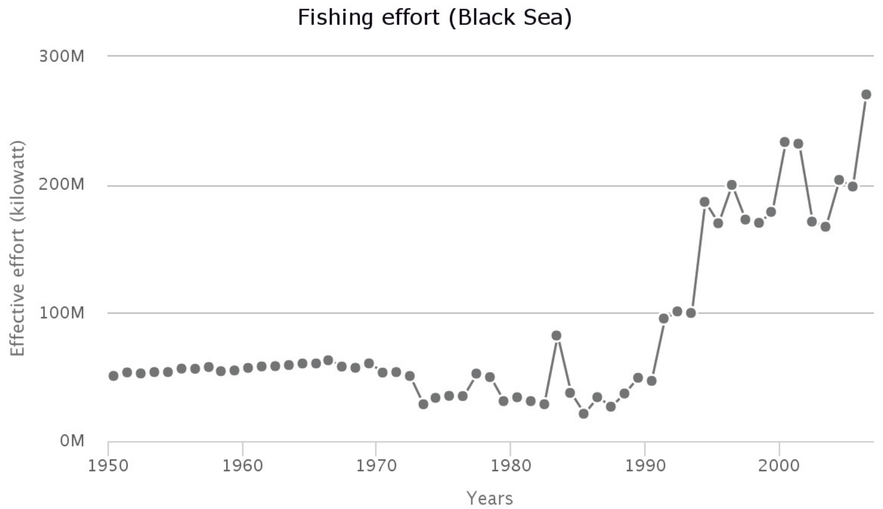
Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch fluctuated between 2 and 30% from 1950 to 2010. This percentage fluctuated between 4 and 16% in the recent decade.

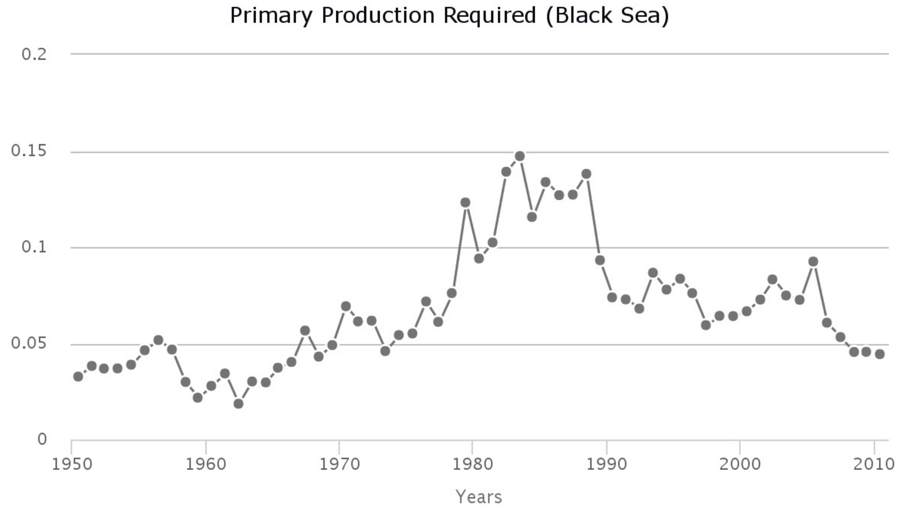


Fishing effort

The total effective effort continuously increased from around 50 million kW in 1950 to its peak around 270 million kW in 2006.



Primary Production Required



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular *nitrogen load*) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the *ratio of nutrients* entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans.

An overall nutrient indicator (*Merged Nutrient Indicator*) based on 2 sub-indicators: *Nitrogen Load* and *Nutrient Ratio* (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was moderate (level 3 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a "current trends" scenario (Global Orchestration), this remained the same in 2030 and 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was high (4). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was high (4). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

2000			2030			2050		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
3	4	4	3	4	4	3	4	4

Legend:
Very low Low Medium High Very high

POPs

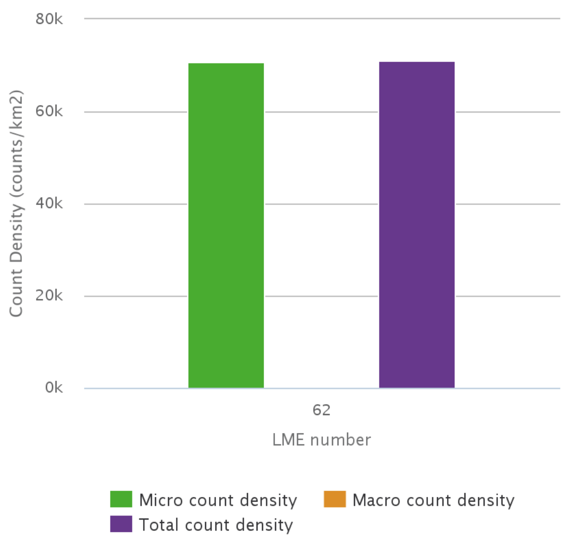
Data are available for only one sample from one location. This shows minimal concentration (ng.g^{-1} of pellets) of 5 for PCBs, low concentration of 15 for DDTs, and moderate concentration of 9.6 for HCHs, corresponding to categories 1,2, and 3, respectively, of the five risk categories (1 = lowest risk; 5 = highest risk). Dominance of DDT over the degradation products was observed, suggesting current inputs of DDTs. Agricultural application and/or antifouling agent may explain the DDTs, although the level was low. The sample was collected in 2009, after the onset of regulation by the Stockholm Convention. Illegal usage is suspected. Extensive monitoring is necessary in this LME.

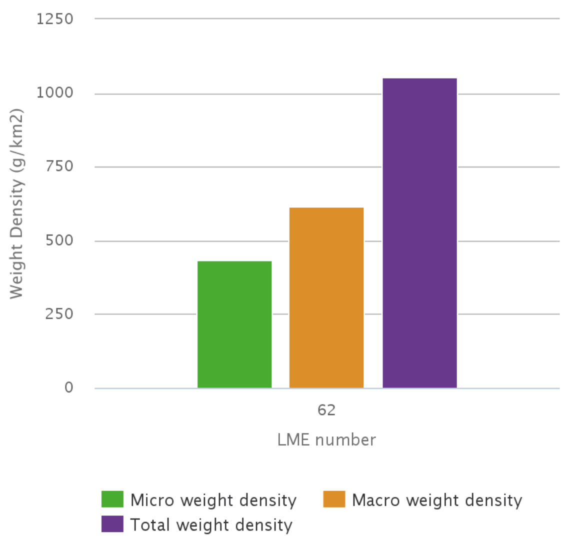
	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk
1	5	**1**	15	**2**	9.6	**3**

Legend: Very low, Low, Medium, High, Very high

Plastic debris

Modelled estimates of floating plastic abundance (items km^{-2}), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with the highest plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The high values are due to relative importance of these sources in this LME. The abundance of floating plastic in this category is estimated to be on average over 400 times higher that those LMEs with lowest values. There is moderate evidence from sea-based direct observations and towed nets to support this conclusion.





Ecosystem Health

Mangrove and coral cover

Not applicable.

Reefs at risk

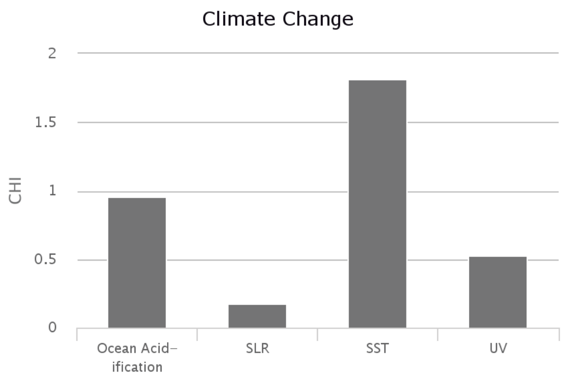
Not applicable.

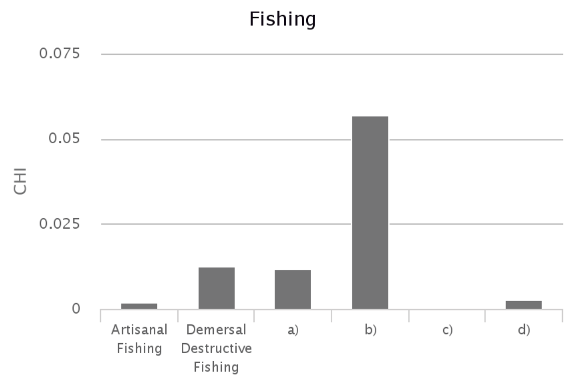
Marine Protected Area change

The Black Sea LME experienced an increase in MPA coverage from 1,905 km^2 prior to 1983 to 4,750 km^2 by 2014. This represents an increase of 149%, within the low category of MPA change.

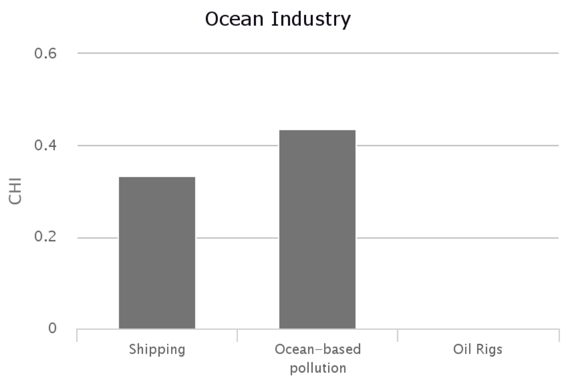
Cumulative Human Impact

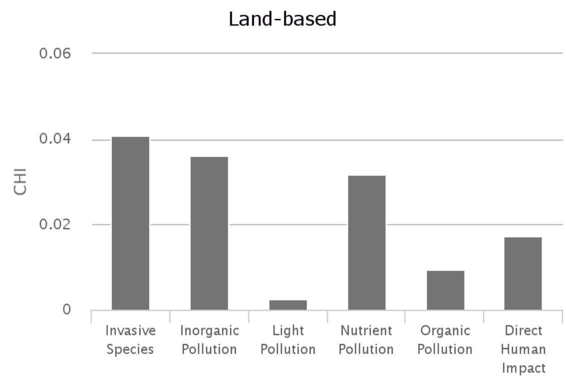
The Black Sea LME experiences well above average overall cumulative human impact (score 4.48; maximum LME score 5.22). It falls in risk category 5 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, three connected to climate change have the highest average impact on the LME: ocean acidification (0.96; maximum in other LMEs was 1.20), UV radiation (0.53; maximum in other LMEs was 0.76), and sea surface temperature (1.82; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, sea level rise, ocean based pollution, invasive species, and demersal non-destructive low-bycatch commercial fishing.





a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing

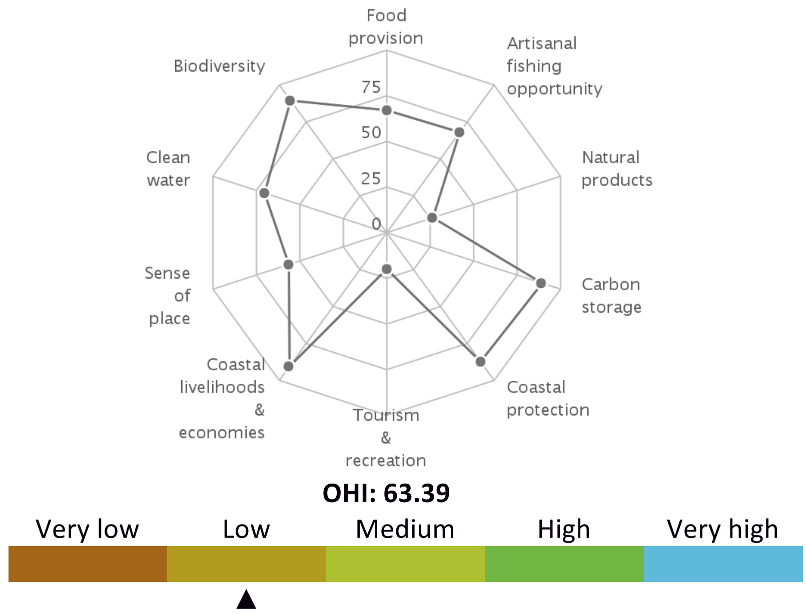




Ocean Health Index

The Black Sea LME scores below average on the Ocean Health Index compared to other LMEs (score 70 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is well below its optimal level of ocean health, although [there are some aspects that are doing well. Its score in 2013 decreased 2 points compared to the previous year, due in large part to changes in the scores for natural products and clean waters. This LME scores lowest on mariculture, natural products, tourism & recreation and iconic species goals and highest on artisanal fishing opportunities, coastal economies, and habitat biodiversity goals. It falls in risk category 3 of the five risk categories, which is an average level of risk (1 = lowest risk; 5 = highest risk).

Ocean Health Index (Black Sea)



Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for this LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The coastal area stretches over 385 846 km^2. A current population of 29 487 thousand in 2010 is projected to decrease to 18 123 thousand in 2100, with a density of 76 persons per km^2 in 2010 decreasing to 47 per km^2 by 2100. About 43% of coastal population lives in rural areas, and is projected to decrease in share to 40% in 2100.

Total population		Rural population	
2010	**2100**	**2010**	**2100**
29,486,553	18,123,039	12,588,784	7,314,617

Legend:

Very low | Low | Medium | High | Very high

Coastal poor

The indigent population makes up 10% of the LME's coastal dwellers. This LME places in the very low-risk category based on percentage and in the medium-risk category using absolute number of coastal poor (present day estimate).

Coastal poor
3,062,470

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. This LME ranks in the medium-revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $601 million for the period 2001-2010. Fish protein accounts for 9% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013 $43 086 million places it in the high-revenue category. On average, LME-based tourism income contributes 11% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for this LME falls in the category with medium risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
600,629,668	8.9	43,085,614,652	10.8	0.7929

Legend: Very low, Low, Medium, High, Very high

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day LME HDI belongs to the high HDI and low-risk category. Based on an HDI of 0.760, this LME has an HDI Gap of 0.240, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.

HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). This LME is projected to assume a place in the very low risk category (very high HDI) in 2100 under a sustainable development pathway. Under a fragmented world scenario, the LME is estimated to place in a very high-risk category (very low HDI) because of reduced income levels and population values from those in a sustainable development pathway..

	HDI 2100	
HDI	SSP1	SSP3
0.7605	0.8912	0.5700

Legend: Very low, Low, Medium, High, Very high

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (*e.g.* overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m^2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index of this LME is within the high-risk (high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is medium. There is no projected data for sea level rise in the Black Sea for year 2100.

2010		2100	
Climate Threat	**Contemporary Threat**	**SSP1**	**SSP3**
0.7576	0.3100	No data	No data

Legend:

Very low | Low | Medium | High | Very high

Governance

Governance architecture

In this LME, neither of the two transboundary arrangements for fisheries (GFCM and EU-CFP) nor the biodiversity arrangement for cetaceans (ACCOBAMS) appear to be linked formally. However, the two arrangements for land-based and marine based pollution and biodiversity (landscape/ habitat modification) are well connected under the Bucharest Convention. No integrating mechanisms, such as an overall policy coordinating organisation for the LME, could be found. There may be interaction amongst the arrangements through participation in each other's meetings, but this appears to be informal.

The overall scores for ranking of risk were:

Engagement	Completeness	Integration
74	**77**	**0.1**

Legend:

Very low | Low | Medium | High | Very high

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The water systems of the world – aquifers, lakes, rivers, large marine ecosystems, and open ocean- sustain the biosphere and underpin the socioeconomic wellbeing of the world's population. Many of these systems are shared by two or more nations. These transboundary waters, stretching over 71% of the planet's surface, in addition to the subsurface aquifers, comprise humanity's water heritage.

Recognizing the value of transboundary water systems and the reality that many of them continue to be degraded and managed in fragmented ways, the Global Environment Facility Transboundary Waters Assessment Programme (GEF TWAP) was developed. The Programme aims to provide a baseline assessment to identify and evaluate changes in these water systems caused by human activities and natural processes, and the consequences these may have on dependent human populations. The institutional partnerships forged in this assessment are envisioned to seed future transboundary assessments as well.

The final results of the GEF TWAP are presented in the following six volumes:
Volume 1 – ***Transboundary Aquifers and Groundwater Systems of Small Island Developing States: Status and Trends***
Volume 2 – ***Transboundary Lakes and Reservoirs: Status and Trends***
Volume 3 – ***Transboundary River Basins: Status and Trends***
Volume 4 – ***Large Marine Ecosystems: Status and Trends***
Volume 5 – ***The Open Ocean: Status and Trends***
Volume 6 – ***Transboundary Water Systems: Crosscutting Status and Trends***

A *Summary* for Policy Makers accompanies each volume. All TWAP publications are available for download at http://www.geftwap.org

This annex – Transboundary waters: A Global Compendium, Water System Information Sheets: Northern Africa & Western Asia, Volume 6-Annex H -- is one of 12 annexes to the Crosscutting Analysis discussed in Volume 6. The global compendium organized into 14 TWAP regions, compiles information sheets on 765 international water systems including the baseline values of quantitative indicators that were used to establish contemporary and relative risk levels at system and regional scales. Over the long term, it is envisioned that these baseline information sheets will continue to be updated by future assessments at multiple spatial and temporal scales to better track the changing states of transboundary waters that are essential in sustaining human wellbeing and ecosystem health.

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