TWAP
TRANSBOUNDARY WATERS ASSESSMENT PROGRAMME

Transboundary Waters: A Global Compendium

Water System Information Sheets: Western & Middle Africa

Volume 6 - Annex F: Western & Middle Africa

UNEP

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Volume 6-Annex F

Transboundary Waters: A Global Compendium

Water System Information Sheets: Western & Middle Africa

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Intergovernmental Oceanographic Commission
GOOS – Global Ocean Observing System
WCRP – World Climate Research Programme
GACS – Global Alliance of CPR Surveys
PML – Plymouth Marine Laboratory
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Contents (Volume 6, Annex F)

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:

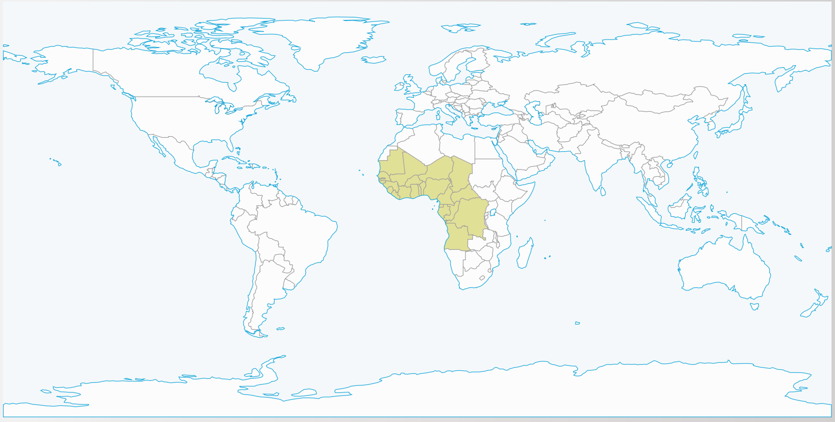
Transboundary Aquifers: http://twapviewer.un-igrac.org
Transboundary Lakes/ Reservoirs: http://ilec.lakes-sys.com/
Transboundary River Basins: http://twap-rivers.org
Large Marine Ecosystems: http://onesharedocean.org
Open Ocean: http://onesharedocean.org

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

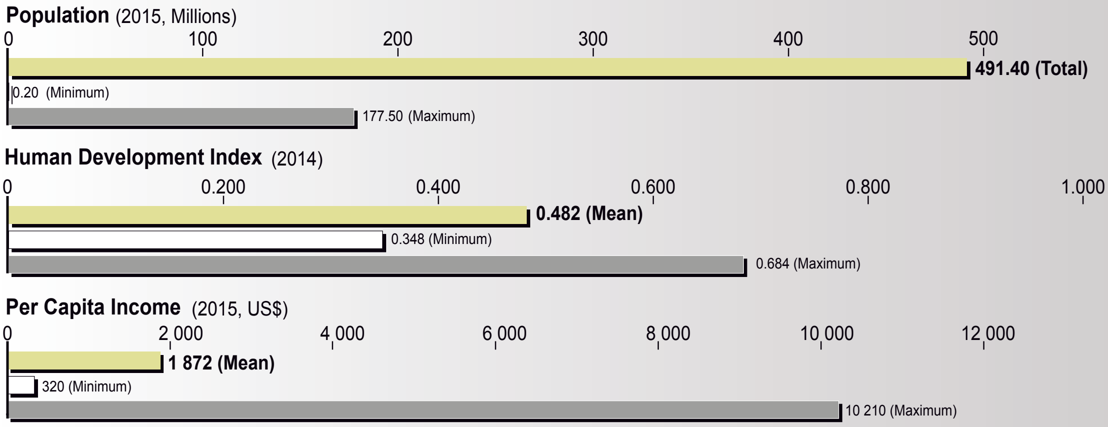
Over the long term, it is envisioned that these baseline information sheets will continue to be updated by future assessments at multiple spatial and temporal scales to better track the changing states of transboundary waters that are essential in sustaining human wellbeing and ecosystem health.

Regional Risks by Theme

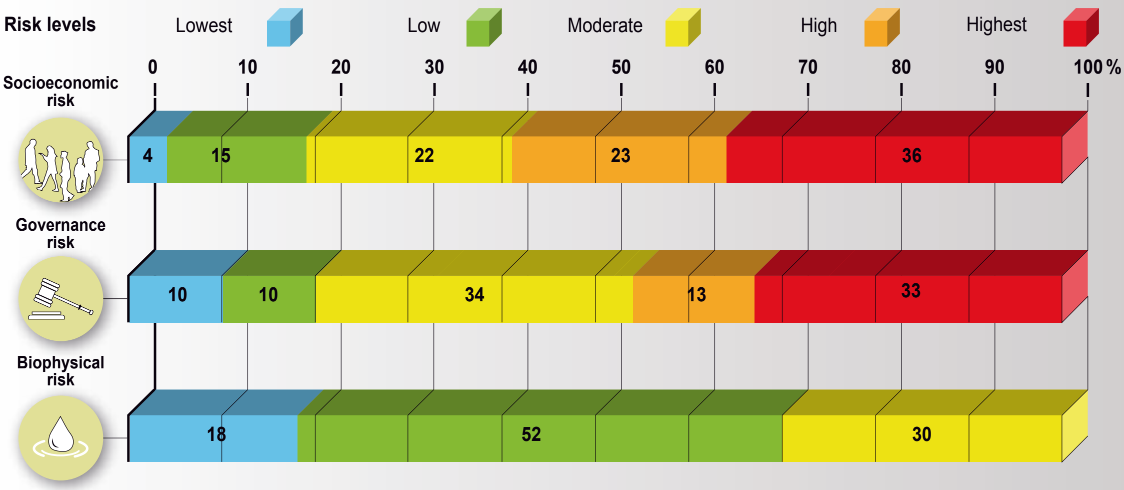
TRANSBOUNDARY WATERS: WESTERN & MIDDLE AFRICA



The region is classified as Low HDI Group with a regional HDI average of 0.482 and a population of 491 million in 2015. Contemporary risks of water systems by water category and theme expressed as percentages are shown at top right. Examining 68 transboundary water systems (bottom left), 59% are subject to high to highest socioeconomic risk; 46% are threatened by high to highest governance risk; and 82% are at low to moderate biophysical risk. On average, the region's transboundary waters (bottom right) are at high socioeconomic risk, moderate governance risk and low biophysical risk. All transboundary water categories- aquifers, lakes, rivers and LMEs -- are at moderate risk across risk themes.

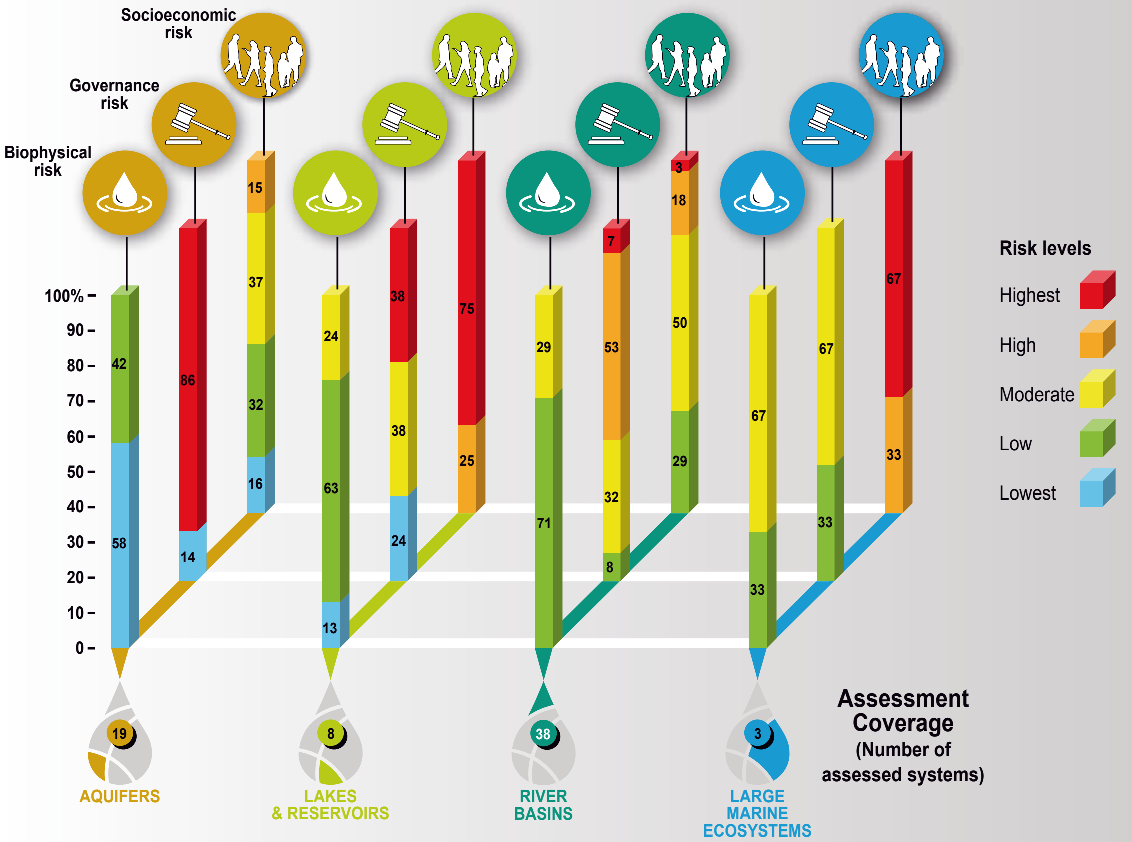


Contemporary Risks by Theme

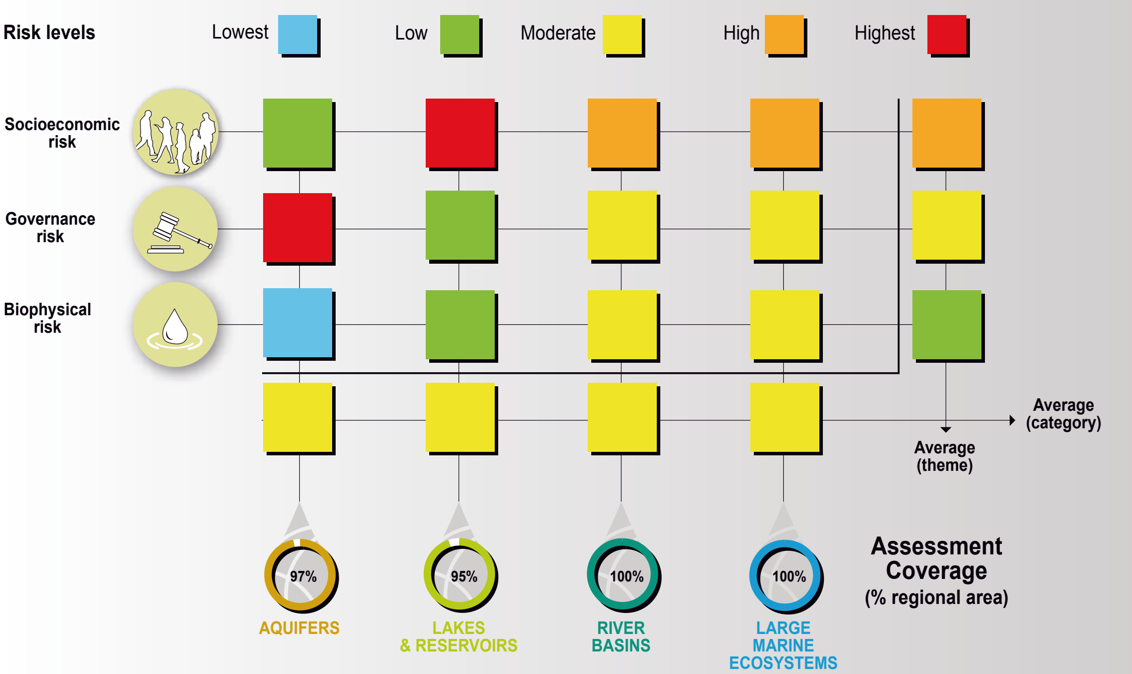


Regional Risks by Water Category

Contemporary Risks by Water Category



Average Risks



1. Aquifer Extension Sud-Est de Taoudeni
2. Aquifer Vallee de la Benoue
3. Aquifére Cötier
4. Aquifere Du Rift
5. Baggara Basin
6. Cestos-Danané
7. Coango
8. Cuvelai and Etosha Basin/ Ohangwena Aquifer System
9. Cuvette Aquifer
10. Irhazer-Illuemeden Basin
11. Karoo-Carbonate
12. Keta/ Dahomey/ Cotier Basin
13. Lake Chad Basin
14. Nata Karoo Sub-Basin – Caprivi Aquifer (Namibia)
15. Nubian Sandstone Aquifer System (NSAS)
16. Rio del Rey
17. Senegalo-Mauretanian Basin
18. Tanganyika Aquifer
19. Tano Basin
20. Taoudéni Basin
21. Volta Basin
22. AF33
23. AF34
24. AF40
25. AF82

AF88 - Aquifer Extension Sud-Est de Taouden

Geography

Total area TBA (km^2): 300 000

No. countries sharing: 4

Countries sharing: Burkina Faso, Guinea, Mali, Niger

Population: 11 000 000

Climate Zone: Tropical Dry

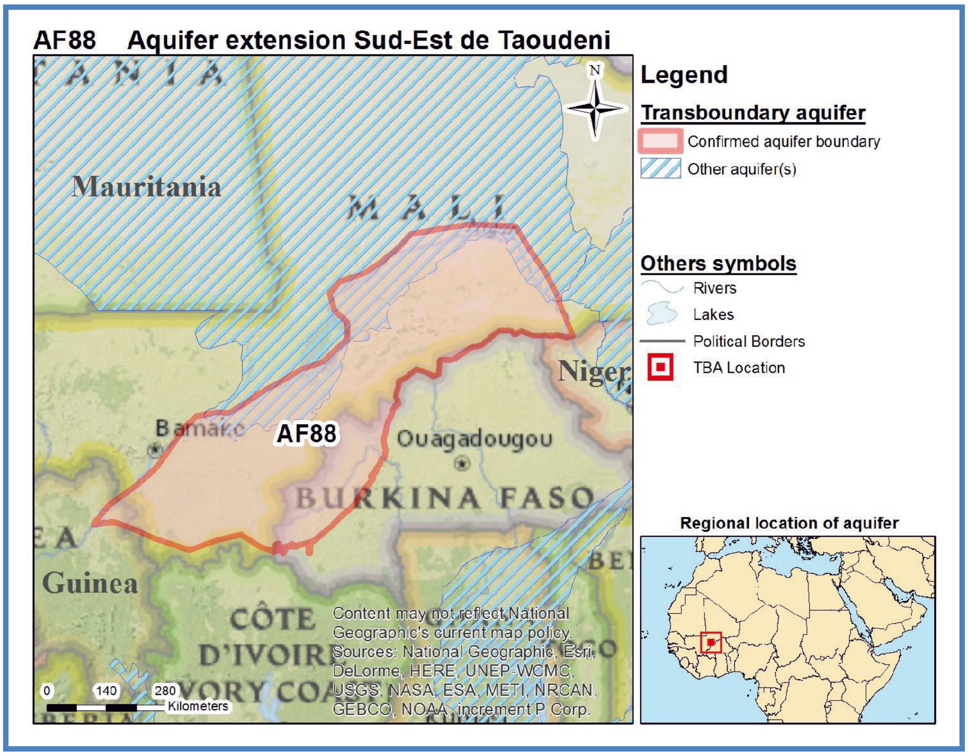
Rainfall (mm/yr): 640

Hydrogeology

Aquifer type: Multiple-layered hydraulically connected system

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

Main Lithology: Sedimentary rocks – sandstone, metamorphic rocks



No cross-section available

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

AF88 - Aquifer Extension Sud-Est de Taouden

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)
Burkina Faso	120	2300					53		A	B
Guinea							28			
Mali	<1	2					33	23	D	B
Niger										
TBA level							**120**			

(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)				
Burkina Faso	94	1700	-34	-60	37	84	7	38
Guinea	110	3700	-37	-60	16	64	0	0
Mali	310	9200	-39	-62	1	4	0	0
TBA level	**280**	**7600**	**-39**	**-62**	**3**	**21**	**1**	**1**

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

AF88 - Aquifer Extension Sud-Est de Taouden

	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)
Burkina Faso	0	56	76	190	1	1	11
Guinea	2	29	64	150	<1	0	2
Mali	0	33	74	180	<1	0	0
TBA level	**0**	**36**	**75**	**180**	<1	**0**	**1**

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)
Burkina Faso	16	64	1800	Aquifer mostly confined, but some parts unconfined	Sedimentary rocks - Sandstone	Low primary porosity intergranular porosity	Secondary porosity: Fractures	<5
Guinea								
Mali	40	20	100	Aquifer mostly confined, but some parts unconfined	Metamorphic rocks	Low primary porosity intergranular porosity	Secondary porosity: Fractures	17
Niger								
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 Transboundary Aquifer is located within the south-eastern part of the Taoudeni basin and the delineation of the boundaries is based upon the lithological properties/ geology and on the topography. It is a multiple-layered hydraulically connected system, that is mostly confined, but some parts are unconfined. The average depth to the water table varies from 7 m in Guinea to 40 m within Mali. The average depth to the top of the aquifer varies from 20 m within Mali to 64 m within Burkina Faso. The average thickness of the aquifer system varies from 57 m within Guinea to 1800 m within Burkina Faso.

Hydrogeological aspects

The predominant aquifer lithology is sedimentary rocks – sandstone, with some metamorphic rocks in Mali. The aquifer has a low primary porosity with secondary porosity fractures. It is characterised by a low horizontal connectivity and with low to high vertical connectivity. The average transmissivity

AF88 - Aquifer Extension Sud-Est de Taouden

varies from less than<5 m^2/d within Burkina Faso and Guinea, to 17 m^2/d within Mali. The total groundwater volume was only recorded from Mali where it is 15 km^3. A significant difference in recharge amounts between years has been recorded to occur within Burkina Faso. The average volume of recharge, which is 100% through natural recharge, within Mali and Burkina Faso is 19 Mm^3/yr and data is not available for the average amount of recharge for the extreme recharge events.

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 within Mali and through spring discharge within Burkina Faso and Guinea.

Environmental aspects

A large part of the aquifer over the entire area is unsuitable for human consumption within Mali, whereas within Guinea this is only the case within parts of the superficial layers but the data is not available to determine the percentage of the aquifer area that has been affected. Whereas this is due to natural salinity within Mali, other causes include elevated Arsenic and Nitrates within Burkina Faso. Although some anthropogenic pollution has been identified/ suspected over parts of the superficial layers, the data is not available to determine the percentage of the aquifer area that has been affected. Although the extent of shallow groundwater over the aquifer area has not been recorded, <5 % of the aquifer area within Mali is covered with groundwater dependent ecosystems.

Socio-economic aspects

The total groundwater abstraction from the aquifer during 2010 was 4.20 Mm^3 in Mali. Data is not available with regard to the total amount of fresh water that was abstracted within the aquifer area.

Legal and Institutional aspects

According to Burkina Faso there is an Agreement with full scope for TBA management signed by all parties. However according to Mali the Agreement is under preparation or available as an unsigned draft. A Dedicated Transboundary Institution in place, but it is not fully operational (Burkina Faso, Mali). Information about the status of the National/ Domestic Institutes has not been recorded.

Emerging Issues

Nothing identified.

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AF88 - Aquifer Extension Sud-Est de Taouden

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Aboubacar Modibo Sidibé	Direction Nationale de l'Hydraulique du Mali	Mali	aboubacar.sidibe@hotmail.fr	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.

All three TBA countries have 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 all 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.

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

AF51 - Aquifer Vallee de la Benoue

Geography

Total area TBA (km^2): 200 000

No. countries sharing: 2

Countries sharing: Cameroon, Nigeria

Population: 30 000 000

Climate Zone: Tropical Dry

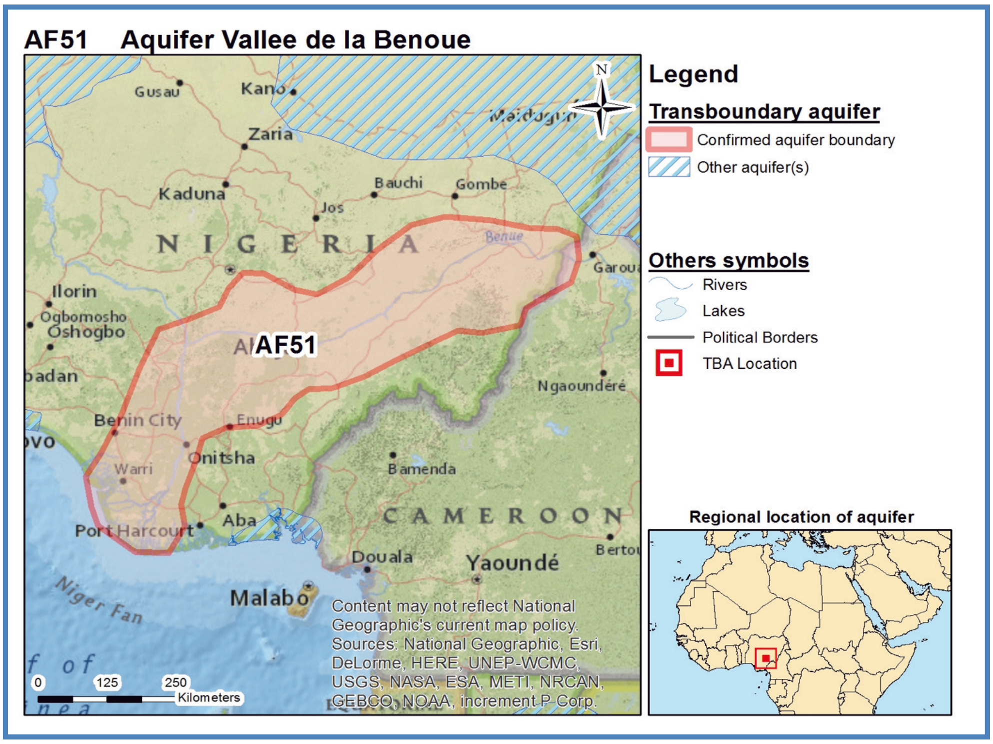
Rainfall (mm/yr): 1500

Hydrogeology

Aquifer type: Data not available

Degree of confinement: Data not available

Main Lithology: Data not available



No Cross-section provided

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

AF51 - Aquifer Vallee de la Benoue

TWAP Groundwater Indicators from Global Inventory

No data available.

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)				
Cameroon	150	2900	-34	-58	35	73	2	28
Nigeria	250	1500	-39	-62	43	89	18	16
TBA level	**250**	**1500**	**-39**	**-62**	**43**	**89**	**17**	**16**

	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)
Cameroon	1	51	56	130	<1	1	4
Nigeria	1	170	62	150	1	3	11
TBA level	**1**	**170**	**62**	**150**	**1**	**3**	**11**

Key parameters table from Global Inventory

No data available.

Aquifer description

No data available.

Contributors to Global Inventory

No contributions.

Considerations and recommendations

Request:

If you have 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.

AF51 - Aquifer Vallee de la Benoue

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.

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

AF81 - Aquifère Côtier

Geography

Total area TBA (km^2): 38 000

No. countries sharing: 4

Countries sharing: Angola, Congo, Democratic Republic of Congo, Gabon

Population: 2 000 000

Climate Zone: Tropical Wet

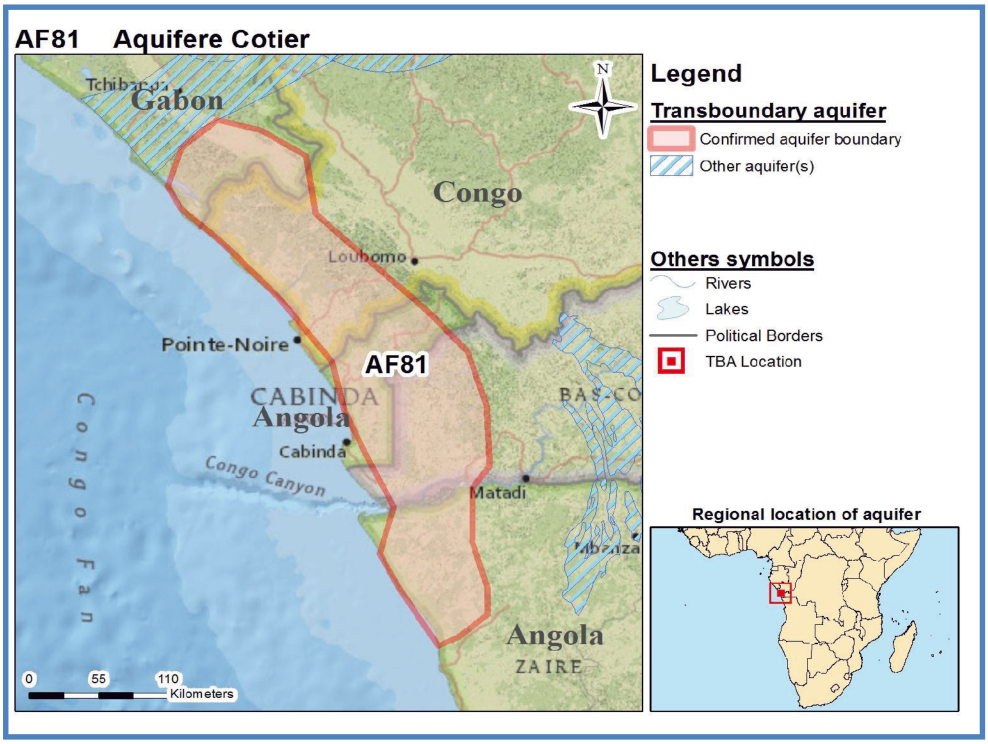
Rainfall (mm/yr): 1200

Hydrogeology

Aquifer type: Data not available

Degree of confinement: Data not available

Main Lithology: Data not available



No cross-section available

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

AF81 - Aquifère Côtier

TWAP Groundwater Indicators from Global Inventory

No data available.

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)				
Angola	130	3400	-45	-64	11	15	12	3
Congo	240	4200	-37	-56	34	54	0	5
Democratic Republic of Congo	140	1400	-42	-59	41	52	12	16
Gabon	310	91000	-33	-52	6	6	0	0
TBA level	**190**	**3600**	**-40**	**-59**	**27**	**38**	**12**	**8**

	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)
Angola	3	39	68	160	<1	0	1
Congo	0	57	54	120	<1	0	1
Democratic Republic of Congo	4	98	61	130	1	0	1
Gabon	-1	3	46	97	<1	0	0
TBA level	**2**	**53**	**60**	**130**	**<1**	**0**	**1**

Key parameters table from Global Inventory

No data available.

Aquifer description

Aquifer geometry
No information was provided on the aquifer geometry of this coastal aquifer.

Hydrogeological aspects
No information was provided on the aquifer lithology or on the aquifer parameters.

Linkages with other water systems
The recharge area is located along the Mayomba Mountain and the major recharge mechanism is through direct infiltration of rain water.

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

AF81 - Aquifère Côtier

Environmental aspects

Data is not available on the natural water quality or on the type and extent of anthropogenic groundwater pollution. However over-abstraction at the pointe Noir leads to a risk in sea water intrusion within the area. No information on shallow groundwater areas was obtained.

Socio-economic aspects

High abstraction along parts of the coastal areas increases the risk of sea water intrusion. Data is not available on the volumes of groundwater abstraction and the total amount of fresh water that is utilised within the aquifer area.

Legal and Institutional aspects

There was no information provided with regard to the legal and institutional set-up within the various Aquifer States.

Emerging Issues

Over-abstraction along parts of the coastal area does have a risk of possible sea water intrusion. This matter needs to be further addressed.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Cheikh Becaye Gaye	Université Cheikh Anta Diop	Senegal	cheikhbecayegaye@gmail.com	Regional coordinator
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator

Considerations and recommendations

Request:

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References:

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AF81 - Aquifère Côtier

- 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

AF83 - AQUIFERE DU RIFT

Geography

Total area TBA (km^2): 40 000

No. countries sharing: 5

Countries sharing: Burundi, Democratic Republic of Congo, Rwanda, South Sudan, Uganda

Population: 8 800 000

Climate Zone: Tropical Dry

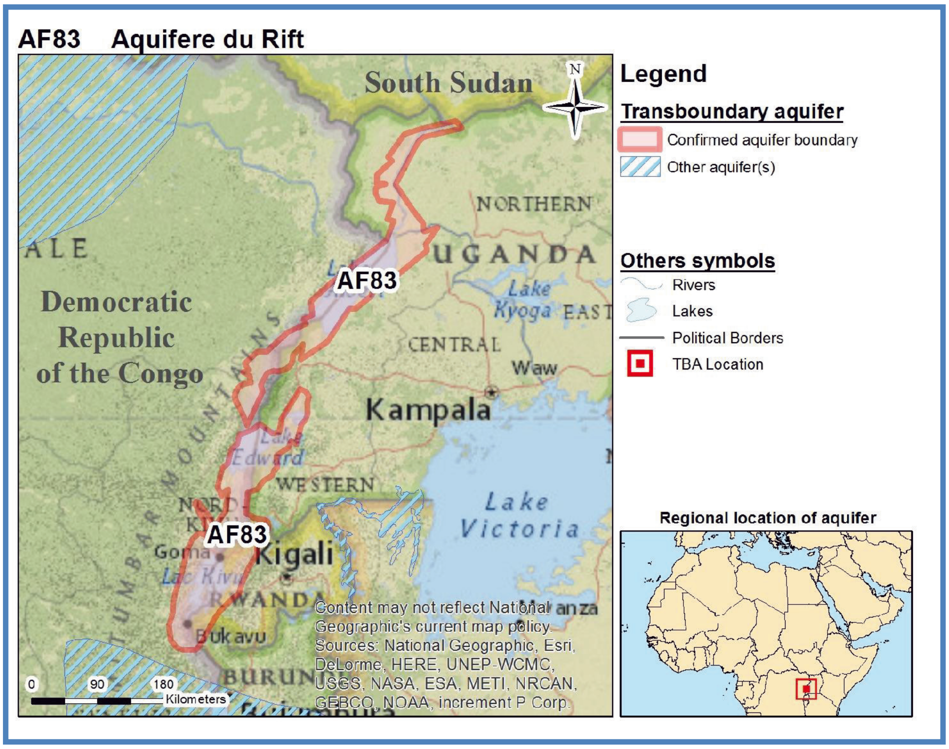
Rainfall (mm/yr): 1200

Hydrogeology

Aquifer type: Multi-layered hydraulically connected system

Degree of confinement: Largely confined with some parts being unconfined

Main Lithology: Crystalline rocks - Granite



No cross-section available

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

AF83 - AQUIFERE DU RIFT

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)
Burundi							380			
Democratic Republic of the Congo							230			
Rwanda							530			
South Sudan							27			
Uganda			85				110		D	D
TBA level										

(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)				
Burundi	50	150	-28	-46	20	25	0	0
Democratic Republic of the Congo	85	430	-36	-55	42	46	1	23
Rwanda	82	210	-36	-55	24	27	0	4
South Sudan	100	7000	-46	-64	2	2	0	1
Uganda	72	600	-45	-64	25	26	1	6
TBA level	**80**	**400**	**-39**	**-58**	**33**	**35**	**0**	**16**

AF83 - AQUIFERE DU RIFT

	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)
Burundi	0	330	48	96	3	1	17
Democratic Republic of the Congo	0	200	64	140	2	3	10
Rwanda	-1	390	64	140	3	11	31
South Sudan	1	15	69	160	<1	0	0
Uganda	0	120	76	170	1	4	13
TBA level	**0**	**190**	**67**	**150**	**2**	**5**	**14**

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)
Burundi								
Democratic Republic of the Congo								
Rwanda								
South Sudan								
Uganda	30	20		Aquifer mostly confined, but some parts unconfined	Crystalline rocks - Granite	Low primary porosity intergranular porosity	Secondary porosity: Fractures	
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

The aquifer is a multi-layered hydraulically connected system that is largely confined with some parts being unconfined. The average rest water level in Uganda is 30 m. The average depth to the top of the aquifer has only been recorded within Uganda where it is 20 m. Data is not available on the average thickness of the aquifer system.

Hydrogeological aspects

The predominant lithology is crystalline rocks - Granite. It is characterized by a low primary porosity, with secondary porosity fractures. It has a high horizontal and a low vertical connectivity.

AF83 - AQUIFERE DU RIFT

Linkages with other water systems

The predominant source of recharge is through precipitation on the aquifer area and the predominant discharge mechanism is through outflow into lakes (Uganda).

Environmental aspects

Around 15% of the aquifer is not suitable for drinking water purposes, mainly due to higher salinity and fluoride levels (Uganda). Some anthropogenic groundwater pollution has been observed but the data is not available to determine the percentage of the aquifer area that has been affected. Data is not available with regard to the percentage of the aquifer area with shallow groundwater and groundwater dependent ecosystems.

Socio-economic aspects

Data is not available for the total amount of groundwater abstraction nor for the total amount of fresh water abstraction within the aquifer area.

Legal and Institutional aspects

Within Uganda no Transboundary Agreement exists. The National Institution is in place, but it is not fully operational.

Emerging Issues

As this area is potentially oil bearing, attention needs to be paid towards groundwater contamination.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Cheikh Becaye Gaye	Université Cheikh Anta Diop	Senegal	cheikhbecayegaye@gmail.com	Regional coordinator
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.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.

Only 1 of the 5 TBA countries contributed to the information. This information was sufficient to describe the aquifer in general terms but it was insufficient to calculate 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.

Colophon

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AF83 - AQUIFERE DU RIFT

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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: September 2015

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

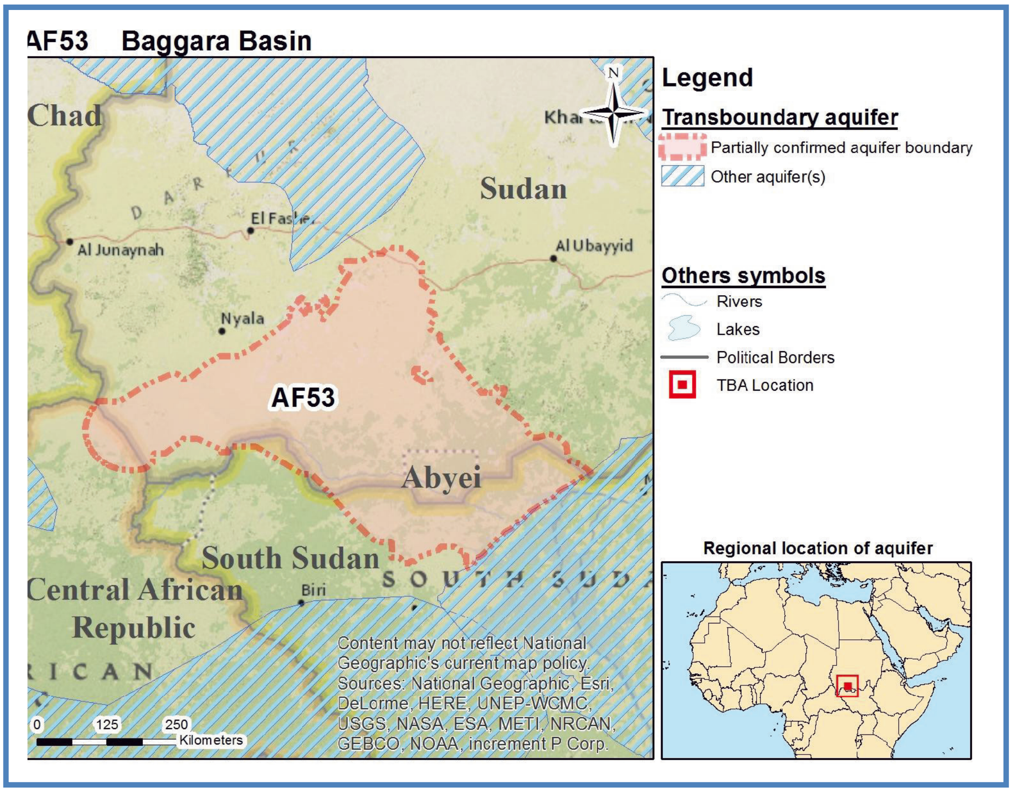
Rainfall (mm/yr): 620

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

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
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

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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: September 2015

AF49 - Cestos-Danané Aquifer

Geography

Total area TBA (km^2): 8400

No. countries sharing: 3

Countries sharing: Côte d'Ivoire, Liberia, Guinea

Population: 610 000

Climate Zone: Tropical Wet

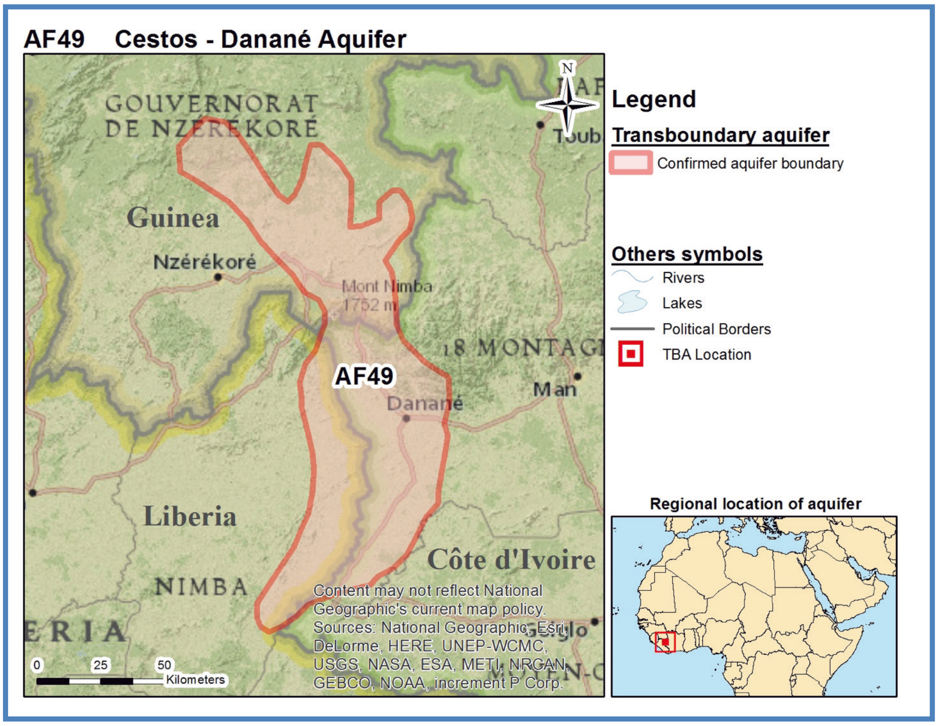
Rainfall (mm/yr): 1900

Hydrogeology

Aquifer type: Multiple layered hydraulically connected to single-layered

Degree of confinement: Aquifer mostly confined, but some parts unconfined and semi-confined

Main Lithology: Crystalline rocks - Granite



No cross-section provided

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

AF49 - Cestos-Danané Aquifer

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)
Côte d'Ivoire	320	4100					79	<5		
Liberia			100				84			E
Guinea							45			
TBA level							**72**			

(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)
Côte d'Ivoire	9	33	35	Aquifer mostly confined, but some parts unconfined				10
Guinea	10			Aquifer mostly confined, but some parts unconfined				

AF49 - Cestos-Danané Aquifer

	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)
Liberia	8	8	12	Whole aquifer semi-confined	Crystalline rocks - Granite		Secondary porosity: Fractures	
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 2-layered hydraulically connected system that is single-layered within Liberia. The multiple layererd portion consists of an alluvial regolith that overlies the fractured granitic horizon. The aquifer is mostly confined, but some parts are unconfined to semi-confined. The average rest water level varies between 8 m within Liberia and 10 m within Guinea. The average depth to the top of the aquifer varies from 8 m to 33m and the average thickness of the aquifer system varies 12 m to 35 m (Côte d'Ivoire, Liberia).

Hydrogeological aspects

The main fractured rock aquifer system is composed of crystalline rocks – granite that is overlain by a regolith of alluvial deposits. The fractured crystalline rocks are characterized by secondary porosity – fractures. The total groundwater volume was only recorded from Côte d'Ivoire and this amounts to 4.54 km^3. The average annual recharge, that is not characterised by extreme recharge events, was only recorded from Côte d'Ivoire and this amounts to 1 000 Mm^3/yr and this is based on expert judgement.

Linkages with other water systems

The predominant source of groundwater recharge is through precipitation over the aquifer area. The predominant discharge mechanism is through outflow from springs in Guinea and through outflow into lakes within Côte d'Ivoire and through river base flow into the Sesto River in Liberia.

Environmental aspects

Within all of the aquifer states some of the superficial layers are sometimes unsuitable for drinking water purposes but the data is not available to determine the percentage of the aquifer area that has been affected. Besides a higher salinity level, the unsuitability is also due to high iron contents in the groundwater (Liberia). Some anthropogenic pollution within the superficial layers has been detected within Côte d'Ivoire and Liberia, with no pollution as yet has being observed within the portion in Guinea. The data is not available to determine the percentage of the aquifer area that has been affected. Within Côte d'Ivoire around <5 % of the groundwater is shallow with 60 % of the area being covered with groundwater dependent ecosystems.

Socio-economic aspects

The total annual groundwater abstraction for 2010 was only recorded from Côte d'Ivoire and this amounted to 4.38 Mm^3. Data is not available on the total amount of fresh water abstraction from the aquifer area.

Legal and Institutional aspects

According to Liberia no Institution exists for TBA management.

AF49 - Cestos-Danané Aquifer

Emerging Issues
Institutional development at a National and Regional level as well as appropriate development of Transboundary Aquifer legislation is in need of support.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Cheikh Becaye Gaye	Université Cheikh Anta Diop	Senegal	cheikhbecayegaye@gmail.com	Regional coordinator
Koffi Ferdnand Kouame	Université Félix Houphouët Boigny	Cote d'Ivoire	kouamef@yahoo.fr	Contributing national expert
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Bouho Jérôme Kouakou	Direction des Ressources en Eau (DRE)	Cote d'Ivoire	kbjero@yahoo.fr	Contributing national expert
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Mandjou Conde		Guinea	mandioucde@gmail.com	Contributing national expert
Mariama Dalanda Diallo		Guinea	dalandiallo2002@yahoo.fr, dalanma@gmail.com	Contributing national expert
Alpha Amadou Diallo		Guinea	alphaballa@yahoo,fr	Contributing 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.

Although all of the TBA countries contributed to the information. The information was adequate to describe the aquifer in general terms. Some quantitative information was also available, but not sufficient to calculate most 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.

Colophon

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AF49 - Cestos-Danané Aquifer

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: May 2017

AF23 - Coango

Geography

Total area TBA (km^2): 330 000

No. countries sharing: 2

Countries sharing: Angola, Democratic Republic of Congo

Population: 4 100 000

Climate Zone: Tropical Dry

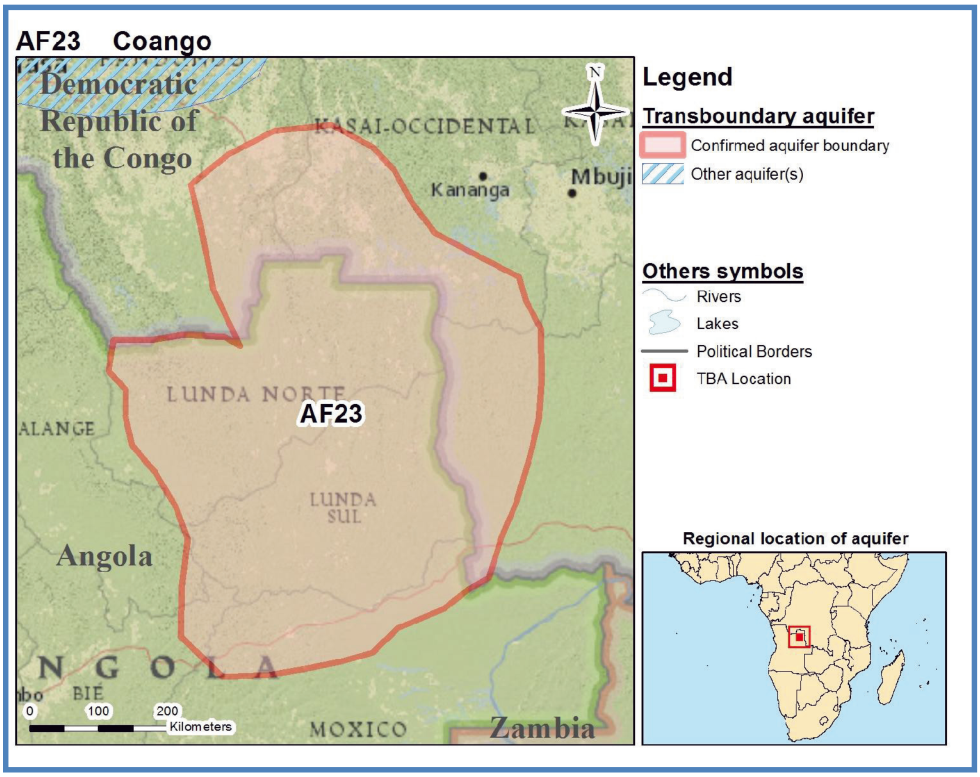
Rainfall (mm/yr): 1500

Hydrogeology

Aquifer type: Multi-layered system

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

Main Lithology: Sediments –sands and gravels and sedimentary rocks – sandstones and shales



No cross-section available

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

AF23 - Coango

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)
Angola							5		D	D
Democratic Republic of Congo							23			
TBA level							**12**			

(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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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)				
Angola	180	31000	-48	-68	7	9	13	1
Democratic Republic of Congo	140	5900	-41	-59	55	56	0	28
TBA level	**160**	**14000**	**-43**	**-62**	**33**	**36**	**13**	**7**

AF23 - Coango

	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)
Angola	1	6	78	190	<1	0	0
Democratic Republic of Congo	-3	24	60	130	<1	0	0
TBA level	**-1**	**12**	**66**	**150**	<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)
Angola				Aquifer mostly semi-confined, but some parts unconfined	Sediments – sands, Sedimentary rocks – sandstones and shale	High Primary porosity fine/ medium sedimentary deposits	Secondary porosity: Fractures	
Democratic Republic of Congo								
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 Aquifer, also known as the Congo Intra-Cratonic Basin / Congo -Zambezi Basins Benguela Ridge Watershed Aquifer, is a multi-layered system that is mostly semi-confined, but some parts are unconfined. The thicknesses of the two main aquifers are about 180 m.

Hydrogeological aspects

This TBA consists of Tertiary-age sediments - Kalahari alluvial, marine sands, and gravels, overlying Cretaceous-age sedimentary rocks - sandstones and shales. They generally have a high primary porosity with secondary porosity: fractures. The Benguela Ridge has high yielding porous sediments in the watershed area between the Congo and Zambezi catchments. The aquifer transmissivity is sometimes up to 2 000 m^2/d in places.

Linkages with other water systems

The predominant source of recharge is through precipitation over the aquifer area. Recharge of the shallower aquifers occurs from the surrounding rivers.

AF23 - Coango

Environmental aspects

The water quality is generally good but some deeper waters are brackish to saline. No further environmental information was available.

Socio-economic aspects

Data is not available on groundwater abstraction.

Legal and Institutional aspects

No agreement exists, nor is it under preparation. The National Institution is in place, but it is not fully operational (Angola).

Priority Issues

The prevailing hydraulic gradient of the water table is likely to mirror the surface drainage and there is some potential for Transboundary groundwater flow especially related to large-scale abstraction for the processing of diamondiferous strata. Alluvial diamonds are found in the basal conglomerate of the Kwango Series. More significantly, pumping on one side of the border could induce degradation across the political border (Wellfield, BGS, SADC - 2011). This possibility needs to be monitored by both countries. The effects of large-scale mining that is occurring on possible pollution must be reviewed as it has a high pollution risk.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
Cheikh Becaye Gaye	Université Cheikh Anta Diop	Senegal	cheikhbecayegaye@gmail.com	Regional coordinator
Pascoal de Campos	Ministry of Sciences and Technology	Angola	micolo.campos@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 obtained from the available literature. Follow-up with the national experts is essential for obtaining the necessary additional information for the calculation 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.

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AF23 - Coango

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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: September 2015

AF13 - Cuvelai And Etosha Basin / Ohangwena Aquifer System

Geography

Total area TBA (km^2): 41 000

No. countries sharing: 2

Countries sharing: Angola, Namibia

Population: 240 000

Climate Zone: Tropical Dry

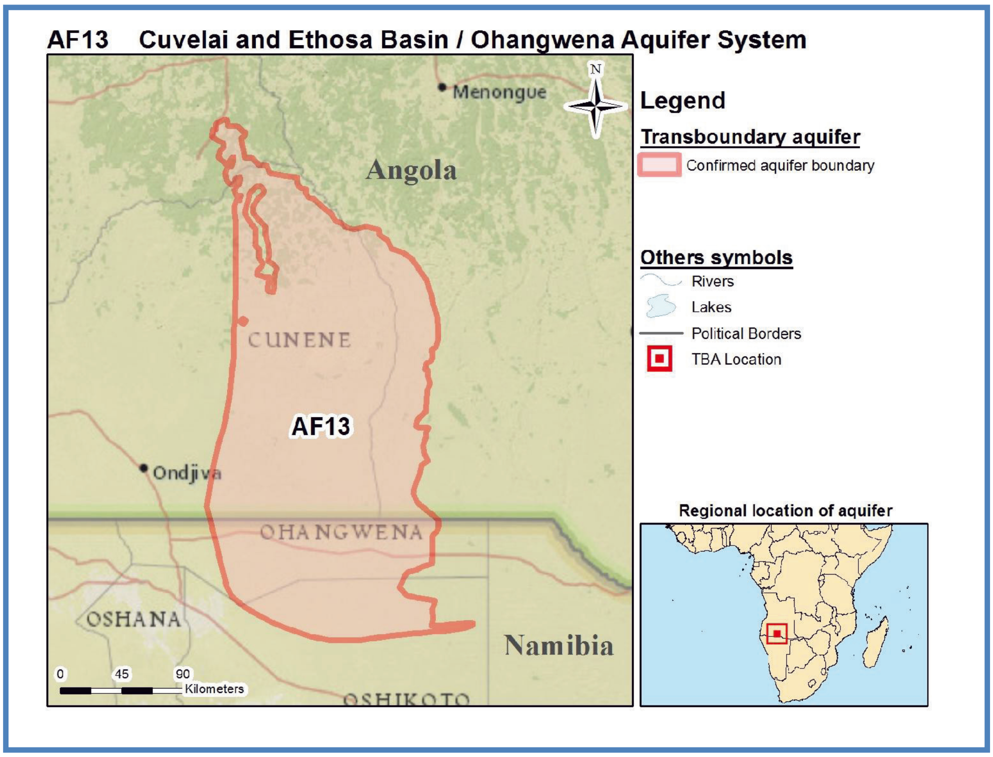
Rainfall (mm/yr): 650

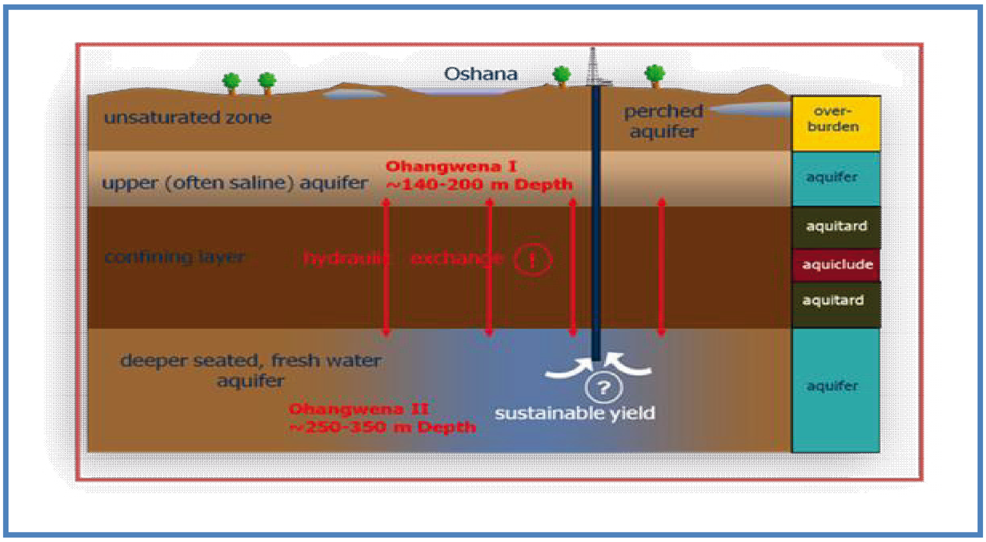
Hydrogeology

Aquifer type: Multi-layered system

Degree of confinement: Mostly confined, but some parts unconfined

Main Lithology: Sediment – sand and sedimentary rocks – sandstones





Geological Cross-section of the Ohangwena Aquifer

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

AF13 - Cuvelai And Etosha Basin / Ohangwena 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)
Angola							5			
Namibia	3	420	65	60	0		8	<5	B	D
TBA level							**6**			

(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)				
Angola	36	6300	-41	-65	5	5	0	5
Namibia	19	1900	0	-11	37	35	0	60
TBA level	**32**	**4600**	**-35**	**-58**	**23**	**22**	**0**	**41**

	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)
Angola	-4	6	74	180	<1	0	0
Namibia	-3	10	36	66	1	20	46
TBA level	**-4**	**7**	**59**	**140**	**<1**	**0**	**1**

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

AF13 - Cuvelai And Etosha Basin / Ohangwena Aquifer System

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)
Angola								
Namibia	30	80	350	Aquifer Mostly confined, but some parts unconfined	Sediment - Sand	High Primary porosity fine/ medium sedimentary deposits	No Secondary porosity	220
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

The shape of the TBA area has been significantly reduced as that is the more relevant part that should be considered for Transboundary cooperation (known as the Ohangwena portion within Namibia). Two of the main aquifer horizons are mostly confined with the upper perched aquifer being unconfined. The average depth to the water table in Namibia is 30 m (see appendix 1). Within Namibia the average depth to the top of the confined aquifer is 80 m and the thickness of the entire aquifer system is 350 m.

Hydrogeological aspects

The predominant lithology is sediment – sand and sedimentary rocks – sandstones that are overlain by unconsolidated sedimentary sands. It has a high primary porosity with no secondary porosity and high horizontal connectivity. The average transmissivity value is 220 m^2 /d. Within Namibia the total groundwater volume 20 km^3 and this calculation is based on GIS-data and/ or groundwater models. Within Namibia the mean annual recharge, that is 100% through natural conditions, is 35 Mm^3/yr over an area of about 35 000 km^2. During extreme recharge events that is characteristic of this area the average recharge rises to 70 Mm^3/yr. The aquifer has not been much utilised and there is no difference as yet in the long-term trend of the water level.

Linkages with other water systems

The predominant source of recharge is from precipitation on the aquifer area, and the major recharge mechanism is through runoff into the aquifer area while the predominant discharge mechanism is through evapotranspiration.

Environmental aspects

Within Namibia 35% of aquifer not suitable, over a significant part of the aquifer due to elevated natural salinity – (see appendix 2) and high fluoride levels (appendix 3). Some pollution within the superficial layers has been observed but more data on this is not available. Shallow groundwater covers around 5% of the area as do the groundwater dependent ecosystems.

Socio-economic aspects

During 2010 the annual groundwater abstraction on the Namibian side was estimated at 0.6Mm^3/yr . The total amount of fresh water abstraction over the aquifer area was 1 Mm^3/yr.

AF13 - Cuvelai And Etosha Basin / Ohangwena Aquifer System

Legal and Institutional aspects

There is a negotiated bilateral agreement with limited scope and there is no Transboundary Aquifer Institute in place although a commission for this basin has been established. The National Institute within Namibia has a full mandate with limited capacity.

Emerging Issues

Most of the recharge is coming from Angola. Water scarcity on the Namibian side makes this a valuable resource. The joint management of this resource needs to be adequately negotiated between the countries.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
Filipus Namupala Shivute	DWAF-BGR project "Groundwater Management in the CEB"	Namibia	fnshivute@outlook.com	Contributing national expert
Martin Penda Amukwaya	Ministry of Agriculture, Water and Forestry	Namibia	amukwayam@mawf.gov.na	Lead National Expert
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Considerations and recommendations

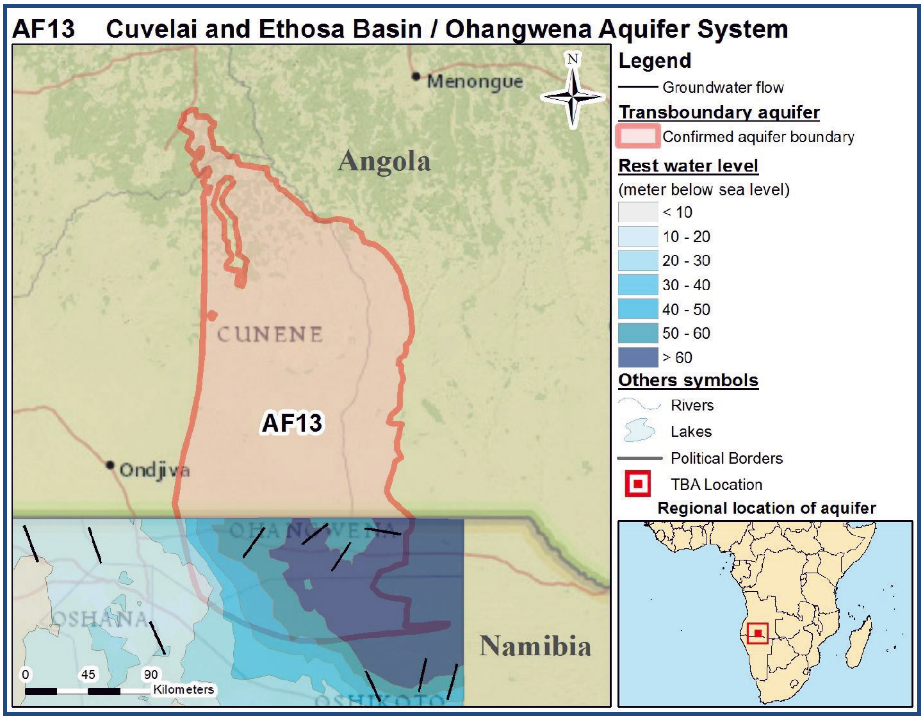
Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Only 1 of the 2 TBA countries has provided information. Information was adequate to describe the aquifer in general terms and the quantitative information was sufficient to calculate most of the indicators 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.

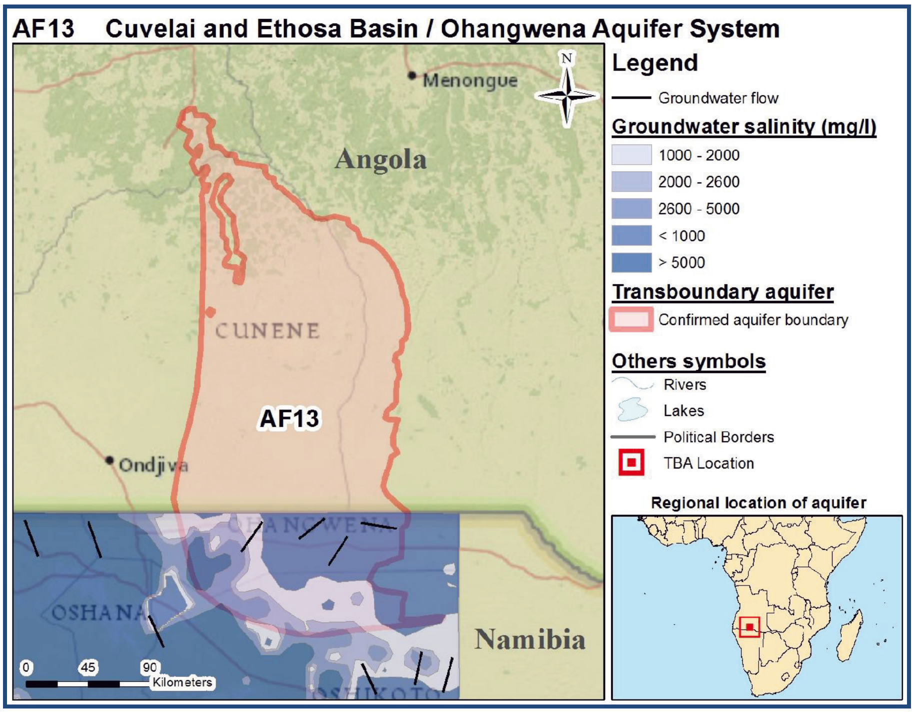
AF13 - Cuvelai And Etosha Basin / Ohangwena Aquifer System

Appendix 1: AF13



Cuvelai-Ethosa Basin / Ohangwena Aquifer System – showing Rest Water Levels within the Namibia part

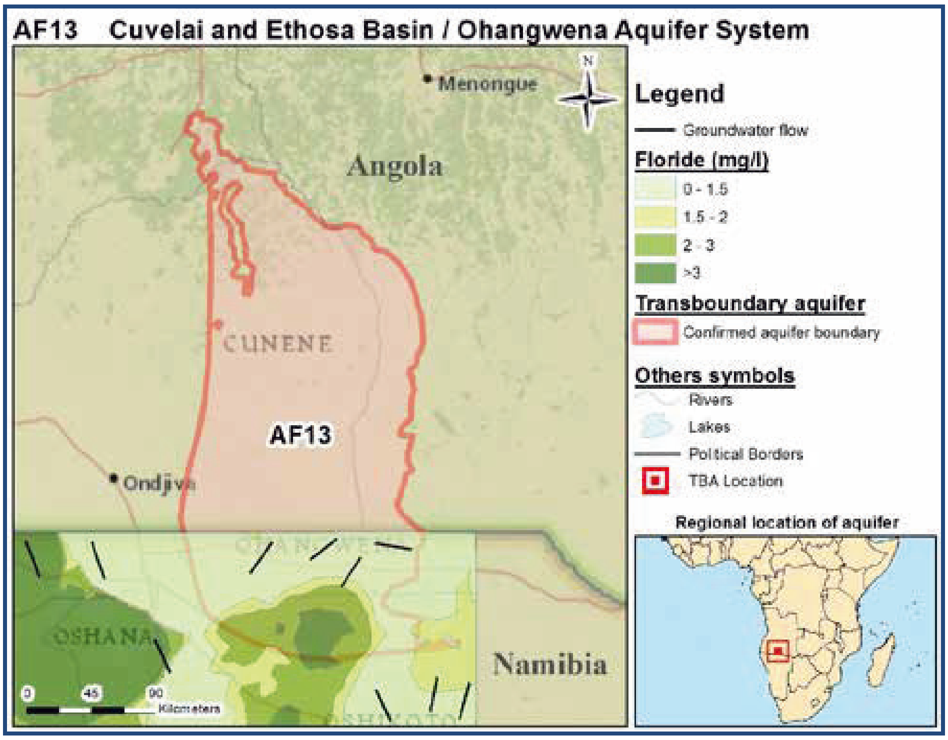
Appendix 2: AF13



Cuvelai And Ethosa Basin / Ohangwena Aquifer System - showing Salinity within the Namibia portion

AF13 - Cuvelai And Etosha Basin / Ohangwena Aquifer System

Appendix 3: AF13



Cuvelai And Ethosa Basin / Ohangwena Aquifer System - showing Fluoride within the Namibia portion

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.

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

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- All other data: TWAP Groundwater (2015).

Version: September 2015


Ohangwena Aquifer

Christoph Lohe

AF29 - Cuvette Aquifer

Geography

Total area TBA (km^2): 790 000

No. countries sharing: 3

Countries sharing: Cameroon, Congo, Democratic Republic of Congo

Population: 22 000 000

Climate Zone: Tropical Wet

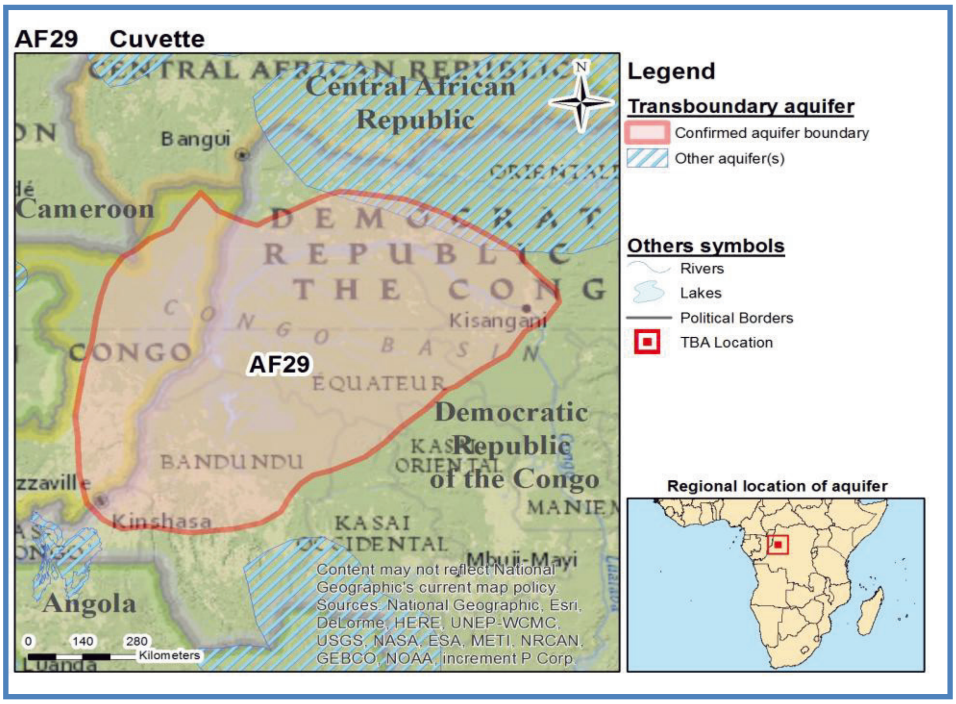
Rainfall (mm/yr): 1800

Hydrogeology

Aquifer type: Data not available

Degree of confinement: Data not available

Main Lithology: Sedimentary rocks - Sandstones



No cross-section available

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

AF29 - Cuvette Aquifer

TWAP Groundwater Indicators from Global Inventory

No data available.

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)				
Cameroon	200	130 000	-41	-60	17	58	0	0
Congo	300	9100	-39	-57	48	58	0	27
Democratic Republic of Congo	400	17 000	-39	-57	55	58	0	27
TBA level	**380**	**15 000**	**-39**	**-57**	**54**	**58**	**0**	**27**

	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)
Cameroon	3	2	50	110	<1	0	0
Congo	2	33	57	120	<1	0	0
Democratic Republic of Congo	0	23	60	120	<1	0	0
TBA level	**0**	**25**	**59**	**120**	<1	**0**	**0**

Key parameters table from Global Inventory

No data available.

Aquifer description

Aquifer geometry

No information was provided on the aquifer geometry.

Hydrogeological aspects

Within the Congo segment, geological formations are mainly sedimentary rocks -sandstones that indicate a good permeability of the aquifer. Data was not available on the aquifer parameters. There is probably no difference in recharge between the years.

Linkages with other water systems

Although recharge is through precipitation over the aquifer area, a major aquifer recharge zone seems to be localized at the Northern Province in Angola (at Lunda North). Major discharge areas are within the Kwango and Wamba Kasai rivers that flow towards the Congo River.

AF29 - Cuvette Aquifer

Environmental aspects
Data was not available on the extent of the aquifer where natural water quality is unfit for human consumption. Furthermore, data was not available on the extent of anthropogenic pollution, and shallow groundwater over the aquifer area.

Socio-economic aspects
Data was not available on the groundwater abstraction or the fresh water abstraction over the aquifer area. Within the vicinty the TBA that is close to the Northern Province of Angola (at Lunda North) and the area within the Kwango and Wamba Kasai rivers, data from different wells show that borehole productivities range on average between 4 to 7 m^3/h.

Legal and Institutional aspects
Data not available on the status of a Transboundary Groundwater Agreement.

Emerging Issues
-

Contributors to Global Inventory

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

Considerations and recommendations

Request:
If you have 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.

Colophon

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AF29 - Cuvette Aquifer

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: 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

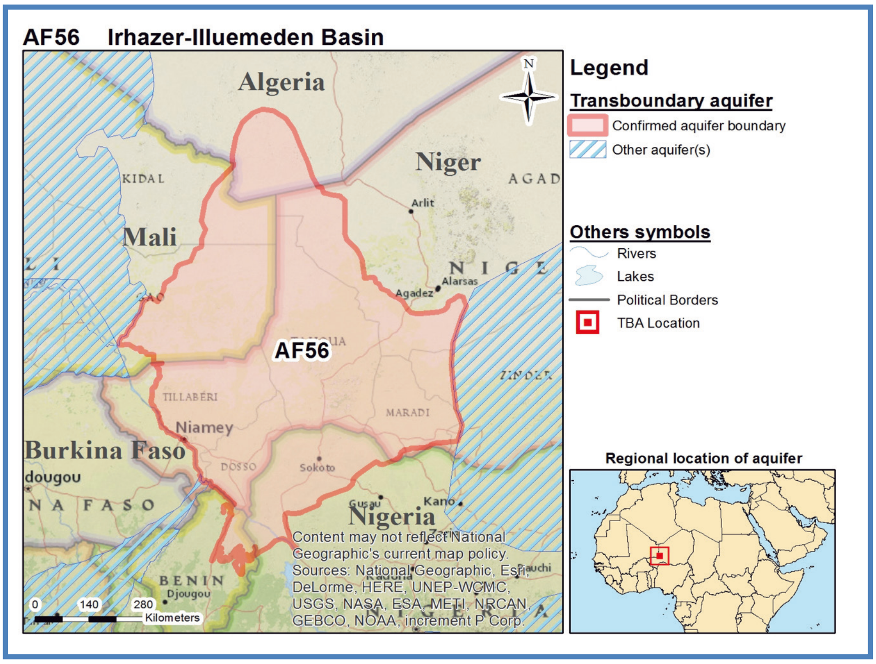
Rainfall (mm/yr): 310

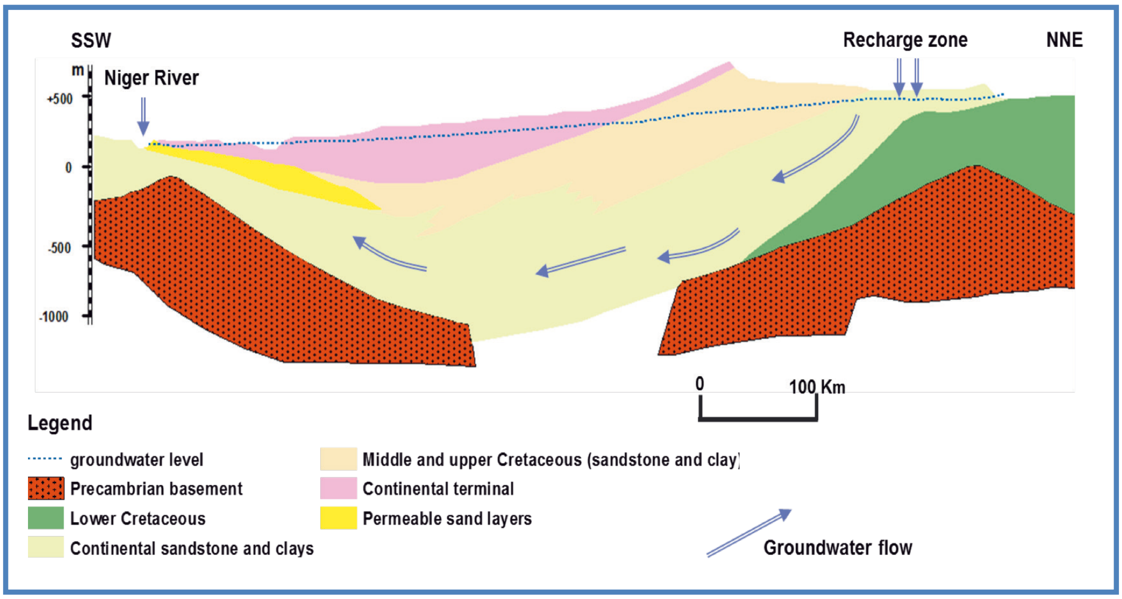
Hydrogeology

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**

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.

AF56 - Irhazer-Iullemeden Basin

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).

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.

AF56 - Irhazer-Iullemeden Basin

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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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
Félix Azonsi	Institut National de l'Eau / Bénin	Benin	felixazonsi@gmail.com	Contributing national expert
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Moussa Boukari	Université d'Abomey-Calavi	Benin	moussaboukari2003@yahoo.fr	Contributing national expert
Léonce Dovonon	Direction Générale de l'Eau	Benin	leoncedovonon@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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Aboubacar Modibo Sidibé	Direction Nationale de l'Hydraulique du Mali	Mali	aboubacar.sidibe@hotmail.fr	Contributing national expert
Moses Beckley	Nigeria Hydrological Services Agency (NIHSA), Federal Ministry of Water Resources, Abuja, Nigeria	Nigeria	moses.beckley@yahoo.com	Contributing national expert
Hycienth Ogunka Nwankwoala	University of Port Harcourt, Nigeria	Nigeria	nwankwoala_ho@yahoo.com, hycienth.nwankwoala@uniport.edu.ng	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 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.

AF56 - Irhazer-Iullemeden Basin

Colophon

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- All other data: TWAP Groundwater (2015).

Version: May 2017

AF25 - KAROO-CARBONATE

Geography

Total area TBA (km^2): 550 000

No. countries sharing: 3

Countries sharing: Central African Republic, Congo, South Sudan

Population: 5 000 000

Climate Zone: Tropical Dry

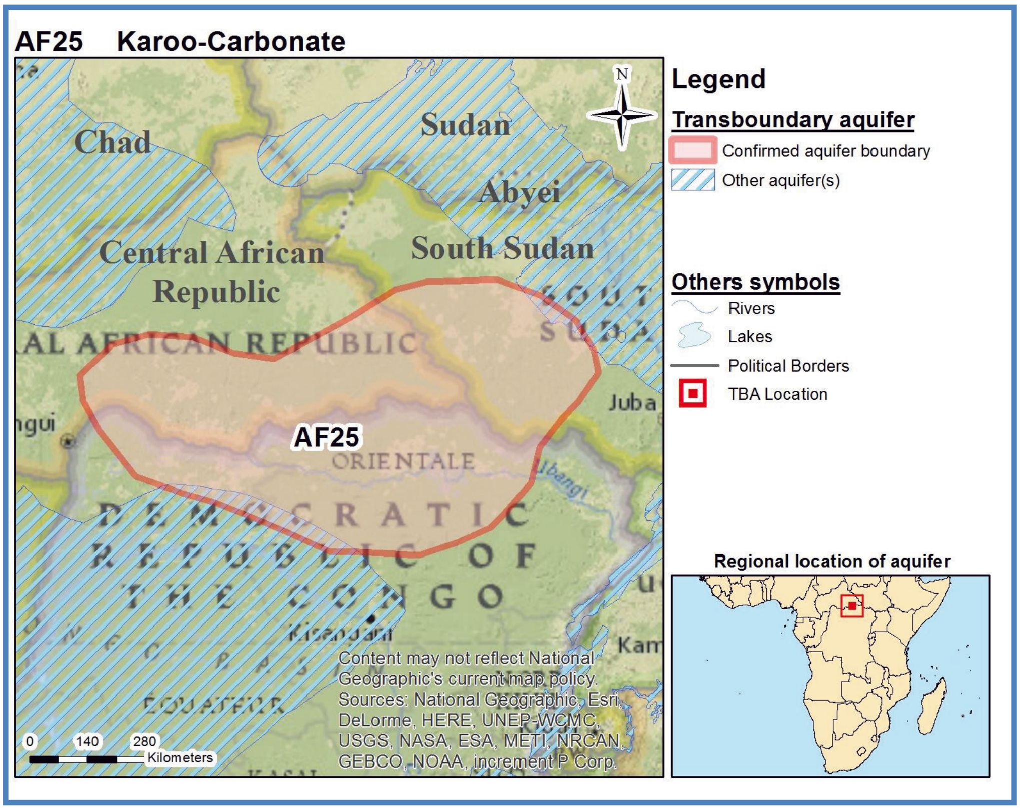
Rainfall (mm/yr): 1600

Hydrogeology

Aquifer type: Data not available

Degree of confinement: Data not available

Main Lithology: Mainly sandstones and limestones



No cross-section available

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)
Central African Republic							6			
Democratic Republic of Congo							12			
South Sudan							8		D	D
TBA level							**9**			

(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)				
Central African Republic	230	42 000	-34	-51	56	58	0	16
Democratic Republic of Congo	260	23 000	-39	-57	57	58	0	19
South Sudan	130	14 000	-42	-62	2	2	0	1
TBA level	**220**	**24 000**	**-39**	**-57**	**43**	**44**	**0**	**12**

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	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)
Central African Republic	3	6	46	94	<1	0	0
Democratic Republic of Congo	3	12	59	120	<1	0	0
South Sudan	1	9	61	130	<1	0	0
TBA level	**2**	**9**	**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)
Central African Republic								
Democratic Republic of Congo								
South Sudan					Sedimentary rocks – sandstones, limestones	High primary porosity fine/ medium	Secondary porosity: Fractures and dissolutions	
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

The core of the transboundary aquifer lies within the Orientale Province in the DRC. The aquifer type has not been specified nor was data available on the depth to the water level, depth to the top of the aquifer, on the thickness of the aquifer system, nor on the degree of confinement of the aquifer.

Hydrogeological aspects

The predominant lithology is sedimentary rocks - limestone and sandstone with some shale. It is characterized by a high primary porosity, with secondary porosity fractures and probable dissolution in the consolidated formations. There is generally a high horizontal and vertical connectivity. The total groundwater volume was only estimated through expert judgment by South Sudan and this is 72 km^3. The mean annual recharge is high to very high. Parts of the area are also characterized by the presence of discontinuous aquifers constituted by magmatic and metamorphic rocks with low

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permeability and the north-eastern part of the aquifer is characterized by a granitic and gneissic complex of the Garamba formation (metamorphic formations that underlie the Congo Craton), while in the extreme northwest, similar formations also constitute part of the aquifer.

Linkages with other water systems

Although recharge is predominantly through direct infiltration of rainwater over the aquifer area there are inter-connections in both directions with the rivers depending on the level of the rivers within the area. As a predominant portion of the aquifer is situated within the equatorial region, except the southern part, discharge areas and the main flow direction is predominantly towards the Congo River system.

Environmental aspects

Data was not available on the extent, depth and percentage of natural groundwater that is unsuitable for human consumption. Furthermore data was not available on the extent and depth of anthropogenic pollution within the system, nor on the percentage of the aquifer with shallow groundwater and groundwater dependent ecosystems.

Socio-economic aspects

The total groundwater abstraction for 2010 was only recorded from South Sudan and this was 2.8 Mm^3 /yr and this was based upon expert judgement. The average yield from the boreholes was reported at 60 m^3/h in the Orientale Province in the DRC. Data was not available on the total amount of fresh water that is utilised over the aquifer area.

Legal and Institutional aspects

According to South Sudan no Transboundary agreement exists, nor is it under preparation. The National Institution is in place, but it is not fully operational.

Emerging Issues

Focus should be placed on establishing Transboundary Groundwater Legislation and an Institute for TBA cooperation.

Contributors to Global Inventory

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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 1 of the 3 countries provided information. Some quantitative information was made available, but this was insufficient to calculate 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.

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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

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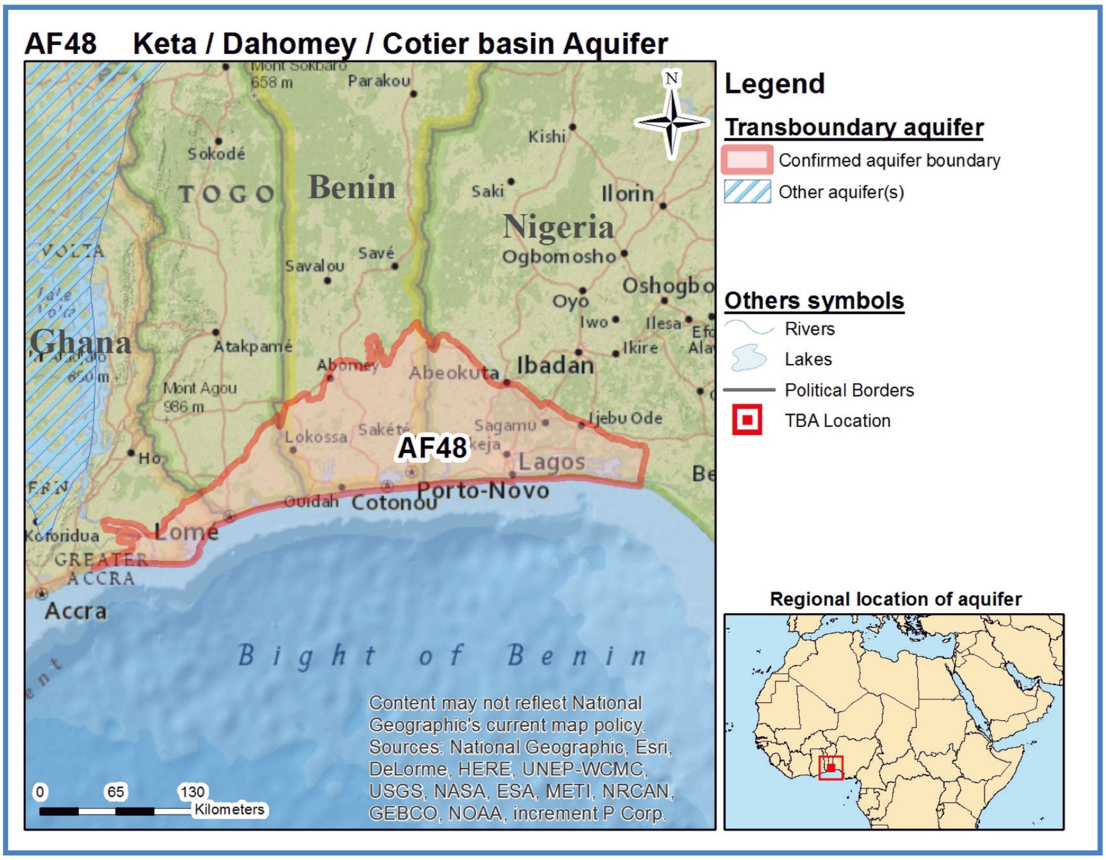
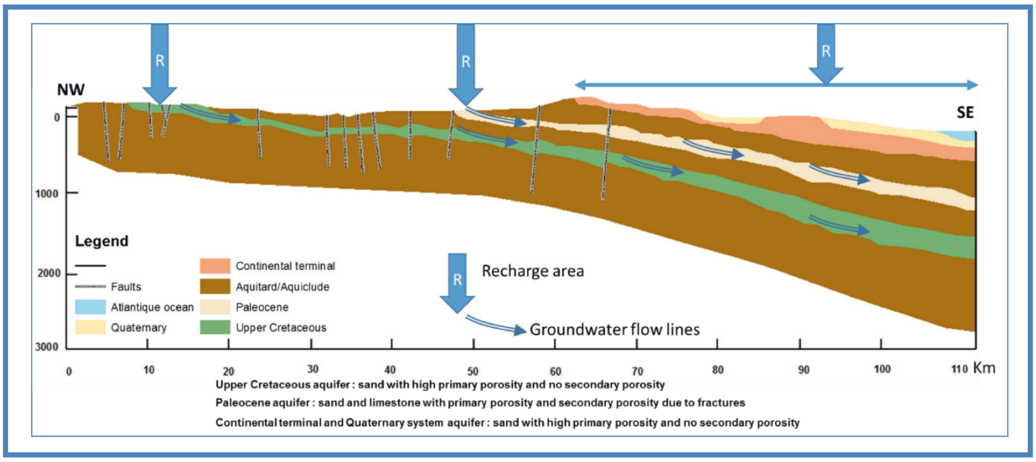
Geography
Total area TBA (km^2): 33 000
No. countries sharing: 4
Countries sharing: Benin, Ghana, Nigeria, Togo
Population: 21 000 000
Climate Zone: Tropical Wet
Rainfall (mm/yr): 1200

Hydrogeology
Aquifer type: Multi-layered hydraulically connected system
Degree of confinement: Mostly confined with some parts unconfined
Main Lithology: Unconsolidated sediment – sand, sedimentary rocks – sandstones and limestones





Geological cross-section of the Keta basin in Togo

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

AF48 - Keta / Dahomey / Cotier Basin Aquifer

TWAP Groundwater Indicators from Global Inventory (for layer 1 - upper)

	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)
Benin			80				380		D	E
Ghana	210	600	80	70	500		340	<5	D	E
Nigeria							1000			
Togo							420			C
TBA level							**640**			

(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 (for layer 1 - upper)

	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)
Benin	<5		25	Whole aquifer unconfined	Sediment - Sand	High primary porosity fine/ medium sedimentary deposits	No secondary porosity	220
Ghana	8	12	100	Aquifer mostly unconfined, but some parts confined	Sediment - Sand	High primary porosity fine/ medium sedimentary deposits		57

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	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)
Nigeria				Aquifer mostly confined, but some parts unconfined				
Togo								
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.

TWAP Groundwater Indicators from Global Inventory (for layer 2 - middle)

	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)
Benin							380		D	E
Ghana							340			
Nigeria							1000			
Togo	730	1800	70	75	0		420	<5	D	D
TBA level							**640**			

(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.

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Key parameters table from Global Inventory (for layer 2 - middle)

	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)
Benin	17	100	30	Aquifer mostly confined, but some parts unconfined	Sedimentary rocks - Limestone	High primary porosity fine/ medium sedimentary deposits	Secondary porosity: Fractures	
Ghana								
Nigeria								
Togo	15	60	270	Aquifer mostly confined, but some parts unconfined	Sediment - Gravel	Very high primary porosity gravels/ pebbles	Secondary porosity: Fractures	820
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.

TWAP Groundwater Indicators from Global Inventory (for layer 3 - lower)

	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)
Benin							380			
Ghana							340			
Nigeria							1000			
Togo							420			
TBA level							**640**			

(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

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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 (for layer 3 - lower)

	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)
Benin	41	500	150	Mostly confined	Sediment sand	high primary porosity fine/medium sedimentary deposits	No secondary porosity	
Ghana								
Nigeria								
Togo								
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.

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)				
Benin	170	470	-43	-64	80	89	12	68
Ghana	73	320	-43	-62	50	62	14	42
Nigeria	260	240	-42	-63	49	89	19	29
Togo	120	260	-41	-60	71	89	3	47
TBA level	**190**	**300**	**-42**	**-63**	**55**	**89**	**12**	**33**

	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)
Benin	1	360	64	140	5	4	36
Ghana	0	230	48	95	5	6	44
Nigeria	0	1100	62	150	11	16	71
Togo	-1	470	47	95	8	6	56
TBA level	**0**	**640**	**61**	**140**	**8**	**11**	**57**

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Aquifer description

Aquifer geometry

The Keta Basin extends from River Volta Estuary in the west to the Okutipupa Ridge in Nigeria in the east. This is a multi-layered hydraulically connected system consisting of 3 main aquifer horizons. The main aquifer formations consist of the upper Quaternary/ Recent aquifer system of unconsolidated sand and gravel (layer 1), that is above the Tertiary semi-confined/ confined sandy-clay with gravel (layer 2), and the upper Cretaceous limestone and the lower Cretaceous basal sandstone aquifers (layer 3) The upper parts of the aquifer system (layer 1) is generally unconfined system while layers 2 and 3 are generally confined. The average depth to the water table in layer 1 varies from <5 m within Benin to 8 m within Ghana. The average piezometric water level within layer 2 varies between 15 m and 17 m. (Benin, Togo), while the average piezometric water level is 41 m in layer 3 (Benin). The average depth to the top of the aquifer of layer 1 is 12 m within Ghana, while in layer 2 this average depth varies between 60 m and 100 m (Benin, Togo), and in layer 3 this is 500 m (Benin). The full vertical thickness of the aquifer system for layer 1 varies between 25m and 100m (Benin, Ghana), while the full vertical thickness of the aquifer system within layer 2 varies from 30 m to 270m (Benin, Togo), and the full vertical thickness of layer 3 is 150 m (Benin).

Hydrogeological aspects

The predominant lithology consists of the upper unconsolidated and semi-consolidated sand and gravel (Continental Terminal Aquifer) that is above the lower Tertiary semi-confined/ confined sandy-clay with gravel (Palaeocene Aquifer), that is above the upper Cretaceous limestone and the lower Cretaceous basal sandstone aquifers. The unconsolidated sands and gravel have a high primary porosity with some secondary porosity fractures within the limestone in the upper part of the Palaeocene Aquifer. The average transmissivity values within layer 1 varies from 57 m^2/d to 215 m^2/d (Benin, Ghana). The average transmissivity value for layer 2 is 820 m^2/d (Togo).The average annual recharge, that is 100 % due to natural conditions, is 612 Mm^3/yr in layer 1 (Ghana) over a recharge area of 4000 km^2 (Benin, Ghana), and 2660 Mm^3/yr in layer 2 (Togo) over a recharge area of 2900 km^2 (Benin, Togo). Groundwater depletion within layer 1 in Ghana is 1.53 km^3 (2000 -2010), whereas it is 0.0003 km^3 in layer 2 within Togo over the same period.

Linkages with other water systems

Recharge is predominantly through precipitation over the aquifer area. The main discharge mechanism is into lakes (Benin) and through evapotranspiration (Ghana) and through submarine outflow (Togo). Within Togo and Benin at the coast the risk of sea water intrusion in deeper layers is of concern (see appendix)..

Environmental aspects

Within layer 1 between 20 % and 22 % of the aquifer area (Benin, Ghana) is unsuitable for drinking water purposes due to natural conditions. This is over a significant part of the aquifer within Benin and Nigeria (where the extent was not quantified), while it is only within the superficial layers in Ghana. The main causes are a high natural salinity and fluorides. Within layer 2 around 29 % of the aquifer area (Togo) is unsuitable for drinking water purposes mainly due to a high natural salinity within the superficial layers. Within layer 3 some of the aquifer has high natural fluoride levels (Benin) but the extent that is affected has not been quantified. With regard to anthropogenic groundwater pollution, within layer 1 this varies between 20% and 22% of the aquifer area (Benin, Ghana) over a significant part of the aquifer (Benin) and within the superficial layers (Ghana). Nigeria has also reported on more limited groundwater pollution within layer 1 but this was not quantified. Within layer 2 a significant amount of anthropogenic pollution has been reported on by Togo within the superficial layers but this was not quantified. Within layer 3 some anthropogenic groundwater pollution was reported on by Benin but this was not quantified. In the Nigerian segment, because of its large population, the water demand from the aquifers of the Basin is extremely high and will most likely be subjected to over-

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abstraction and pollution from natural and man-made causes. Within layer 1 between 14 % (Ghana) and 90 % (Benin) of the aquifer areas are shallow (<5m depth), but the extent of coverage with groundwater dependent ecosystems was not quantified. Within layer 2 around 14% of the aquifer area is shallow and 20 % of the aquifer area is covered with dependent ecosystems(Togo).

Socio-economic aspects
The total amount of groundwater abstraction from the upper aquifer (layer 1) for 2010 was 0.01 Mm^3 (Ghana). Togo reported on an amount of 29 Mm^3 that was abstracted from layer 2 during the same year. Although it has not been quantified, the groundwater abstraction from the system is very high particularly within Nigeria, where over-abstraction has been identified. In Ghana the total amount of fresh water that was abstracted over the aquifer area during 2010 was 0.13 Mm^3, whereas in Togo this was 39.61 Mm^3.

Legal and Institutional aspects
No Transboundary Agreement is currently exists, nor is it under preparation, and no institution exists for TBA management (Benin, Ghana). The Legal Framework differs between Aquifer States. Within Togo the National Institute has a full mandate and capacity.

Priority Issues and Hotspots
The negative impact due to large-scale abstraction from the Nigerian segment could contribute to the potential for transboundary conflict and this must be addressed. The monitoring of ground water level trends with regard to quality and quantity is an important aspect that should receive further attention. The current legal and institutional arrangements for this TBA within the Basin States must be reviewed. The large-scale leakage from artesian boreholes within Benin is a point of concern that must be taken up.

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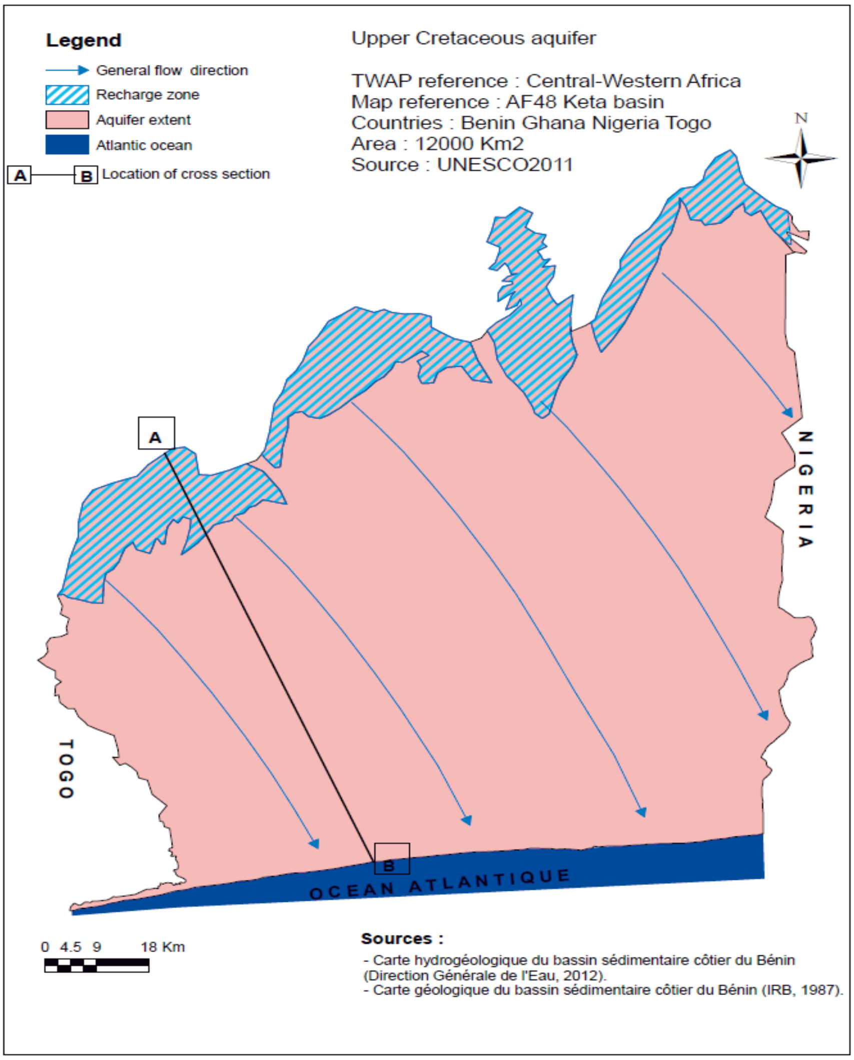
Considerations and recommendations

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.

Various amounts of information were provided by all of the countries, and this was adequate to describe the aquifer in general terms. Although some quantitative information was also made available, it was only sufficient to calculate the indicators partially at a national for the 2 upper aquifer horizons (layers 1 and 2).

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: AF48



Recharge-discharge regime within Benin

AF48 - Keta / Dahomey / Cotier Basin Aquifer

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: May 2017

AF52 - Lake Chad Basin

Geography

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

No. countries sharing: 7

Countries sharing: Algeria, Cameroon, Central Africa Republic, Chad, Libya, Niger, Nigeria

Population: 40 000 000

Climate Zone: Arid

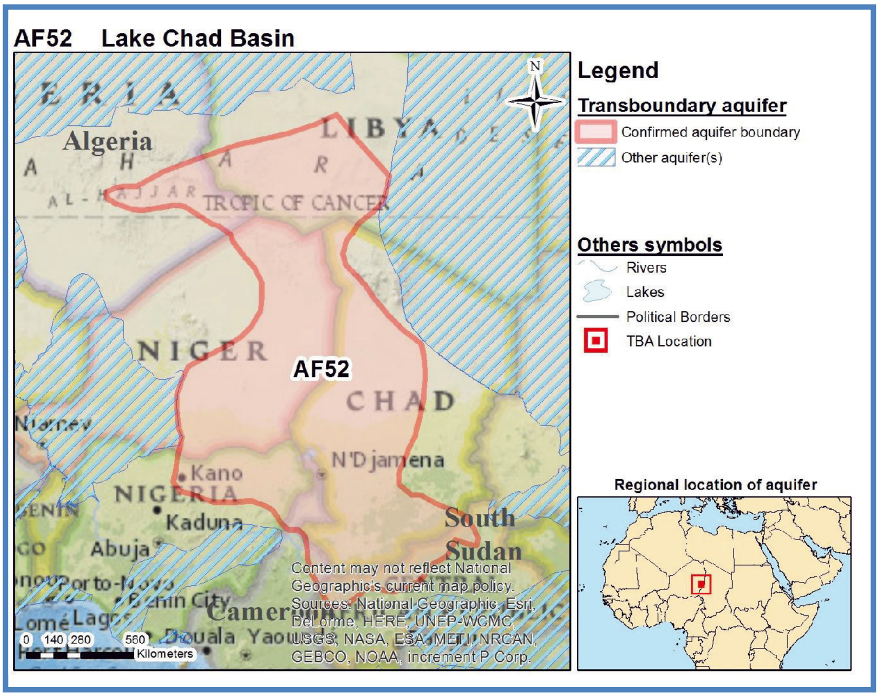
Rainfall (mm/yr): 310

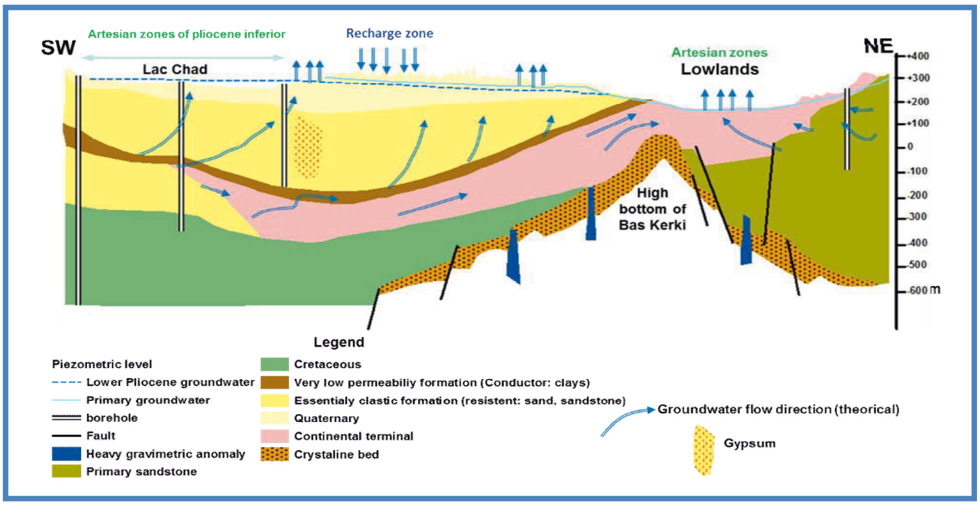
Hydrogeology

Aquifer type: Multiple layers hydraulically connected

Degree of confinement: Mostly unconfined but some parts confined

Main Lithology: Sediment - Sand and Limestones





Cross section along Maiduguri to the SW and Faya Largeau to the NE of the Lake Chad Basin (after Schneider & Wolff, 1992 modified)

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

AF52 - Lake Chad 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							0			
Cameroon							70			
Central African Republic	X	<1				B	8	> 1000	C	C
Chad	<1	<1	70			B	13	>1000		
Libya							1		A	D
Niger							6			
Nigeria							130			A
TBA level										

(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.

AF52 - Lake Chad Basin

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita: Current state (m^3/y/capita)	Renewable groundwater per capita: Projection 2030 (% change to current state)	Renewable groundwater per capita: Projection 2050 (% change to current state)	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 (%)
Algeria	<1	1000	40	-7	68	22	99	<1
Cameroon	320	4500	-30	-52	29	59	6	29
Central African Republic	160	19000	-32	-52	55	57	12	27
Chad	200	15000	-29	-54	27	52	12	1
Libya	<1	670	-12	-26	91	69	100	<1
Niger	10	1500	-15	-48	42	87	9	67
Nigeria	230	1700	-25	-52	42	89	18	84
TBA level	**110**	**5300**	**-29**	**-55**	**48**	**76**	**36**	**56**

	Groundwater depletion (mm/y)	Population density: Current state (Persons/km2)	Population density: Projection 2030 (% change to current state)	Population density: Projection 2050 (% change to current state)	Groundwater development stress: Current state (%)	Groundwater development stress: Projection 2030 (% point change to current state)	Groundwater development stress: Projection 2050 (% point change to current state)
Algeria	0	<1	33	56	19	9	13
Cameroon	0	72	49	100	<1	0	1
Central African Republic	1	8	47	99	<1	0	0
Chad	1	13	63	140	<1	0	0
Libya	1	1	26	49	350	-17	-8
Niger	0	7	92	240	1	1	8
Nigeria	1	130	62	150	2	3	14
TBA level	**1**	**21**	**63**	**150**	**1**	**1**	**3**

AF52 - Lake Chad Basin

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								
Cameroon	30	40						
Central African Republic	60**	100**	300	Aquifer mostly unconfined, but some parts confined	Sediment -Sand		Secondary porosity: Fractures	
Chad	33	7	530	Aquifer mostly unconfined, but some parts confined				X
Libya			700	Aquifer mostly confined, but some parts unconfined	Sediment - Sand	High primary porosity fine/medium sedimentary deposits	Secondary porosity: Dissolution	
Nigeria				Aquifer mostly unconfined, but some parts confined	Sediment -Sand	High primary porosity fine/ medium sedimentary deposits	Secondary porosity: Weathering	
Niger								
TBA level								

* Including aquitards/aquicludes

** These values would need revision as a groundwater table higher than depth to top of the aquifer is un-realistic for an unconfined aquifer.

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

Aquifer description

Aquifer geometry

Although it is mainly a multi 3-layered hydraulically connected system, it reduces to 2 layers within Libya, and is single-layered within Nigeria. The aquifers are generally unconfined with parts being confined. However within Libya the aquifers are generally confined with some unconfined parts. The average water level varies from 30 m (Cameroon) to 60 m (Central African Republic). The average depth to the top of the aquifer varies from 7 m (Chad) to 100 m (Central African Republic). The average full vertical thickness of the aquifer system varies from 300 m (Central African Republic0 to 700 m (Libya).

Hydrogeological aspects

The predominant aquifer lithology consists of sediments – sands, and sandstones, that are calcareous in places (dissolution was noted within Libya as a secondary porosity). These generally have a high primary porosity with secondary porosity that is either due to weathering, fractures, and/ or dissolution (Central African Republic, Libya, Nigeria). Furthermore it is characterised by a high

AF52 - Lake Chad Basin

horizontal and a high to low vertical connectivity (Central African Republic, Libya, Nigeria). The total groundwater volume within two of the countries is 5059 km^3 (Chad, Libya). There is a seasonal difference in recharge events (Central African Republic, Libya, Nigeria). The average annual recharge within part of the aquifer is 100Mm^3/annum (Central African Republic). The amounts for the extreme recharge events have not been recorded. The recharge area within part of the aquifer covers an area of 40 000km^2 (Central African Republic, Nigeria). The total percentage of groundwater recharge that is due to natural recharge varies from 32 % (Nigeria) to 100 % (Cameroon).

Linkages with other water systems

The predominant source of recharge is through infiltration from a surface water body (Chad), and from precipitation on the aquifer area (Cameroon). The natural discharge mechanism is through evapotranspiration (Chad, Cameroon, Niger), through outflow into lakes (Nigeria), and through discharge from springs (Libya where an amount of 1.8 Mm^3/yr was measured).

Environmental aspects

The percentage of natural groundwater quality that is not suitable for human consumption has only been quantified in Chad where this comprises 30% of the aquifer. Elevated amounts of natural salinity within the superficial layers have been reported (Chad, Libya) and this is over a significant part of the aquifer (Nigeria), which also shows elevated amounts of fluoride and other heavy metals. High amounts of fluoride and other undisclosed negative elements have been reported within the superficial layers (Cameroon). Elevated amounts of nitrates, iron, and manganese occur (Central African Republic), but the extent thereof was not specified. Anthropogenic groundwater pollution has been reported on (Cameroon, Central African Republic, Chad, Nigeria). This has been quantified between <5 % (Central African Republic) to 30 % (Chad) of the aquifer area, mainly within the superficial layers. A significant part of the aquifer has been polluted within Nigeria but the data is not available to determine the percentage of the aquifer area that has been affected. Data is also not available on shallow groundwater and groundwater dependent ecosystems over the aquifer area.

Socio-economic aspects

Groundwater abstraction for 2010 from the Aquifer amounted to 0.28 Mm^3 (Chad) and 0.15 Mm^3 (Central African Republic), totalling to an amount of 0.43 Mm^3. This information was based on data from a database and/ or a dedicated study. Data was not available on the total amount of fresh water abstraction over the entire aquifer area.

Legal and Institutional aspects

The information on Agreements is not consistent. Libya reports that a signed Agreement with full scope exists, and the Central African Republic reports on an Agreement with limited scope that has been prepared. A Dedicated Transboundary Institution is in place, and is fully operational (Nigeria). National Institutes exist with a full mandate and capacity (Central African Republic, Nigeria), and with a limited mandate and capacity (Libya).

Priority Issues

With regard to water quality about 30% of the aquifer area within Chad is unsuitable for human consumption based on the natural conditions and on pollution, whereas in some of the other countries this has not been quantified. This is also an important aspect that should receive more attention at a TBA level. The current status of the signed and limited scope Agreements must be reviewed with the purpose of broadening these for application for all of the Basin States.

AF52 - Lake Chad Basin

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.

5 of the 7 TBA countries have contributed to the information. Information was adequate to describe the aquifer in general terms. Some quantitative information was provided but this was insufficient to calculate most of the indicators. The transmissivity values that were provided appear to be unrealistic and these values should be reviewed. The issue of the total amount of groundwater abstraction from the aquifer, that is thought to be a significant amount, must be re-assessed.

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

AF52 - Lake Chad Basin

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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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:

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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.
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- All other data: TWAP Groundwater (2015).

Version: September 2015

AF14 - Nata Karoo Sub-Basin - Caprivi Aquifer (Namibia)

Geography

Total area TBA (km^2): 80 000

No. countries sharing: 5

Countries sharing: Angola, Botswana, Namibia, Zambia, Zimbabwe

Population: 260 000

Climate Zone: Tropical Dry

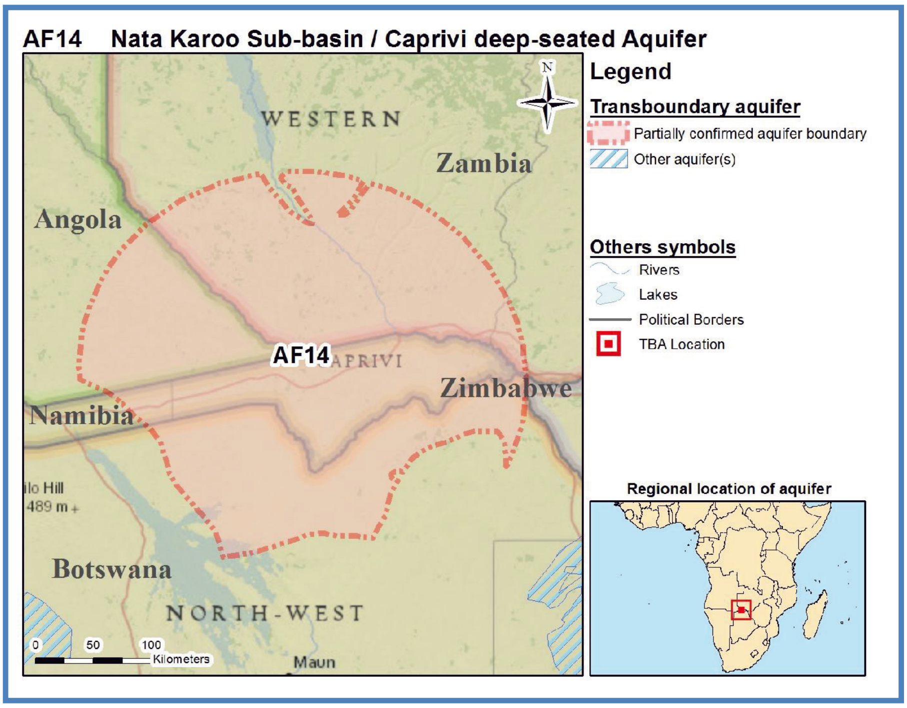
Rainfall (mm/yr): 630

Hydrogeology

Aquifer type: Single to multi-layered aquifer

Degree of confinement: Mainly unconfined – confined in places

Main Lithology: Sediments - sands and sedimentary rocks - sandstone



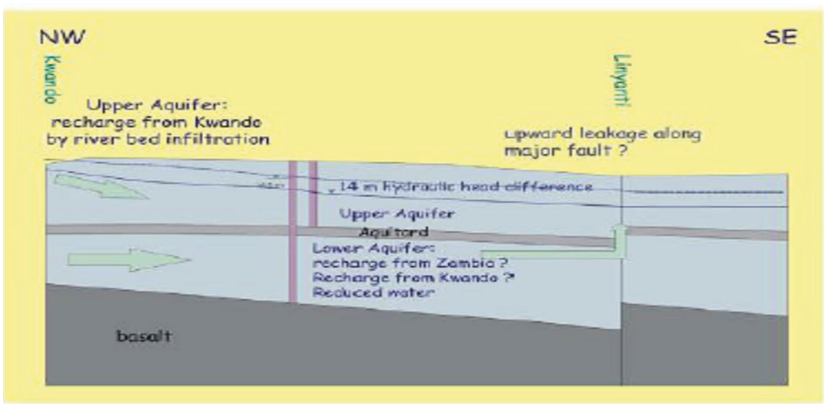


Figure 41: Schematic Concept showing the Structure of the Aquifer System in the Eastern Caprivi

Geological Cross-section of the aquifer system in the Eastern Caprivi - Namibia

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

AF14 - Nata Karoo Sub-Basin - Caprivi Aquifer (Namibia)

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)
Angola							2			
Botswana							1			
Namibia	1	240	40	75	0		4	35	D	B
Zambia	2	450	95		33	B	5	15	B	D
Zimbabwe							4			
TBA level							**3**			

(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)				
Angola	260	130 000	-45	-70	9	9	0	0
Botswana	170	95 000	-28	-47	29	40	1	67
Namibia	410	100 000	-29	-46	18	36	0	67
Zambia	160	32 000	-45	-71	4	28	0	0
Zimbabwe	780	110 000	-42	-66	6	28	3	0
TBA level	**230**	**65 000**	**-41**	**-66**	**10**	**33**	**1**	**67**

AF14 - Nata Karoo Sub-Basin - Caprivi Aquifer (Namibia)

	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)
Angola	-4	2	72	190	0	0	0
Botswana	-3	2	35	72	<1	0	0
Namibia	-3	4	39	75	<1	0	0
Zambia	-1	5	85	240	<1	0	0
Zimbabwe	0	7	73	200	<1	0	0
TBA level	**-2**	**4**	**67**	**180**	<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)
Angola								
Botswana								
Namibia	13**	130**	190	Aquifer Mostly unconfined, but some parts confined	Sediment - Sand	High Primary porosity fine/ medium sedimentary deposits	No Secondary porosity	190
Zambia	20**	24**	18	Whole Aquifer unconfined	Sediment - Gravel	High Primary porosity fine/ medium sedimentary deposits	No Secondary porosity	25
Zimbabwe								
TBA level								

* Including aquitards/aquicludes

** These values would need revision as a groundwater table higher than depth to top of the aquifer is un-realistic for an unconfined aquifer.

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

Aquifer description

Aquifer geometry

Regionally this is largely a single-layered system within the unconfined Kalahari sediments. In Namibia and stretching into Botswana it is a 2-layered system and a deep-seated confined Caprivi aquifer underlies the shallower aquifer. The average depth to the water table varies from 13 m (Namibia) to 20 m (Zambia). The average depth to the top of the shallower aquifer is 24 m (Zambia)

AF14 - Nata Karoo Sub-Basin - Caprivi Aquifer (Namibia)

and the average depth to the top of the deeper aquifer is 128 m (Namibia). The average thickness of the aquifer system varies from 18 m (Zambia) to 190 m (Namibia).

Hydrogeological aspects

The predominant lithology is sediments – sands that are underlain by consolidated sedimentary rocks – sandstone. The formations have a high primary porosity with no secondary porosity and a high vertical and horizontal connectivity. The shallower aquifer is characterized by a relatively low transmissivity value with an average value of 25 m^2/d (Zambia) whereas the deep-seated aquifer has an average value of 190 m^2/d (Namibia). The total groundwater volume within part of the aquifer is estimated at 40 km^3 (Namibia, Zambia). The total mean annual groundwater recharge is 95 Mm^3/yr over an area of about 85 000 km^2 (Namibia, Zambia). During extreme events this figure rises to 117 Mm^3/yr.

Linkages with other water systems

The predominant source of recharge is through precipitation over the aquifer area with some infiltration from rivers in the northern parts of the aquifer. The predominant discharge mechanism is through evapotranspiration and through groundwater flow into surrounding aquifers (Namibia, Zambia).

Environmental aspects

Between 5 % (Zambia) and 60% (Namibia) of the shallower aquifer is not suitable for human consumption. This is mainly due to high salinity and fluoride levels (see Appendix). The deep-seated aquifer has generally fresh water although elevated fluoride levels in places have been noticed. Anthropogenic pollution within the aquifer is limited (Namibia) whereas it is around 10% (Zambia), mainly within the superficial layers. Around 10% of the aquifer area contains shallow groundwater, and around 9% of the area is covered with groundwater dependent ecosystems (Namibia).

Socio-economic aspects

During 2010 the estimated annual groundwater abstraction was around 15.5Mm^3 (Namibia, Zambia). The total fresh water abstraction over the aquifer area was estimated at around 7.4 Mm^3 (Namibia).

Legal and Institutional aspects

No formal TBA Agreement exists, and although a dedicated Transboundary River Basin Institution exists through ZAMCOM, it has a limited mandate and capacity for groundwater. The National Institutes have a limited mandate and capacity (Namibia, Zambia).

Emerging and Priority Issues

The adequate management and extent of the deep-seated aquifer must be further explored. The removal of high fluoride contents, for drinking water purposes, in an economical way, within parts of the lower deep-seated aquifer, that is otherwise of good quality, should receive further attention.

Contributors to Global Inventory

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AF14 - Nata Karoo Sub-Basin - Caprivi Aquifer (Namibia)

Name	Organisation	Country	E-mail	Role
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Pasca Mwila	Ministry of Mines Energy and Water Development	Zambia		Contributing national expert
Simon Kangomba	Ministry of Mines Energy and Water Development	Zambia	kangomba@yahoo.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.

Only 2 of the 5 TBA countries have provided information. The information was adequate to describe the aquifer in general terms. The quantitative information did allow for the calculation of the indicators at the relevant 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.

Appendix: AF14

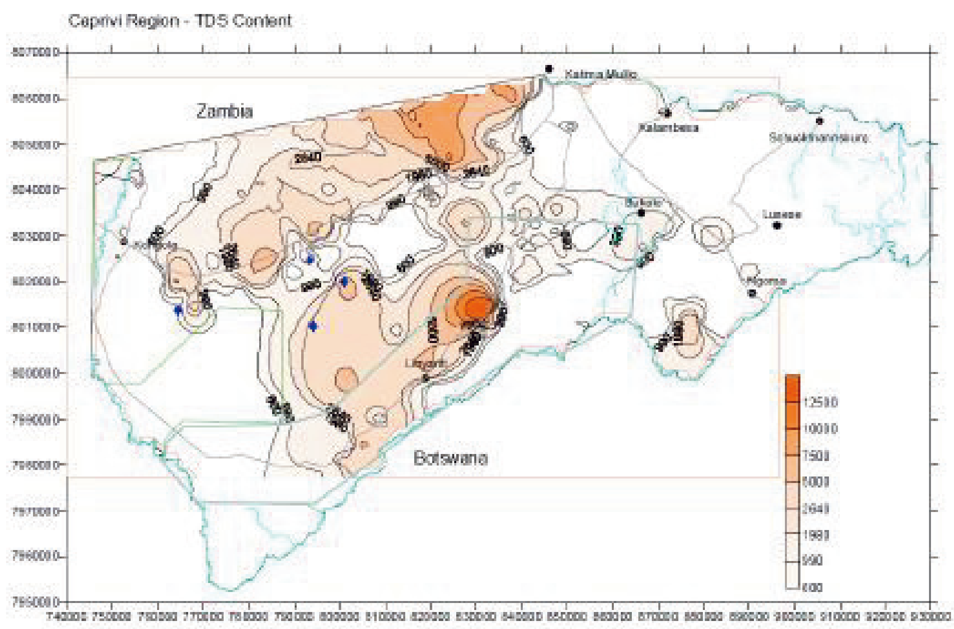

Figure 38: Distribution of Total Dissolved Solids (TDS; in mg/l) in the Upper Aquifer (grey line: HEM survey area; blue symbols: new DWA-BGR boreholes)

Groundwater salinity contours within the Namibia side

AF14 - Nata Karoo Sub-Basin - Caprivi Aquifer (Namibia)

Colophon

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References:

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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: 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

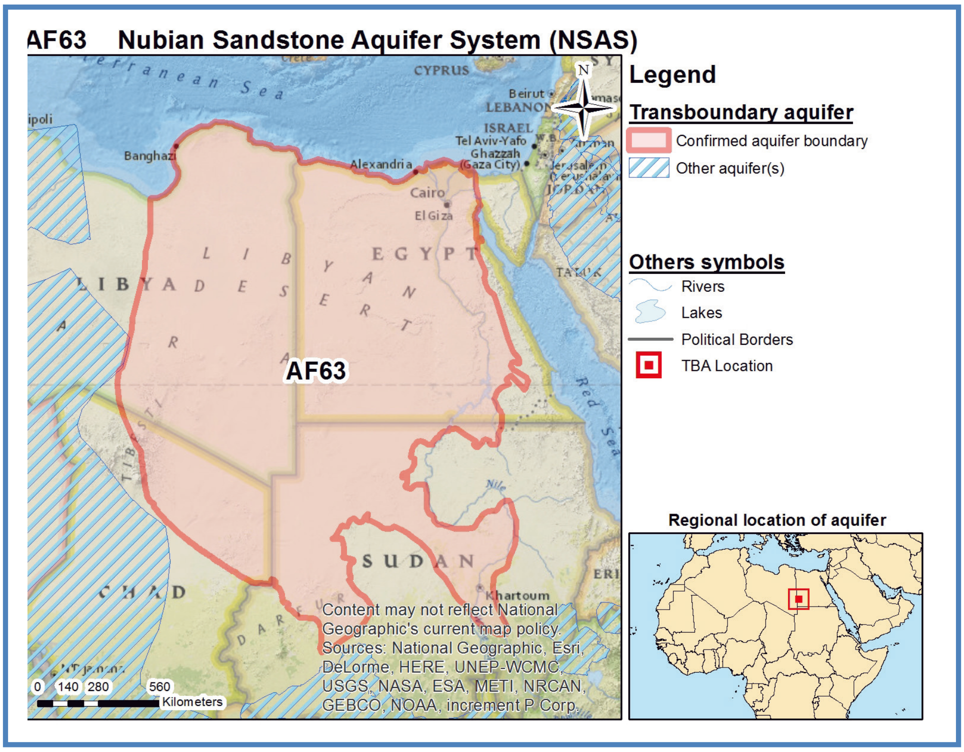
Rainfall (mm/yr): 30

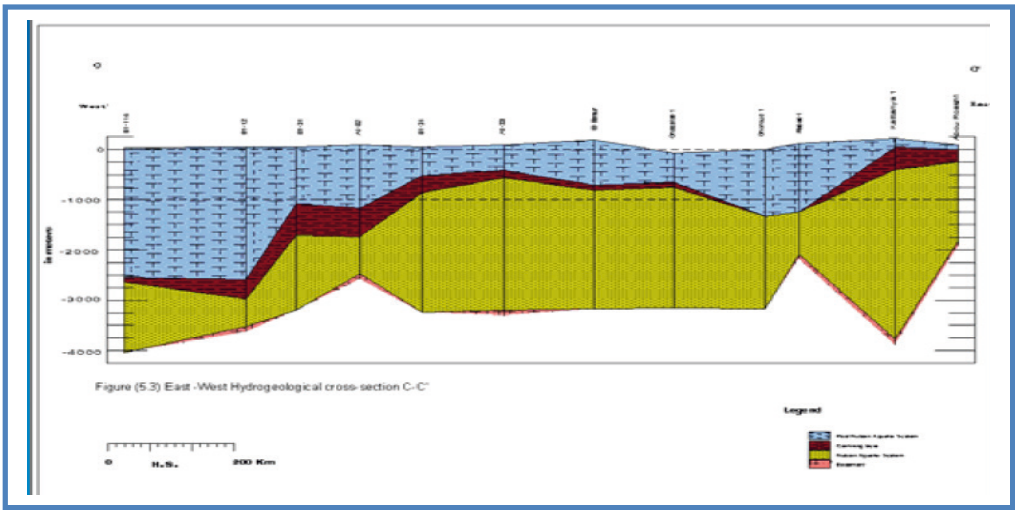
Hydrogeology

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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Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator
Cheikh Becaye Gaye	Université Cheikh Anta Diop	Senegal	cheikhbecayegaye@gmail.com	Regional coordinator

AF63 - Nubian Sandstone Aquifer System

Name	Organisation	Country	E-mail	Role
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Nahed el Sayed El Arabi	Research Institute for Groundwater	Egypt	elarabinahed@gmail.com	Lead National Expert

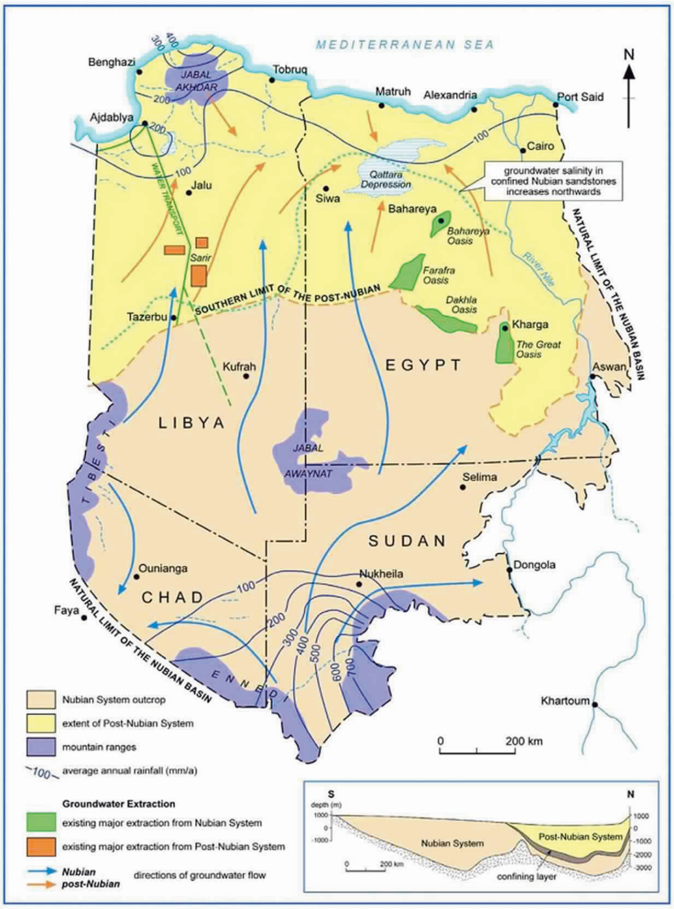
Considerations and recommendations

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

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- All other data: TWAP Groundwater (2015).

Version: May 2017

AF42 - Rio Del Rey

Geography

Total area TBA (km^2): 5700

No. countries sharing: 2

Countries sharing: Cameroon, Nigeria

Population: 2 000 000

Climate Zone: Tropical Wet

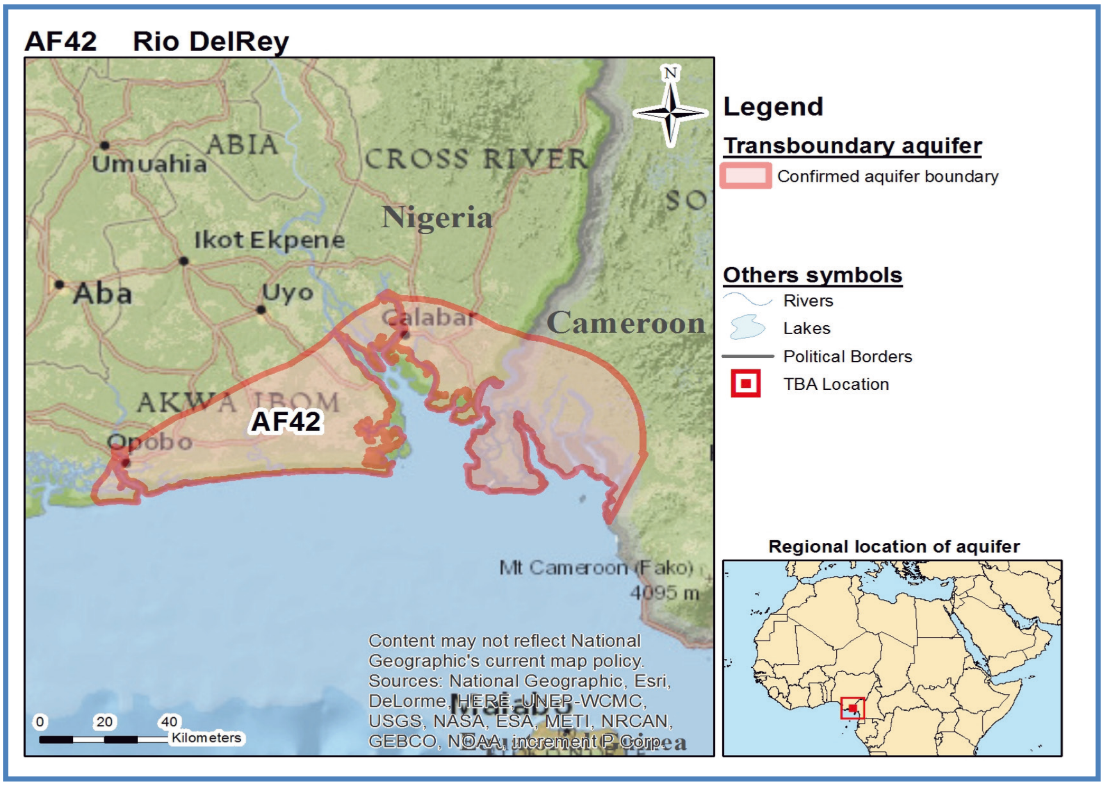
Rainfall (mm/yr): 3100

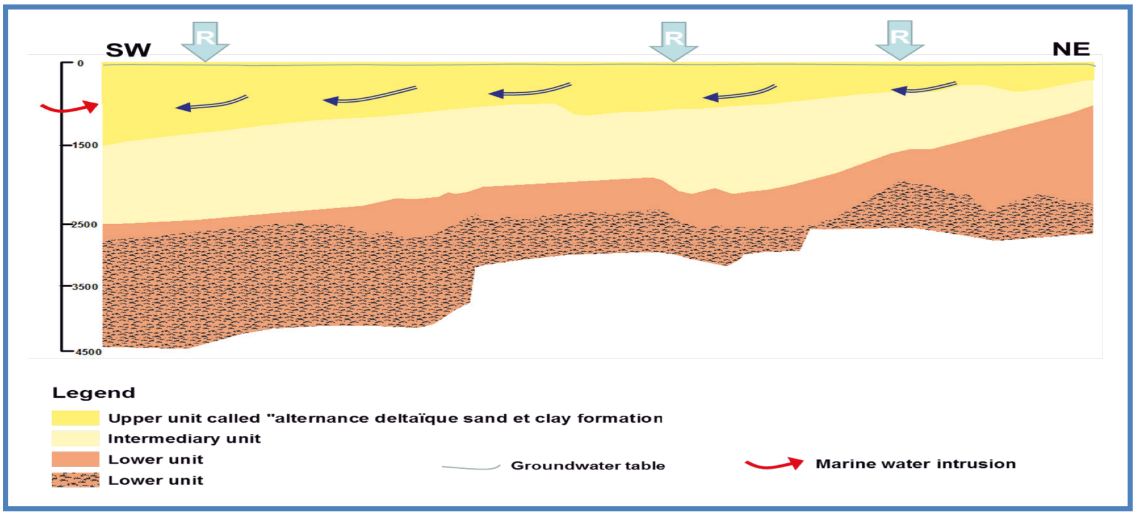
Hydrogeology

Aquifer type: A multi-layered hydraulically connected system

Degree of confinement: Data not available

Main Lithology: Sediments – sands, and sedimentary sandstones, shales and limestones





Geological cross-section of the Rio del Rey Bassin

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

AF42 - Rio Del Rey

TWAP Groundwater Indicators from Global Inventory

No data available.

Key parameters table from Global Inventory

No data available.

Aquifer description

Aquifer geometry

This coastal aquifer is an extension of the western margin of the Niger Delta and is also bordered by the Niger Delta Basin in the northwest. In the south it is limited by the Gulf of Guinea (Atlantic Ocean) and in the north by the Rumpi Hills and to the east by the Cameroon Volcanic Line which separates it from the Douala Basin. It is a multi-layered hydraulically connected system. There is no data available about the average depth of the water level, on the aquifer geometry, or on the degree of confinement of the aquifer system.

Hydrogeological aspects

The predominant lithology consists of Quaternary sediments that overlie Tertiary sediments and Cretaceous limestones. The main lithologies of the aquifer formation are sediments – sands, and sedimentary sandstones, shales and limestones. There is no information about the aquifer parameters, groundwater volumes or on the recharge quantity.

Linkages with other water systems

Besides the recharge through precipitation over the aquifer area, interaction through recharge from and discharge to the Niger River system occurs. Within Cameroon and Nigeria the water quality within the aquifer is affected by sea water intrusion.

Environmental aspects

Within Cameroon and there is no data available with regard to the natural water quality within, and the extent and depth of the aquifer that has been affected by sea water intrusion. No information has been provided with regard to the amount and the extent of anthropogenic groundwater pollution within the aquifer, or on shallow groundwater and on groundwater dependent ecosystems.

Socio-economic aspects

There is no data available with regard to the total amount of groundwater abstraction from the aquifer. Within the Bacasi region between Cameroon and Nigeria there is possibly over-abstraction that is occurring.

Legal and Institutional aspects

There was no information provided with regard to the legal and institutional set-up within the Aquifer States.

Hotspots

Disputes between Cameroon and Nigeria in the Bacasi region is possibly due to over-abstraction that has a direct impact on the water quality. This aspect must be further investigated.

Contributors to Global Inventory

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

AF42 - Rio Del Rey

Considerations and recommendations

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- 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

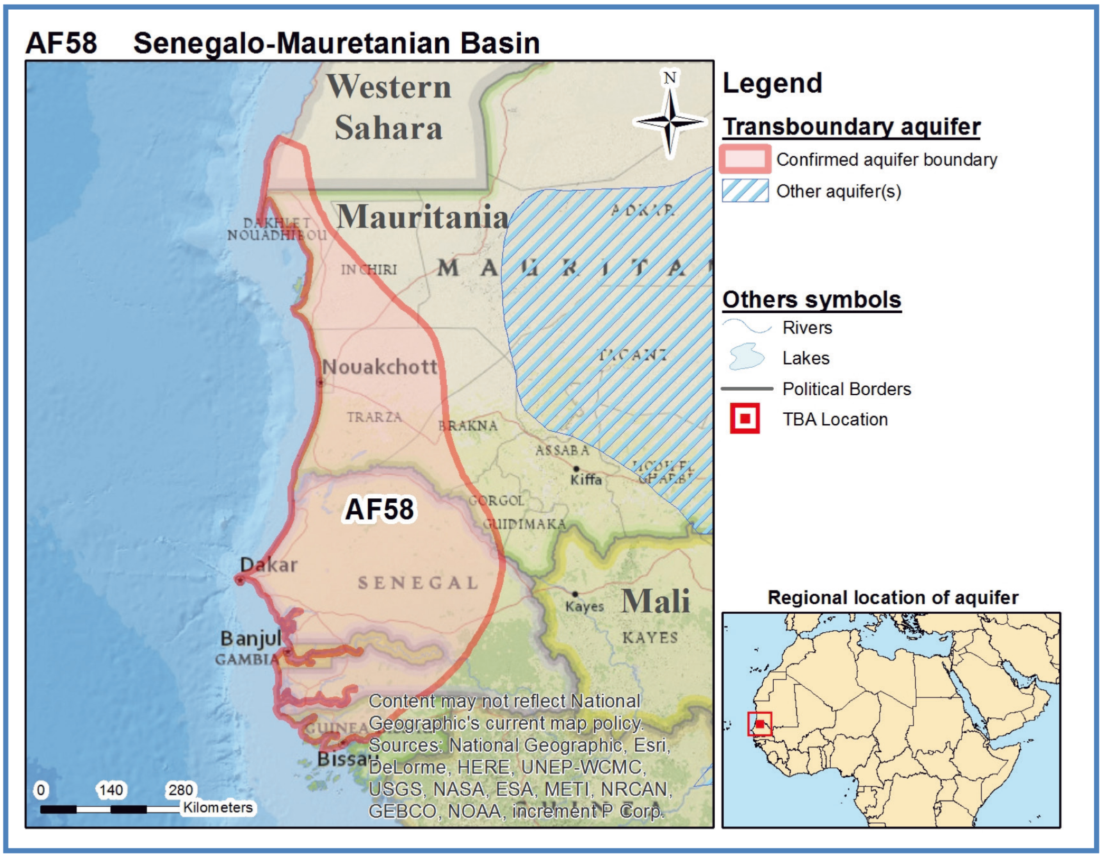
Rainfall (mm/yr): 460

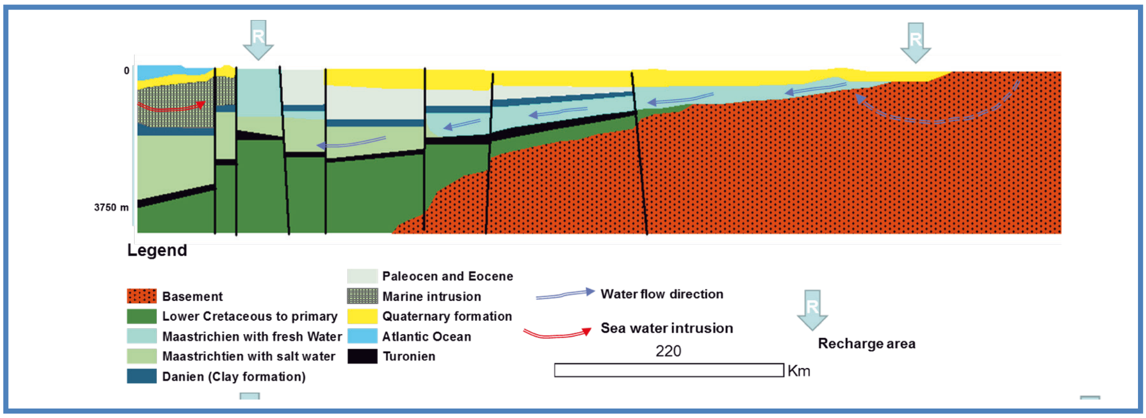
Hydrogeology

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

AF58 - Senegalo-Mauretanian Basin

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

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Considerations and recommendations

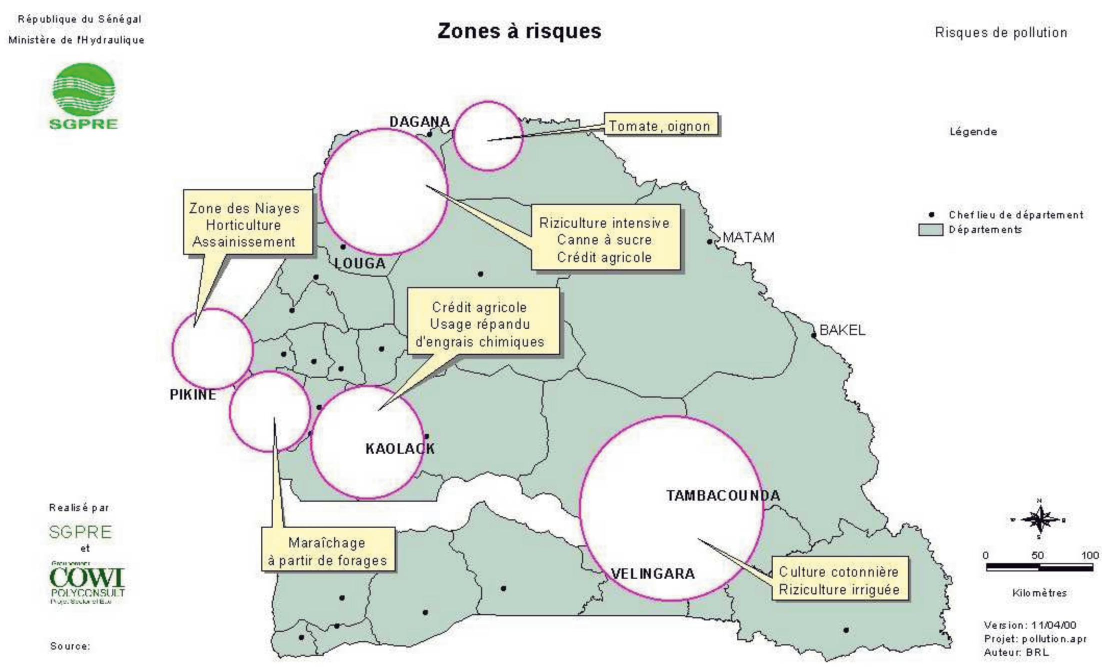
Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

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.

AF58 - Senegalo-Mauretanian Basin

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.

AF58 - Senegalo-Mauretanian Basin

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

AF26 - Tanganyika Aquifer

Geography

Total area TBA (km^2): 170 000

No. countries sharing: 3

Countries sharing: Burundi, Democratic Republic of Congo, Tanzania

Population: 9 400 000

Climate Zone: Tropical Dry

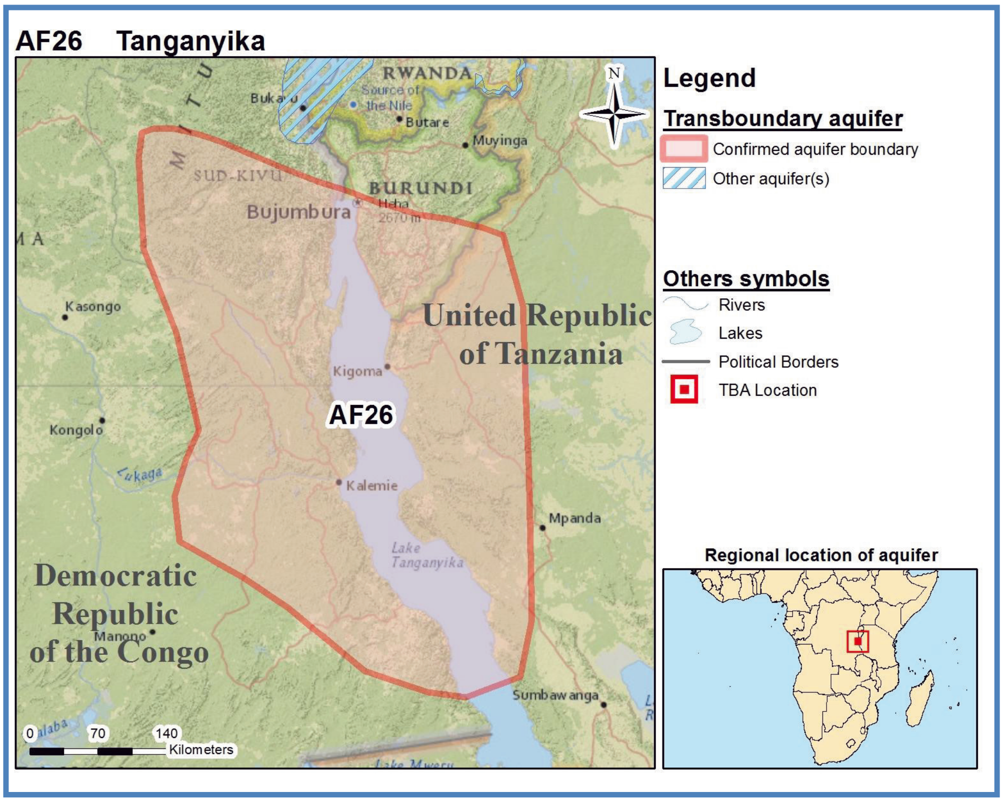
Rainfall (mm/yr): 1200

Hydrogeology

Aquifer type: Multi-layered hydraulically connected system – single layered in Burundi

Degree of confinement: Largely confined but some parts are unconfined

Main Lithology: Basalts and metamorphosed rocks



No cross-section available

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

AF26 - Tanganyika Aquifer

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)
Burundi							300			
Democratic Republic of Congo							32			
Tanzania	32	600	95				53		B	D
TBA level							**57**			

(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)				
Burundi	120	590	-23	-40	18	25	0	1
Democratic Republic of Congo	89	3100	-35	-55	41	53	0	25
United Republic of Tanzania	71	1600	-37	-63	21	25	5	0
TBA level	**85**	**1900**	**-33**	**-55**	**28**	**37**	**1**	**11**

AF26 - Tanganyika Aquifer

	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)
Burundi	-1	200	40	73	1	0	3
Democratic Republic of Congo	-1	28	56	120	<1	0	1
United Republic of Tanzania	0	43	76	190	<1	0	1
TBA level	**-1**	**45**	**57**	**130**	**<1**	**0**	**1**

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)
Burundi				Whole aquifer unconfined				
Democratic Republic of Congo								
Tanzania	5	5	50	Mostly confined but unconfined in parts	Basalts and metamorphosed rocks,	Low primary porosity	Secondary porosity fractures	50
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 hydraulically connected system, although it is reduced to a single layer within Burundi. The aquifer is mostly confined but some parts are unconfined. The average depth to the water table is 5 m, and the average depth to the top of the aquifer is also 5 m while the average thickness of the aquifer system is 50m (Tanzania).

Hydrogeological aspects

The predominant lithology is basalts and metamorphosed rocks that are characterized by a low primary porosity and with secondary porosity fractures. It is also characterized by a low horizontal and a low to high vertical connectivity. The average transmissivity value is 50 m^2/d, and the total

AF26 - Tanganyika Aquifer

groundwater volume within Tanzania is 195 km^3. Recharge is 100% due to natural conditions and the mean annual recharge was calculated as 1 670 Mm^3/yr over an area of about 56 000 km^2 (Tanzania).

Linkages with other water systems

The predominant source of recharge is through precipitation on the aquifer area in Tanzania and through runoff into aquifer area within Burundi. The predominant discharge mechanism is through springs in Tanzania and through and through outflow into lakes within Burundi.

Environmental aspects

Within Tanzania the percentage of the aquifer that is not suitable for drinking water due to natural quality problems is around 5 %. This is mainly due to high salinity in the superficial layers. Some anthropogenic groundwater 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. There are risks related to pollution from Lake Tanganyika and this is through fractures where there is connection between the lake and the aquifer. Shallow groundwater has only been quantified in Tanzania where about 30 % of the aquifer's water table is reported to be <5 m below ground level and around 25 % covered with groundwater dependent ecosystems.

Socio-economic aspects

The total amount of groundwater that was abstracted from the system during 2010 was not recorded. The total amount of fresh water abstracted from the entire aquifer area was also not specified.

Legal and Institutional aspects

A signed Transboundary agreement with limited scope is reported by Tanzania. There is no Transboundary Institute in place and the national institution in Tanzania has a limited mandate and capacity.

Emerging Issues

There is no Transboundary Institute in place and further attention to this aspect should be given. Furthermore there is a relatively high population density over the aquifer and it seems to be quite vulnerable to pollution. The level of groundwater quality monitoring must be reviewed.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
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AF26 - Tanganyika Aquifer

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 2 of the 3 TBA countries provided information. The information was not sufficient to describe some of the aspects such as the socio-economic aspects. Only the information from Tanzania 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.

Colophon

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- All other data: TWAP Groundwater (2015).

Version: September 2015

Groundwater TWAP TRANSBOUNDARY WATERS ASSESSMENT PROGRAMME

AF47 - Tano Basin

Geography

Total area TBA (km^2): 14 000

No. countries sharing: 2

Countries sharing: Côte d'Ivoire, Ghana

Population: 4 900 000

Climate Zone: Tropical Dry

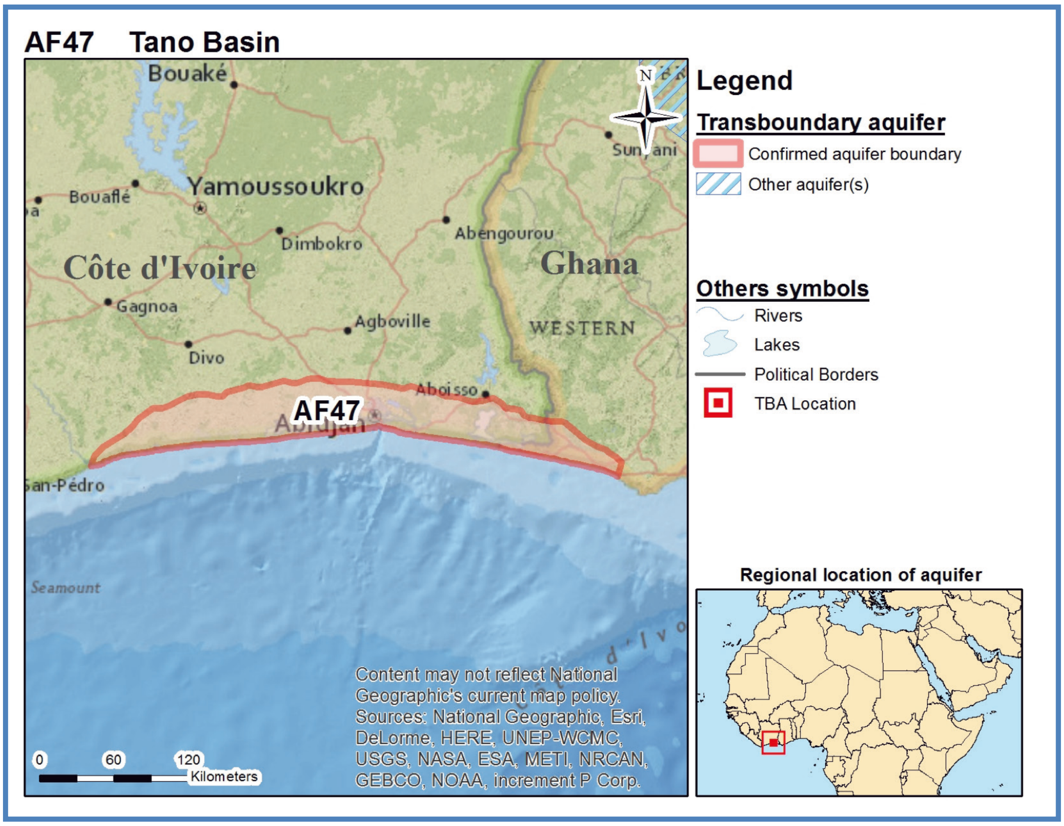
Rainfall (mm/yr): 1800

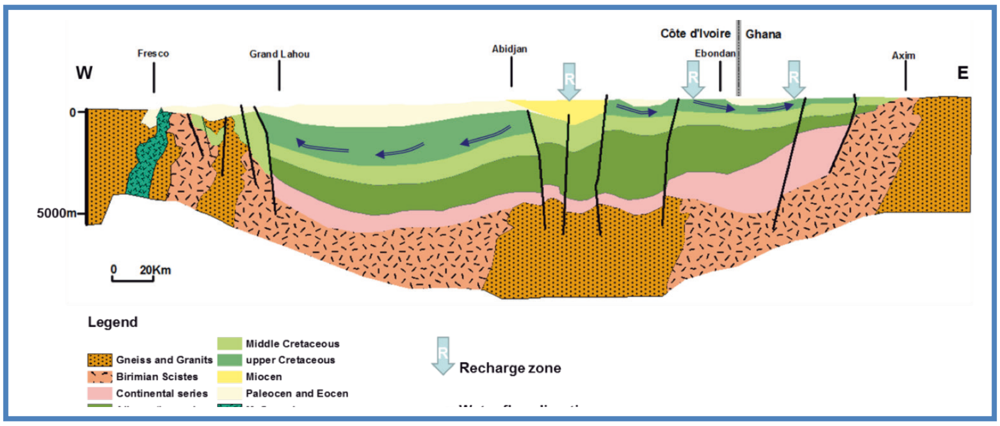
Hydrogeology

Aquifer type: A multiple layered hydraulically connected system to single layered in places

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

Main Lithology: Sediment – sands with some silt and clay, sedimentary limestones





Geological cross-section of the Tano basin

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

AF47 - Tano 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)
Côte d'Ivoire	20	52			0		380	<5		
Ghana	450	4100	85	65	-250	B	110	<5	D	E
TBA level							**350**			

(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.

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)
Côte d'Ivoire	30	80	120	Aquifer mostly unconfined, but some parts confined				<5
Ghana	<5	<5	61	Aquifer mostly unconfined, but some parts confined	Sediment - Sand	High primary porosity fine/ medium sedimentary deposits		22
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.

AF47 - Tano Basin

Aquifer description

Aquifer geometry

About 5% of aquifer's total surface is located in Ghana and 95% in Côte Ivoire. Within the Côte d'Ivoire this is a 3-layered hydraulically connected system, whereas within Ghana it is only single layered. The aquifer is mostly unconfined, but some parts are confined. The average depth to the water table varies from 30 m in Côte d'Ivoire to <5 m within Ghana. The average depth to the top of the aquifer varies from 80 m within Côte d'Ivoire to <5 m within Ghana. The average thickness of the entire aquifer system varies from 120 m within Côte d'Ivoire to 61 m within Ghana.

Hydrogeological aspects

This basin contains three major aquifers i.e. the upper Quaternary aquifers, followed by the Continental Terminal aquifer that is a continuous system, while the underlying Cretaceous Maastrichtian aquifer is sometimes discontinuous. The predominant lithology of the Quaternary and Continental Terminal aquifers are composed mainly of coarse-to-fine sediments, sandy loam, red clay while the Maastrichtian aquifer comprises sediments – sands and sedimentary limestones. Within Ghana there is a high primary porosity of fine/medium sedimentary deposits. It is characterised by a high vertical connectivity. The average transmissivity varies from <5 m^2/d within Côte d'Ivoire to 22 m^2/d within Ghana. The average horizontal conductivity varies from low in Côte d'Ivoire to relatively high within Ghana. The total groundwater volume within the system is 22 km^3. There are no extreme recharge events within this system and the average annual recharge is 930 Mm^3/yr. The recharge area within Ghana covers 1 200 km^2.

Linkages with other water systems

Within Ghana it is estimated that only 31 % of the recharge is through natural processes i.e. through precipitation over the aquifer area. The source of indirect recharge was not specified. The major groundwater discharge mechanism within Ghana is through evapotranspiration while in Côte d'Ivoire it is through outflow into lakes.

Environmental aspects

Within Ghana 15% of the superficial layers is unsuitable for human consumption and this is due mainly to natural salinity and excess Arsenic. Within Côte d'Ivoire this has not been quantified although in areas high natural nitrates are prevalent within some areas. These areas have been mapped out within Ghana. The aquifer has been subject to anthropogenic pollution within the superficial layers and the amount has been quantified within Ghana at 15% of the area. Within Ghana around 8% of the area has shallow groundwater levels but this has not been quantified within the Côte d'Ivoire. Data was not available on the extent of the aquifer area covered with groundwater dependent ecosystems.

Socio-economic aspects

The total annual abstraction of groundwater from the system was 2.47 Mm^3/yr. This was based on summations of data from the database and/ or dedicated studies. The total groundwater depletion between 2000 and 2010 was 0.385 km^3 and 0.0023 km^3 within Côte d'Ivoire and these figures have been derived through dedicated studies. The total fresh water abstraction over the aquifer area was only provided by Ghana and this amounted to 0.25 Mm^3/yr.

Legal and Institutional aspects

According to Togo no transboundary agreement exists, nor is it under preparation, and no institution exists for TBA management.

AF47 - Tano Basin

Priority Issues and Hotspots

It is important that attention be placed on institutional development at a Transboundary and national level within both countries. Oil exploitation is creating disputes between both countries in the border of this TBA and the causes thereof relative to Transboundary cooperation should be further investigated.

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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.

Most of the quantitative information was provided by Ghana. Aspects of the aquifer geometry and parameters have been addressed with consistent and realistic information, allowing indicator estimates at a 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.

AF47 - Tano 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

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

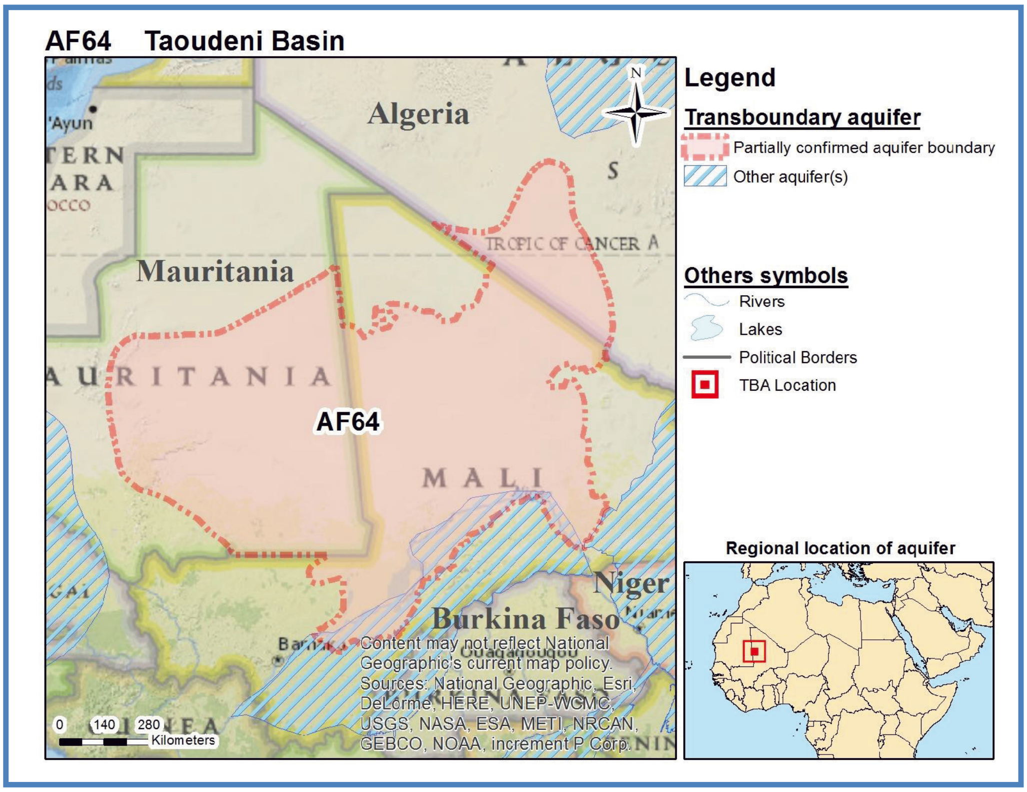
Rainfall (mm/yr): 110

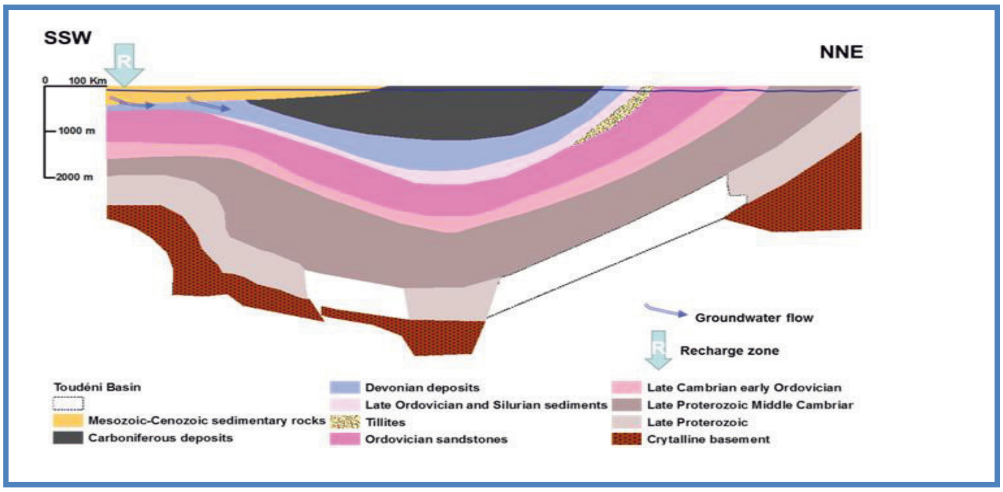
Hydrogeology

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**

AF64 - Taoudéni Basin

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
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
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
Aboubacar Modibo Sidibé	Direction Nationale de l'Hydraulique du Mali	Mali	aboubacar.sidibe@hotmail.fr	Contributing national expert

Considerations and recommendations

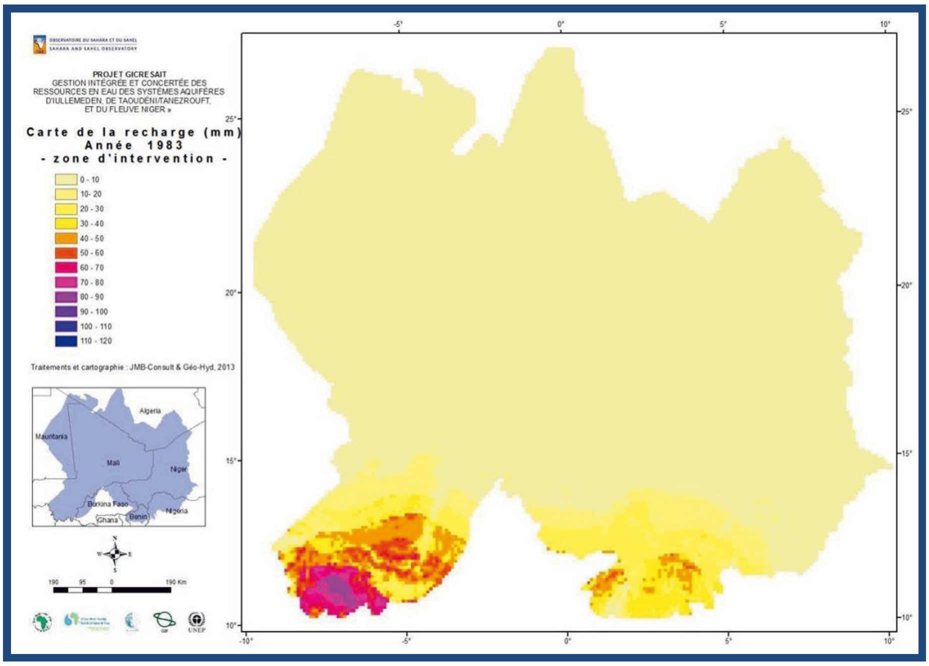
Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

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

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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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- 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

AF54 - Volta Basin

Geography

Total area TBA (km^2): 130 000

No. countries sharing: 5

Countries sharing: Benin, Burkina Faso, Ghana, Niger, Togo

Population: 6 100 000

Climate Zone: Tropical Dry

Rainfall (mm/yr): 1200

Hydrogeology

Aquifer type: Multiple layered to single layered

Degree of confinement: Confined to unconfined

Main Lithology: Sedimentary rocks - sandstones

No cross-section available

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

AF54 - Volta 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)
Benin	330	9800					33		D	
Burkina Faso							25			
Ghana							48			
Niger							7			
Togo	30	480		65			62	<5	B	D
TBA level							**47**			

(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)				
Benin	110	3300	-31	-54	68	89	6	88
Burkina Faso	87	3200	-28	-56	77	89	7	88
Ghana	130	2600	-33	-53	35	46	14	23
Niger	60	4600	-31	-59	36	87	5	0
Togo	180	2700	-28	-47	65	83	3	85
TBA level	**130**	**2700**	**-32**	**-52**	**40**	**53**	**12**	**25**

AF54 - Volta 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)
Benin	1	35	57	130	1	0	3
Burkina Faso	1	27	74	180	1	0	6
Ghana	1	50	50	100	<1	0	3
Niger	1	13	87	220	<1	0	3
Togo	2	67	47	94	1	0	3
TBA level	**1**	**49**	**51**	**100**	**<1**	**0**	**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)
Benin	9		1200	Aquifer mostly unconfined, but some parts confined	Sedimentary rocks - Sandstone	Low primary porosity intergranular porosity	Secondary porosity: Weathering	
Burkina Faso								
Ghana								
Niger								
Togo	10	120	210	Aquifer mostly confined, but some parts unconfined	Sedimentary rocks - Sandstone	Low primary porosity intergranular porosity	Secondary porosity: Fractures	
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 is single layered within Togo. The Aquifer is mostly confined, but some parts are unconfined. The average depth to the water table varies between 9 m and 10 m (Benin, Togo). The average depth to the top of the aquifer is 115 m within Togo. The average vertical thickness of the aquifer system varies from 210 m in Togo to 1200 m within Benin.

AF54 - Volta Basin

Hydrogeological aspects

The aquifer system is a sedimentary aquifer with three main aquifers: the Upper Quaternary, the lower Pliocene and the Terminal Continental (Oligocene–Miocene). The aquifer system is mainly composed of sandstone with some limestone. It is an integranular aquifer that is characterised by a low primary porosity with secondary porosity through weathering and fractures. It also has a low horizontal and vertical connectivity. Data was not available on the average transmissivity value. There is no seasonal difference in recharge, that is 100 % due to natural conditions, and the average recharge is 3 040 Mm^3/yr (Benin, Togo). Within Togo the main recharge area covers 2 100 km^2.

Linkages with other water systems

The predominant source of recharge is through precipitation over the aquifer area. The natural discharge mechanism is through river base flow (Togo, Benin).

Environmental aspects

Data is not available on the percentage of natural water that is unsuitable for human consumption and there are no pollutants of natural origin that have been listed. Within Togo anthropogenic groundwater pollution has been observed but the data is not available to determine the percentage of the aquifer area that has been affected. Within Togo around 20 % of the aquifer is represented by shallow groundwater systems but data is not available on the % of the aquifer area that is covered by groundwater dependent ecosystems. Within Benin no shallow groundwater is present within the aquifer.

Socio-economic aspects

Within Togo the annual groundwater abstraction for 2010 was 0.29 Mm^3 and the total fresh water abstraction over the aquifer area was 0.46 Mm^3.

Legal and Institutional aspects

According to Togo there is an Agreement with limited scope for TBA management signed by all parties. However according to Benin no agreement exists, nor is under preparation. Within Togo the National institution is in place, but it is not fully operational.

Emerging issues

Attention should be given towards reviewing and drafting of a Transboundary Agreement and towards Institutional support.

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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Kpadja Agouda	Mnistère en Charge de l'Eau	Togo	agoudakpadja@yahoo.fr	Contributing national expert
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Bisse Ndim	TdE et FORATEC	Zambia		Contributing national expert
Abla Tozo	Ministère de l'Eau	Zambia		Contributing national expert

AF54 - Volta 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.

Only 2 of the 5 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 all of the indicators at the national levels for the 2 contributing 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.

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: September 2015

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

AF33

Geography

Total area TBA (km^2): 21 000

No. countries sharing: 2

Countries sharing: Congo, Gabon

Population: 103 000

Climate Zone: Tropical Wet

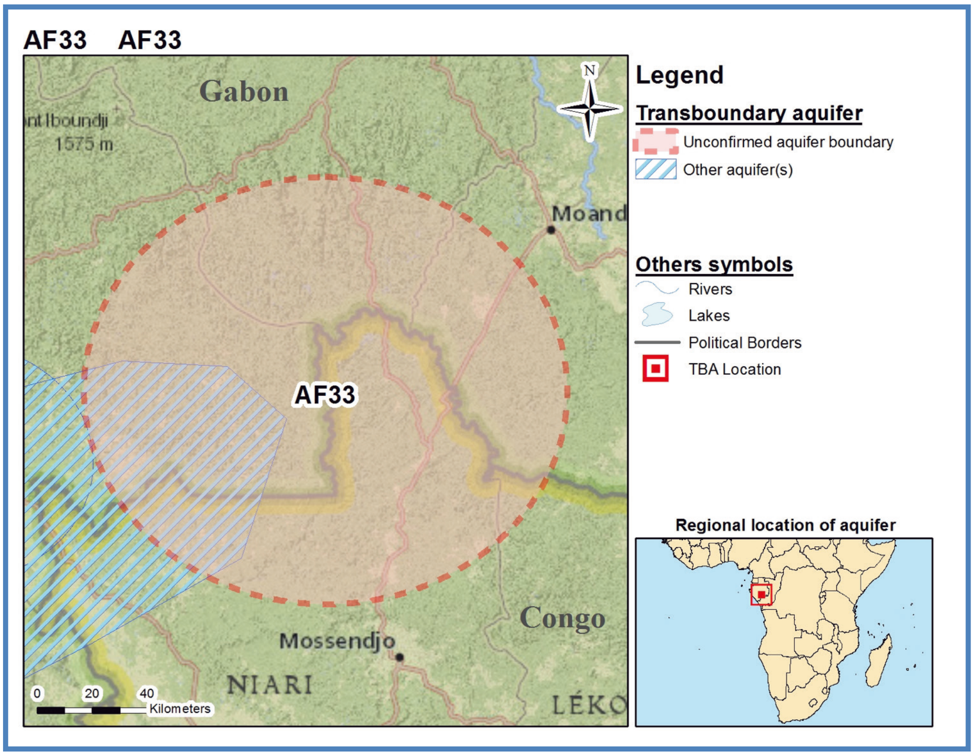
Rainfall (mm/yr): 1900

Hydrogeology

Aquifer type: Data not available

Degree of confinement: Data not available

Main Lithology: Data not available



No cross-section provided

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

AF33

TWAP Groundwater Indicators from Global Inventory

No data available.

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)				
Congo	340	56 000	-36	-55	21	22	<1	<1
Gabon	440	100 000	-32	-49	1	1	<1	<1
TBA level	**400**	**82 000**	**-34**	**-52**	**3**	**4**	**<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)
Congo	1	6	51	110	<1	0	0
Gabon	2	4	44	91	<1	0	0
TBA level	**2**	**5**	**47**	**100**	**<1**	**0**	**0**

Key parameters table from Global Inventory

No data available.

Aquifer description

No data available

Contributors to Global Inventory

No contributors

Considerations and recommendations

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AF33

Colophon

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- All other data: TWAP Groundwater (2015).

Version: May 2017

AF34

Geography

Total area TBA (km^2): 6500

No. countries sharing: 2

Countries sharing: Congo, Gabon

Population: 33 000

Climate Zone: Tropical Wet

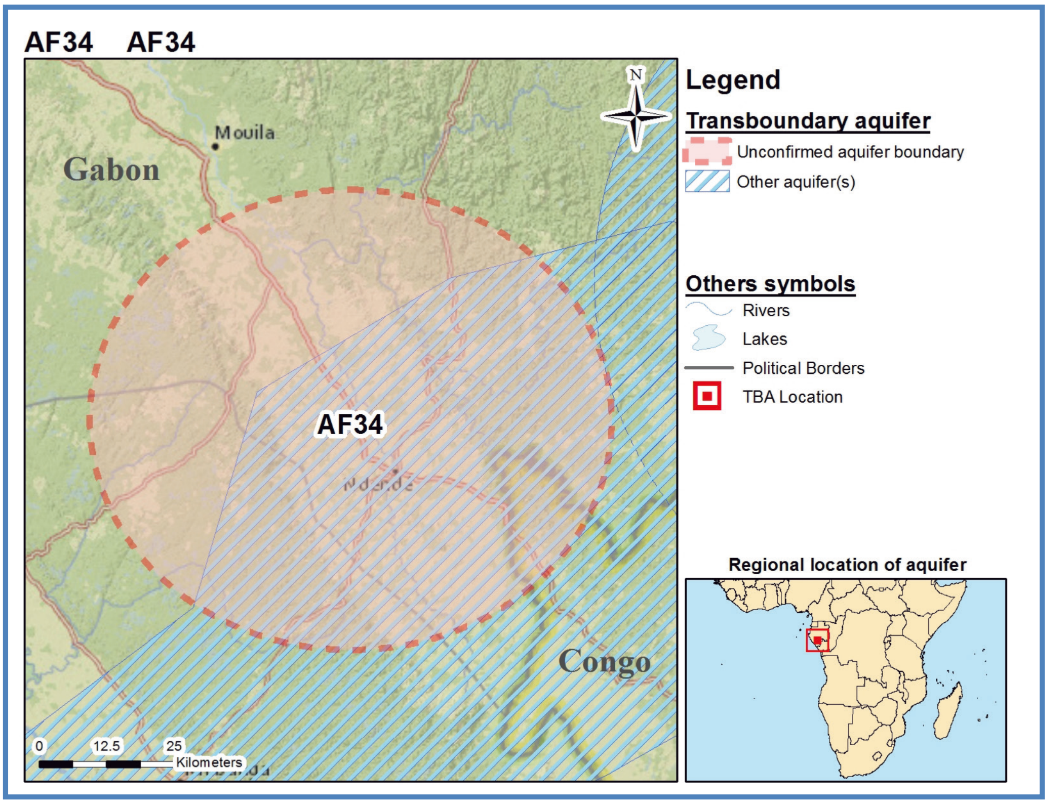
Rainfall (mm/yr): 1810

Hydrogeology

Aquifer type: Data not available

Degree of confinement: Data not available

Main Lithology: Data not available



No cross-section provided

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

AF34

TWAP Groundwater Indicators from Global Inventory

No data available.

Key parameters table from Global Inventory

No data available.

Aquifer description

No data available

Contributors to Global Inventory

No contributors

Considerations and recommendations

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- All other data: TWAP Groundwater (2015).

Version: May 2017

AF40

Geography

Total area TBA (km^2): 17 800

No. countries sharing: 2

Countries sharing: Congo, Gabon

Population: 47 000

Climate Zone: Tropical Wet

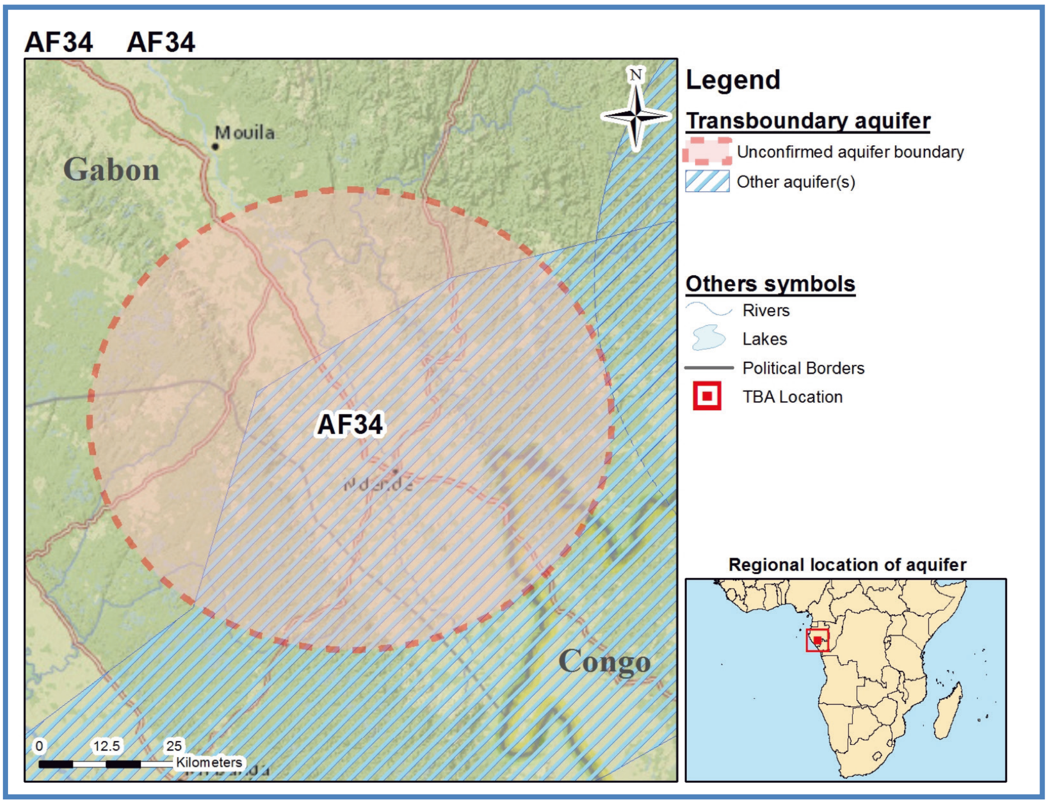
Rainfall (mm/yr): 1620

Hydrogeology

Aquifer type: Data not available

Degree of confinement: Data not available

Main Lithology: Data not available



No cross-section provided

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AF40

TWAP Groundwater Indicators from Global Inventory

No data available.

Key parameters table from Global Inventory

No data available.

Aquifer description

No data available

Contributors to Global Inventory

No contributors

Considerations and recommendations

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- All other data: TWAP Groundwater (2015).

Version: May 2017

AF82

Geography

Total area TBA (km^2): 17 000

No. countries sharing: 2

Countries sharing: Congo, Gabon

Population: 75 000

Climate Zone: Tropical Wet

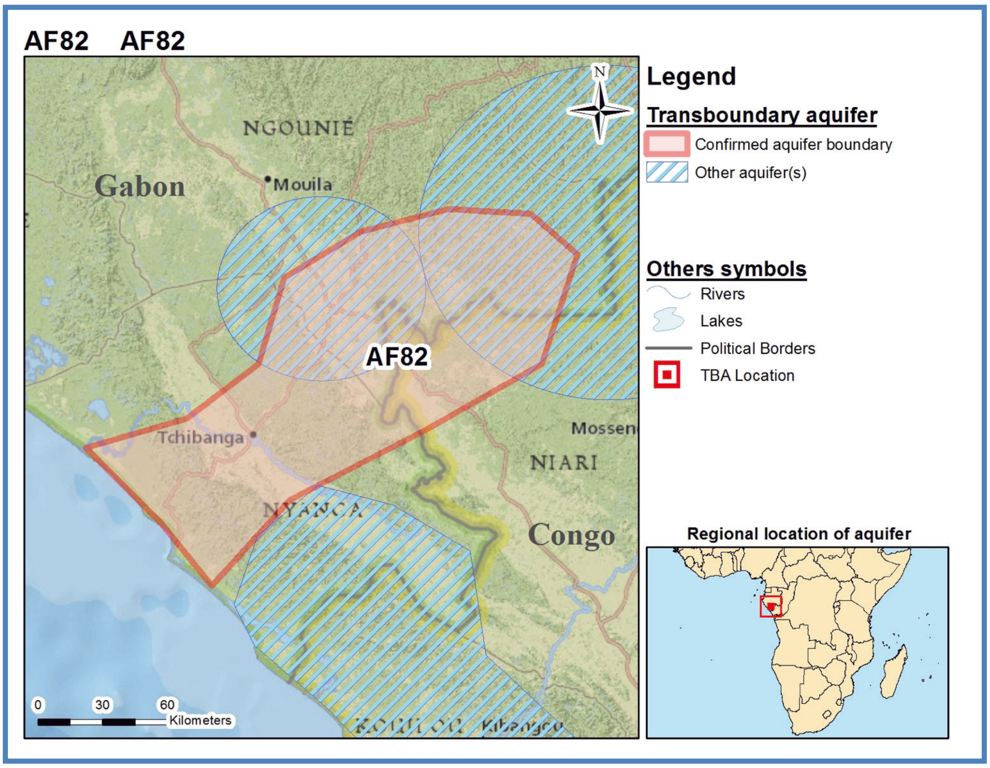
Rainfall (mm/yr): 1700

Hydrogeology

Aquifer type: Data not available

Degree of confinement: Data not available

Main Lithology: Data not available



No Cross-section provided

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AF82

TWAP Groundwater Indicators from Global Inventory

No data available.

Key parameters table from Global Inventory

No data available.

Aquifer description

No data available.

Contributors to Global Inventory

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Version: May 2017

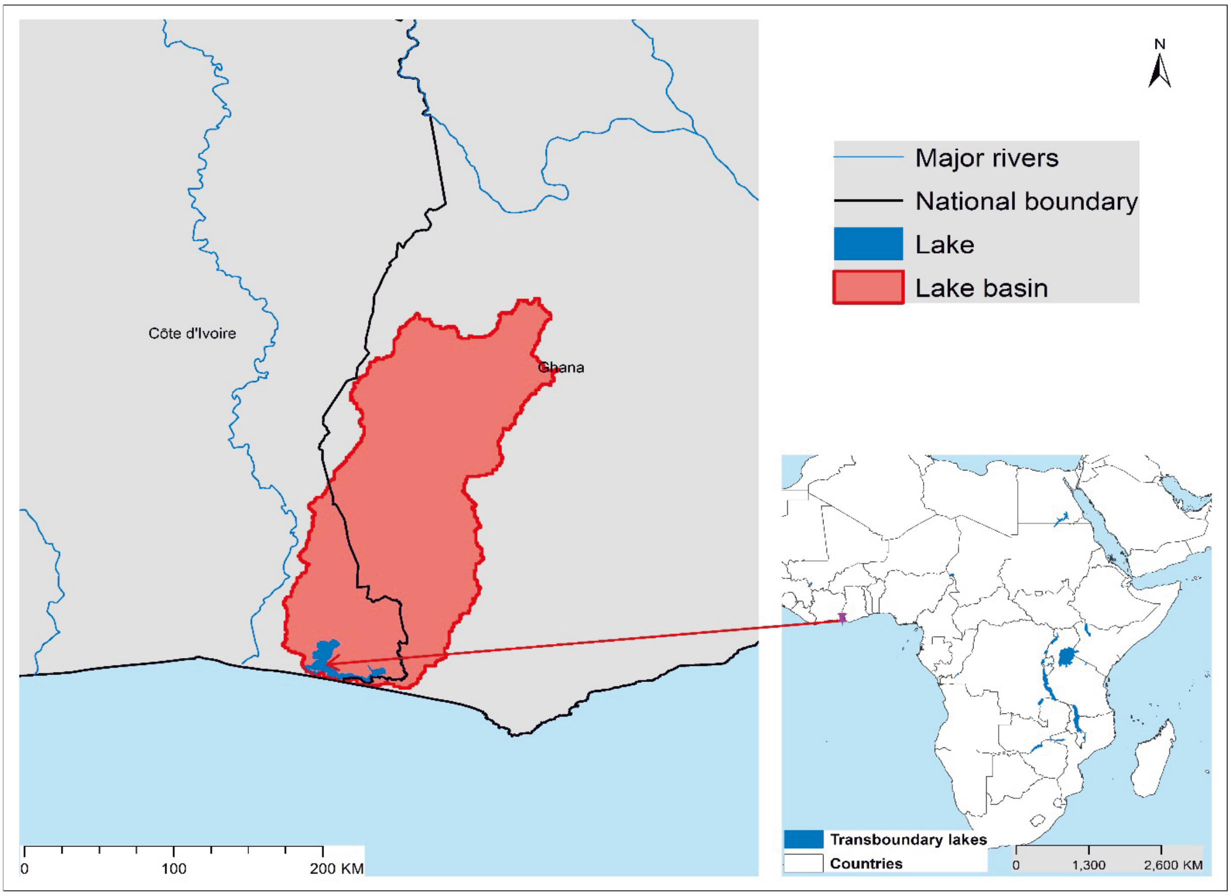

Lake Tanganyika Aquifer

1. Aby
2. Albert
3. Chad
4. Congo
5. Kivu
6. Mweru
7. Sélingué
8. Tanganyika

Lake Aby

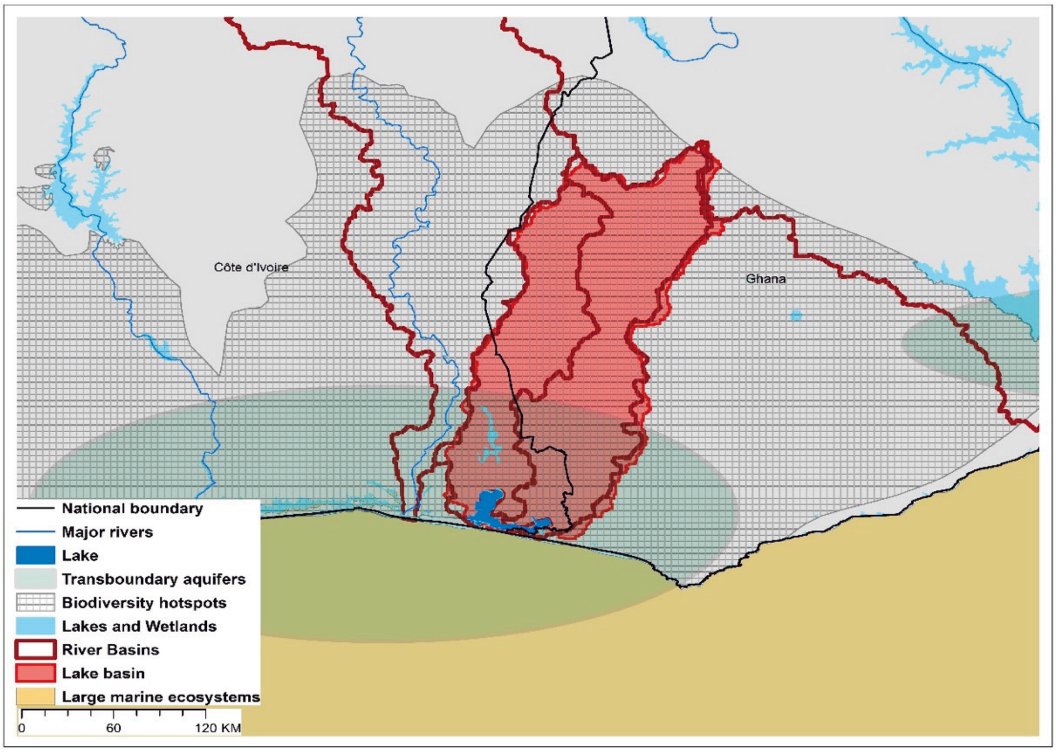
Geographic Information

Located near the eastern African coast, Lake Aby is a relatively small lake, although with a large drainage basin, comprised primarily of agricultural land. It also contains some forested and urban areas. Lake Aby is reportedly exhibiting a gradually deteriorating lake environment, and would probably benefit greatly from a GEF-facilitated management intervention. The lake has received GEF funding in the past, and any future GEF-catalyzed management intervention possibilities would ideally be linked to the Lake Volta and the Volta River basin situation.

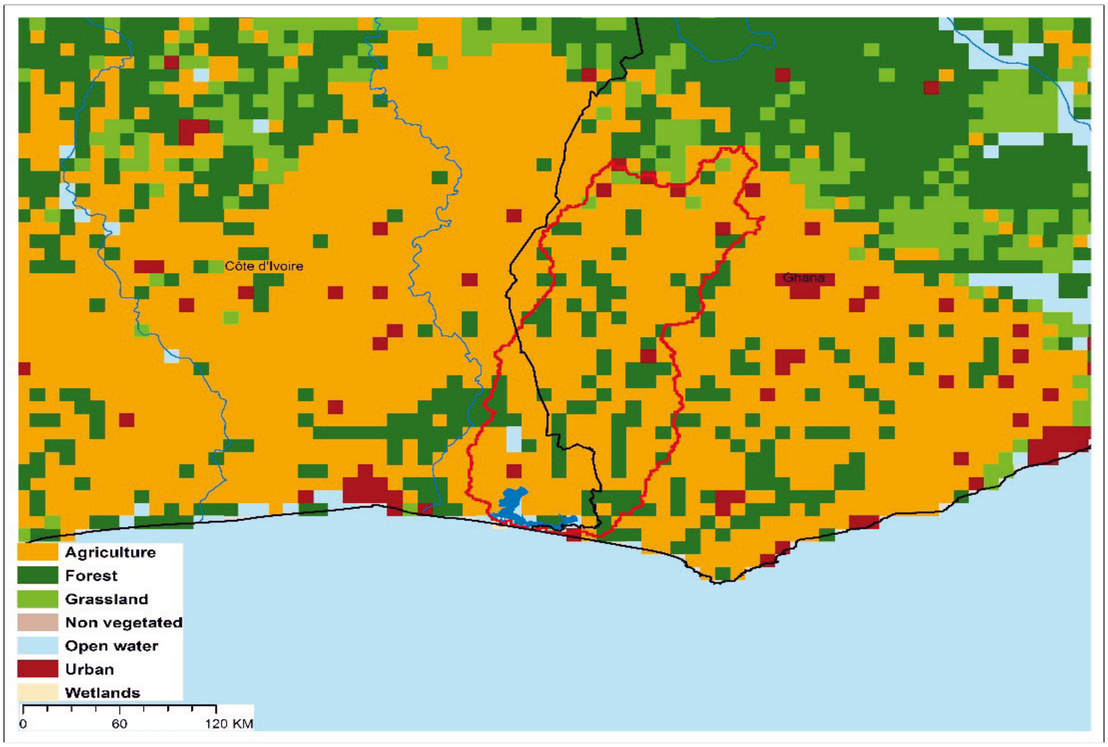


TWAP Regional Designation	Western & Middle Africa	**Lake Basin Population (2010)**	2,587,139
River Basin	Bia & Tano	**Lake Basin Population Density (2010; # km^{-2})**	105.3
Riparian Countries	Cote d'Ivoire, Ghana	**Average Basin Precipitation (mm yr^{-1})**	1,545
Basin Area (km^2)	22,829	**Shoreline Length (km)**	234.7
Lake Area (km^2)	438.8	**Human Development Index (HDI)**	0.52
Lake Area:Lake Basin Ratio	0.015	**International Treaties/Agreements Identifying Lake**	No

Lake Aby Basin Characteristics



(a) Lake Aby basin and associated transboundary water systems



(b) Lake Aby basin land use

Lake Aby 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 Aby 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 Aby 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 Aby 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 Aby 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
0.83	28		0.65	22		0.52	24

It is emphasized that the Lake Aby 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 Aby indicates a medium threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lake Ayb, which is meant to describe its biodiversity sensitivity to basin-derived degradation, 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 Aby basin in a moderately high threat rank in regard to its health, educational and economic status.

Table 2. Lake Aby 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
28	24	21		49	27		52	30		72	27

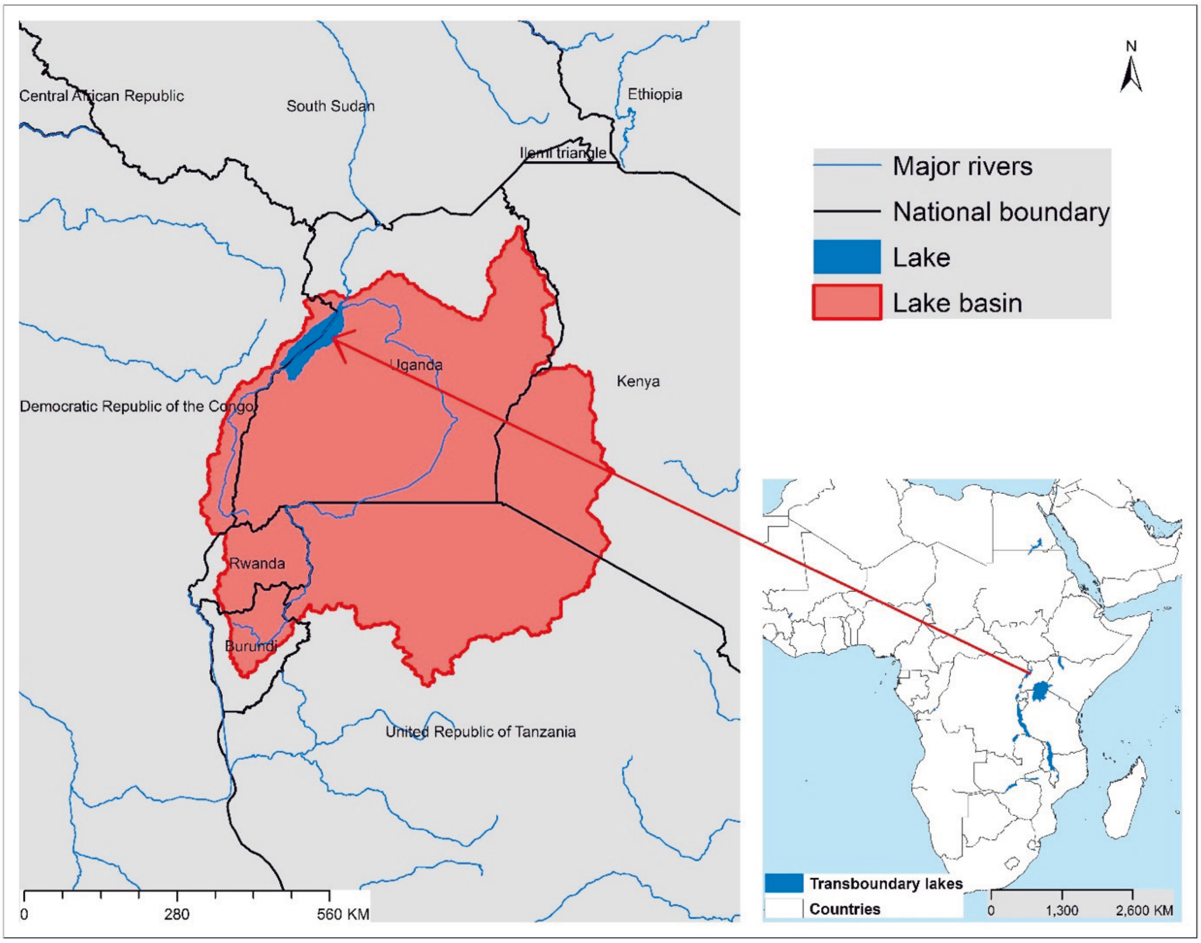
When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Aby in the lower half of the threat ranks. The relative threat is somewhat reduced when the Adj-HWS and RvBD threats are considered together. Considering all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

Interactions between the ranking parameters for Lake Aby indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Victoria 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 Victoria basin? Accurate answers to such questions for Lake Aby, 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.

Lake Albert

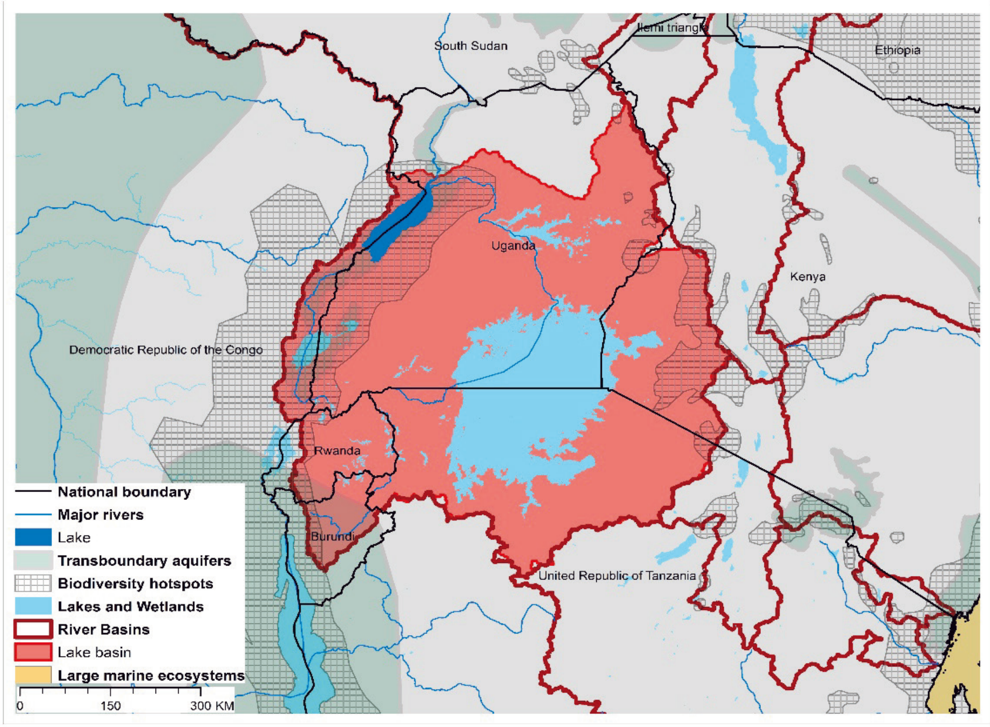
Geographic Information

Lake Albert, Africa's seventh largest lake, is located approximately in the center of the African continent, being one of the East African Great Lakes. Its upstream water sources include Lake Victoria. Because of a high evaporation rate, its waters are somewhat saline. Compared to some other lakes in the region (e.g., Malawi/Nyasa, Tanganyika, Victoria), Lake Albert has not received as much attention, with information on its scientific and management challenges being rather sparse. Nevertheless, the riparian population is facing increasing serious environmental challenges, an example being emerging oil exploration projects posing some politically-volatile challenges for Lake Albert. In regard to possible management interventions, joint implementation with Lake Edward could be an option.

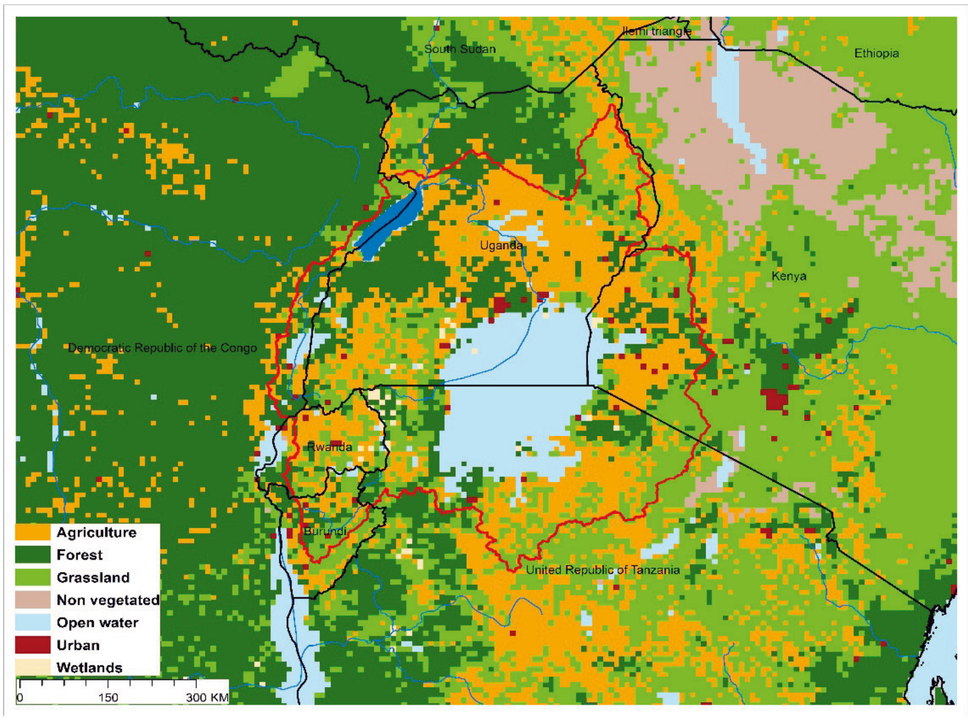


TWAP Regional Designation	Eastern & Southern Africa; Western & Middle Africa	**Lake Basin Population (2010)**	70,651,448
River Basin	Nile	**Lake Basin Population Density (2010; # km^{-2})**	186.6
Riparian Countries	Democratic Republic of Congo, Uganda	**Average Basin Precipitation (mm yr^{-1})**	1,197
Basin Area (km^2)	331,660	**Shoreline Length (km)**	1,157
Lake Area (km^2)	5,502	**Human Development Index (HDI)**	0.41
Lake Area:Lake Basin Ratio	0.014	**International Treaties/Agreements Identifying Lake**	No

Lake Albert Basin Characteristics



(a) **Lake Albert basin and associated transboundary water systems**



(b) Lake Albert basin land use

Lake Albert 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 Albert 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 Albert 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 Albert 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 Albert 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
0.91	**10**		**0.63**	**24**		**0.46**	**20**

It is emphasized that the Lake Albert 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 Albert indicates a moderately high threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lake Albert, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a 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 Albert basin in a moderately high threat rank in regard to its health, educational and economic status.

Table 2. Lake Albert 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
10	19	24	34	15	29	12	53	17

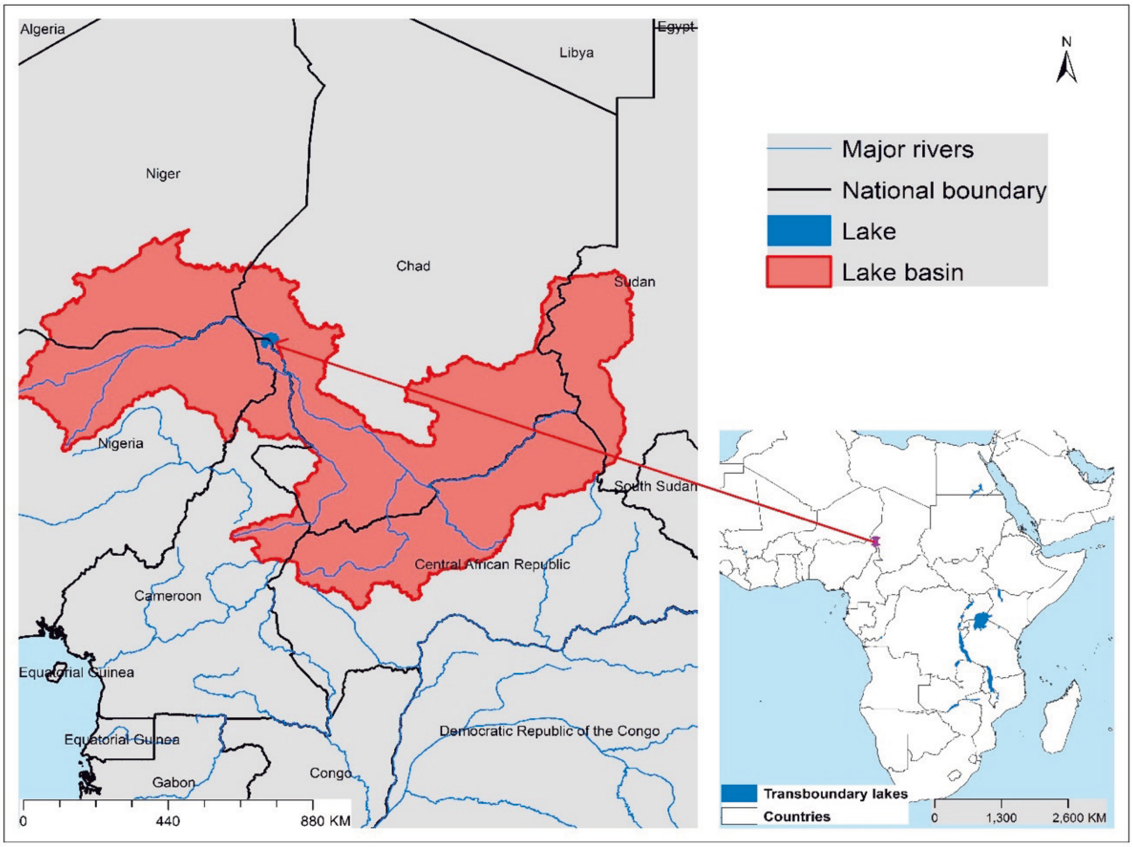
When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Albert in the upper one-third of the threat ranks. The relative threat is increased when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Lake Albert exhibits a moderately high threat ranking.

Interactions between the ranking parameters for Lake Albert indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Albert 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 Albert basin? Accurate answers to such questions for Lake Albert, 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.

Lake Chad

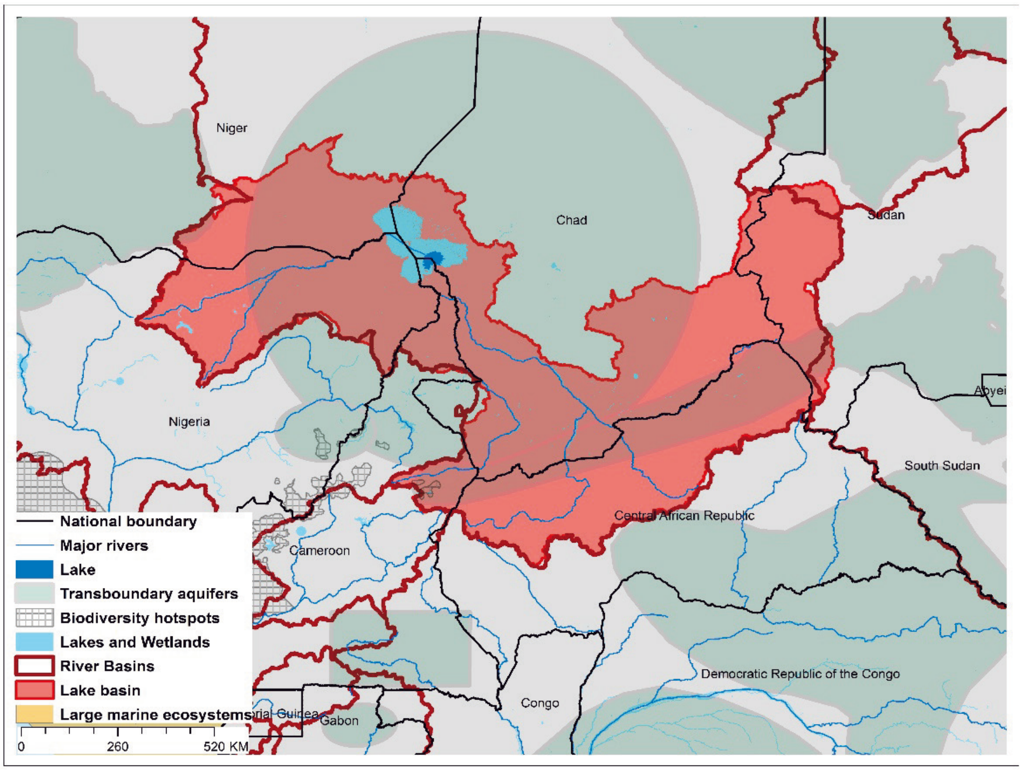
Geographic Information

Lake Chad is a shallow terminal lake in a very arid region, being the largest lake in the Chad basin, and once the fourth largest lake in Africa. It remains a freshwater lake in spite of high evaporation rates. The lake surface area varies greatly seasonally and annually, having shrank in area by as much as 95% between 1963 to 1998, although exhibiting improvement in recent years. The shorelines contain extensive wetland areas, with the lake area varying seasonally with their flooding. It provides water for more than 68 million basin inhabitants, and is economically important in the region. Its changing size is attributed to shifting climate patterns, and to inefficient damming and irrigation methods by the basin inhabitants not allowing the lake to replenish. The lake shrinkage has caused conflicts between farmers, who want the water for crops and livestock, and fishers are concerned about its impacts on their fishing livelihoods. The lake has previously received GEF funding, with future GEF-catalyzed management interventions warranting a review of its GEF status.

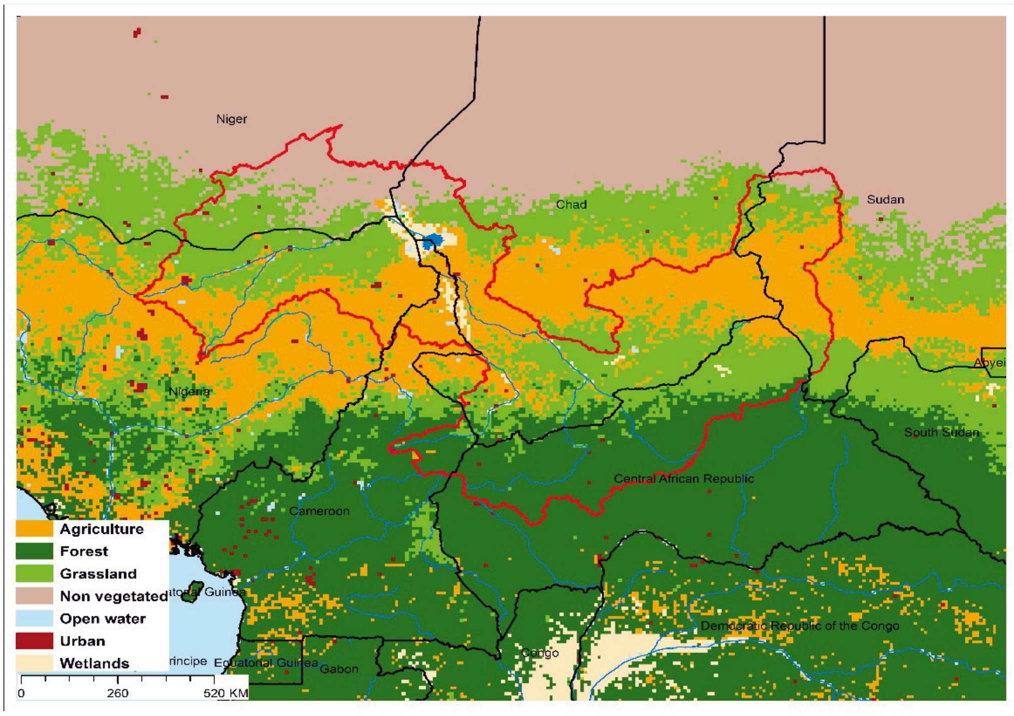


TWAP Regional Designation	Western & Middle Africa	**Lake Basin Population (2010)**	43,764,044
River Basin	Chad (endorheic)	**Lake Basin Population Density (2010; # km^{-2})**	38.2
Riparian Countries	Chad, Cameroon	**Average Basin Precipitation (mm yr^{-1})**	755.7
Basin Area (km^2)	808,366	**Shoreline Length (km)**	1,814
Lake Area (km^2)	1,295	**Human Development Index (HDI)**	0.43
Lake Area:Lake Basin Ratio	0.001	**International Treaties/Agreements Identifying Lake**	Yes

Lake Chad Basin Characteristics



(a) Lake Chad basin and associated transboundary water systems



(b) Lake Chad basin land use

Lake Chad 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 Chad 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 Chad 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 Chad 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 Chad 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
0.84	25		0.64	23		0.43	16

It is emphasized that the Lake Chad 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 Chad indicates a moderately high threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lake Chad, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a slightly less threatened 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 Lake Chad basin in a moderately high threat rank in regard to its health, educational and economic conditions.

Table 2. Lake Chad 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)

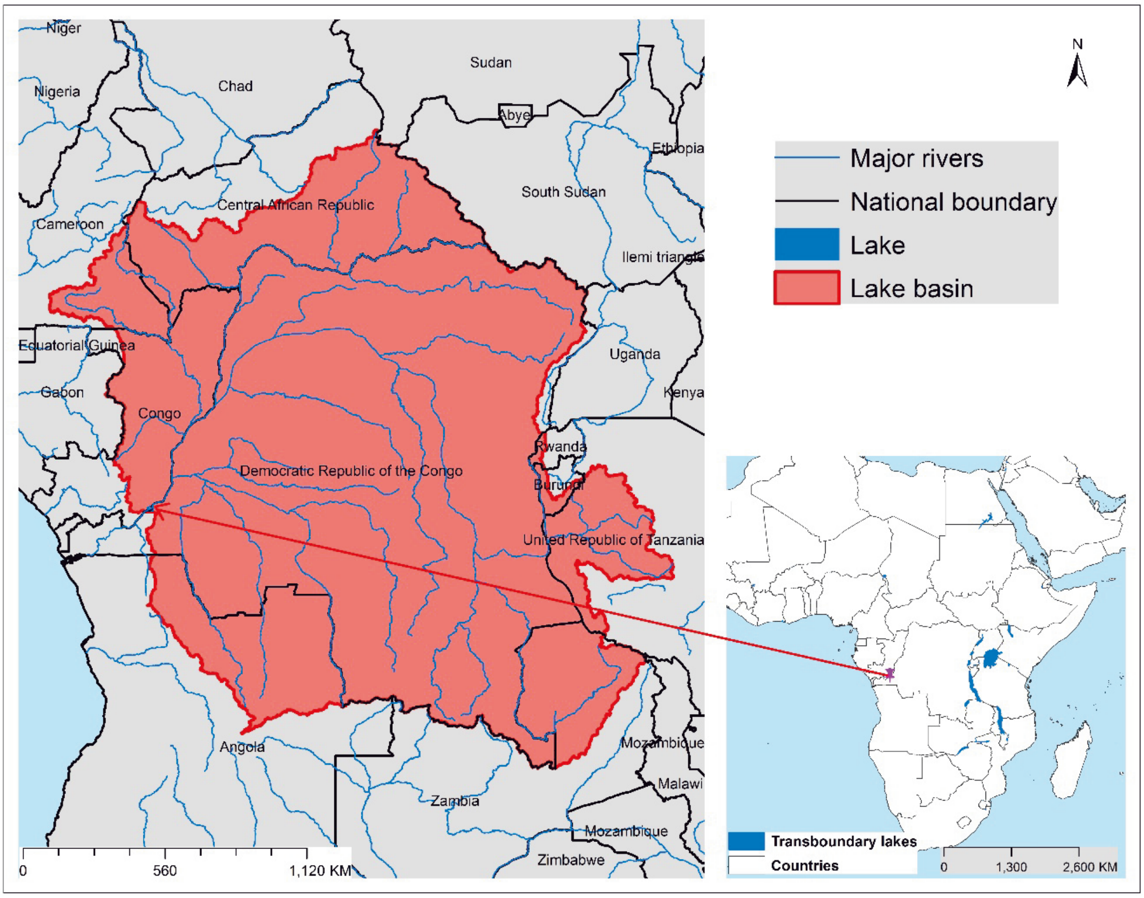
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
25	17	23		48	26		42	21		65	23

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Chad in the upper third 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 Chad exhibits an overall moderately high threat ranking.

Interactions between the ranking parameters for Lake Chad indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Chad 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 Chad basin? Accurate answers to such questions for Lake Chad, 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.

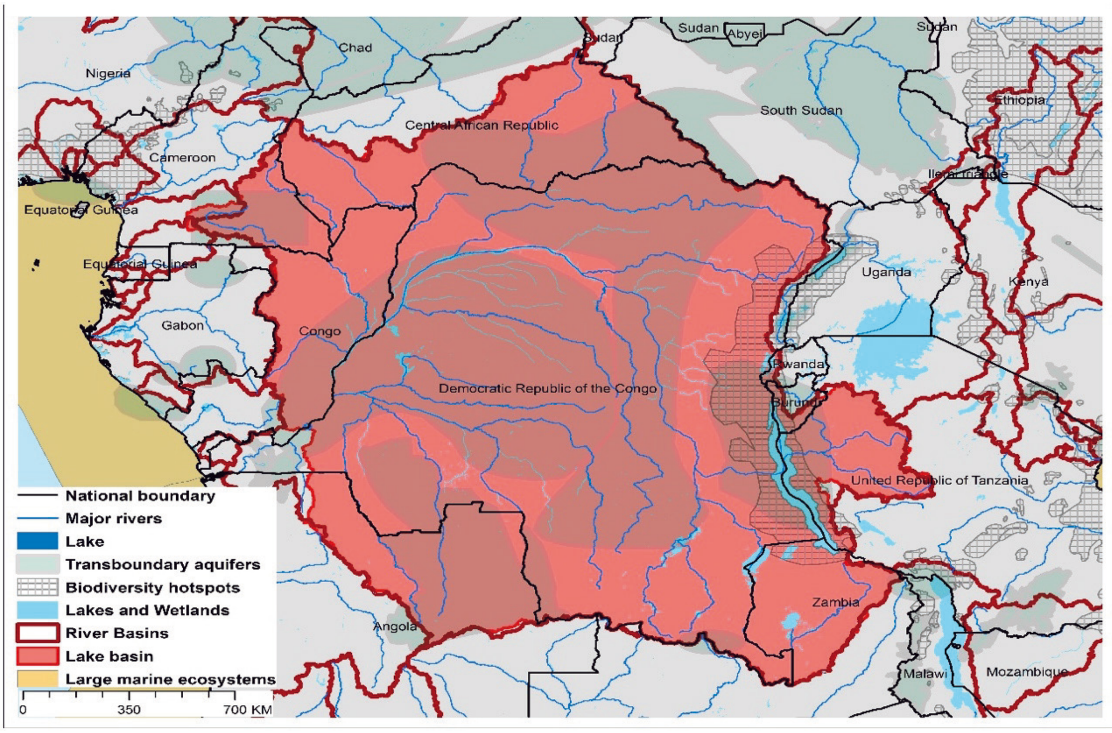
Lake Congo River — Geographic Information

Lake Congo River was determined on the basis of GIS-based spatial analysis of the transboundary Congo River. It is not unequivocally clear that it can be considered a transboundary lake in the common usage sense. Nevertheless, it occupied a sufficiently large areal extent along the course of the river that it could constitute a lentic waterbody, at least for the identified section of the river. There is very little information, however, regarding environmental or other transboundary issues for the lake, although the entire Congo River System may be of interest for support through the GEF. A first step in regard to considering management interventions would be to confirm how the lake is assessed and considered within the Congo River transboundary system.

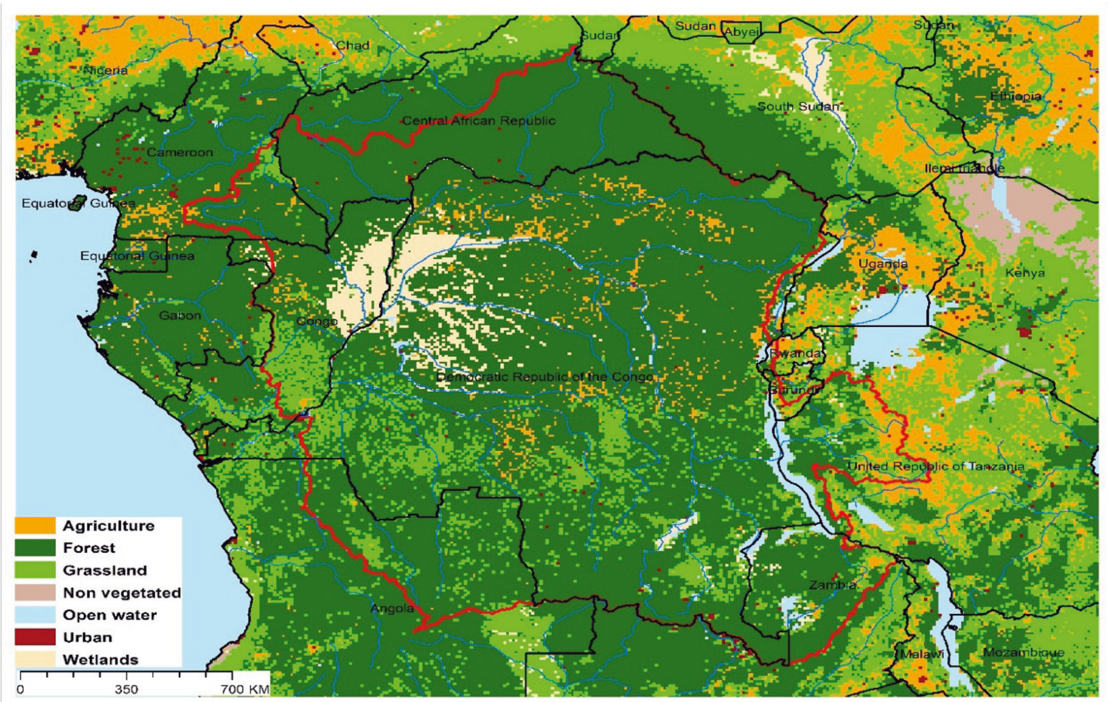


TWAP Regional Designation	Western & Middle Africa	**Lake Basin Population (2010)**	76,295,784
River Basin	Congo/Zaire	**Lake Basin Population Density (2010; # km^{-2})**	18.2
Riparian Countries	Democratic Republic of Congo, Congo	**Average Basin Precipitation (mm yr^{-1})**	1,533
Basin Area (km^2)	2,972,599	**Shoreline Length (km)**	725.5
Lake Area (km^2)	306.0	**Human Development Index (HDI)**	0.34
Lake Area:Lake Basin Ratio	0.001	**International Treaties/Agreements Identifying Lake**	No

Lake Congo River Basin Characteristics



(a) Lake Congo River basin and associated transboundary water systems



(b) Lake Congo River basin land use

Lake Congo River 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 Congo River 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 Congo River 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 Congo River 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 Congo River 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
0.75	38		0.80	1		0.34	1

It is emphasized that the Lake Congo River 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 Congo River indicates a moderately low threat rank compared to other priority transboundary lakess.

The Reverse Biodiversity (RvBD) for Lake Congo River, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a high threat rank, compared to the other transboundary lakes, suggesting a large sensitivity to human disturbances. 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 Congo River basin in a high threat rank in regard to its health, educational and economic conditions.

Table 2. Lake Congo River 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)

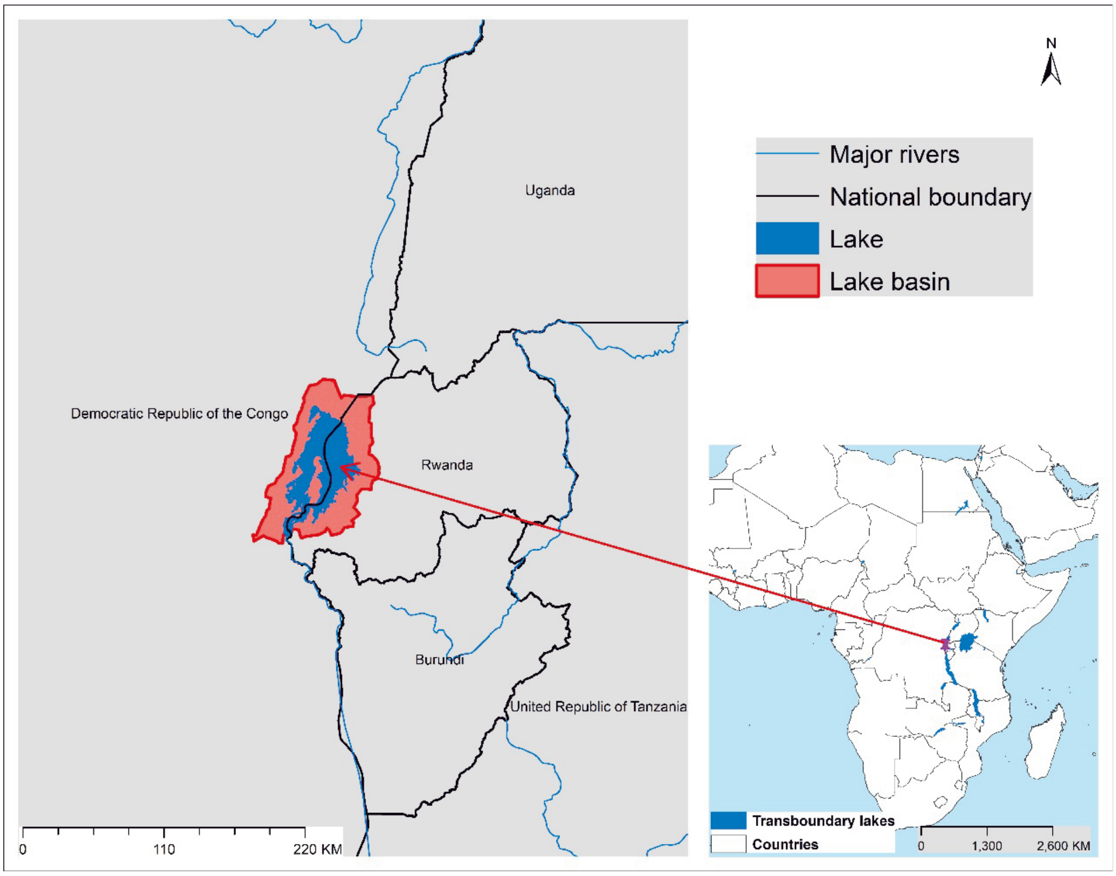
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
35	1	1		36	18		36	19		37	8

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Congo River in the upper third of the threat ranks. The situation is similar to the calculated threat rank when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, however, Lake Congo River exhibits an overall high threat ranking.

Interactions between the ranking parameters for Lake Congo River indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Congo River 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 Congo River basin? Accurate answers to such questions for Lake Congo River, 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.

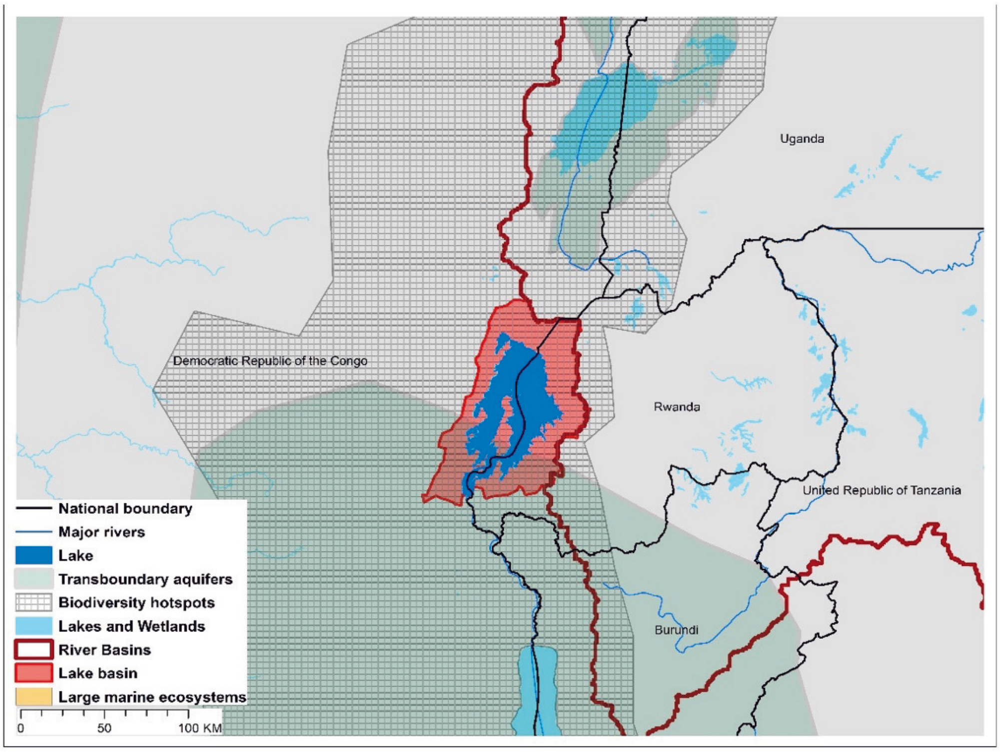
Lake Kivu — Geographic Information

Lake Kivu is an ancient lake, being particularly deep (maximum depth of 485 m). It also is one of the African Great Lakes, and contains the world's tenth-largest inland islands (Idiwi). It also is located in an area subject to volcanic activity, with a defining feature of being one of three lakes (Nyos, Monoun) that can undergo dramatic (although rare) overturn events that can release massive gas (methane, carbon dioxide) accumulations in its deep water layers. The release of its estimated 500 million tonnes of carbon dioxide accumulated over approximately 800 years could suffocate large numbers of people and livestock in the lake basin. Although the estimated risks from such an overturn would dwarf previously-documented Lake Nyos and Monoun overturns, no plan has yet been initiated to effectively reduce these limnic eruption risks.

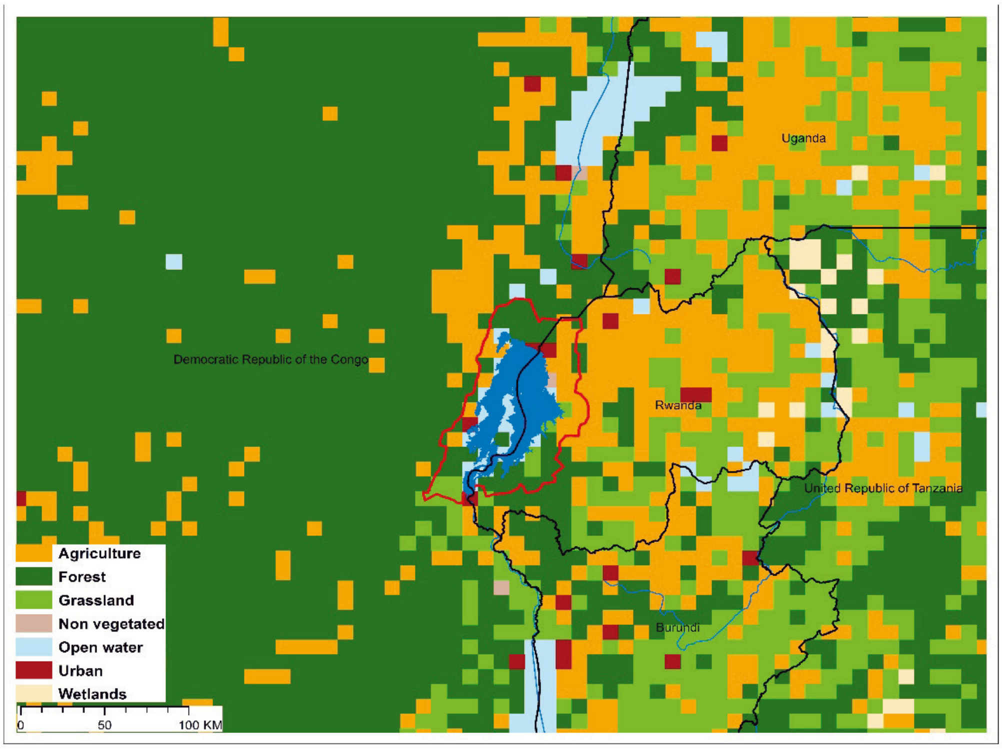


TWAP Regional Designation	Eastern & Southern Africa; Western & Middle Africa	**Lake Basin Population (2010)**	2,203,403
River Basin	Congo/Zaire	**Lake Basin Population Density (2010; # km^{-2})**	345.2
Riparian Countries	Democratic Republic of the Congo, Rwanda	**Average Basin Precipitation (mm yr^{-1})**	1,455
Basin Area (km^2)	6,044	**Shoreline Length (km)**	1,417
Lake Area (km^2)	2,375	**Human Development Index (HDI)**	0.38
Lake Area:Lake Basin Ratio	0.324	**International Treaties/Agreements Identifying Lake**	Yes

Lake Kivu Basin Characteristics



(a) Lake Kivu basin and associated transboundary water systems



(b) Lake Kivu basin land use

Lake Kivu 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 Kivu 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 Kivu 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 Kivu 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 Kivu 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
0.91	11		0.67	17		0.38	5

It is emphasized that the Lake Kivu 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 Kivu indicates a high threat rank, compared to other priority transboundary lakes, a common situation for transboundary lakes in many developing countries.

The Reverse Biodiversity (RvBD) for Lake Kivu, which is meant to describe its biodiversity sensitivity to basin-derived degradation, 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 Kivu basin in a high threat rank in regard to its health, educational and economic status.

Table 2. Lake Kivu 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
12	6	18		30	8		18	4		36	7

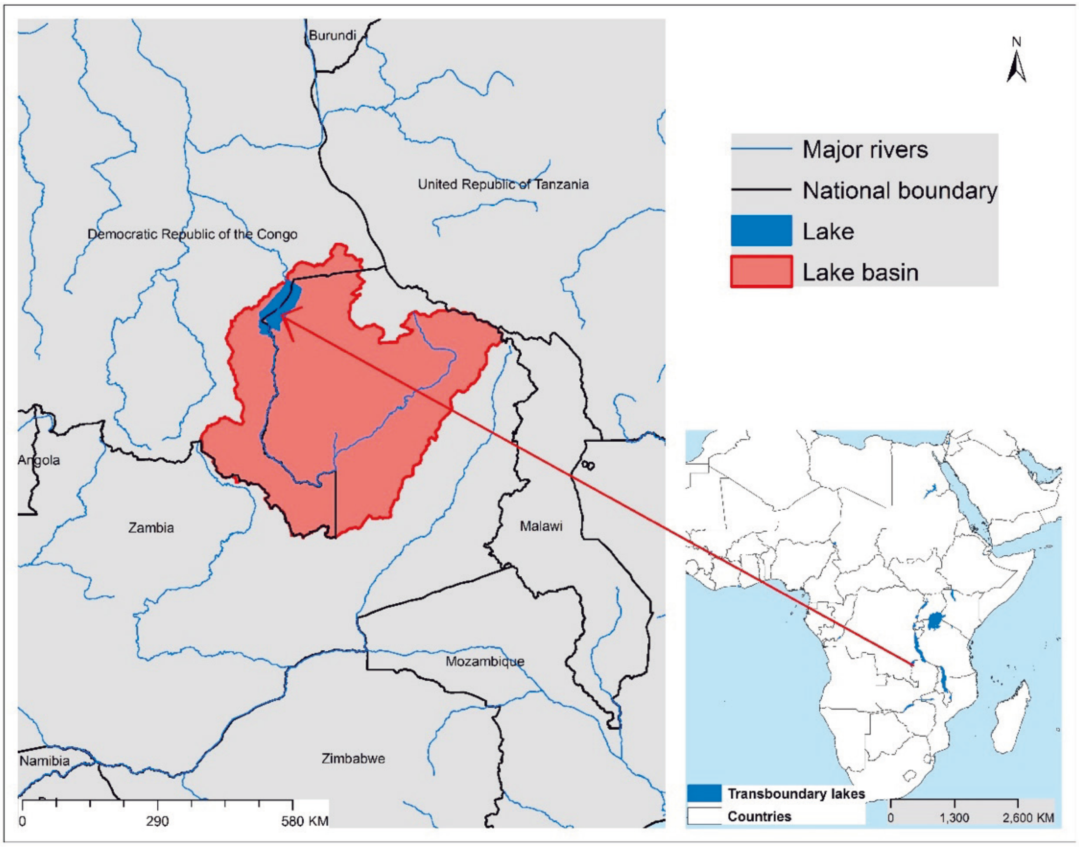
When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Kivu among the most threatened transboundary lakes. The relative threat is only slightly reduced when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Lake Kivu exhibits a high threat ranking.

Interactions between the ranking parameters for Lake Kivu indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Kivu 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 Kivu basin? Accurate answers to such questions for Lake Kivu, 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.

Lake Mweru

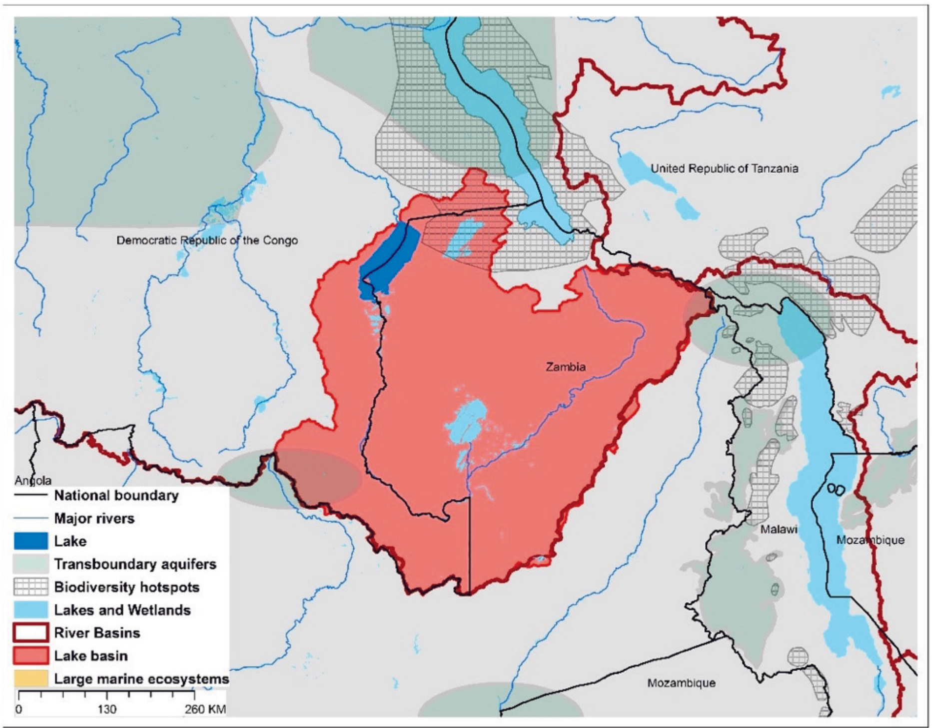
Geographic Information

Lake Mweru is located on the longest arm of the Congo River, approximately 150 km west of Lake Tanganyika. Extensive adjoin it to the east and south. The lake shoreline contains many fishing villages. The lake does not exhibit major water level changes, in spite of pronounced wet and dry seasons, being attributed to the Bangweulu swamps that tend to absorb the annual floods and release them slowly, as well as the outflowing Luvua River, which tends to flow faster during flood periods. Despite being considered a beautiful lake, it has not been developed extensively for tourism, attributed mainly to a lack of wildlife conservation and wars in the Democratic Republic of the Congo. The lake supports fisheries, mining and some tourism industries, although the magnitude of their environmental impacts is not clear. Any potential management interventions should be considered together with Lakes Rweru/Moero and Cohoha.

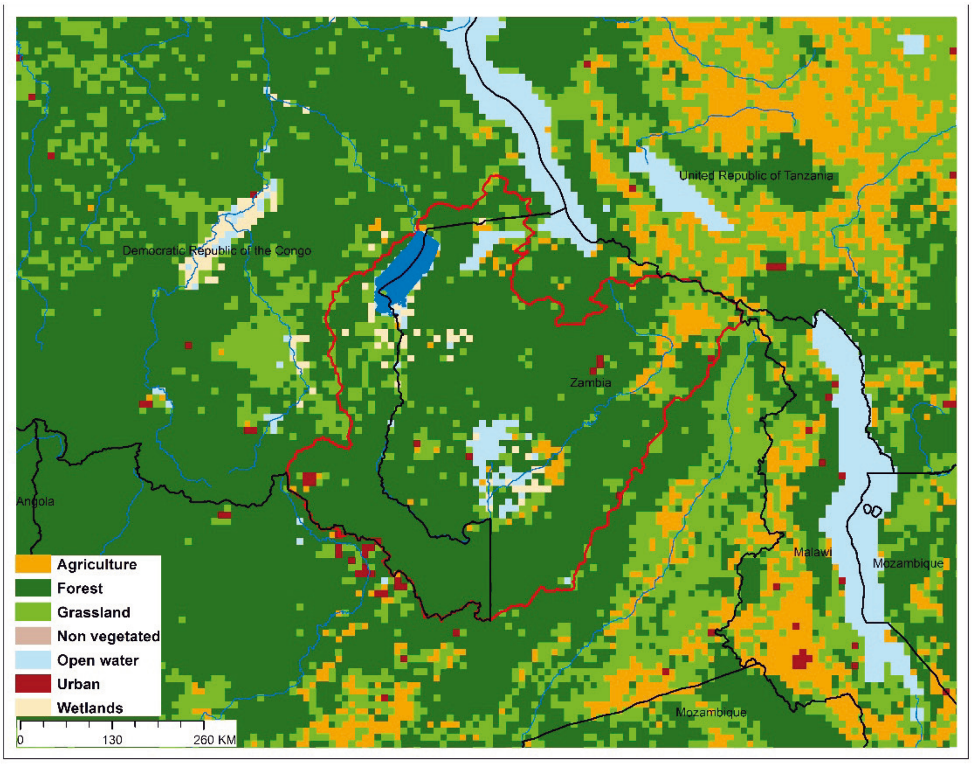


TWAP Regional Designation	Eastern & Southern Africa; Western & Middle Africa	**Lake Basin Population (2010)**	4,269,364
River Basin	Congo	**Lake Basin Population Density (2010; # km^{-2})**	17.2
Riparian Countries	Democratic Republic of Congo, Zambia	**Average Basin Precipitation (mm yr^{-1})**	1,200
Basin Area (km^2)	29,429	**Shoreline Length (km)**	681.3
Lake Area (km^2)	179,444	**Human Development Index (HDI)**	0.38
Lake Area:Lake Basin Ratio	0.023	**International Treaties/Agreements Identifying Lake**	No

Lake Mweru Basin Characteristics



(a) Lake Mweru basin and associated transboundary water systems



(b) Lake Mweru basin land use

Lake Mweru 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 Mweru 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 Mweru 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 Mweru 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 Mweru 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
0.81	**33**		**0.74**	**4**		**0.38**	**6**

It is emphasized that the Lake Mweru 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 Mweru indicates a medium threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lake Mweru, which is meant to describe its biodiversity sensitivity to basin-derived degradation, reveals a different picture, placing the lake in a 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 Mweru basin in a high threat rank in regard to its health, educational and economic status.

Table 2. Lake Mweru 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)

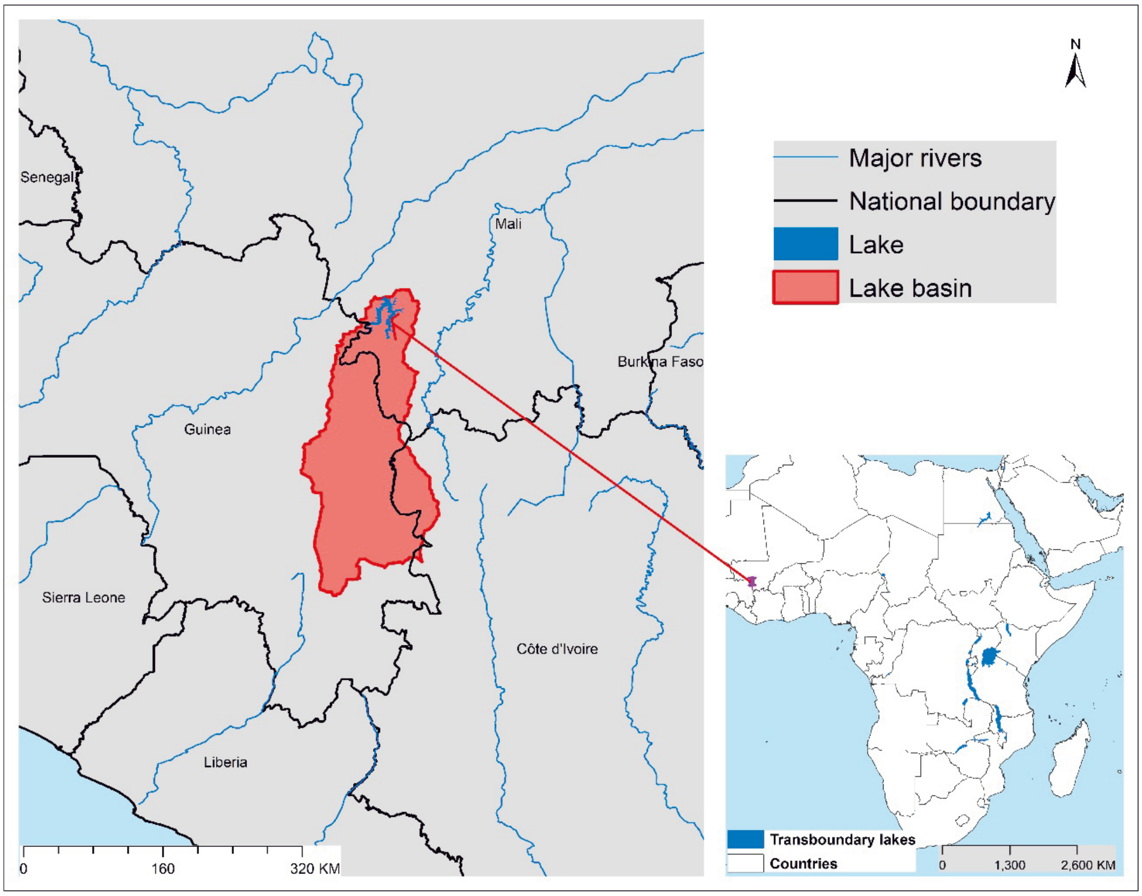
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
33	6	4		43	24		33	16		65	23

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

Interactions between the ranking parameters for Lake Mweru indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Mweru 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 Mweru basin? Accurate answers to such questions for Lake Mweru, 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.

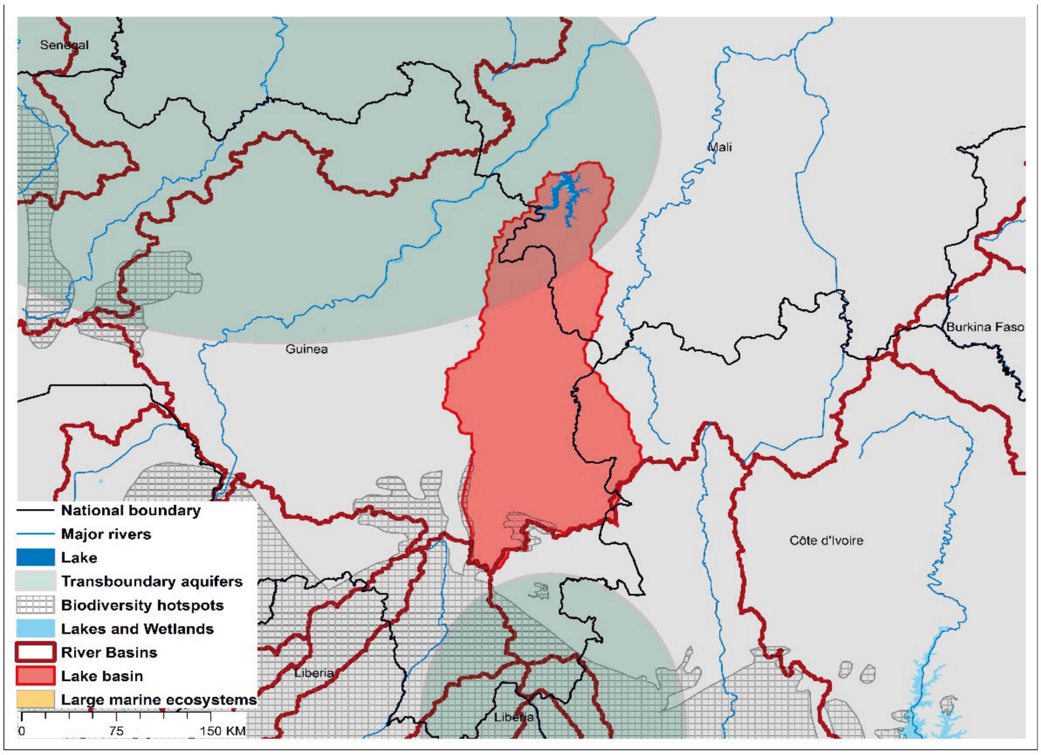
Lake Sélingué — Geographic Information

Lake Sélingué is a multipurpose transboundary reservoir located between Mali and Guinea in West Africa. It is used for hydropower production and as an irrigation water source. It is an important energy source particularly for Mali, being its second largest reservoir. It appears to be facing environmental challenges related mainly to climate-driven causes. It is not clear, however, how a GEF-catalyzed management intervention could currently be usefully developed for this lake. There is a need to undertake a preliminary scientific assessment of the lake and its basin before considering this possibility.

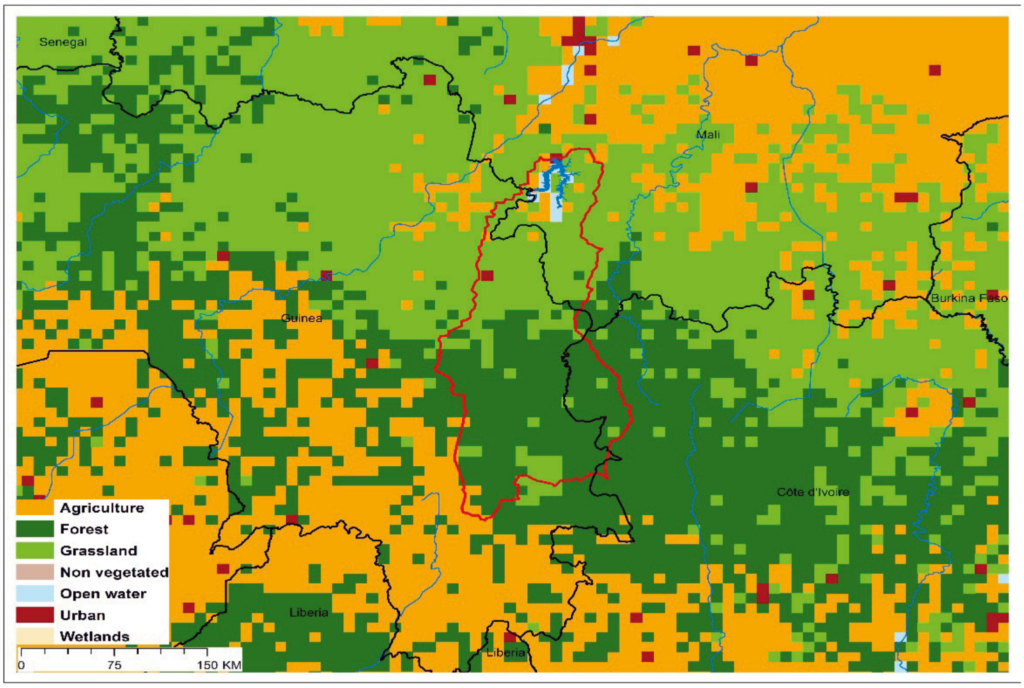


TWAP Regional Designation	Western & Middle Africa	Lake Basin Population (2010)	729,567
River Basin	Nile	Lake Basin Population Density (2010; # km^{-2})	19.3
Riparian Countries	Guinea, Mali	Average Basin Precipitation (mm yr^{-1})	651.8
Basin Area (km^2)	26,379	Shoreline Length (km)	627.2
Lake Area (km^2)	334.4	Human Development Index (HDI)	0.36
Lake Area:Lake Basin Ratio	0,011	International Treaties/Agreements Identifying Lake	No

Lake Sélingué Basin Characteristics



(a) Lake Sélingué basin and associated transboundary water systems



(b) Lake Sélingué basin land use

Lake Sélingué 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 Sélingué 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 Sélingué 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 Sélingué 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 Sélingué 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	19		0.68	16		0.36	2

It is emphasized that the Lake Sélingué 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 Sélingué indicates a moderately high threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lake Sélingué, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a similar 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 Sélingué basin in the highest quarter of the priority transboundary lake basins in regard to its health, educational and economic conditions.

Table 2. Lake Sélingué 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)

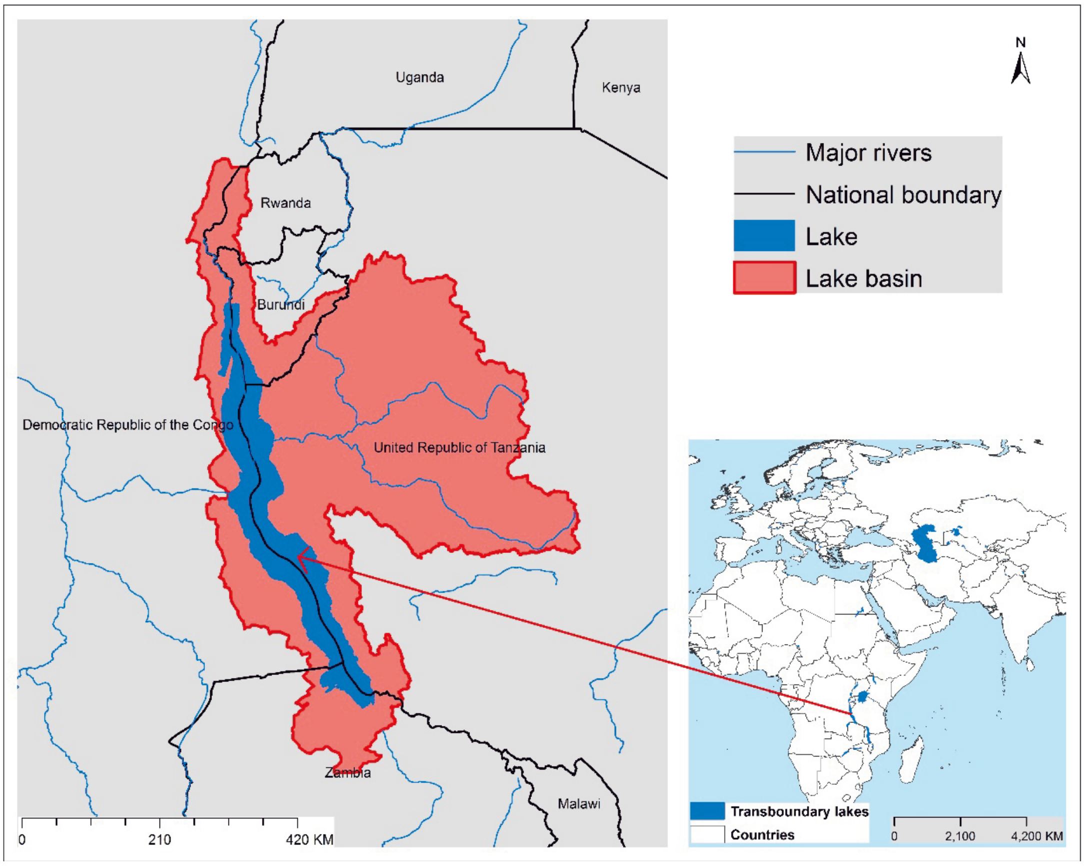
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
16	2	15		31	11		18	5		33	3

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Sélingué in the upper third 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 Sélingué exhibits a high threat ranking.

Interactions between the ranking parameters for Lake Sélingué indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Sélingué 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 Sélingué basin? Accurate answers to such questions for Lake Sélingué, 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.

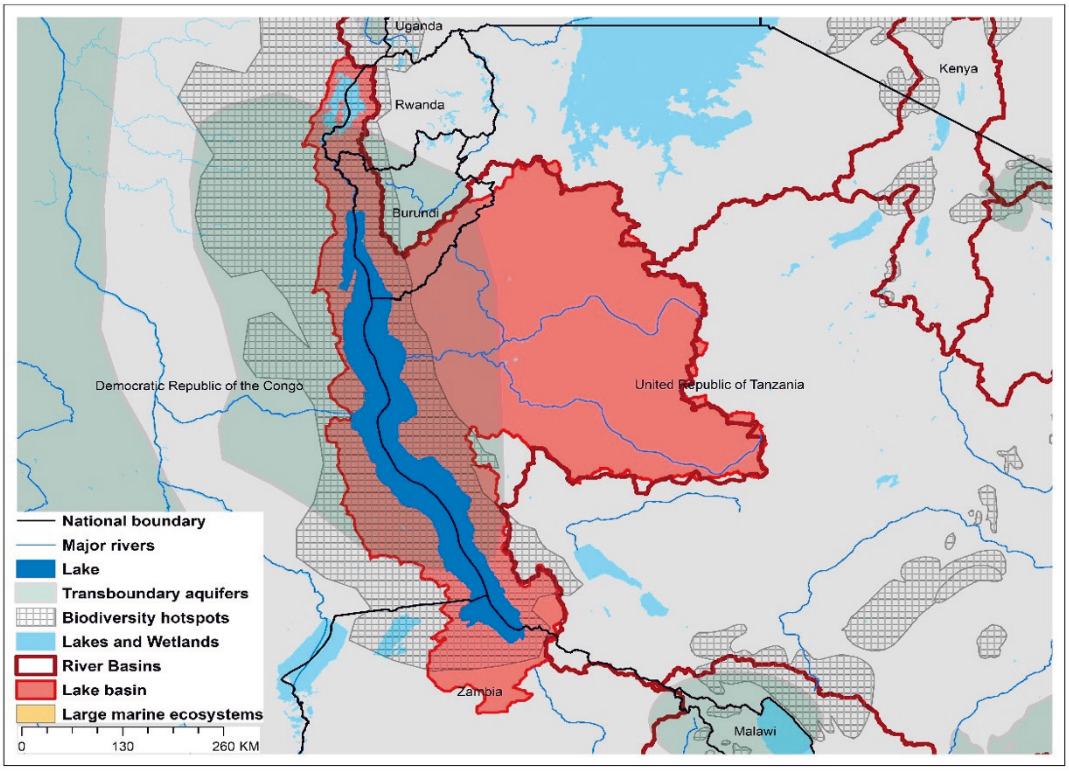
Lake Tanganyika — Geographic Information

Lake Tanganyika, an ancient lake in the Western Rift of the African Great Rift Valley, is the largest Rift lake and second largest by surface area, as well as being the deepest and holding the greatest water volume among African lakes. It also is the second largest (volume), deepest and longest freshwater lake in the world. It is located on a line dividing the eastern and western Africa floral regions, being one of the richest freshwater ecosystems in the world, and home to more than 2,000 plant and animal species, about 600 species endemic to its watershed. Although an estimated 25–40 percent of the protein in the diets of the one million people living around the lake comes from lake fish, unregulated large-scale commercial fishing has depleted the lake's fish resources. There also is evidence that climate change and related factors are shrinking fish and algae populations. Thus, its current environmental and management challenges should be reviewed prior to considering any GEF-catalyzed management interventions.

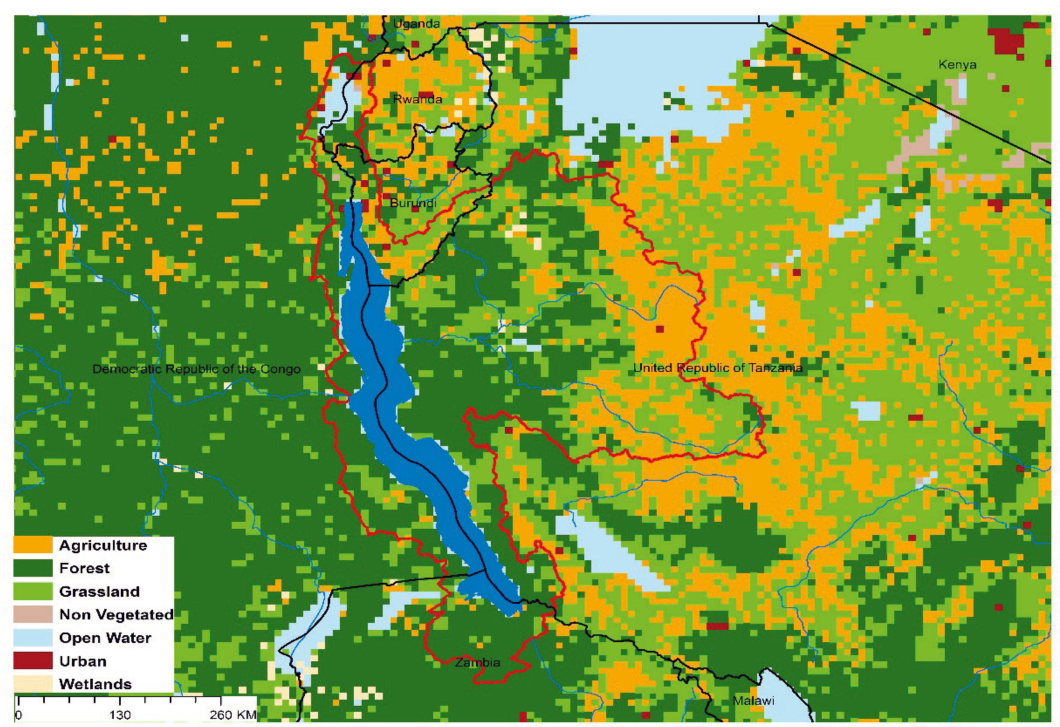


TWAP Regional Designation	Eastern & Southern Africa; Western & Middle Africa		**Lake Basin Population (2010)**	13,754,496
River Basin	Congo		**Lake Basin Population Density (2010; # km^{-2})**	57.7
Riparian Countries	Burundi, Democratic Republic of Congo, Tanzania, Zambia		**Average Basin Precipitation (mm yr^{-1})**	1,048
Basin Area (km^2)	194,317		**Shoreline Length (km)**	2,530
Lake Area (km^2)	32,685		**Human Development Index (HDI)**	0.40
Lake Area:Lake Basin Ratio	0.138		**International Treaties/Agreements Identifying Lake**	Yes

Lake Tanganyika Basin Characteristics



(a) Lake Tanganyika basin and associated transboundary water systems



(b) Lake Tanganyika basin land use

Lake Tanganyika 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 Tanganyika 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 Tanganyika 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 Tanganyika 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 Tanganyika 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
0.84	27		0.71	6		0.40	8

It is emphasized that the Lake Tanganyika 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 Tanganyika indicates a medium threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lake Tanganyika, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a 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 Tanganyika basin in the upper quarter of the priority transboundary lake basins in regard to its health, educational and economic conditions.

Table 2. Lake Tanganyika 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
26	8	6		32	14		34	17		40	10

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Tanganyika in the upper third of the threat ranks. The relative threat is slightly increased when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Lake Tanganyika exhibits a high threat ranking.

Interactions between the ranking parameters for Lake Tanganyika indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Tanganyika 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 Tanganyika basin? Accurate answers to such questions for Lake Tanganyika, 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.

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

Lake	Cont.	Surface Area (km^2)	Adj-HWS Threat Score	Rank
Sistan	Asia	488.2	0.98	1
Ihema	Afr.	93.2	0.97	2
Azuei	S.Am	117.3	0.96	3
Rweru/Moero	Afr.	125.6	0.96	4
Cohoha	Afr.	64.8	0.96	5
Edward	Afr.	2232.0	0.94	6
Natron/Magadi	Afr.	560.4	0.93	7
Abbe/Abhe	Afr.	310.6	0.93	8
Victoria	Afr.	66841.5	0.91	9
Albert	Afr.	5502.3	0.91	10
Kivu	Afr.	2371.1	0.91	11
Malawi/Nyasa	Afr.	29429.2	0.91	12
Dead Sea	Eur	642.7	0.90	13
Turkana	Afr.	7439.2	0.90	14
Aras Su Qovsaginin Su Anbari	Asia	52.1	0.89	15
Mangla	Asia	85.4	0.87	16
Galilee	Eur	162.0	0.87	17
Darbandikhan	Asia	114.3	0.87	18
Selingue	Afr.	334.4	0.87	19
Shardara/Kara-Kul	Asia	746.1	0.86	20
Nasser/Aswan	Afr.	5362.7	0.86	21
Chilwa	Afr.	1084.2	0.86	22
Josini/Pongola-poort Dam	Afr.	128.6	0.85	23

(B) Lakes Ranked on Basis of Reverse Biodiversity (RvBD) Threats

Lake	Cont.	Surface area (km^2)	RvBD Threat Score	Rank
Lake Congo River	Afr.	306.0	0.80	1
Sarygamysh	Asia	3777.7	0.75	2
Chiuta	Afr.	143.3	0.74	3
Mweru	Afr.	5021.5	0.72	4
Aral Sea	Asia	23919.3	0.72	5
Tanganyika	Afr.	32685.5	0.71	6
Abbe/Abhe	Afr.	310.6	0.71	7
Titicaca	S.Am	7480.0	0.71	8
Chilwa	Afr.	1084.2	0.70	9
Salto Grande	S.Am	532.9	0.70	10
Turkana	Afr.	7439.2	0.70	11
Cahora Bassa	Afr.	4347.4	0.69	12
Chungarkkota	S.Am	52.6	0.69	13
Malawi/Nyasa	Afr.	29429.2	0.68	14
Nasser/Aswan	Afr.	5362.7	0.68	15
Selingue	Afr.	334.4	0.68	16
Kivu	Afr.	2371.1	0.67	17
Natron/Magadi	Afr.	560.4	0.67	18
Lago de Yacyreta	S.Am	1109.4	0.66	19
Kariba	Afr.	5258.6	0.66	20
Edward	Afr.	2232.0	0.65	21
Aby	Afr.	438.8	0.65	22
Chad	Afr.	1294.6	0.64	23

(C) Lakes Ranked on Basis of Human Development Index (HDI) Scores

Lake	Cont.	Surface area (km^2)	HDI Score	Rank
Lake Congo River	**Afr**	**306.0**	**0.34**	**1**
Selingue	**Afr**	**334.4**	**0.36**	**2**
Rweru/Moero	**Afr**	**125.6**	**0.36**	**3**
Cohoha	**Afr**	**64.8**	**0.38**	**4**
Kivu	**Afr**	**2371.1**	**0.38**	**5**
Mweru	**Afr**	**5021.5**	**0.38**	**6**
Abbe/Abhe	**Afr**	**310.6**	**0.40**	**7**
Tanganyika	**Afr**	**32685.5**	**0.40**	**8**
Turkana	**Afr**	**7439.2**	**0.41**	**9**
Chiuta	**Afr**	**143.3**	**0.41**	**10**
Chilwa	**Afr**	**1084.2**	**0.41**	**11**
Malawi/Nyasa	**Afr**	**29429.2**	**0.42**	**12**
Edward	**Afr**	**2232.0**	**0.43**	**13**
Nasser/Aswan	**Afr**	**5362.7**	**0.43**	**14**
Cahora Bassa	**Afr**	**4347.4**	**0.43**	**15**
Chad	**Afr**	**1294.6**	**0.43**	**16**
Kariba	**Afr**	**5358.6**	**0.43**	**17**
Ihema	**Afr**	**93.2**	**0.44**	**18**
Sistan	**Asia**	**488.2**	**0.46**	**19**
Albert	**Afr**	**5502.3**	**0.46**	**20**
Azuei	**S.Am,**	**117.3**	**0.46**	**21**
Victoria	**Afr**	**66841.5**	**0.47**	**22**
Natron/Magadi	**Afr**	**560.4**	**0.51**	**23**

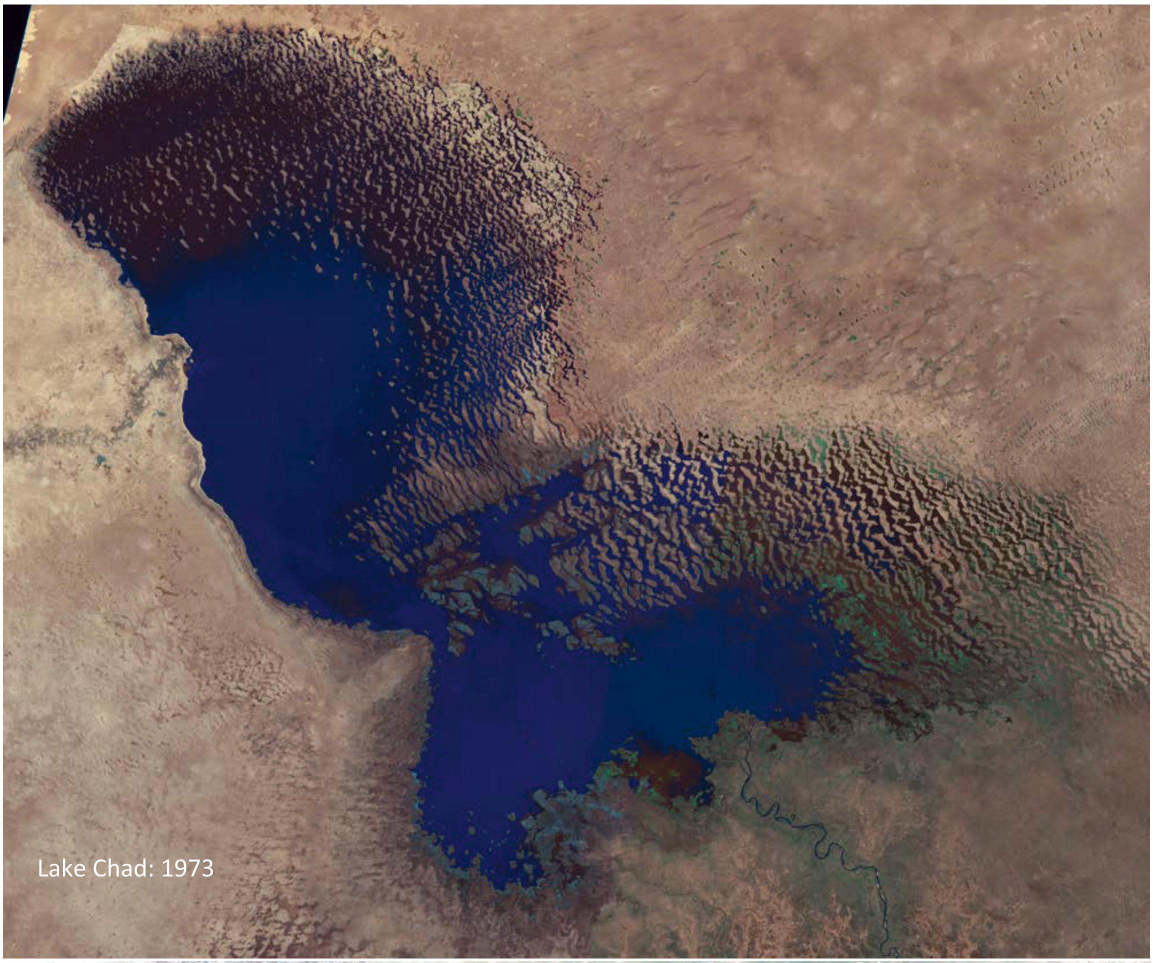
	Afr.	143.3	0.85	24		Albert	Afr.	5502.3	0.63	24		Aby	Afr	438.8	0.52	24
Chad	Afr.	1294.6	0.84	25		Sistan	Asia	488.2	0.62	25		Mangla	Asia	85.4	0.54	25
Aral Sea	Asia	23919.3	0.84	26		Amistad	N.Am	131.3	0.61	26		Aral Sea		23919.3	0.60	26
Tanganyika	Afr.	32685.5	0.84	27		Caspian Sea	Asia	377543.2	0.60	27		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

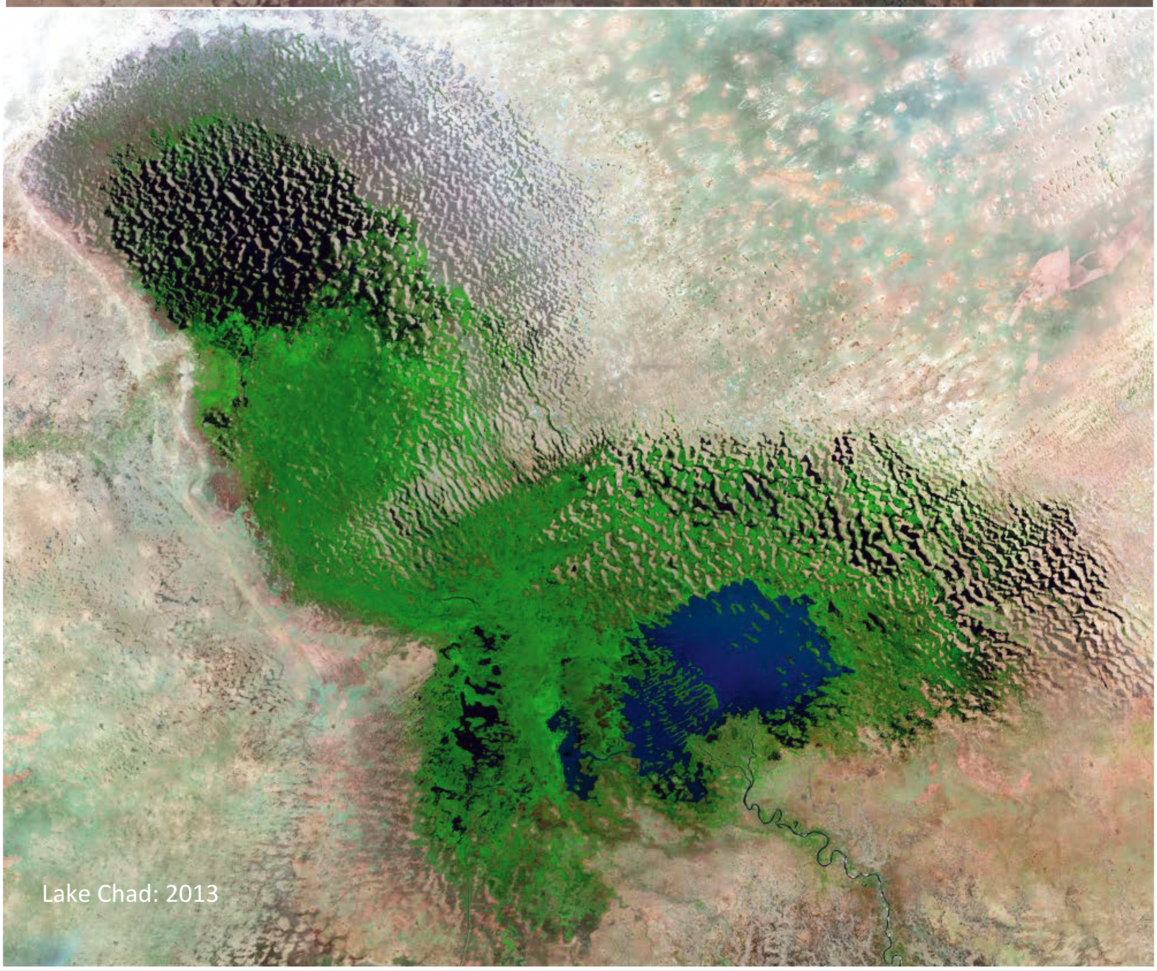
Transboundary Lake Threat Ranks by Multiple Ranking Criteria

(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





Earthshots.usgs.gov

1. Akpa
2. Atui
3. Benito/ Ntem
4. Bia
5. Chiloango
6. Congo/ Zaire
7. Corubal
8. Cross
9. Cestos
10. Cavally
11. Cuvelai/ Etosha
12. Gambia
13. Geba
14. Great Scarcies
15. Komoe
16. Kunene
17. Lake Chad
18. Little Scarcies
19. Loffa
20. Mana-Morro
21. Mbe
22. Moa
23. Mono
24. Niger
25. Nile
26. Nyanga
27. Ogooue
28. Okavango
29. Oueme
30. Sanaga
31. Sassandra
32. Senegal
33. St. John (Africa)
34. St. Paul
35. Tano
36. Utamboni
37. Volta
38. Zambezi

Akpa Basin

Geography

Total drainage area (km^2)	2,434
No. of countries in basin	2
BCUs in basin	Cameroon (CMR), Nigeria (NGA)
Population in basin (people)	132,325
Country at mouth	Cameroon, Nigeria
Average rainfall (mm/year)	2,672

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)
AKPA_CMR		1,540.95				
AKPA_NGA		2,224.79				
Total in Basin	4.58	1,882.74			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 (%)
AKPA_CMR	3.54	0.61	0.11	0.00	0	2.34	181.83	
AKPA_NGA	2.32	0.04	0.19	0.00	0	2.09	20.56	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
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Total in Basin	5.86	0.66	0.30	0.00	0.48	4.43	44.28	0.13

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)
AKPA_CMR	1	0.24	19	33.76	2.20			0	1,315.49	0	0.00
AKPA_NGA	2	0.76	113	60.77	2.50			0	3,005.51	0	0.00
Total in Basin	2	1.00	132	54.37	2.75	0.00	0.00	0	2,756.94	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
AKPA_CMR	1		2		5	3			2	5	3	5	1	3	2
AKPA_NGA	1	1	1		5	1	4	2	2	4	3	4	1	4	1
River Basin	1	1	1	2	5	2	4	2	2	4	3	4	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
AKPA_CMR	2	2					3	5	4
AKPA_NGA	2	2	1	1			3	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	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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Disputed areas
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Atui Basin

Geography

Total drainage area (km²)	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 (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)
ATUI_ESH		8.65				
ATUI_MRT		6.39				
Total in Basin	0.61	7.37			0.00	0.00

Water Withdrawals

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 (%)
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

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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
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.

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Benito/Ntem Basin

Geography

Total drainage area (km²)	44,328
No. of countries in basin	3
BCUs in basin	Cameroon (CMR), Equatorial Guinea (GNQ), Gabon (GAB)
Population in basin (people)	656,841
Country at mouth	Equatorial Guinea
Average rainfall (mm/year)	2,931

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 (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)
BENT_CMR		1,638.81				
BENT_GAB		1,207.97				
BENT_GNQ		1,760.66				
Total in Basin	71.67	1,616.83			0.00	0.00

Water Withdrawals

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 (%)
BENT_CMR	14.04	0.00	0.92	0.11	0	12.76	43.52	

[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/

BENT_GAB	8.45	0.00	0.10	2.92	0	5.29	114.96	
BENT_GNQ	219.08	0.00	0.11	2.68	154	62.30	840.63	
Total in Basin	241.57	0.00	1.12	5.72	154.39	80.35	367.78	0.34

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)
BENT_CMR	18	0.40	323	17.98	2.20	3.61	96.39	0	1,315.49	0	0.00
BENT_GAB	11	0.26	73	6.40	1.88	3.74	96.26	0	11,571.08	0	0.00
BENT_GNQ	15	0.34	261	17.49	2.84	15.74	84.26	0	20,572.34	0	0.00
Total in Basin	44	1.00	657	14.82	2.61	8.44	91.56	0	10,103.45	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**
BENT_CMR	1	1	1		5	1	2	4	3	5	5	5	1	3	2
BENT_GAB	1	1	1		5	1	2		2	5	3	5	1	3	3
BENT_GNQ	1	1	1		5	3	2		3	5	5		1	4	3
River Basin	1	1	1	2	5	2	2	4	2	5	5		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
BENT_CMR	2	2	1	1			2	4	5
BENT_GAB	2	2	1	1			2	4	3
BENT_GNQ	2	2	1	1			3	5	5
River Basin	2	2	1	1	2	2	3	5	5

[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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Bia Basin

Geography

Total drainage area (km²)	11,328
No. of countries in basin	2
BCUs in basin	Côte D'Ivoire (CIV), Ghana (GHA)
Population in basin (people)	1,198,604
Country at mouth	Côte D'Ivoire
Average rainfall (mm/year)	1,448

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	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)
BIAX_CIV		664.57			586.89	5.24
BIAX_GHA		365.76			13.18	0.10
Total in Basin	5.84	515.30			600.07	5.34

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 (%)
BIAX_CIV	25.48	0.50	0.21	0.00	7	17.70	36.94	
BIAX_GHA	16.75	0.05	0.40	0.00	2	14.62	32.92	

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Total in Basin	42.23	0.55	0.61	0.00	8.75	32.32	35.23	0.72

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)
BIAX_CIV	5	0.42	690	145.27	1.82	0.00	100.00	0	1,521.22	2	421.24
BIAX_GHA	7	0.58	509	77.34	2.39	0.00	100.00	0	1,850.20	0	0.00
Total in Basin	11	1.00	1,199	105.81	2.26	0.00	100.00	0	1,660.89	2	176.56

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
BIAX_CIV	2	1	1		5	2	4	2	2	4	3	5	1	3	2
BIAX_GHA	1	1	1		5		3	2	2	5	3	1	1	3	2
River Basin	2	1	1	2	5	1	3	3	2	4	3	3	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
BIAX_CIV	2	3	2	4			3	5	3
BIAX_GHA	2	3	4	5			2	5	3
River Basin	2	3	3	4	2	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	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

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

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Cavally Basin

Geography

Total drainage area (km^2)	29,495
No. of countries in basin	3
BCUs in basin	Côte D'Ivoire (CIV), Guinea (GIN), Liberia (LBR)
Population in basin (people)	1,524,512
Country at mouth	Côte D'Ivoire, Liberia
Average rainfall (mm/year)	2,148

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)
CVLY_CIV		1,111.32				
CVLY_GIN		1,254.23				
CVLY_LBR		1,415.12				
Total in Basin	37.61	1,275.17			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 (%)
CVLY_CIV	19.75	1.63	0.24	0.00	3	15.30	20.83	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
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CVLY_GIN	4.22	0.00	0.09	0.00	0	3.78	42.72	
CVLY_LBR	13.77	0.07	0.30	0.00	3	10.79	28.85	
Total in Basin	37.74	1.70	0.63	0.00	5.54	29.87	24.76	0.10

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)
CVLY_CIV	16	0.55	948	58.69	1.82	100.00	0.00	0	1,521.22	0	0.00
CVLY_GIN	1	0.05	99	70.56	1.98			0	527.26	0	0.00
CVLY_LBR	12	0.40	477	39.99	4.54	4.36	95.64	0	454.34	0	0.00
Total in Basin	29	1.00	1,525	51.69	2.41	63.57	29.95	0	1,122.69	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**
CVLY_CIV	1	1	1		5	1	2	2	2	4	3	5	1	3	2
CVLY_GIN	1	1	1		5		1	2	2	5	3	4	1	4	2
CVLY_LBR	1	1	1		5	1	1	2	2	5	3	4	2	3	3
River Basin	1	1	1	2	5	1	2	3	2	4	3	5	1	5	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
CVLY_CIV	2	2	1	1			3	5	3
CVLY_GIN	2	2	1	1			3	5	3
CVLY_LBR	2	2	1	1			3	5	3
River Basin	2	2	1	1	2	2	3	5	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				

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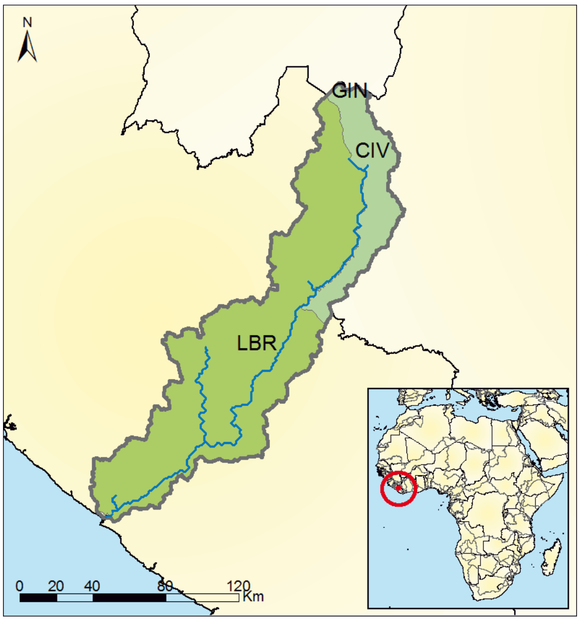
Cestos Basin



Geography

Total drainage area (km²)	12,723
No. of countries in basin	3
BCUs in basin	Côte D'Ivoire (CIV), Guinea (GIN), Liberia (LBR)
Population in basin (people)	711,346
Country at mouth	Liberia
Average rainfall (mm/year)	2,244

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 (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)
CSTO_CIV		1,307.80				
CSTO_GIN						
CSTO_LBR		1,468.76				
Total in Basin	18.35	1,441.98			0.00	0.00

Water Withdrawals

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 (%)
CSTO_CIV	4.57	0.00	0.09	0.00	1	3.65	20.92	

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CSTO_GIN								
CSTO_LBR	19.22	0.04	0.27	0.00	4	14.68	39.04	
Total in Basin	23.79	0.04	0.36	0.00	5.06	18.33	33.44	0.13

Socioeconomic Geography

BCU	Area ('000 km²)	BCU area in basin (%)	Population ('000 people)	Population density (people/km²)	Annual pop. growth (%)	Rural population (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km²)
CSTO_CIV	2	0.18	218	97.94	1.82	0.00	100.00	0	1,521.22	0	0.00
CSTO_GIN	0	0.00	1	89.88	1.98			0	527.26	0	0.00
CSTO_LBR	10	0.82	492	46.95	4.54	0.00	100.00	0	454.34	0	0.00
Total in Basin	13	1.00	711	55.91	2.42	0.00	99.89	0	781.72	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**
CSTO_CIV	1	1	1		5		2	2	2	4	3	5	1	3	2
CSTO_GIN					5				2	5	3	4	1	4	1
CSTO_LBR	1	1	1		5	1	1	2	2	5	3	4	2	3	2
River Basin	1	1	1	2	5	1	1	3	2	4	3	4	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**
CSTO_CIV	2	2	1	1			3	5	3
CSTO_GIN									3
CSTO_LBR	2	2	1	1			3	5	3
River Basin	2	2	1	1	2	2	3	5	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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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 .

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Chiloango Basin

Geography

Total drainage area (km^2)	12,996
No. of countries in basin	3
BCUs in basin	Angola (AGO), Congo (COG), Congo, The Democratic Republic Of The (ZAR)
Population in basin (people)	1,169,060
Country at mouth	Angola
Average rainfall (mm/year)	1,251

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)
CLNG_AGO		265.74				
CLNG_COG		327.82				
CLNG_ZAR		365.61				
Total in Basin	4.24	326.47			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 (%)
CLNG_AGO	17.20	0.90	0.04	0.00	5	11.07	93.11	

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CLNG_COG	9.15	1.84	0.06	3.09	0	4.16	346.04	
CLNG_ZAR	21.43	0.00	0.14	0.04	4	17.68	22.37	
Total in Basin	47.78	2.73	0.25	3.13	8.76	32.91	40.87	1.13

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)
CLNG_AGO	5	0.35	185	40.32	2.92			0	5,668.12	0	0.00
CLNG_COG	1	0.08	26	24.92	2.70			0	3,172.06	0	0.00
CLNG_ZAR	7	0.57	958	130.24	2.78	0.00	100.00	0	453.67	0	0.00
Total in Basin	13	1.00	1,169	89.95	2.77	0.00	81.94	0	1,338.94	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**
CLNG_AGO	1	1	2		5	3	2	3	2	3	3	5	1	4	2
CLNG_COG	1		2		5	3			2	5	3	5	4	4	2
CLNG_ZAR	1	1	1		5	1	2	3	2	3	3	5	1	4	2
River Basin	1	1	2	2	5	2	2	3	1	3	3	5	1	5	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

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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
CLNG_AGO	2	2	1	1			3	5	3
CLNG_COG	2	2							3
CLNG_ZAR	2	2	4	4			3	5	3
River Basin	2	2	2	4	2	2	3	5	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				

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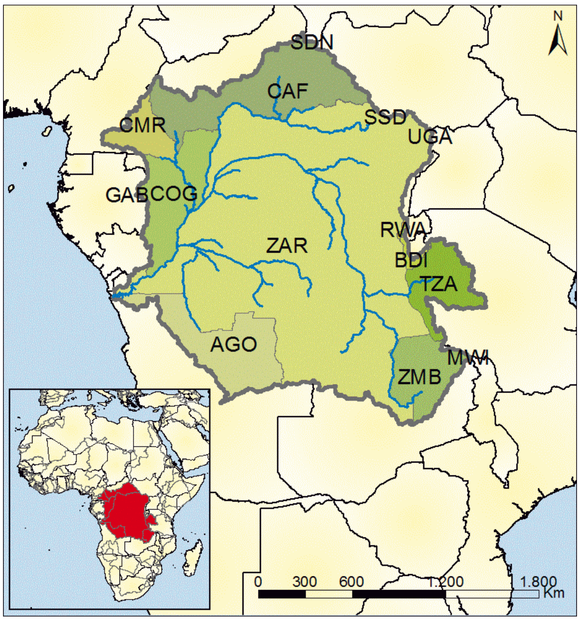
Congo/Zaire Basin



Geography

Total drainage area (km^2)	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 (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)
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						

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[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

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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
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

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UNEP-DHI PARTNERSHIP
Centre on Water and Environment

Corubal Basin

Geography

Total drainage area (km²)	24,300
No. of countries in basin	2
BCUs in basin	Guinea (GIN), Guinea-Bissau (GNB)
Population in basin (people)	661,849
Country at mouth	Guinea-Bissau
Average rainfall (mm/year)	1,564

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

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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)
CRBL_GIN		732.40				
CRBL_GNB		686.58			63.50	0.37
Total in Basin	17.52	720.95			63.50	0.37

Water Withdrawals

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 (%)
CRBL_GIN	30.00	0.41	5.50	5.85	1	17.57	53.55	
CRBL_GNB	5.46	0.57	1.90	0.00	0	2.98	53.64	

[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	35.45	0.98	7.41	5.85	0.66	20.56	53.56	0.20

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)
CRBL_GIN	18	0.72	560	31.83	1.98	42.25	57.75	0	527.26	0	0.00
CRBL_GNB	7	0.28	102	15.17	2.05			0	503.83	0	0.00
Total in Basin	24	1.00	662	27.24	2.52	35.76	48.87	0	523.66	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
CRBL_GIN	1	1	1		5	2	1	2	1	3	2	4	1	4	2
CRBL_GNB	1	1	1		5	5	1	2	1	3	2		1	4	1
River Basin	1	1	1	2	5	3	1	2	1	3	2		1	5	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
CRBL_GIN	2	2	1	1			3	5	2
CRBL_GNB	2	2	1	1			3	5	2
River Basin	2	2	1	1	3	3	3	5	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

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Cross Basin

Geography

Total drainage area (km²)	52,471
No. of countries in basin	2
BCUs in basin	Cameroon (CMR), Nigeria (NGA)
Population in basin (people)	10,765,688
Country at mouth	Niger
Average rainfall (mm/year)	2,196

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)
CROS_CMR		2,078.92				
CROS_NGA		1,448.15				
Total in Basin	83.52	1,591.66			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 (%)
CROS_CMR	33.65	1.61	2.68	0.00	6	23.28	32.71	
CROS_NGA	598.48	0.41	5.90	212.88	114	265.59	61.47	

[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/

Total in Basin	632.14	2.02	8.59	212.88	119.78	288.88	58.72	0.76

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)
CROS_CMR	13	0.26	1,029	76.79	2.20	14.79	85.21	0	1,315.49	0	0.00
CROS_NGA	39	0.74	9,737	249.20	2.50	0.00	100.00	6	3,005.51	1	25.59
Total in Basin	52	1.00	10,766	205.17	2.77	1.41	98.59	6	2,844.01	1	19.06

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
CROS_CMR	1	1	1		5	1	3	3	4	5	3	5	1	3	2
CROS_NGA	1	1	1		5	2	3	2	3	4	3	4	1	4	2
River Basin	1	1	1	2	5	2	3	3	3	4	3	4	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
CROS_CMR	2	2	1	1			2	4	4
CROS_NGA	2	2	1	2			3	5	4
River Basin	2	2	1	1	3	4	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	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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Cuvelai/Etosha Basin

Geography

Total drainage area (km^2)	173,682
No. of countries in basin	2
BCUs in basin	Angola (AGO), Namibia (NAM)
Population in basin (people)	1,159,010
Country at mouth	Namibia
Average rainfall (mm/year)	450

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	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)
ETOS_AGO		68.25				
ETOS_NAM		29.42				
Total in Basin	7.07	40.70			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 (%)
ETOS_AGO	65.61	37.35	11.73	0.00	2	14.92	236.35	
ETOS_NAM	80.37	3.52	6.83	0.00	6	63.61	91.19	

[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	145.99	40.87	18.55	0.00	8.03	78.53	125.96	2.07

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)
ETOS_AGO	54	0.31	278	5.13	2.92			0	5,668.12	0	0.00
ETOS_NAM	120	0.69	881	7.37	1.87	13.48	86.52	0	5,461.53	1	8.36
Total in Basin	174	1.00	1,159	6.67	2.20	10.25	65.79	0	5,511.01	1	5.76

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**
ETOS_AGO	1	1	2		5	2	3	1	2	3	3	5	2	5	3
ETOS_NAM	2	4	2		5	3	4	1	2	3	3	3	1	3	4
River Basin	2	1	2	3	5	3	4	1	2	3	3	4	1	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
ETOS_AGO	3	2	1	1			3	5	3
ETOS_NAM	3	3	4	5			2	3	3
River Basin	3	3	1	3	3	3	2	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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Gambia Basin

Geography

Total drainage area (km²)	72,158
No. of countries in basin	3
BCUs in basin	Gambia (GMB), Guinea (GIN), Senegal (SEN)
Population in basin (people)	1,793,018
Country at mouth	Gambia
Average rainfall (mm/year)	808

Governance

No. of treaties and agreements[1]	6
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 (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)
GAMB_GIN		298.12				
GAMB_GMB		32.11				
GAMB_SEN		95.00				
Total in Basin	7.95	110.14			0.00	0.00

Water Withdrawals

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 (%)
GAMB_GIN	4.81	0.00	1.02	0.00	0	3.80	14.76	

[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/

GAMB_GMB	24.93	7.02	3.38	3.05	0	11.47	50.51	
GAMB_SEN	77.03	26.32	16.77	0.80	1	31.81	79.13	
Total in Basin	106.77	33.34	21.17	3.85	1.33	47.08	59.55	1.34

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)
GAMB_GIN	12	0.16	326	27.73	1.98	0.00	100.00	0	527.26	0	0.00
GAMB_GMB	7	0.10	494	71.18	2.79	44.51	55.49	0	494.40	0	0.00
GAMB_SEN	53	0.74	973	18.21	2.69	1.16	98.84	0	1,071.92	0	0.00
Total in Basin	72	1.00	1,793	24.85	2.93	12.88	87.12	0	813.92	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**
GAMB_GIN	1	1	1		5	1	1	2	2	2	2	4	1	4	1
GAMB_GMB	1	1	2		5	5	1	3	1	2	1	3	4	5	3
GAMB_SEN	2	1	2		5	3	1	2	2	2	1		1	3	3
River Basin	2	1	2	3	5	3	1	3	2	2	1		2	5	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
GAMB_GIN	2	2	1	1			3	5	2
GAMB_GMB	4	4	2	2			2	4	1
GAMB_SEN	3	3	1	1			2	3	2
River Basin	3	3	1	1	3	4	2	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.

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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Geba Basin

Geography

Total drainage area (km²)	12,327
No. of countries in basin	3
BCUs in basin	Guinea (GIN), Guinea-Bissau (GNB), Senegal (SEN)
Population in basin (people)	497,858
Country at mouth	Guinea-Bissau
Average rainfall (mm/year)	1,240

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)
GEBA_GIN						
GEBA_GNB		753.59				
GEBA_SEN		302.77				
Total in Basin	6.91	560.64			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 (%)
GEBA_GIN								

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GEBA_GNB	17.34	7.96	1.83	0.00	0	7.56	53.91	
GEBA_SEN	12.64	1.65	2.60	2.20	0	6.18	73.34	
Total in Basin	29.98	9.61	4.43	2.20	0.00	13.74	60.21	0.43

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)
GEBA_GIN	0	0.01	4	25.51	1.98			0	527.26	0	0.00
GEBA_GNB	8	0.64	322	40.51	2.05	3.16	96.84	0	503.83	0	0.00
GEBA_SEN	4	0.34	172	40.70	2.69			0	1,071.92	0	0.00
Total in Basin	12	1.00	498	40.39	2.59	2.04	62.57	0	700.59	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**
GEBA_GIN					5	5			1	5	2	4	1	4	1
GEBA_GNB	1	1	2		5	5	1	2	1	4	2		4	4	2
GEBA_SEN	1	1	2		5	5	1	3	1	5	2		1	3	2
River Basin	1	1	2	2	5	5	1	3	1	4	2		3	5	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
GEBA_GIN									2
GEBA_GNB	3	3	1	1			2	5	2
GEBA_SEN	3	4	1	1			1	2	3
River Basin	3	3	1	1	3	4	2	4	2

[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

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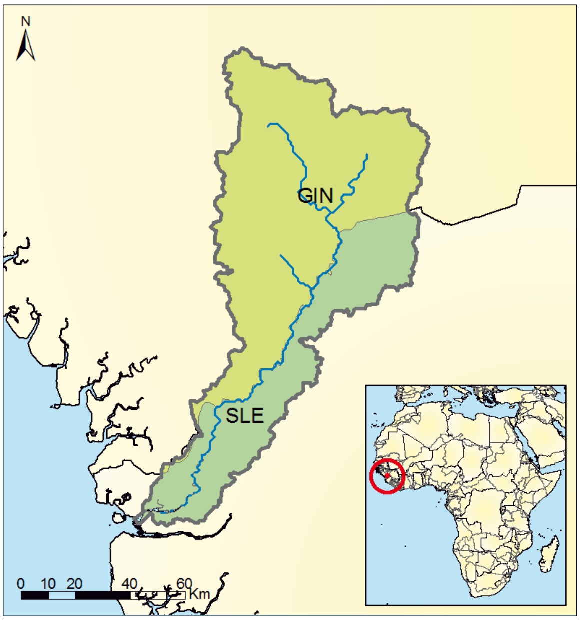
Great Scarcies Basin



Geography

Total drainage area (km^2)	7,832
No. of countries in basin	2
BCUs in basin	Guinea (GIN), Sierra Leone (SLE)
Population in basin (people)	515,933
Country at mouth	Sierra Leone
Average rainfall (mm/year)	2,408

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)
GSCR_GIN		1,570.79				
GSCR_SLE		1,796.89				
Total in Basin	13.37	1,706.54			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 (%)
GSCR_GIN	7.70	0.25	0.87	0.00	0	6.13	25.80	
GSCR_SLE	31.56	20.62	0.80	0.00	1	9.18	145.20	

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Total in Basin	39.26	20.87	1.66	0.00	1.42	15.31	76.10	0.29

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)
GSCR_GIN	5	0.67	299	57.03	1.98	0.00	100.00	1	527.26	0	0.00
GSCR_SLE	3	0.33	217	83.70	2.60	39.38	60.62	0	809.12	0	0.00
Total in Basin	8	1.00	516	65.88	2.26	16.59	83.41	1	646.02	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
GSCR_GIN	1	1	1		5	3	4	3	2	5	2	4	1	5	2
GSCR_SLE	1	1	2		5	5	4	3	2	5	2	5	2	5	2
River Basin	1	1	2	2	5	4	4	3	1	5	2	5	1	5	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
GSCR_GIN	2	2	1	1			3	5	2
GSCR_SLE	2	2	1	1			2	3	2
River Basin	2	2	1	1	2	2	2	5	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				

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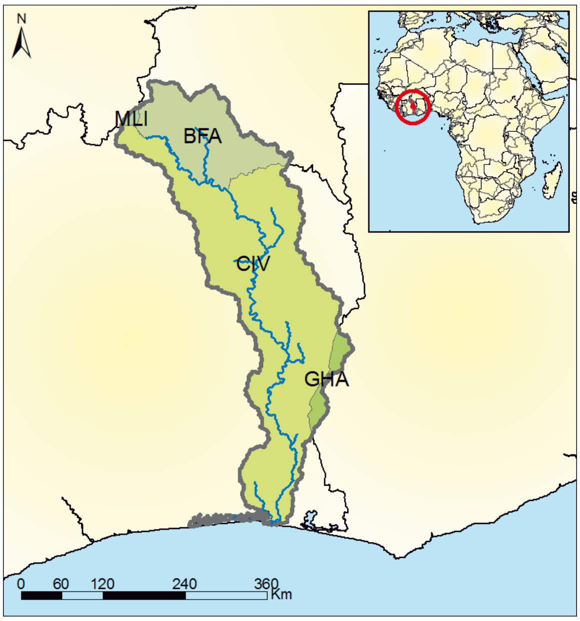
Komoe Basin



Geography

Total drainage area (km^2)	83,391
No. of countries in basin	4
BCUs in basin	Burkina Faso (BFA), Côte D'Ivoire (CIV), Ghana (GHA), Mali (MLI)
Population in basin (people)	3,672,323
Country at mouth	Côte D'Ivoire
Average rainfall (mm/year)	1,251

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	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)
KMOE_BFA		136.76				
KMOE_CIV		248.32			578.95	0.19
KMOE_GHA						
KMOE_MLI						
Total in Basin	19.21	230.32			578.95	0.19

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 (%)

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KMOE_BFA	58.50	44.36	4.09	0.42	0	9.63	118.26	
KMOE_CIV	651.23	53.41	7.55	431.86	41	117.10	221.81	
KMOE_GHA								
KMOE_MLI								
Total in Basin	709.73	97.77	11.64	432.28	41.31	126.73	193.26	3.70

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)
KMOE _BFA	18	0.21	495	27.82	2.97	0.00	100.00	0	683.95	5	281.21
KMOE _CIV	63	0.75	2,936	46.86	1.82	1.82	98.18	0	1,521.22	1	15.96
KMOE _GHA	3	0.03	213	84.05	2.39	0.00	100.00	0	1,850.20	0	0.00
KMOE _MLI	0	0.01	29	68.12	3.08	0.00	100.00	0	715.13	0	0.00
Total in Basin	83	1.00	3,672	44.04	2.42	1.45	98.55	0	1,421.25	6	71.95

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**
KMOE_BFA	2	1	2		5	3	4	2	1	4	3	1	2	4	2
KMOE_CIV	2	1	2		5	1	3	2	2	5	3	5	4	3	2
KMOE_GHA					5				2	5	3	1	1	3	1
KMOE_MLI					5	4			1	5	3		1	4	1
River Basin	2	1	2	2	5	1	3	2	1	5	3	4	3	5	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

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KMOE_BFA	4	3	1	1			3	5	3
KMOE_CIV	2	3	1	3			3	5	3
KMOE_GHA									3
KMOE_MLI									3
River Basin	3	3	1	2	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**
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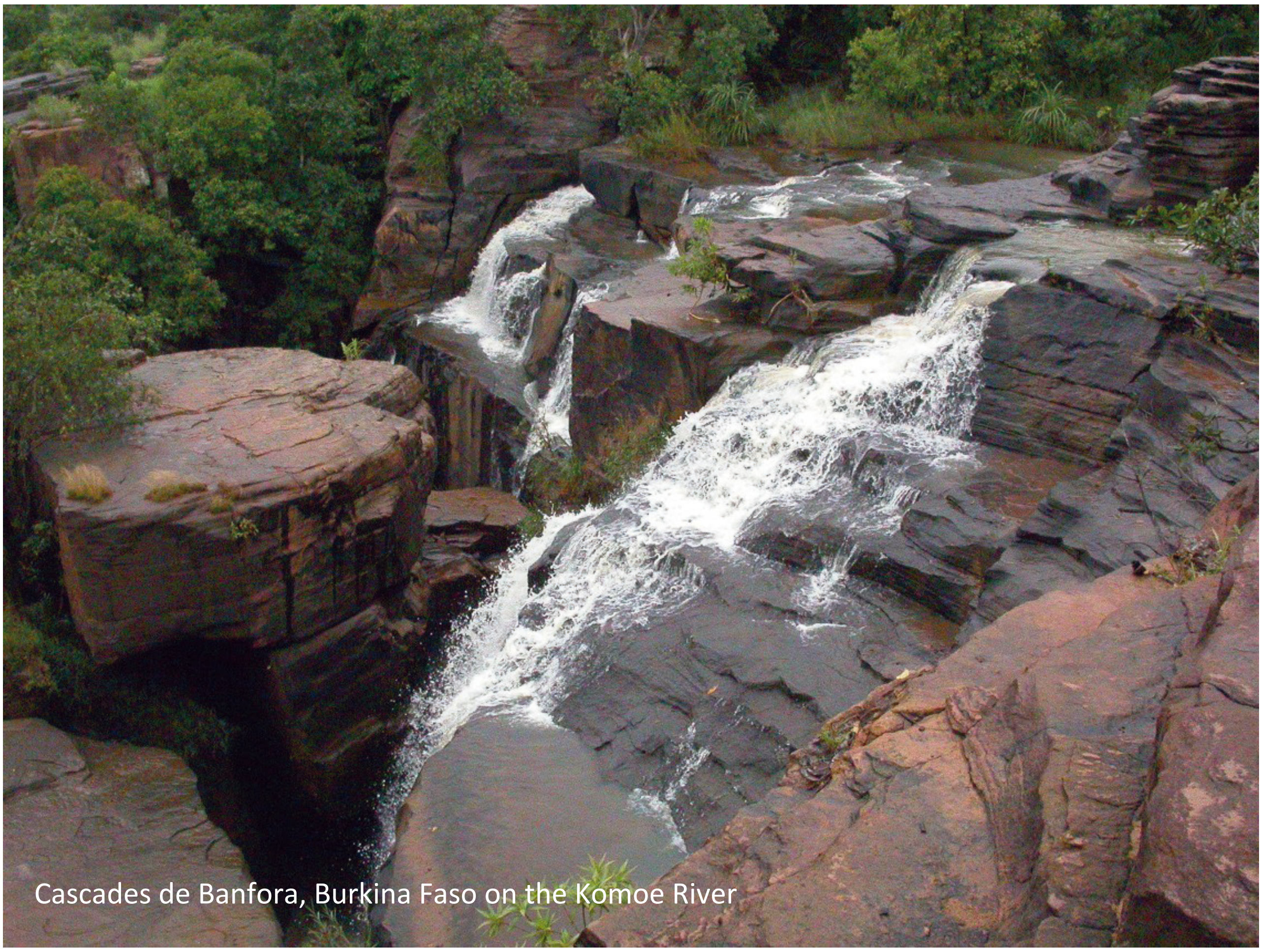

Kunene Basin

Geography

Total drainage area (km²)	108,563
No. of countries in basin	2
BCUs in basin	Angola (AGO), Namibia (NAM)
Population in basin (people)	1,933,121
Country at mouth	Angola, Namibia
Average rainfall (mm/year)	622

Governance

No. of treaties and agreements[1]	3
No. of RBOs and Commissions[2]	3

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	1
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 (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)
KUNE_AGO		127.11			377.48	2.82
KUNE_NAM		31.62			0.02	0.00
Total in Basin	11.63	107.09			377.50	2.82

Water Withdrawals

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 (%)
KUNE_AGO	239.30	60.07	27.66	16.80	35	99.75	124.37	
KUNE_NAM	4.30	0.00	1.89	0.00	0	2.41	473.32	

[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	243.60	60.07	29.55	16.80	35.02	102.16	126.01	2.10

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)
KUNE_AGO	94	0.87	1,924	20.44	2.92	0.00	100.00	1	5,668.12	5	53.12
KUNE_NAM	14	0.13	9	0.63	1.87			0	5,461.53	0	0.00
Total in Basin	109	1.00	1,933	17.81	3.07	0.00	99.53	1	5,667.15	5	46.06

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**
KUNE_AGO	2	1	2		5	1	4	2	2	2	3	5	3	5	2
KUNE_NAM	2	1	1		5	1	4	2	2	2	3	3	1	3	4
River Basin	2	1	2	3	5	1	4	2	1	2	3	4	3	5	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**
KUNE_AGO	3	2	1	1			4	5	3
KUNE_NAM	3	3	1	1			3	5	3
River Basin	3	3	1	1	3	3	4	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.

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

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[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

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

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

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Little Scarcies Basin

Geography

Total drainage area (km^2)	18,552
No. of countries in basin	2
BCUs in basin	Guinea (GIN), Sierra Leone (SLE)
Population in basin (people)	926,142
Country at mouth	Sierra Leone
Average rainfall (mm/year)	2,485

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)
LSCR_GIN		798.10				
LSCR_SLE		1,886.31				
Total in Basin	30.52	1,645.14			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 (%)
LSCR_GIN	4.81	0.46	0.60	0.00	0	3.63	21.67	
LSCR_SLE	65.77	37.13	2.07	0.08	3	23.31	93.37	

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Total in Basin	70.58	37.59	2.66	0.08	3.30	26.94	76.20	0.23

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)
LSCR_GIN	6	0.30	222	40.30	1.98	0.00	100.00	0	527.26	0	0.00
LSCR_SLE	13	0.70	704	53.98	2.60	29.68	70.32	0	809.12	0	0.00
Total in Basin	19	1.00	926	49.92	2.04	22.57	77.43	0	741.63	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**
LSCR_GIN	1	1	1		5	1	3	2	2	5	3	4	1	5	1
LSCR_SLE	1	1	2		5	4	3	3	2	5	3	5	3	5	2
River Basin	1	1	2	2	5	3	3	3	2	5	3	5	3	5	2

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LSCR_SLE	2	2	1	1			1	2	3
River Basin	2	2	1	1	2	2	2	3	3

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

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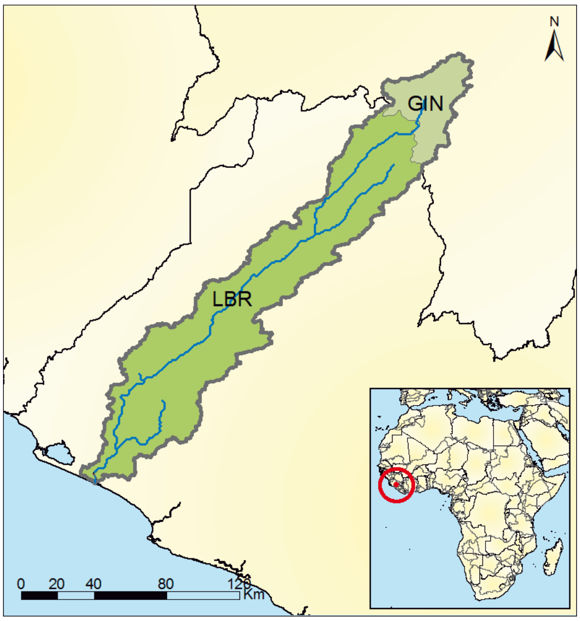
Loffa Basin



Geography

Total drainage area (km^2)	10,446
No. of countries in basin	2
BCUs in basin	Guinea (GIN), Liberia (LBR)
Population in basin (people)	223,464
Country at mouth	Liberia
Average rainfall (mm/year)	2,588

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)
LOFF_GIN						
LOFF_LBR		1,783.32				
Total in Basin	18.63	1,783.32			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 (%)
LOFF_GIN								
LOFF_LBR	2.11	0.00	0.10	0.00	0	2.01	14.20	

[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/

Total in Basin	2.11	0.00	0.10	0.00	0.00	2.01	9.45	0.01

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)
LOFF_GIN	1	0.14	75	51.83	1.98	0.00	100.00	0	527.26	0	0.00
LOFF_LBR	9	0.86	149	16.52	4.54	0.00	100.00	0	454.34	0	0.00
Total in Basin	10	1.00	223	21.39	2.47	0.00	100.00	0	478.73	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
LOFF_GIN					5				2	5	3	4	1	5	1
LOFF_LBR	1	1	1		5	1	2	2	2	5	3	4	1	3	2
River Basin	1	1	1	2	5	1	2	3	2	5	3	4	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
LOFF_GIN									3
LOFF_LBR	2	3	1	1			3	5	3
River Basin	2	3	1	1	2	2	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.

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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Mana-Morro Basin

Geography

Total drainage area (km^2)	7,634
No. of countries in basin	3
BCUs in basin	Guinea (GIN), Liberia (LBR), Sierra Leone (SLE)
Population in basin (people)	179,952
Country at mouth	Liberia, Sierra Leone
Average rainfall (mm/year)	2,612

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	1
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)
MANA_GIN						
MANA_LBR						
MANA_SLE		1,469.26				
Total in Basin	11.22	1,469.26			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 (%)
MANA_GIN								

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UNEP gef UNEP-DHI PARTNERSHIP Centre on Water and Environment UNEP DHI

MANA_LBR								
MANA_SLE	12.58	0.13	0.12	0.00	2	9.87	174.81	
Total in Basin	12.58	0.13	0.12	0.00	2.46	9.87	69.89	0.11

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)
MANA_GIN	0	0.00	1	34.98				0	527.26	0	0.00
MANA_LBR	6	0.75	107	18.78	4.54	0.00	100.00	0	454.34	0	0.00
MANA_SLE	2	0.25	72	37.67	2.60	11.79	88.21	0	809.12	0	0.00
Total in Basin	8	1.00	180	23.57	2.22	4.71	94.64	0	596.65	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**
MANA_GIN					5				2	5	3	4	1	5	1
MANA_LBR					5	2			2	5	2	4	1	3	2
MANA_SLE	1	1	1		5	4	1	3	2	5	2	5	1	5	2
River Basin	1	1	1	2	5	3	2	3	1	5	2	5	1	5	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
MANA_GIN									3
MANA_LBR							3	5	2
MANA_SLE	2	2	1	1			2	3	2
River Basin	2	2	1	1	2	2	2	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.

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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Mbe Basin

Geography

Total drainage area (km^2)	7,123
No. of countries in basin	2
BCUs in basin	Equatorial Guinea (GNQ), Gabon (GAB)
Population in basin (people)	24,251
Country at mouth	Gabon
Average rainfall (mm/year)	3,721

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)
MBEX_GAB		2,730.83				
MBEX_GNQ						
Total in Basin	19.45	2,730.83			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 (%)
MBEX_GAB	0.57	0.00	0.02	0.00	0	0.54	30.77	
MBEX_GNQ								

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Total in Basin	0.57	0.00	0.02	0.00	0.01	0.54	23.38	0.00

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)
MBEX_GAB	6	0.91	18	2.85	1.88	100.00	0.00	0	11,571.08	1	154.62
MBEX_GNQ	1	0.09	6	8.89	2.84	0.00	100.00	0	20,572.34	0	0.00
Total in Basin	7	1.00	24	3.40	2.47	76.00	24.00	0	13,731.74	1	140.40

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**
MBEX_GAB	1	1	1		5	3	2		2	5	3	5	1	3	2
MBEX_GNQ					5				2	5	3		1	4	1
River Basin	1	1	1	2	5	3	2		1	5	3	5	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
MBEX_GAB	2	2	1	1			2	4	3
MBEX_GNQ									3
River Basin	2	2	1	1	2	2	2	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				

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Moa Basin

Geography

Total drainage area (km^2)	19,560
No. of countries in basin	3
BCUs in basin	Guinea (GIN), Liberia (LBR), Sierra Leone (SLE)
Population in basin (people)	1,757,912
Country at mouth	Sierra Leone
Average rainfall (mm/year)	2,470

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)
MOAX_GIN		1,512.37				
MOAX_LBR		1,750.41				
MOAX_SLE		1,730.33				
Total in Basin	32.94	1,684.18			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 (%)
MOAX_GIN	11.57	0.04	0.33	0.00	1	10.05	15.65	

[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/

MOAX_LBR	3.61	0.00	0.04	0.00	1	2.82	55.94	
MOAX_SLE	33.38	1.57	0.87	0.39	4	26.57	34.98	
Total in Basin	48.56	1.60	1.25	0.39	5.87	39.45	27.62	0.15

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)
MOAX_GIN	9	0.44	739	86.86	1.98	0.00	100.00	0	527.26	0	0.00
MOAX_LBR	2	0.09	64	37.66	4.54			0	454.34	0	0.00
MOAX_SLE	9	0.48	954	102.18	2.60	11.49	88.51	1	809.12	0	0.00
Total in Basin	20	1.00	1,758	89.87	2.17	6.24	90.09	1	677.60	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**
MOAX_GIN	1	1	1		5	1	1	2	1	4	3	4	1	5	2
MOAX_LBR	1	1	1		5	1	2	2	1	5	3	4	1	3	2
MOAX_SLE	1	1	1		5	3	1	3	2	4	3	5	1	4	2
River Basin	1	1	1	2	5	2	1	3	1	4	3	5	1	5	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
MOAX_GIN	2	3	1	1			3	5	3
MOAX_LBR	2	3	1	1			2	4	3
MOAX_SLE	2	3	1	1			2	3	3
River Basin	2	3	1	1	2	2	2	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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Mono Basin

Geography

Total drainage area (km^2)	23,988
No. of countries in basin	2
BCUs in basin	Benin (BEN), Togo (TGO)
Population in basin (people)	2,159,469
Country at mouth	Togo
Average rainfall (mm/year)	1,160

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)
MONO_BEN		140.59				
MONO_TGO		355.03				
Total in Basin	7.87	328.18			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 (%)
MONO_BEN	25.45	0.52	0.42	0.00	8	17.00	34.65	
MONO_TGO	45.16	3.86	2.32	0.00	5	34.28	31.69	

[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	70.60	4.37	2.74	0.00	12.22	51.28	32.69	0.90

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)
MONO_BEN	3	0.11	734	271.50	2.96	9.54	90.46	0	804.67	0	0.00
MONO_TGO	21	0.89	1,425	66.96	2.17	1.03	98.97	1	636.44	1	46.99
Total in Basin	24	1.00	2,159	90.02	2.62	3.92	96.08	1	693.65	1	41.69

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**
MONO_BEN	3	5	2		5	4	3	3	1	4	5	3	1	4	2
MONO_TGO	2	1	2		5	1	3	3	1	5	5	3	2	4	2
River Basin	2	1	2	2	5	1	3	3	1	4	5	3	2	5	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**
MONO_BEN	3	3	5	5					5
MONO_TGO	3	3	1	2			2	4	5
River Basin	3	3	2	4	4	4	2	4	5

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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Niger Basin

Geography

Total drainage area (km²)	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 (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)
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 (%)	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)
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
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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

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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**

[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

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Nile Basin

Geography

Total drainage area (km²)	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 (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)
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

[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/

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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Disputed areas
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Nyanga Basin

Geography

Total drainage area (km^2)	24,963
No. of countries in basin	2
BCUs in basin	Congo (COG), Gabon (GAB)
Population in basin (people)	100,329
Country at mouth	Gabon
Average rainfall (mm/year)	2,525

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	4
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)
NYGA_COG		466.38				
NYGA_GAB		1,432.83			61.20	0.49
Total in Basin	32.32	1,294.74			61.20	0.49

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 (%)
NYGA_COG	0.44	0.00	0.04	0.00	0	0.39	10.37	
NYGA_GAB	6.22	0.00	0.16	0.47	0	5.48	107.04	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
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Total in Basin	6.66	0.00	0.20	0.47	0.11	5.88	66.37	0.02

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)
NYGA_COG	5	0.20	42	8.50	2.70			0	3,172.06	0	0.00
NYGA_GAB	20	0.80	58	2.91	1.88	3.64	96.36	0	11,571.08	0	0.00
Total in Basin	25	1.00	100	4.02	2.43	2.11	55.82	0	8,037.54	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
NYGA_COG	1	1	1		5	1	1		2	5	3	5	1	4	2
NYGA_GAB	1	1	1		5	1	1		2	5	3	5	1	3	2
River Basin	1	1	1	2	5	1	1		2	5	3	5	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
NYGA_COG	2	2	1	1					3
NYGA_GAB	2	2	1	1			2	4	3
River Basin	2	2	1	1	2	2	2	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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Ogooue Basin

Geography

Total drainage area (km^2)	214,254
No. of countries in basin	4
BCUs in basin	Cameroon (CMR), Congo (COG), Equatorial Guinea (GNQ), Gabon (GAB)
Population in basin (people)	767,736
Country at mouth	Gabon
Average rainfall (mm/year)	3,574

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	5
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)
OGOO_CMR		712.71				
OGOO_COG		934.11				
OGOO_GAB		1,547.05			440.50	5.37
OGOO_GNQ						
Total in Basin	310.05	1,447.13			440.50	5.37

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 (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 (%)
OGOO_CMR	1.99	0.00	0.13	0.00	0	1.82	37.43	
OGOO_COG	2.26	0.00	0.20	0.00	0	2.03	38.11	
OGOO_GAB	64.52	4.25	1.09	11.48	1	46.64	102.08	
OGOO_GNQ								
Total in Basin	68.77	4.25	1.42	11.48	1.14	50.48	89.58	0.02

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)
OGOO_CMR	5	0.02	53	10.28	2.20	100.00	0.00	0	1,315.49	0	0.00
OGOO_COG	21	0.10	59	2.87	2.70			0	3,172.06	0	0.00
OGOO_GAB	187	0.87	632	3.38	1.88	4.06	95.94	0	11,571.08	0	0.00
OGOO_GNQ	2	0.01	23	14.04	2.84			0	20,572.34	0	0.00
Total in Basin	214	1.00	768	3.58	2.40	10.26	78.99	0	10,485.39	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**
OGOO_CMR	1	1	1		5	1	2	3	2	5	3	5	1	3	2
OGOO_COG	1	1	1		5	1	1	3	3	5	3	5	1	4	2
OGOO_GAB	1	1	1		5	2	1	3	3	5	5	5	4	3	3
OGOO_GNQ					5				2	5	3		1	4	1
River Basin	1	1	1	2	5	2	1	3	3	5	5	5	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

[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: 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
OGOO_CMR	2	2	1	1			2	4	3
OGOO_COG	2	2	1	1			2	5	3
OGOO_GAB	2	2	1	1			2	4	5
OGOO_GNQ									3
River Basin	2	2	1	1	1	1	2	4	5

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

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Okavango Basin

Geography

Total drainage area (km^2)	690,181
No. of countries in basin	4
BCUs in basin	Angola (AGO), Botswana (BWA), Namibia (NAM), Zimbabwe (ZWE)
Population in basin (people)	2,013,152
Country at mouth	Botswana
Average rainfall (mm/year)	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	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)
OKVG_AGO		94.22				
OKVG_BWA		42.91			194.30	0.76
OKVG_NAM		37.39				
OKVG_ZWE		55.78				
Total in Basin	37.21	53.91			194.30	0.76

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 (%)

[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/

OKVG_AGO	99.84	10.19	2.46	1.32	22	63.40	108.80	
OKVG_BWA	86.94	2.13	11.63	6.92	8	58.33	185.45	
OKVG_NAM	47.42	11.17	8.40	0.00	0	27.36	135.63	
OKVG_ZWE	4.60	0.00	1.46	0.00	0	3.14	16.58	
Total in Basin	238.79	23.49	23.95	8.24	30.87	152.23	118.62	0.64

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)
OKVG _AGO	150	0.22	918	6.11	2.92	100.00	0.00	0	5,668.12	0	0.00
OKVG _BWA	344	0.50	469	1.36	1.35	52.91	47.09	0	7,316.88	1	2.90
OKVG _NAM	170	0.25	350	2.05	1.87	6.90	93.10	0	5,461.53	1	5.88
OKVG _ZWE	25	0.04	277	10.88	0.00			0	904.76	3	117.81
Total in Basin	690	1.00	2,013	2.92	2.36	59.10	27.13	0	5,360.46	5	7.24

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**
OKVG_AGO	1	1	2		5	1	3	2	2	2	1	5	1	5	2
OKVG_BWA	2	1	2		5	2	3	2	2	2	3	3	1	3	5
OKVG_NAM	2	1	2		5	2	3	2	2	1	3	3	1	3	5
OKVG_ZWE	1	1	1		5	2	5	2	1	3	3	2	1	3	4
River Basin	2	1	2	3	5	2	3	2	1	2	2	3	1	5	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**

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

OKVG_AGO	2	2	1	1			4	5	1
OKVG_BWA	5	5	1	1			2	3	3
OKVG_NAM	4	5	1	1			2	3	3
OKVG_ZWE	5	5	1	1			2	3	4
River Basin	5	5	1	1	3	3	3	5	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				

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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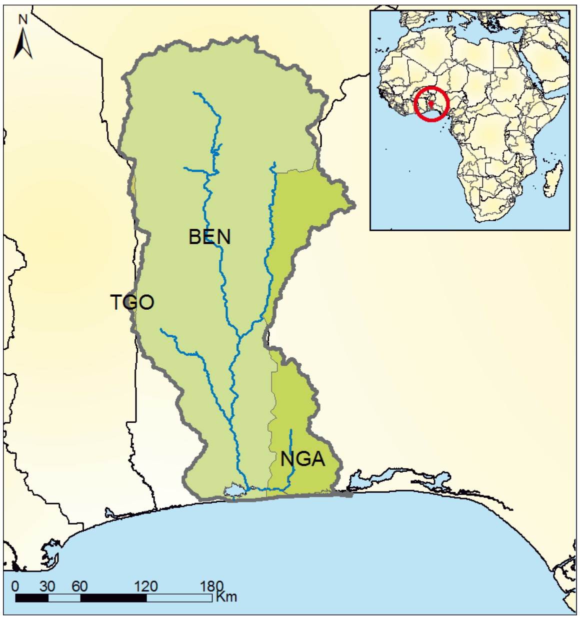
Oueme Basin



Geography

Total drainage area (km^2)	59,873
No. of countries in basin	3
BCUs in basin	Benin (BEN), Nigeria (NGA), Togo (TGO)
Population in basin (people)	8,482,698
Country at mouth	Benin
Average rainfall (mm/year)	1,183

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	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)
OUEM_BEN		283.90				
OUEM_NGA		446.34				
OUEM_TGO						
Total in Basin	20.24	338.10			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 (%)
OUEM_BEN	122.42	15.14	6.40	0.71	21	79.48	27.85	

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OUEM_NGA	352.25	0.71	3.49	59.23	104	184.55	86.47	
OUEM_TGO								
Total in Basin	474.67	15.85	9.89	59.93	124.97	264.03	55.96	2.34

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)
OUEM_BEN	49	0.82	4,395	89.53	2.96	1.22	98.78	2	804.67	1	20.37
OUEM_NGA	10	0.17	4,074	389.66	2.50	0.00	100.00	1	3,005.51	0	0.00
OUEM_TGO	0	0.01	14	41.98	2.17			0	636.44	0	0.00
Total in Basin	60	1.00	8,483	141.68	2.73	0.63	99.21	3	1,861.35	1	16.70

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**
OUEM_BEN	1	1	2		5	1	3	3	1	4	3	3	5	4	5
OUEM_NGA	2	4	1		5	3	4	2	1	4	3	4	1	3	2
OUEM_TGO					5				1	5	3	3	1	4	1
River Basin	2	2	2	3	5	2	3	3	1	4	3	3	4	5	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
OUEM_BEN	2	3	2	4			3	5	3
OUEM_NGA	2	3	5	5			3	5	3
OUEM_TGO									3
River Basin	2	3	4	4	4	4	3	5	3

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UNEP gef UNEP-DHI PARTNERSHIP Centre on Water and Environment UNEP DHI

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

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Sanaga Basin

Geography

Total drainage area (km^2)	133,047
No. of countries in basin	3
BCUs in basin	Cameroon (CMR), Central African Republic (CAF), Nigeria (NGA)
Population in basin (people)	5,057,006
Country at mouth	Cameroon
Average rainfall (mm/year)	1,776

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	3
Large Marine Ecosystems	1

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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)
SANA_CAF						
SANA_CMR		647.48			1,188.10	12.47
SANA_NGA						
Total in Basin	86.15	647.48			1,188.10	12.47

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 (%)
SANA_CAF								

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SANA_CMR	234.56	1.52	27.38	14.48	39	152.05	46.46	
SANA_NGA								
Total in Basin	234.56	1.52	27.38	14.48	39.13	152.05	46.38	0.27

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)
SANA_CAF	1	0.01	7	9.03	1.82			0	333.20	0	0.00
SANA_CMR	132	0.99	5,049	38.17	2.20	5.19	94.81	4	1,315.49	4	30.24
SANA_NGA	0	0.00	1	37.91	2.50			0	3,005.51	0	0.00
Total in Basin	133	1.00	5,057	38.01	2.52	5.19	94.66	4	1,314.70	4	30.06

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**
SANA_CAF					5	4			2	5	3		1	5	1
SANA_CMR	2	1	1		5	3	3	3	3	5	5	5	1	3	2
SANA_NGA					5				2	4	3	4	1	5	1
River Basin	2	1	1	2	5	4	3	3	3	5	5	5	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
SANA_CAF									3
SANA_CMR	2	2	1	1			2	4	5
SANA_NGA									3
River Basin	2	2	1	1	2	3	2	4	5

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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
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Sassandra Basin

Geography

Total drainage area (km²)	68,124
No. of countries in basin	2
BCUs in basin	Côte D'Ivoire (CIV), Guinea (GIN)
Population in basin (people)	4,143,065
Country at mouth	Côte D'Ivoire
Average rainfall (mm/year)	1,614

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	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 (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)
SASS_CIV		450.21			988.90	8.24
SASS_GIN		537.62				
Total in Basin	30.87	453.11			988.90	8.24

Water Withdrawals

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 (%)
SASS_CIV	140.08	8.74	3.27	0.00	28	99.77	36.46	
SASS_GIN	1.41	0.00	0.20	0.00	0	1.20	4.67	

[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	141.48	8.74	3.47	0.00	28.30	100.97	34.15	0.46

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)
SASS_CIV	60	0.88	3,842	64.06	1.82	0.90	99.10	1	1,521.22	1	16.67
SASS_GIN	8	0.12	301	36.92	1.98			0	527.26	0	0.00
Total in Basin	68	1.00	4,143	60.82	2.38	0.84	91.90	1	1,449.01	1	14.68

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**
SASS_CIV	2	1	2		5	1	3	2	2	4	3	5	1	3	2
SASS_GIN	1	1	1		5		3	2	2	5	3	4	1	5	2
River Basin	2	1	2	2	5	1	3	3	2	4	3	5	1	5	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
SASS_CIV	2	3	1	1			3	5	3
SASS_GIN	2	3	1	1			3	5	3
River Basin	2	3	1	1	2	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				

[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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Senegal Basin

Geography

Total drainage area (km²)	448,379
No. of countries in basin	4
BCUs in basin	Guinea (GIN), Mali (MLI), Mauritania (MRT), Senegal (SEN)
Population in basin (people)	7,409,034
Country at mouth	Senegal
Average rainfall (mm/year)	483

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	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 (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)
SENG_GIN		434.47				
SENG_MLI		71.57			477.00	11.26
SENG_MRT		65.41			325.30	2.84
SENG_SEN		52.14			256.20	0.75
Total in Basin	40.44	90.20			1,058.50	14.84

Water Withdrawals

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 (%)

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
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SENG_GIN	39.62	6.38	5.60	0.00	1	26.20	39.35	
SENG_MLI	251.95	35.17	22.29	9.77	114	71.11	84.99	
SENG_MRT	846.87	600.77	17.07	0.96	10	218.49	457.19	
SENG_SEN	1,864.55	1,776.70	18.26	6.77	4	59.19	1,175.95	
Total in Basin	3,002.99	2,419.02	63.20	17.51	128.27	374.99	405.31	7.42

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)
SENG_GIN	31	0.07	1,007	31.99	1.98	0.00	100.00	0	527.26	0	0.00
SENG_MLI	172	0.38	2,964	17.28	3.08	20.03	79.97	0	715.13	1	5.83
SENG_MRT	168	0.38	1,852	11.00	2.54	4.90	95.10	0	1,070.09	2	11.88
SENG_SEN	77	0.17	1,586	20.59	2.69	0.00	100.00	1	1,071.92	0	0.00
Total in Basin	448	1.00	7,409	16.52	2.77	9.24	90.76	1	854.70	3	6.69

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**
SENG_GIN	1	1	2		5	1	3	2	2	2	2	4	1	5	2
SENG_MLI	2	1	2		5	2	3	2	2	2	3		1	4	2
SENG_MRT	2	5	2		5	5	2	2	1	2	3		4	4	2
SENG_SEN	2	2	3		5	2	2	2	1	2	3		4	3	4
River Basin	2	1	2	2	5	2	3	2	2	2	3		3	5	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**

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

SENG_GIN	2	2	1	1			3	5	2
SENG_MLI	5	5	1	1			3	5	3
SENG_MRT	5	5	4	4			2	5	3
SENG_SEN	4	4	2	3			1	2	4
River Basin	5	5	1	1	2	2	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	2	4	2	2	4

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St. John (Africa) Basin

Geography

Total drainage area (km^2)	16,157
No. of countries in basin	3
BCUs in basin	Côte D'Ivoire (CIV), Guinea (GIN), Liberia (LBR)
Population in basin (people)	761,691
Country at mouth	Liberia
Average rainfall (mm/year)	2,489

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)
SJAF_CIV						
SJAF_GIN						
SJAF_LBR		1,688.05				
Total in Basin	27.27	1,688.05			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 (%)
SJAF_CIV								

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SJAF_GIN								
SJAF_LBR	12.14	0.03	0.23	0.00	1	10.67	20.98	
Total in Basin	12.14	0.03	0.23	0.00	1.20	10.67	15.93	0.04

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)
SJAF_CIV	0	0.00	0	0.00				0	1,521.22	0	0.00
SJAF_GIN	3	0.16	183	69.07	1.98	0.00	100.00	0	527.26	0	0.00
SJAF_LBR	14	0.84	578	42.84	4.54	11.32	88.68	0	454.34	0	0.00
Total in Basin	16	1.00	762	47.14	2.47	8.60	91.40	0	471.88	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**
SJAF_CIV					5				2	4	3	5	1	4	
SJAF_GIN					5				2	5	3	4	1	5	2
SJAF_LBR	1	1	1		5	1	1	2	2	5	3	4	1	4	2
River Basin	1	1	1	2	5	1	1	3	2	5	3	4	1	5	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**
SJAF_CIV									3
SJAF_GIN									3
SJAF_LBR	2	2	1	1			3	5	3
River Basin	2	2	1	1	2	2	3	5	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				

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St. Paul Basin

Geography

Total drainage area (km^2)	20,317
No. of countries in basin	2
BCUs in basin	Guinea (GIN), Liberia (LBR)
Population in basin (people)	1,026,515
Country at mouth	Liberia
Average rainfall (mm/year)	2,516

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.
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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)
SPAU_GIN		1,421.61				
SPAU_LBR		1,964.64				
Total in Basin	35.51	1,747.71			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 (%)
SPAU_GIN	16.74	0.00	0.43	0.00	1	14.94	26.71	
SPAU_LBR	14.91	0.04	0.37	0.00	3	11.55	37.30	

[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	31.65	0.04	0.80	0.00	4.32	26.49	30.83	0.09

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)
SPAU_GIN	9	0.46	627	67.61	1.98	0.00	100.00	1	527.26	0	0.00
SPAU_LBR	11	0.54	400	36.18	4.54	0.00	100.00	0	454.34	1	90.54
Total in Basin	20	1.00	1,027	50.53	2.50	0.00	100.00	1	498.87	1	49.22

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
SPAU_GIN	1	1	1		5		1	2	2	5	3	4	1	5	2
SPAU_LBR	1	1	1		5	1	1	2	3	5	3	4	2	4	2
River Basin	1	1	1	2	5	1	1	2	2	5	3	4	1	5	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
SPAU_GIN	2	3	1	1			3	5	3
SPAU_LBR	2	3	1	1			3	5	3
River Basin	2	3	1	1	2	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				

[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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Basin Delineation
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Tano Basin

Geography

Total drainage area (km^2)	16,773
No. of countries in basin	2
BCUs in basin	Côte D'Ivoire (CIV), Ghana (GHA)
Population in basin (people)	1,750,016
Country at mouth	Ghana
Average rainfall (mm/year)	1,484

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)
TANO_CIV					0.73	0.01
TANO_GHA		403.27			0.05	0.00
Total in Basin	6.76	403.27			0.78	0.01

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 (%)
TANO_CIV								
TANO_GHA	146.13	7.20	1.15	29.41	28	80.62	97.45	

[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	146.13	7.20	1.15	29.41	27.74	80.62	83.50	2.16

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)
TANO_CIV	2	0.11	251	136.20	1.82			0	1,521.22	0	0.00
TANO_GHA	15	0.89	1,499	100.41	2.39	0.32	99.68	0	1,850.20	0	0.00
Total in Basin	17	1.00	1,750	104.34	2.14	0.27	85.41	0	1,803.10	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**
TANO_CIV					5	4			2	4	3	5	1	3	2
TANO_GHA	1	1	2		5	1	2	3	2	5	3	1	1	3	2
River Basin	1	1	2	2	5	1	2	3	2	5	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
TANO_CIV									3
TANO_GHA	2	3	3	4			2	5	3
River Basin	2	3	3	4	3	4	2	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.

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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Utamboni Basin

Geography

Total drainage area (km²)	7,400
No. of countries in basin	2
BCUs in basin	Equatorial Guinea (GNQ), Gabon (GAB)
Population in basin (people)	67,062
Country at mouth	Equatorial Guinea, Gabon
Average rainfall (mm/year)	3,907

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)
UTBN_GAB		2,600.46				
UTBN_GNQ		2,893.82				
Total in Basin	20.54	2,776.47			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 (%)
UTBN_GAB	23.69	0.33	0.17	0.00	1	22.54	3,053.50	
UTBN_GNQ	122.12	0.00	0.04	0.28	94	27.59	2,059.21	

[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	145.81	0.33	0.21	0.28	94.86	50.12	2,174.26	0.71

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)
UTBN_GAB	4	0.48	8	2.18	1.88			0	11,571.08	0	0.00
UTBN_GNQ	4	0.52	59	15.45	2.84			0	20,572.34	0	0.00
Total in Basin	7	1.00	67	9.06	2.73	0.00	0.00	0	19,530.84	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
UTBN_GAB	1	1	1		5	2	3		2	5	3	5	1	3	2
UTBN_GNQ	1	1	1		5	2	3		2	5	3		1	4	2
River Basin	1	1	1	2	5	2	3		1	5	3		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-2050	Projected
UTBN_GAB	2	2	1	1			2	4	3
UTBN_GNQ	2	2	1	1			3	5	3
River Basin	2	2	1	1	2	2	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.

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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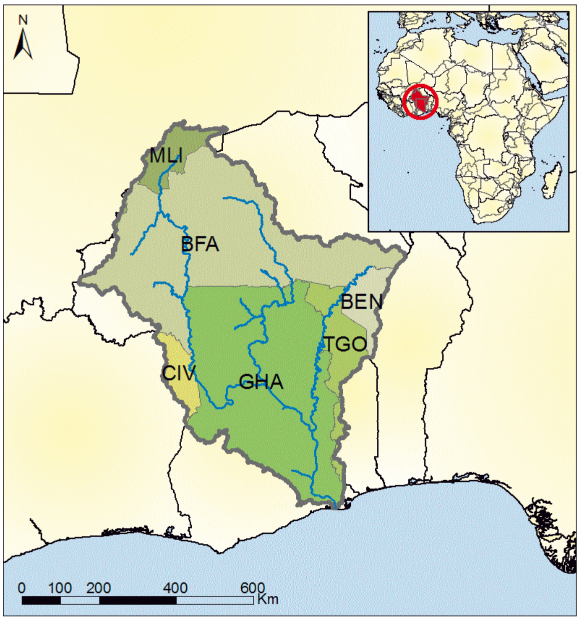
Volta Basin



Geography

Total drainage area (km²)	410,992
No. of countries in basin	6
BCUs in basin	Benin (BEN), Burkina Faso (BFA), Côte D'Ivoire (CIV), Ghana (GHA), Mali (MLI), Togo (TGO)
Population in basin (people)	24,282,921
Country at mouth	Ghana
Average rainfall (mm/year)	1,004

Governance

No. of treaties and agreements[1]	4
No. of RBOs and Commissions[2]	2

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	6
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)
VOLT_BEN		240.01				
VOLT_BFA		69.79			220.00	1.51
VOLT_CIV		124.14				
VOLT_GHA		261.67			7,668.60	142.01
VOLT_MLI		51.33				
VOLT_TGO		336.78				
Total in Basin	73.67	179.24			7,888.60	143.52

Water Withdrawals

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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 (%)
VOLT_BEN	12.24	2.44	1.89	0.00	0	7.92	19.74	
VOLT_BFA	510.28	136.81	43.26	36.26	72	222.28	41.79	
VOLT_CIV	17.75	7.30	2.10	0.00	1	7.71	54.50	
VOLT_GHA	469.85	116.13	20.03	12.29	64	257.41	54.91	
VOLT_MLI	23.26	0.00	2.90	0.05	10	10.14	40.27	
VOLT_TGO	59.35	6.44	4.45	0.00	4	44.80	29.80	
Total in Basin	1,092.73	269.12	74.62	48.60	150.13	550.26	45.00	1.48

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)
VOLT_BEN	15	0.04	620	41.01	2.96	0.00	100.00	0	804.67	0	0.00
VOLT_BFA	172	0.42	12,210	70.95	2.97	0.00	100.00	2	683.95	31	180.14
VOLT_CIV	13	0.03	326	25.12	1.82	3.04	96.96	0	1,521.22	0	0.00
VOLT_GHA	167	0.41	8,557	51.22	2.39	1.00	99.00	2	1,850.20	5	29.93
VOLT_MLI	17	0.04	578	34.34	3.08	0.00	100.00	0	715.13	0	0.00
VOLT_TGO	27	0.07	1,992	73.97	2.17	3.24	96.76	0	636.44	1	37.14
Total in Basin	411	1.00	24,283	59.08	2.55	0.66	99.34	4	1,106.10	37	90.03

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**
VOLT_BEN	1	1	2		5	3	4	2	1	2	2	3	1	4	2
VOLT_BFA	2	2	2		5	3	4	2	1	2	2	1	5	3	2
VOLT_CIV	1	1	2		5	1	4	2	1	2	2	5	1	4	2
VOLT_GHA	2	1	2		5	3	4	3	2	2	2	1	4	3	2
VOLT_MLI	2	4	1		5	2	4	2	1	2	2		1	4	3
VOLT_TGO	2	1	2		5	4	4	3	1	2	2	3	3	4	2
River Basin	2	1	2	2	5	3	4	3	2	2	2	2	4	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.

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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
VOLT_BEN	3	3	1	1			3	5	2
VOLT_BFA	5	5	3	4			4	5	2
VOLT_CIV	3	3	1	2			3	5	2
VOLT_GHA	3	3	1	2			3	5	2
VOLT_MLI	5	5	2	3			3	5	2
VOLT_TGO	2	3	1	1			2	4	2
River Basin	4	5	1	3	3	3	3	5	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	4	4	3	4

Indicators

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Zambezi Basin

Geography

Total drainage area (km²)	1,373,184
No. of countries in basin	9
BCUs in basin	Angola (AGO), Botswana (BWA), Congo, The Democratic Republic Of The (ZAR), Malawi (MWI), Mozambique (MOZ), Namibia (NAM), Tanzania, United Republic Of (TZA), Zambia (ZMB), Zimbabwe (ZWE)
Population in basin (people)	37,979,690
Country at mouth	Mozambique
Average rainfall (mm/year)	931

Governance

No. of treaties and agreements[1]	10
No. of RBOs and Commissions[2]	2

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	8
Large Marine Ecosystems	4

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)
ZAMB_AGO		122.22				
ZAMB_BWA		28.35				
ZAMB_MOZ		259.32			11,064.77	2,048.70
ZAMB_MWI		297.75			22,843.55	6,580.04
ZAMB_NAM		21.62				
ZAMB_TZA		329.96			23.86	6.97
ZAMB_ZAR						
ZAMB_ZMB		152.49			3,617.79	79.03

[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/

ZAMB_ZWE		103.55			2,877.73	86.49
Total in Basin	226.95	165.27			40,427.70	8,801.23

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 (%)
ZAMB_AGO	30.37	0.37	0.76	1.99	1	25.97	52.86	
ZAMB_BWA	3.38	0.00	0.32	0.00	0	2.90	184.48	
ZAMB_MOZ	144.61	70.33	4.81	1.17	2	66.74	46.88	
ZAMB_MWI	627.00	193.42	10.26	112.87	47	263.89	50.65	
ZAMB_NAM	9.73	4.38	0.89	0.00	0	4.46	124.86	
ZAMB_TZA	380.92	25.93	2.92	320.09	1	31.46	280.58	
ZAMB_ZAR								
ZAMB_ZMB	1,296.07	892.04	26.23	28.55	158	191.06	125.31	
ZAMB_ZWE	959.23	519.26	36.21	280.92	2	121.13	94.64	
Total in Basin	3,451.30	1,705.74	82.39	745.59	209.98	707.61	90.87	1.52

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)
ZAMB_AGO	256	0.19	574	2.25	2.92	100.00	0.00	0	5,668.12	0	0.00
ZAMB_BWA	17	0.01	18	1.07	1.35	100.00	0.00	0	7,316.88	0	0.00
ZAMB_MOZ	157	0.11	3,085	19.67	2.38	0.00	100.00	2	592.98	1	6.38
ZAMB_MWI	110	0.08	12,379	112.38	3.00	0.30	99.70	2	226.46	0	0.00
ZAMB_NAM	17	0.01	78	4.56	1.87	0.00	100.00	0	5,461.53	0	0.00
ZAMB_TZA	28	0.02	1,358	49.07		0.00	100.00	0	694.77	0	0.00
ZAMB_ZAR	0	0.00	9	23.20	2.78			0	453.67	0	0.00
ZAMB_ZMB	576	0.42	10,343	17.97	2.65	0.41	99.59	7	1,539.60	5	8.68
ZAMB_ZWE	213	0.15	10,136	47.70	0.00	0.09	99.91	4	904.76	53	249.40
Total in Basin	1,373	1.00	37,980	27.66	2.98	1.80	98.18	15	908.12	59	42.97

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

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

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**
ZAMB_AGO	1	1	1		5	3	3	3	2	2	1	5	1	5	3
ZAMB_BWA	1	1	1		5	3	3	3	2	2	3	3	1	4	5
ZAMB_MOZ	2	1	2		5	2	4	3	4	2	3	3	1	5	4
ZAMB_MWI	2	1	2		5	3	4	3	4	2	3	3	5	3	2
ZAMB_NAM	1	1	2		5	4	3	3	2	1	3	3	1	4	5
ZAMB_TZA	1	1	2		5	1	3	3	4	2	3	2	1	3	2
ZAMB_ZAR					5	3			2	3	2	5	1	4	1
ZAMB_ZMB	2	1	2		5	3	3	3	2	2	3	3	5	4	2
ZAMB_ZWE	2	1	2		5	1	4	3	2	2	3	2	5	3	4
River Basin	2	1	2	3	5	3	3	3	4	2	3	3	5	5	2

Indicators

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Thematic group	Lake Influence Indicator	Delta Vulnerability Index

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Large Marine Ecosystems

1. LME 27 – Canary Current
2. LME 28 – Guinea Current
3. LME 29 – Benguela Current

United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

Center for Marine Assessment and Planning, UCSB

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.

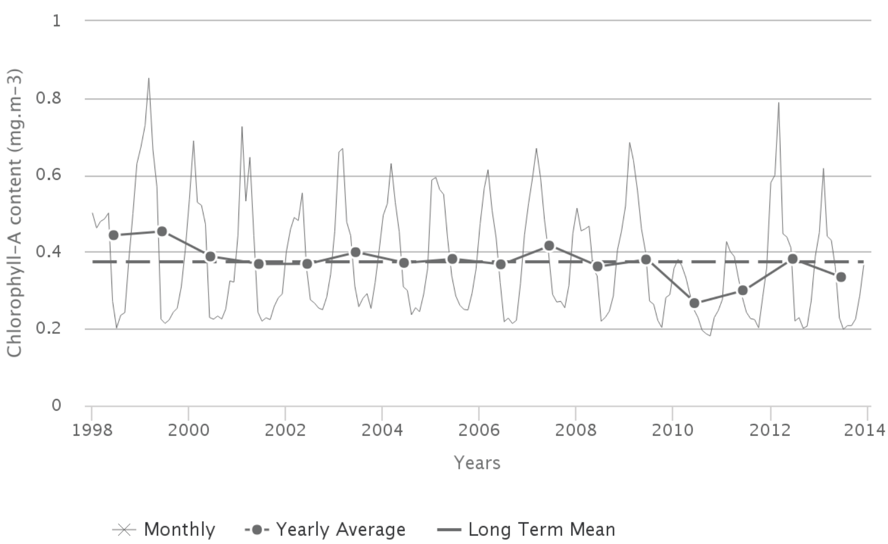
Very low | Low | Medium | High | Very high

Productivity

Chlorophyll-A

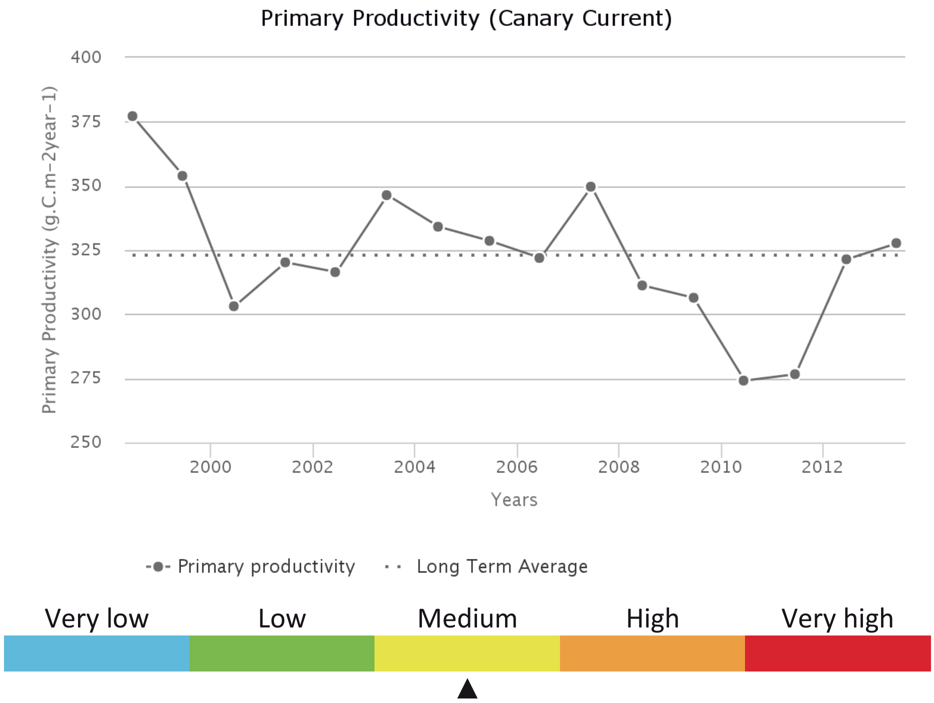
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.570 mg.m^{-3}) in February and a minimum (0.241 mg.m^{-3}) during September. The average CHL is 0.374 mg.m^{-3}. Maximum primary productivity (377 g.C.m^{-2}.y^{-1}) occurred during 1998 and minimum primary productivity (274 g.C.m^{-2}.y^{-1}) 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)



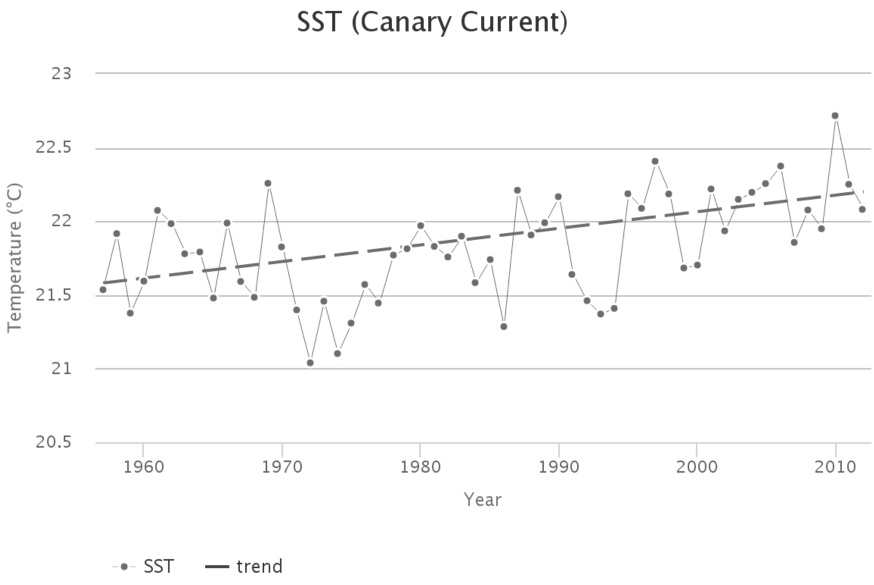
Very low | Low | Medium | High | Very high

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.

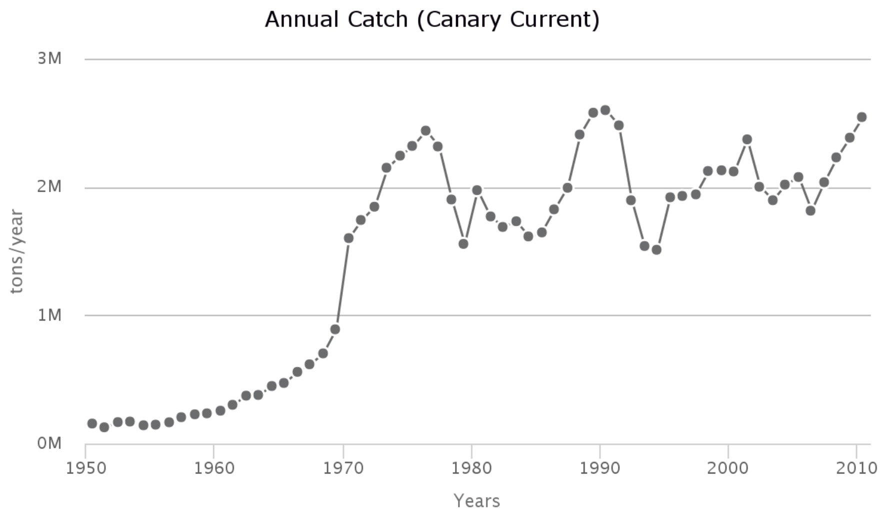


Fish and Fisheries

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.

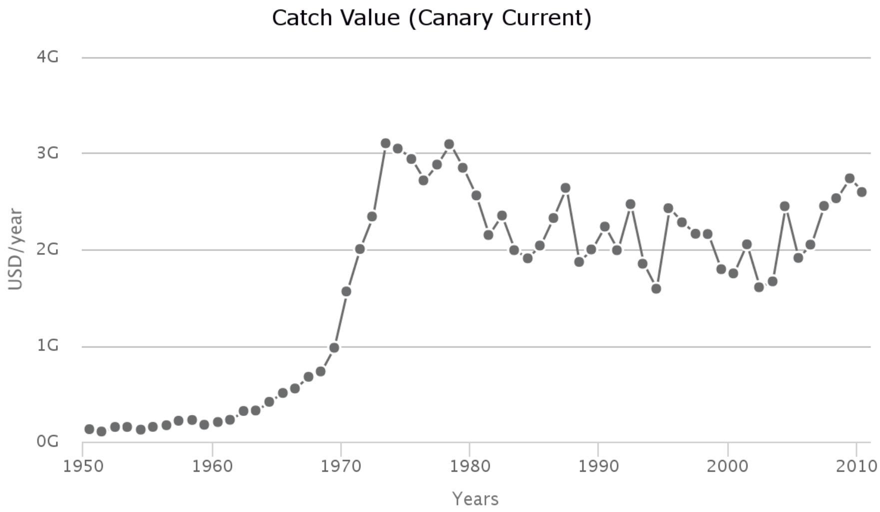
Annual Catch

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.



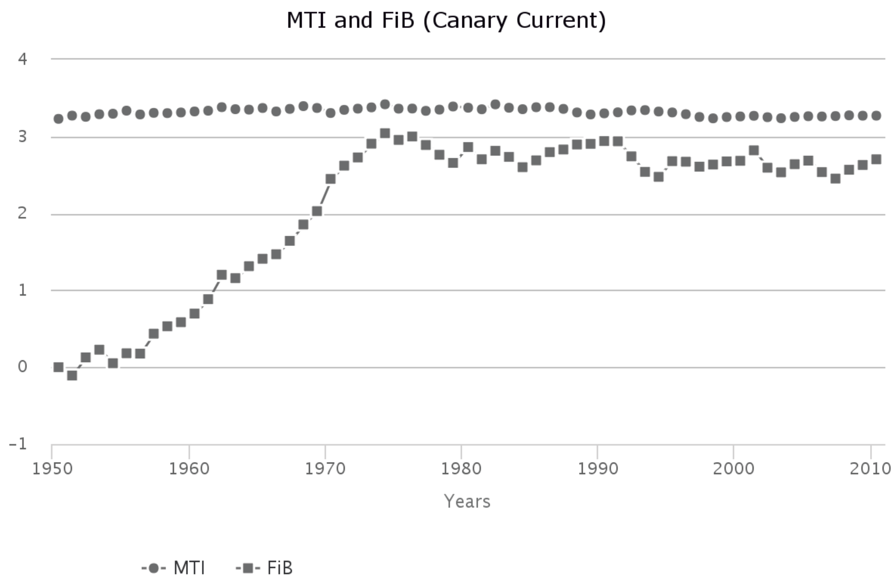
Catch value

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$).



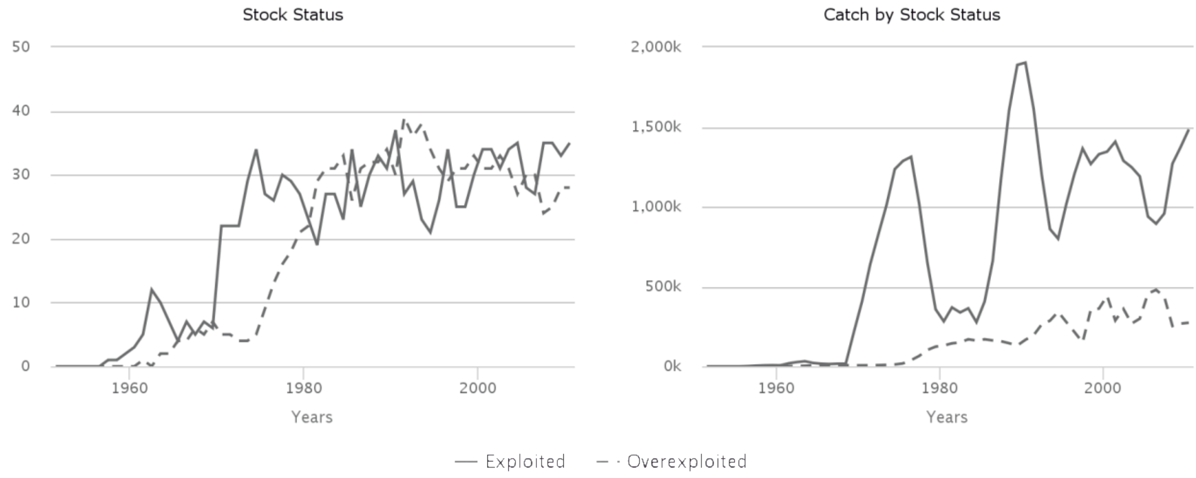
Marine Trophic Index and Fishing-in-Balance index

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.



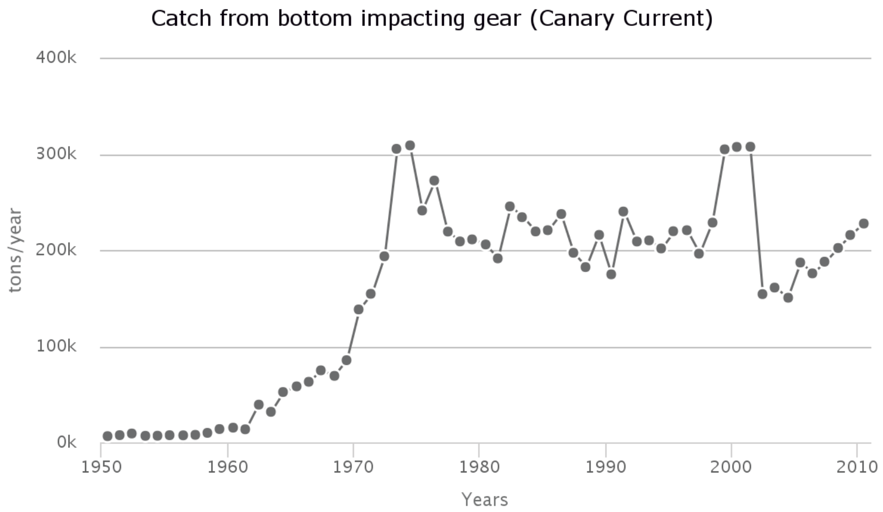
Stock status

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".



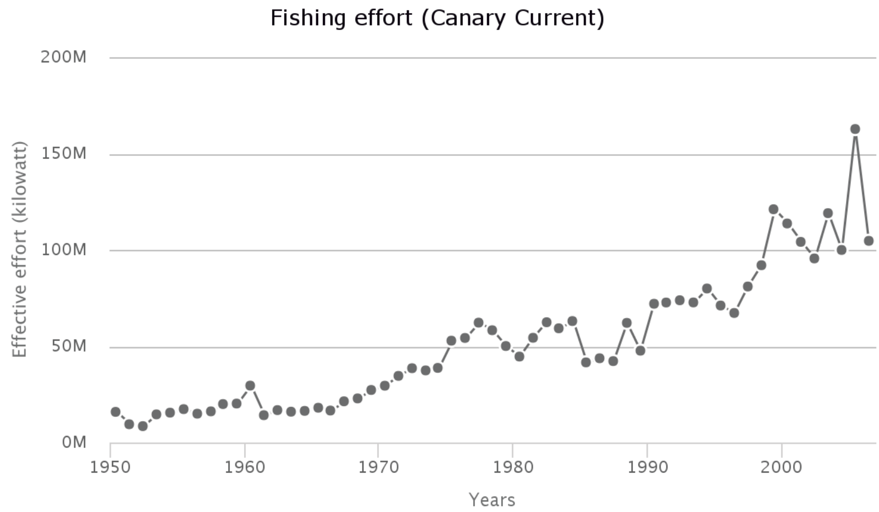
Catch from bottom impacting gear

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.



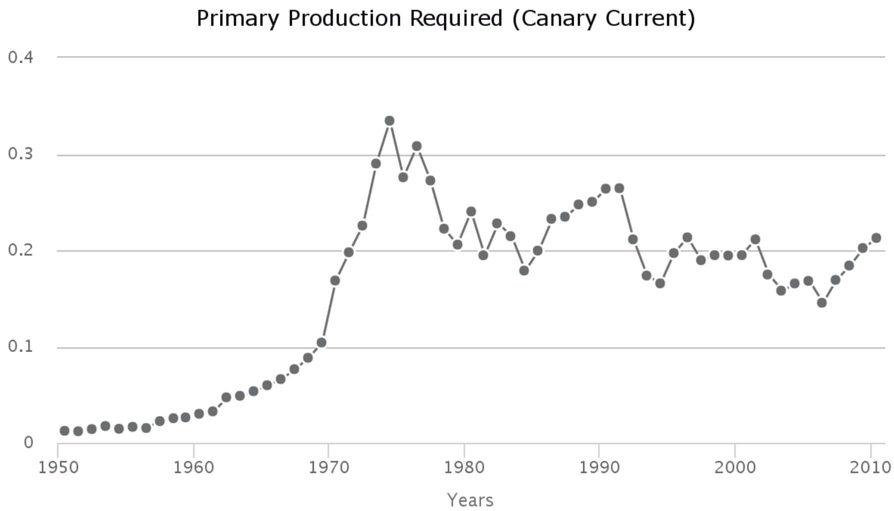
Fishing effort

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

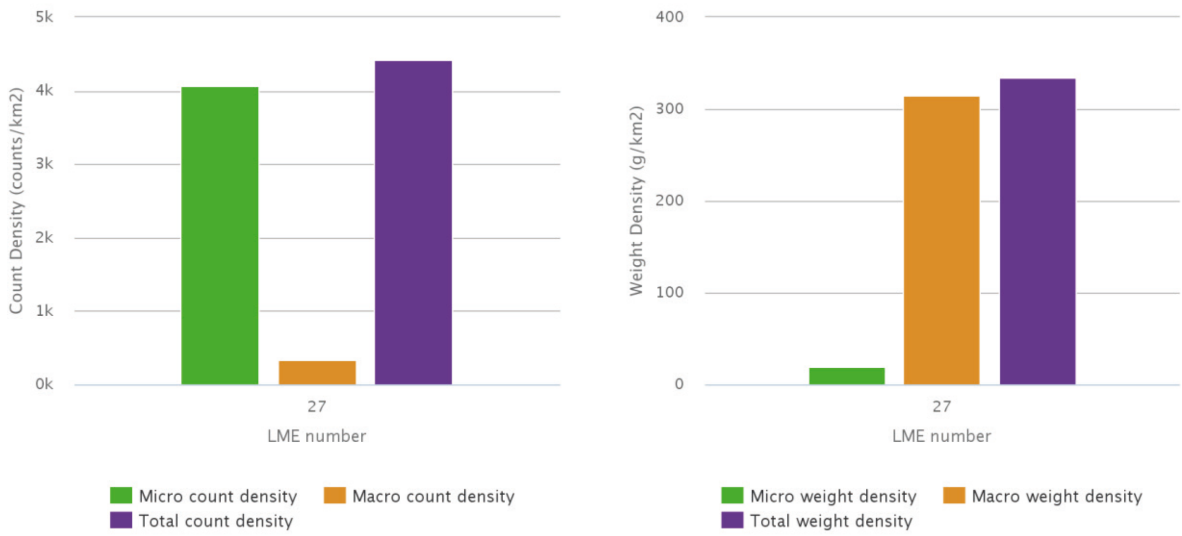
Data are available only for one sample at one location in the Canary Islands. This location shows minimal concentrations (ng.g-1 of pellets) for all the indicators (10 for PCBs, 4 for DDTs, and not detected for HCHs). This is probably due to remoteness from anthropogenic activities involving the use 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

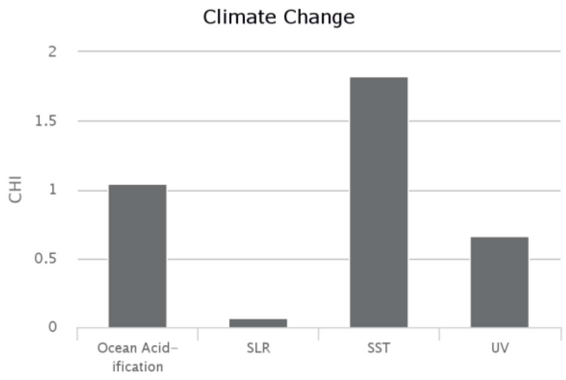
Not applicable.

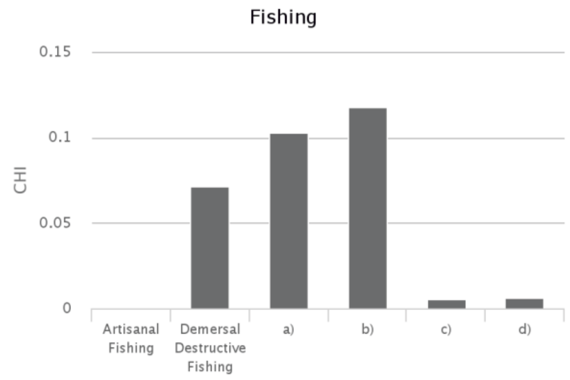
Marine Protected Area change

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.

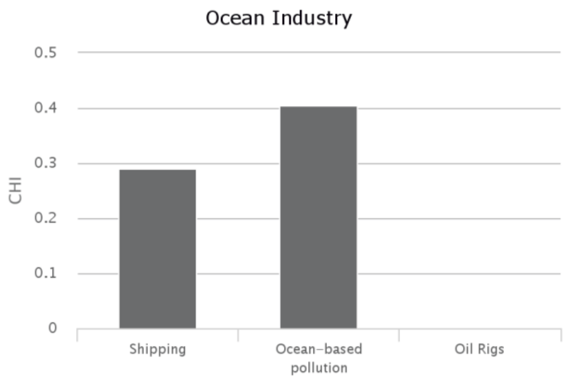
Cumulative Human Impact

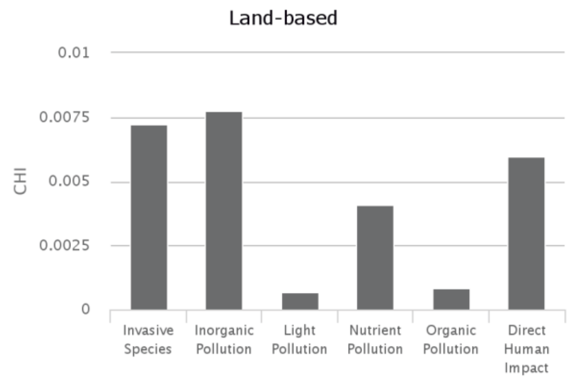
The Canary Current LME experiences well above average overall cumulative human impact (score 4.63; maximum LME score 5.22). It falls in risk category 5 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, three 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).





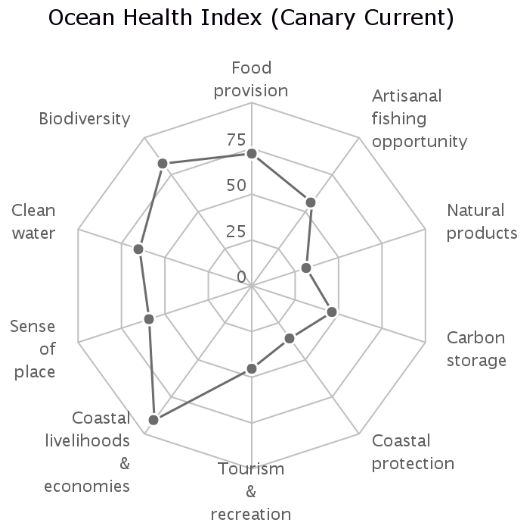
a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing





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).



OHI: 63.4

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 28 – Guinea Current

Bordering countries: Guinea-Bissau, Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Benin, Nigeria, Cameroon, Equatorial Guinea, Gabon, Congo, Angola, The Democratic Republic of Congo, Sao Tome and Principe.
LME Total area: 1,958,802 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.

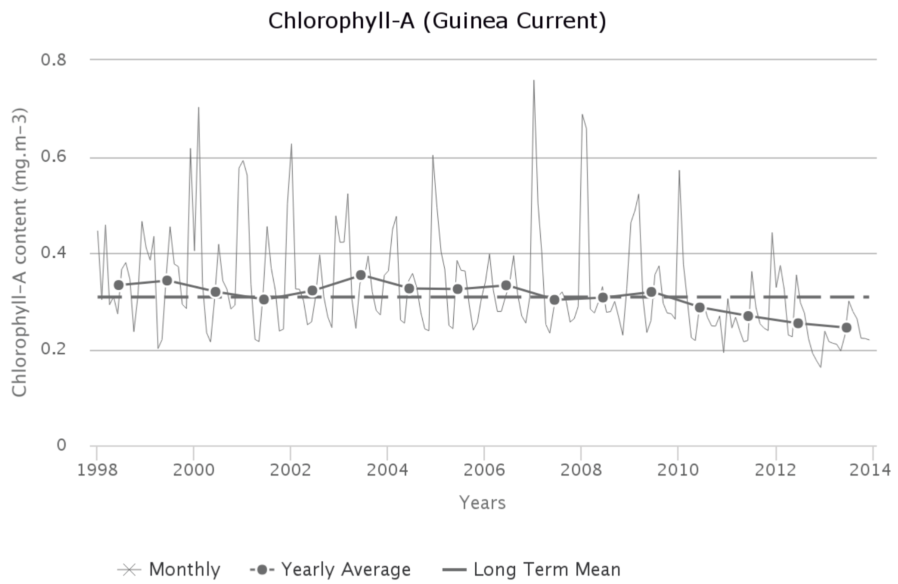
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is very high.

Very low | Low | Medium | High | Very high

Productivity

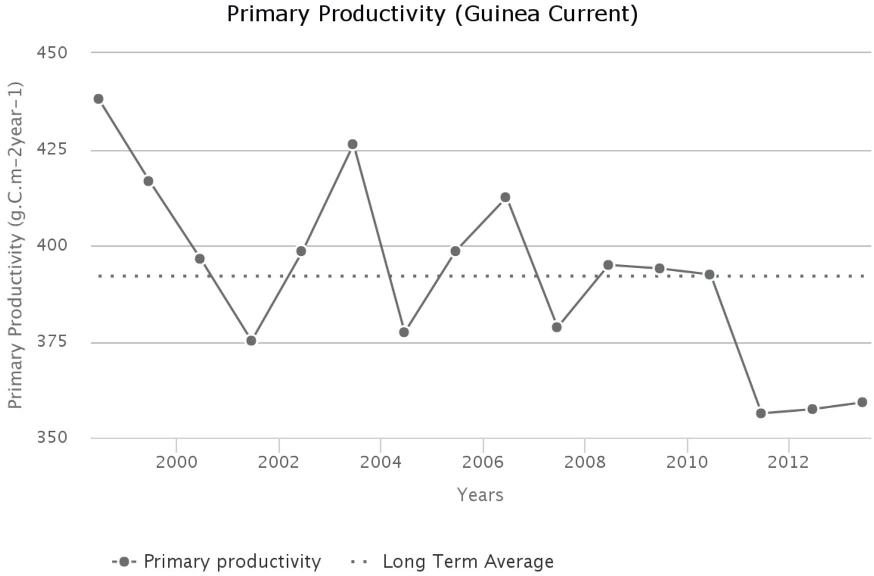
Chlorophyll-A

The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.415 mg.m-3) in August and a minimum (0.243 mg.m-3) during May. The average CHL is 0.308 mg.m-3. Maximum primary productivity (438 g.C.m-2.y-1) occurred during 1998 and minimum primary productivity (356 g.C.m-2.y-1) during 2011. There is a statistically insignificant increasing trend in Chlorophyll of 1.99 % from 2003 through 2013. The average primary productivity is 392 g.C.m-2.y-1, which places this LME in Group 4 of 5 categories (with 1 = lowest and 5= highest).



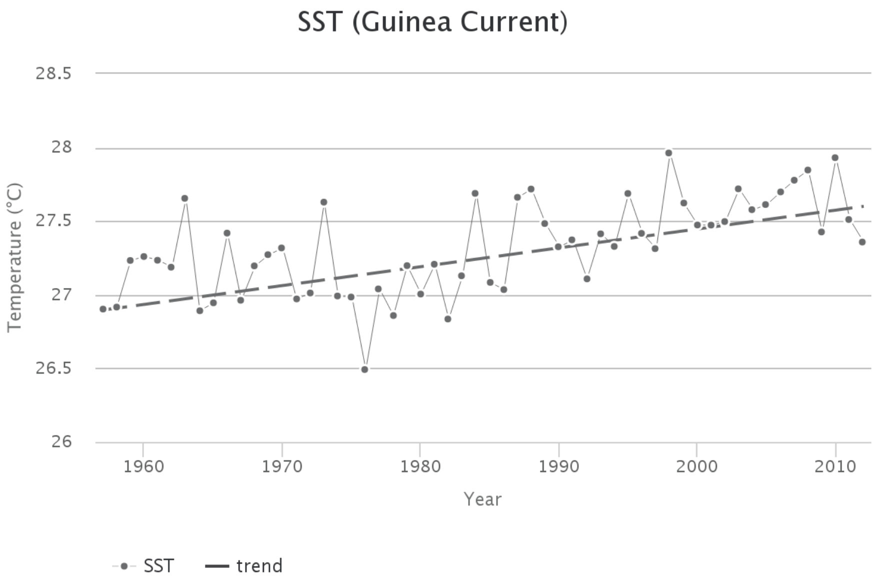
Very low | Low | Medium | High | Very high

Primary productivity



Sea Surface Temperature

From 1957 to 2012, the Guinea Current LME #28 has warmed by 0.66°C, thus belonging to Category 3 (moderate warming LME). The thermal history of the Guinea Current LME included (1) a relatively stable period until a sharp drop that culminated in the all-time minimum of 26.5°C in 1976; (2) long-term warming until present, at a rate of ~1°C in 30 years. During the latest warming epoch, SST approached 28.0°C in 1998 (El Niño year). Interannual variability of SST in this LME is rather small, with year-to-year variations of about 0.5°C. The SST variability mirrors the local upwelling's intensity, with strong upwelling in 1982-83, and weak upwelling in 1984 and 1987-1990 (Hardman and McGlade, 2002).

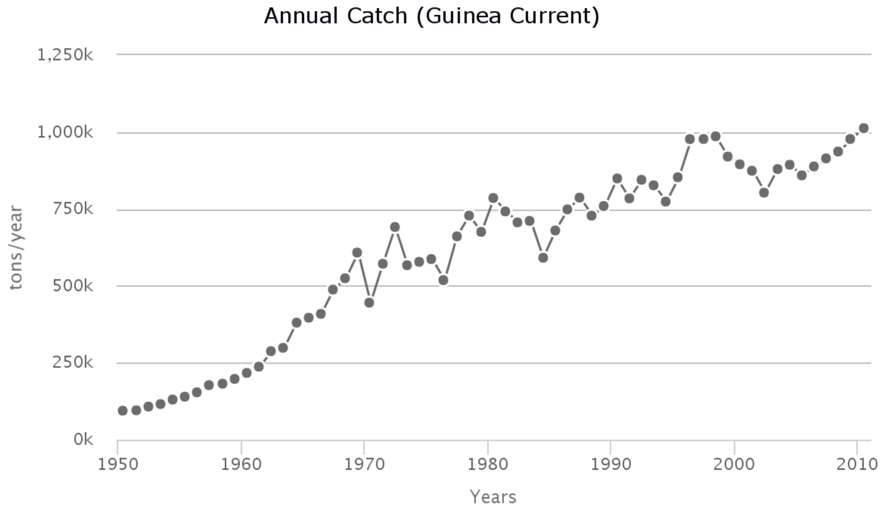


Fish and Fisheries

The Guinea Current LME is rich in living marine resources. These include both locally important resident stocks supporting artisanal fisheries, as well as transboundary straddling and migratory stocks that have attracted large commercial offshore foreign fishing fleets. Exploited species include small pelagic fishes (e.g., *Sardinella aurita*, *Engraulis encrasicolus*, *Caranx spp.*), large migratory pelagic fishes such as tuna (*Katsuwonus pelamis*, *Thunnus albacares* and *T. obesus*) and billfishes (e.g., *Istiophorus albicans*, *Xiphias gladius*), crustaceans (e.g., *Penaeus notialis*, *Panulirus regius*), molluscs and demersal fish.

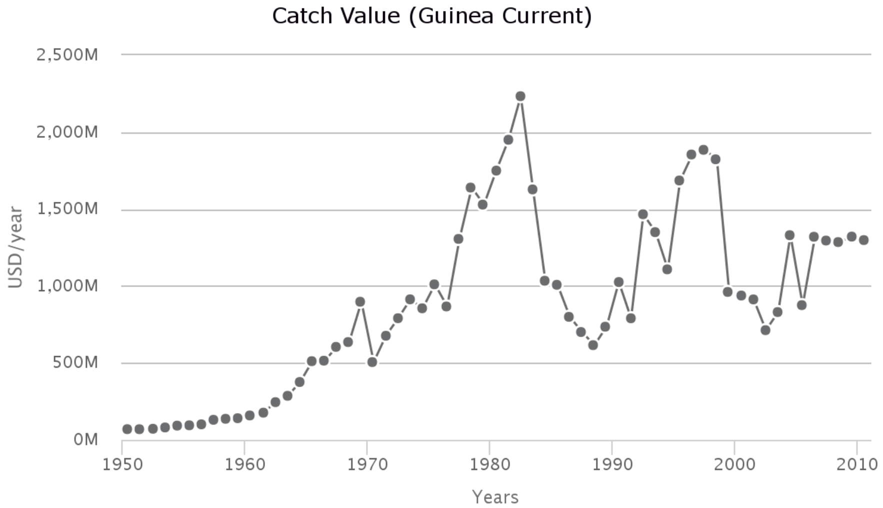
Annual Catch

Total reported landings show a series of peaks and troughs, although there has been an overall trend of a steady increase from 1950 to the early 1990, followed by fluctuations with a peak at just over 900,000 t. Due to the poor species break-down in the official landings statistics, a large proportion of the landings falls in the category named "mixed groups".



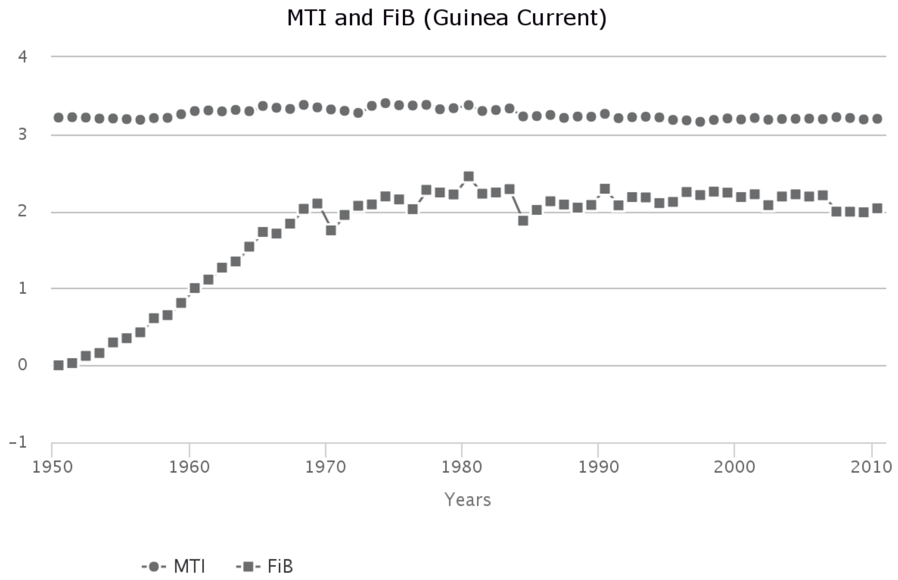
Catch value

The value of the reported landings increased to a peak of around 2 billion US$ (in 2005 real US$) in 1982, and thereafter declined considerably until the 1990s.



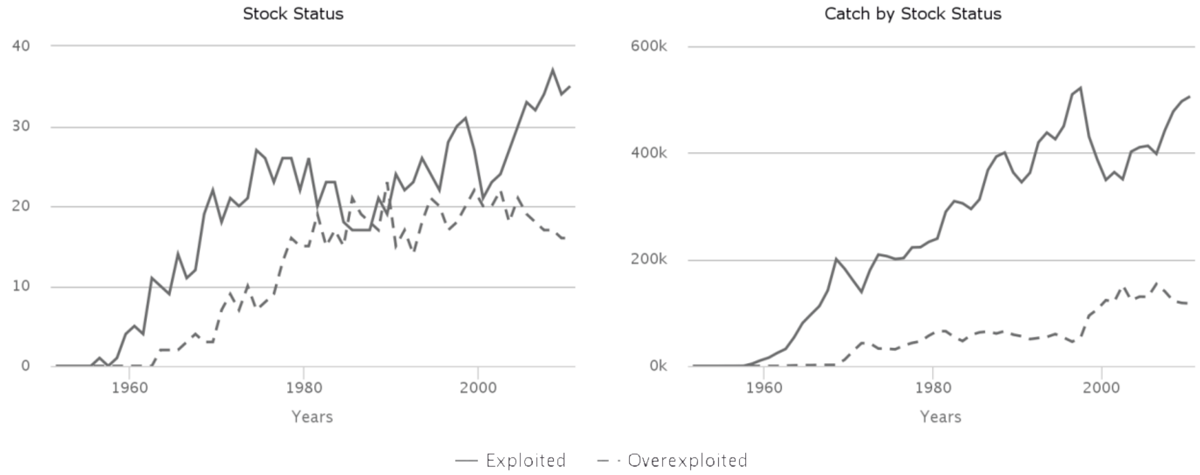
Marine Trophic Index and Fishing-in-Balance index

Since the mid-1970, the MTI has declined, which is an indication of a 'fishing down' of the local food webs The FiB index, on the other hand, has remained stable suggesting that the increase in the reported landings over this period has compensated for the decline in the MTI.



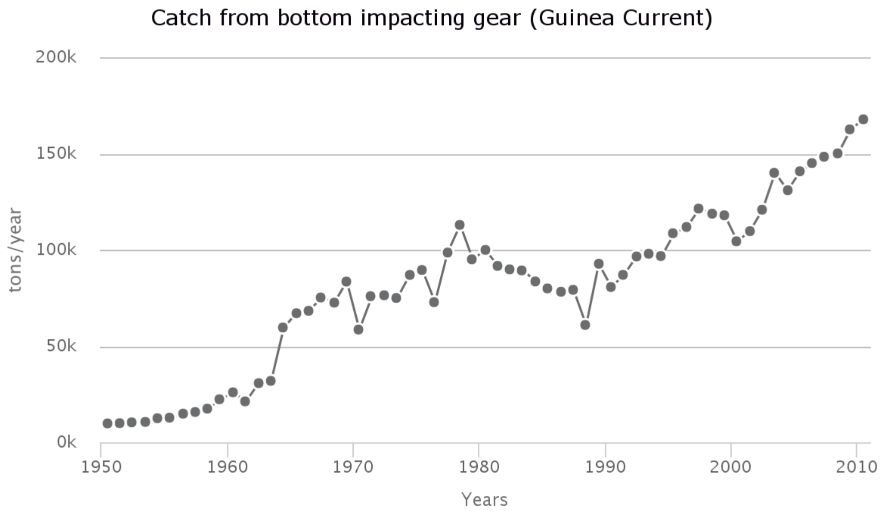
Stock status

The Stock-Catch Status Plots show that fisheries on collapsed stocks are rapidly increasing in numbers. However, the catch is still overwhelmingly supplied by stocks in the fully exploited category, which account for just 30% of the stocks.



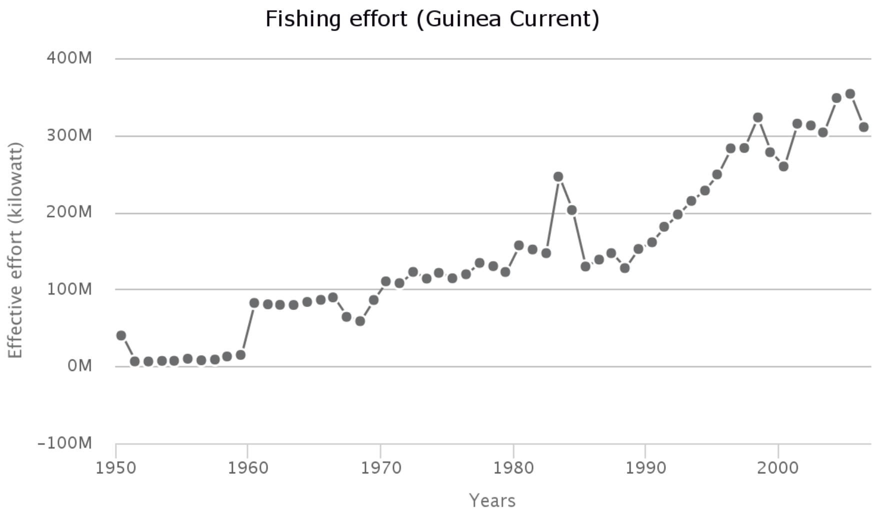
Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch fluctuated between 8 and 17% from 1950 to 2010. This percentage fluctuated around 15% in the recent decade.



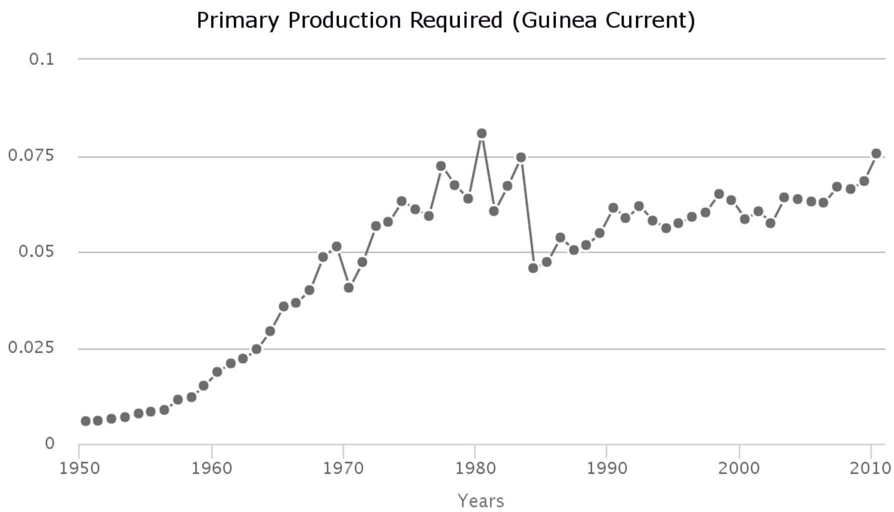
Fishing effort

The total effective effort continuously increased from around 10 million kW in the mid-1950s to its peak at 350 million kW in the mid-2000s.



Primary Production Required

The primary production required (PPR) to sustain the reported landings in the LME reached 9% of the observed primary production in the early 1990s and has since fluctuated between 6 to 9%.



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 high (level 4 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 increased to very high in 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was low (2). According to the Global Orchestration scenario, this increased to high in 2030 and remained high in 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 increased to very 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
4	2	4	4	4	4	5	4	5

Legend: Very low; Low; Medium; High; Very high

POPs

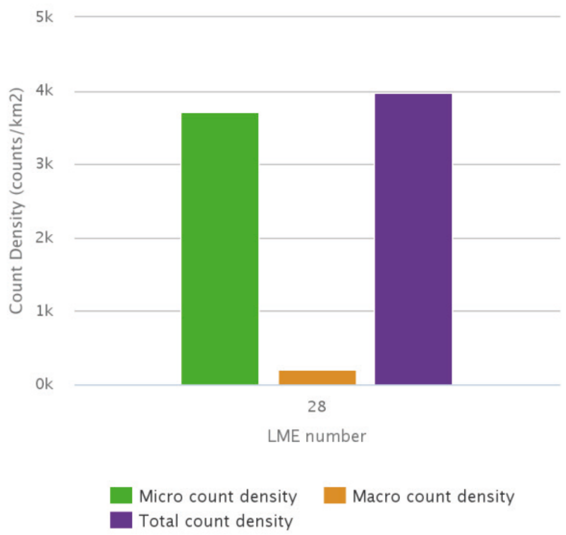
Twelve samples from 12 locations were available. The Guinea Current LME exhibits low average concentrations ($ng.g^{-1}$ of pellets) for all the indicators: 32 (range 1-69 $ng.g^{-1}$) for PCBs, 28 (range 2-172 $ng.g^{-1}$) for DDTs, and 4 (range 0.1-36.1) for HCHs. PCBs and HCHs averages correspond to risk category 2, whereas DDTs average corresponds to risk category 3 of the five risk categories (1 = lowest risk; 5 = highest risk). In certain locations, PCB concentrations were significantly higher than the global background levels (10 $ng.g^{-1}$ of pellets), especially in Accra, the capital of Ghana (PCBs concentrations about 50 $ng.g^{-1}$), where an electronic wastes (e-waste) scrap yard is in operation, indicating local inputs of PCBs. Introduction of e-waste to this LME from external sources and improper management within the bordering countries could lead to the emission of PCBs to the environment. Further monitoring, better management, and regulation of e-waste is recommended. Relatively higher concentrations of DDTs (28 $ng.g^{-1}$ of pellets), including in rural areas, are probably due to use of DDT for Malaria control in this tropical region. A high concentration of HCHs (36.1 $ng.g^{-1}$ of pellets) was observed at only one location in Ghana. This might be due to illegal usage and/or dumping of Lindane pesticide. However, it is based on only one location in this large system and further monitoring is recommended.

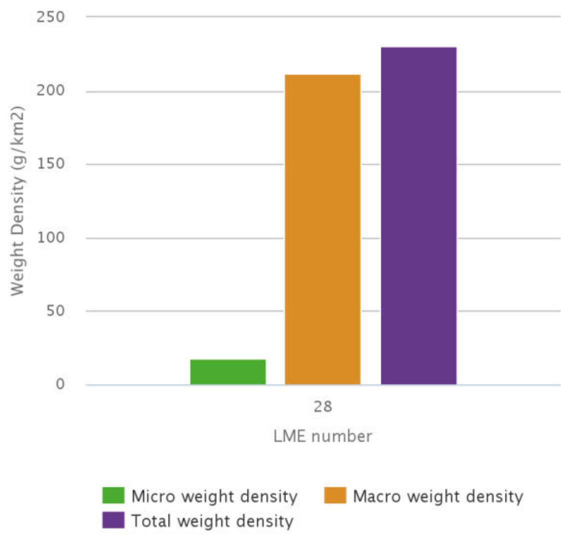
Locations	PCBs		DDTs		HCHs	
	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk
12	32	**2**	28	**3**	3.7	**2**

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

0.82% of this LME is covered by mangroves (US Geological Survey, 2011).

Reefs at risk

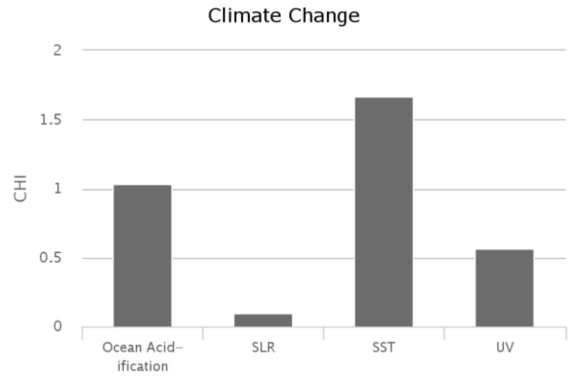
Not applicable

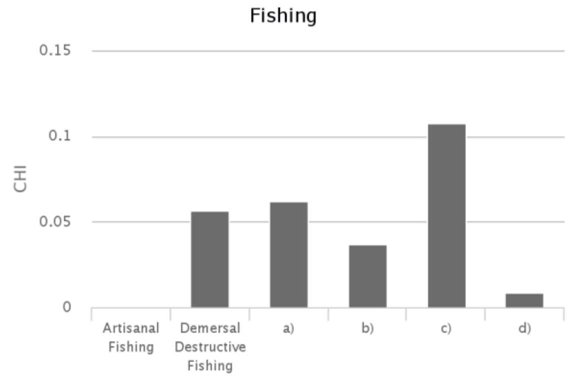
Marine Protected Area change

The Guinea Current LME experienced an increase in MPA coverage from 829 km^2 prior to 1983 to 16,216 km^2 by 2014. This represents an increase of 1,857%, within the low category of MPA change.

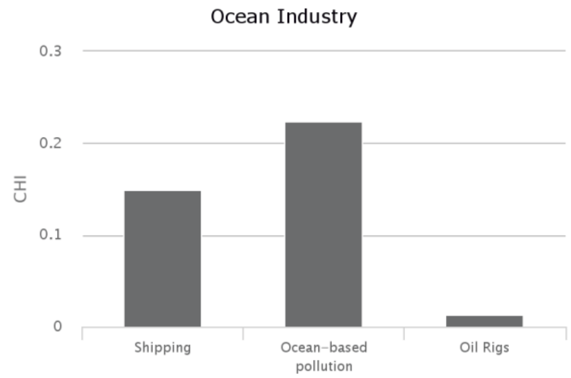
Cumulative Human Impact

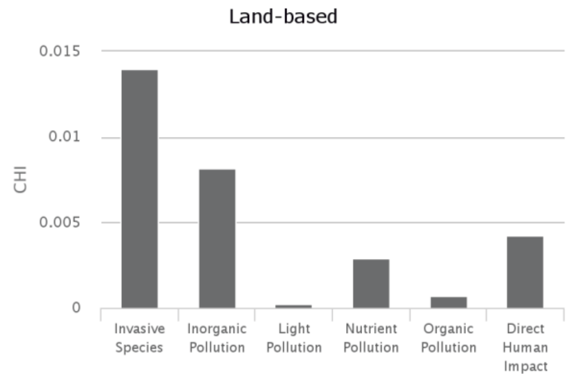
The Guinea Current LME experiences above average overall cumulative human impact (score 4.06; maximum LME score 5.22), which is also well above the LME with the least cumulative impact. It falls in risk category 4 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, three connected to climate change have the highest average impact on the LME: ocean acidification (1.04; maximum in other LMEs was 1.20), UV radiation (0.57; maximum in other LMEs was 0.76), and sea surface temperature (1.67; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, sea level rise, ocean based pollution, pelagic high-bycatch commercial fishing, and demersal non-destructive high-bycatch commercial fishing.





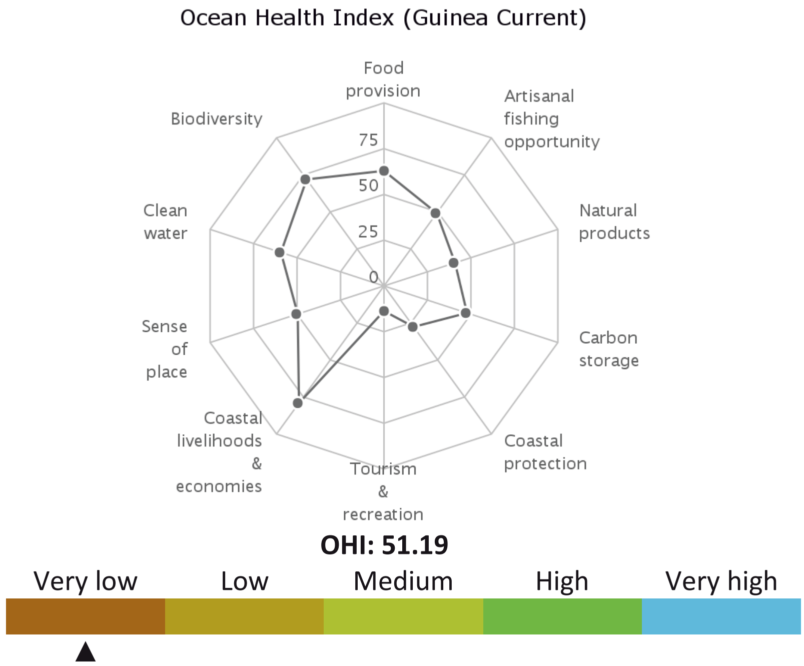
a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing





Ocean Health Index

The Guinea Current LME has one of the lowest scores on the Ocean Health Index compared to other LMEs (score 58 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 increased 1 point compared to the previous year, due in large part to changes in the scores for natural products and coastal economies. This LME scores lowest on mariculture, coastal protection, carbon storage, tourism & recreation, and sense of place goals and highest on the artisanal fishing opportunities goal. 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 481 863 km^2. A current population of 81 104 thousand in 2010 is projected to increase to 251 497 thousand in 2100, with a density of 168 persons per km^2 in 2010 increasing to 522 per km^2 by 2100. About 47% of coastal population lives in rural areas, and is projected to increase in share to 52% in 2100.

Total population		Rural population	
2010	2100	2010	2100
81,103,844	251,496,615	38,165,997	131,941,527

Legend: Very low, Low, Medium, High, Very high

Coastal poor

The indigent population makes up 46% of the LME's coastal dwellers. This LME places in the very high-risk category based on percentage and in the very high-risk category using absolute number of coastal poor (present day estimate).

Coastal poor
37,490,193

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. This LME ranks in the high-revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $1 330 million for the period 2001-2010. Fish protein accounts for 42% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013

$4 798 million places it in the low-revenue category. On average, LME-based tourism income contributes 5% 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 very high risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
1,330,357,127	41.8	4,797,874,361	4.9	0.8599

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 0.495, this LME has an HDI Gap of 0.505, 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
0.4954	0.8374	0.3497

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 very high. In a sustainable development scenario, the risk index from sea level rise in 2100 is low, and increases to very high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	Contemporary Threat	SSP1	SSP3
0.7476	0.4996	0.4833	0.7662

Legend: Very low, Low, Medium, High, Very high

Governance

Governance architecture

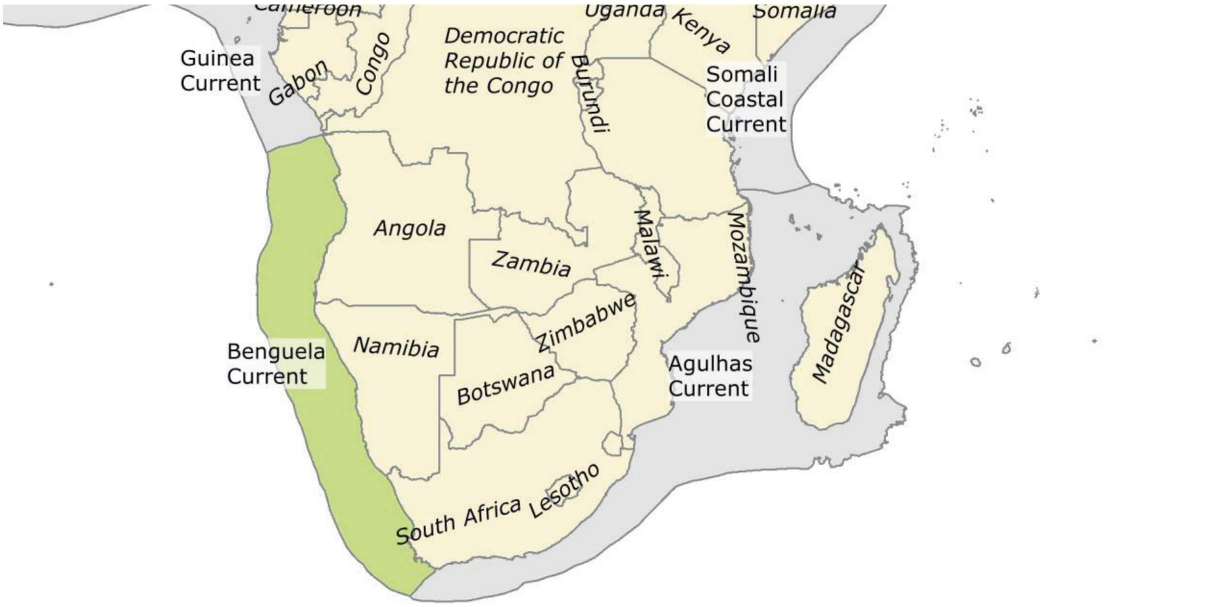
The two transboundary arrangements (COMHAFAT and CECAF) in this LME for fisheries in the areas within national jurisdiction are closely connected. So are the arrangements for pollution and biodiversity that fall under the Abidjan Convention. However neither of these pairs appears to be integrated with each other or with the tuna arrangement ICCAT. No agreed integrating mechanisms, such as an overall policy coordinating organisation for the LME, could be identified. There may be interaction amongst the arrangements through participation in each other's meetings, but this appears to be informal. It appears that the Interim Guinea Current Commission (IGCC) was been established with a view overall integration and coordination of marine ecosystem governance issues. However, the current status and level of acceptance among the countries and other organizations in the region, of the IGCC's role in overarching coordination is unclear.

The overall scores for ranking of risk were:

Engagement	Completeness	Integration
56	54	0.2

Legend: Very low, Low, Medium, High, Very high

LME 29 – Benguela Current



Bordering countries: Angola, Namibia, South Africa
LME Total area: 1,470,134 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.

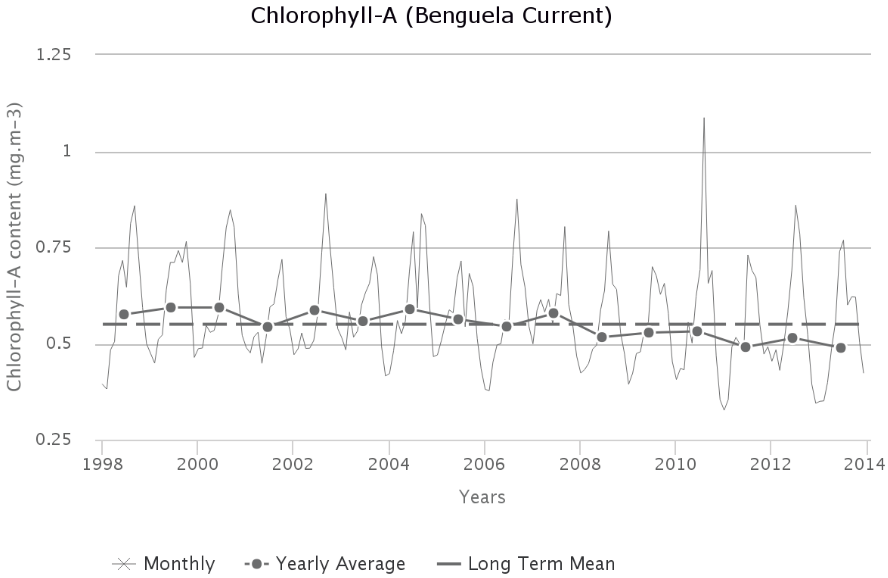
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is very high.

Very low | Low | Medium | High | Very high

Productivity

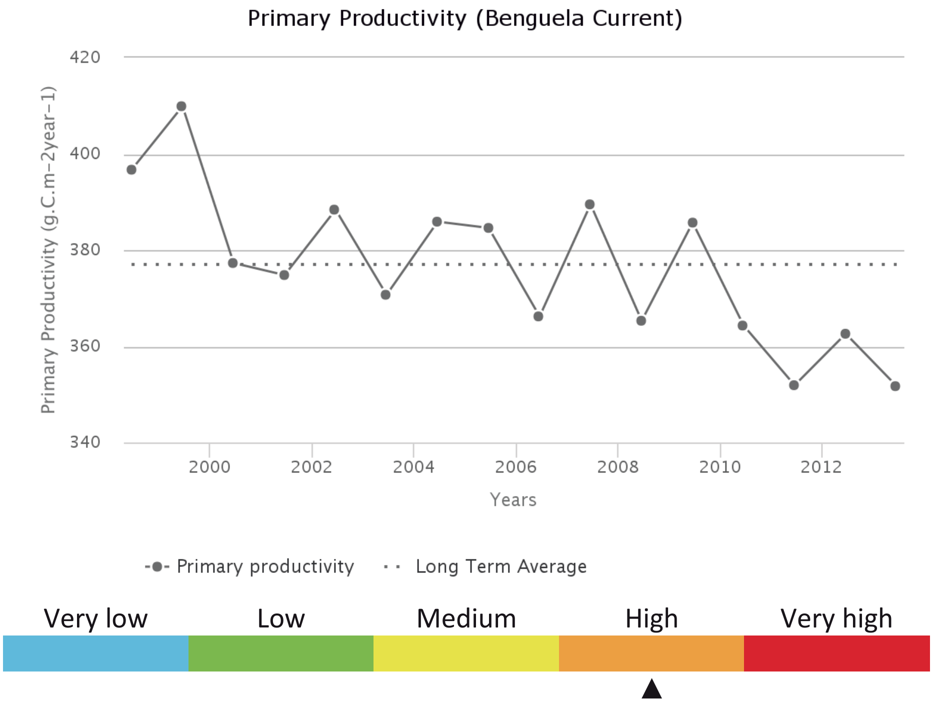
Chlorophyll-A 2

The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.835 mg.m^{-3}) in September and a minimum (0.434 mg.m^{-3}) during January. The average CHL is 0.550 mg.m^{-3}. Maximum primary productivity (410 g.C.m^{-2}.y^{-1}) occurred during 1999 and minimum primary productivity (352 g.C.m^{-2}.y^{-1}) during 2013. There is a statistically insignificant decreasing trend in Chlorophyll of -6.25 % from 2003 through 2013. The average primary productivity is 377 g.C.m^{-2}.y^{-1}, which places this LME in Group 4 of 5 categories (with 1 = lowest and 5= highest).



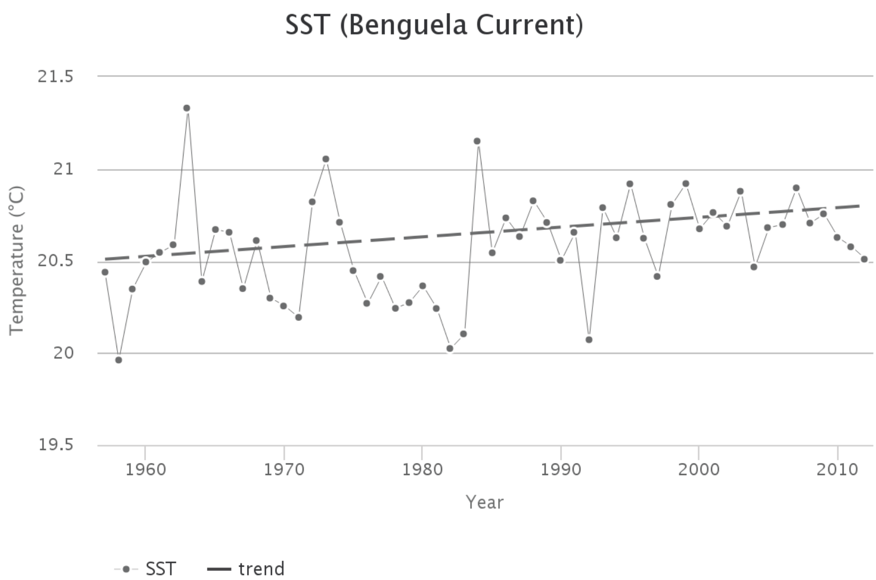
Very low | Low | Medium | High | Very high

Primary productivity



Sea Surface Temperature

From 1957 to 2012, the Benguela Current LME #29 has warmed by 0.27°C, thus belonging to Category 4 (slow warming LME). The Benguela Current's thermal history was punctuated by events associated with Benguela El Niños and La Niñas. Fidel and O'Toole (2007) distinguished five major Benguela El Niños over the last 50 years. The most pronounced warming of >1.2°C occurred after the all-time minimum of 1958 and took 5 years to peak in 1963. Other warm events peaked in 1973 and 1984, alternated with cold events of 1982 and 1992. Clearly, decadal variability in the Benguela Current was strong through the last warm event of 1984. After that, the Benguela Current experienced a shift to a new, warm regime, in which decadal variability is subdued. The thermal history of this LME bears almost no resemblance to either that of the Guinea Current LME #28 (its northern neighbor) or that of the Agulhas Current LME #30 (its southern neighbor).

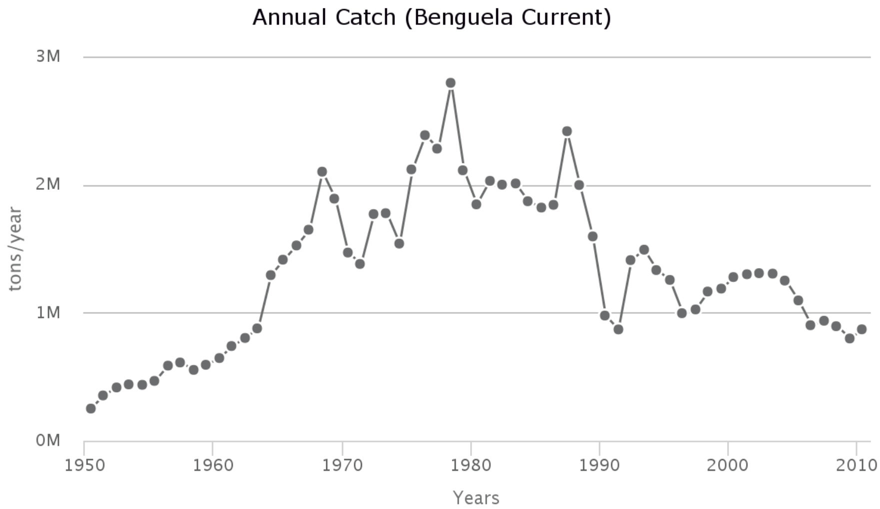


Fish and Fisheries

The Benguela Current LME is very rich in pelagic and demersal fish. Most of the LME's major fisheries resources are shared between the bordering countries or migrate across national jurisdictional zones, and include sardine (*Sardinops sagax*), anchovy (*Engraulis capensis*), hake (*Merluccius capensis* and *M. paradoxus*), horse mackerel (*Trachurus* and *T. trecae*), sardinella (*Sardinella spp.*), and rock lobster (*Jasus lalandii*). Artisanal, commercial (industrial) and recreational fisheries are all of significance in the LME, with artisanal fisheries being particularly important for Angola.

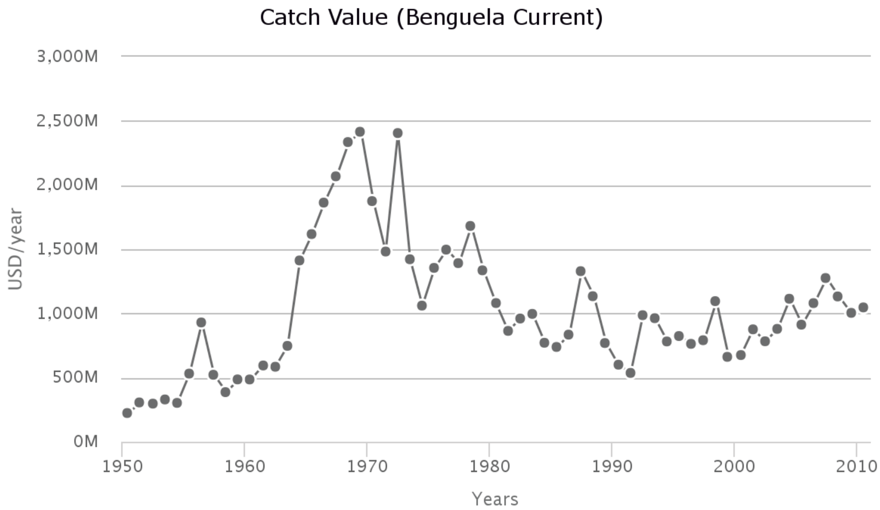
Annual Catch

Total reported landings of the LME increased steadily from 1950 to a peak of about 2.8 million t in 1978. In the subsequent years, however, the landings show a general decline, down to about 1.1 million t in the 2000s.



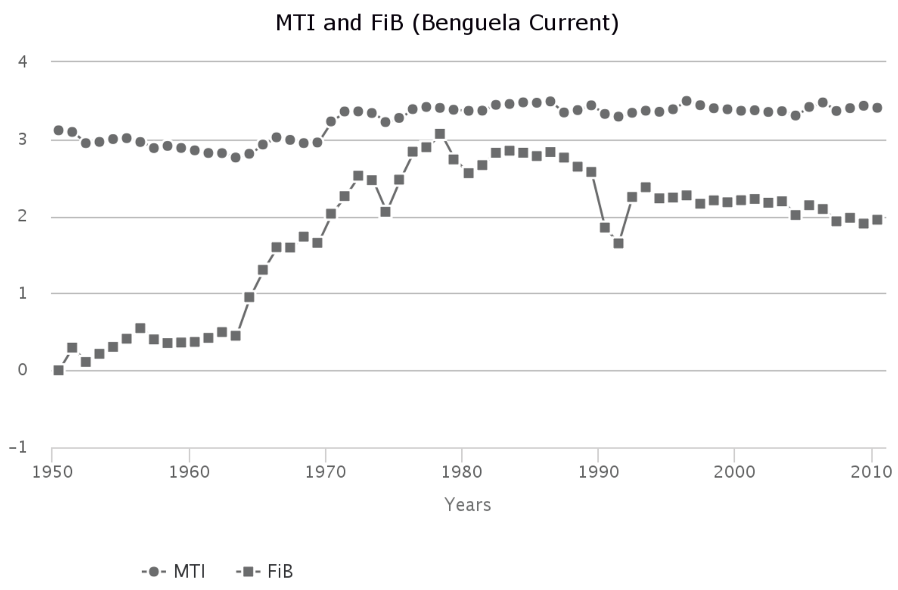
Catch value

The trend in the value of the reported landings closely resembles that of the reported landings, peaking at just under 2.4 billion US$ (in 2005 real US$) in 1969.



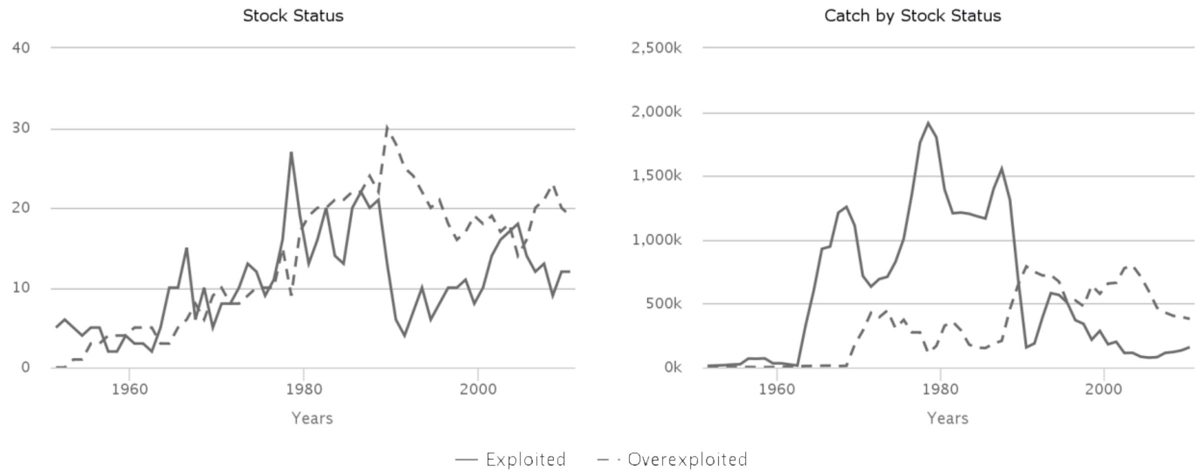
Marine Trophic Index and Fishing-in-Balance index

Since the mid-1970s, the mean MTI has been relatively stable in this LME, but as the amount of catch (tonnage) has declined over the same period, the FiB index shows a rapid decline. This decline of the FiB index is particularly strong off Namibia, which is a case of 'fishing down marine food webs' but one in which the species that replaced the exploited species are presently not targeted by fisheries.



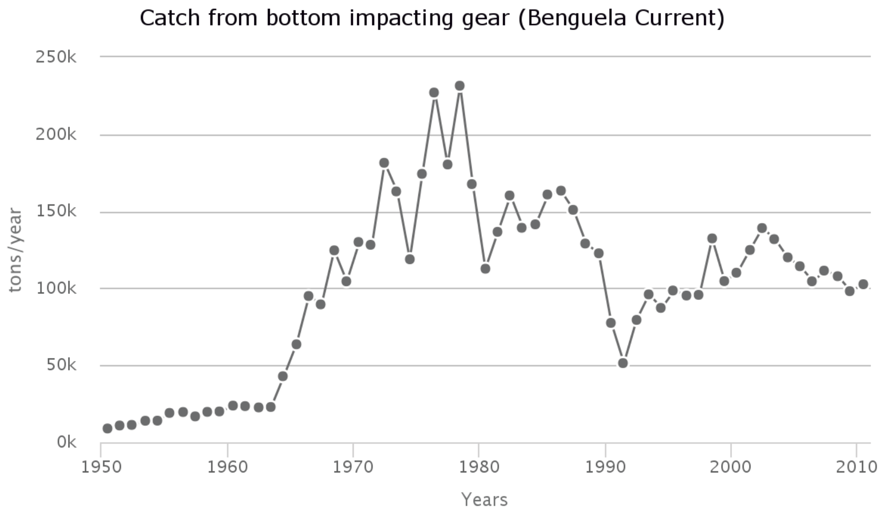
Stock status

The Stock-Catch Status Plots indicate that about 35% of commercially exploited stocks in the LME has collapsed with another 25% overexploited stocks contributing 50% of the catch. However, fully exploited stocks, while accounting for less than 20% of the stocks, provide less than 20% of the reported landings.



Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch increased from 3% in the 1950s to its first peak at around 10% in 1971. In the recent decade, this percentage kept increasing and reached its maximum at 12% in 2008.

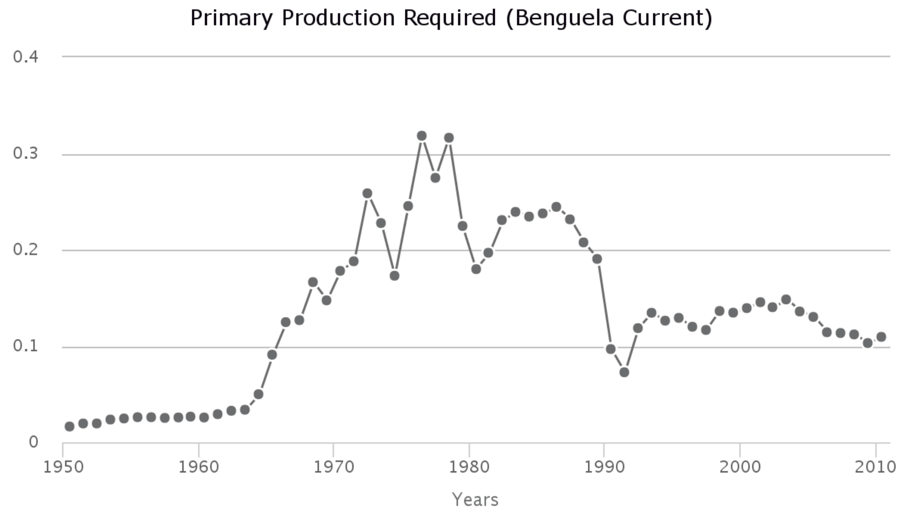


Fishing effort

The total effective effort continuously increased from around 2 million kW in the 1950s to its peak at 83 million kW in 1990. The fishing effort then fluctuated between 10 and 80 million kW in the recent two decades.

Primary Production Required

The primary production required (PPR) to sustain the reported landings in the LME reached one third of the observed primary production by the mid-1970s, but has since declined to half that level.



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 increased to low in 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 increased to low 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
1	4	1	1	4	1	2	4	2

Legend:
Very low | Low | Medium | High | Very high

POPs

Data are available for one sample from one location near Yzerfontein. This location shows moderate concentration (ng.g-1 of pellets) of PCBs (61) and DDTs (24), and low concentration of HCHs (3.0). PCBs and DDTs concentrations at this location correspond to risk category 3, while HCHs to category 2 of the five risk categories (1 = lowest risk; 5 = highest risk). At this location, Ryan et al. (2012) studied temporal trends by using time-series pellet samples and a showed drastic decrease in DDTs and HCHs concentrations from 1980s to 2008. However, PCBs showed an increase from 1999 to 2008, suggesting current inputs. Continuous monitoring is recommended.

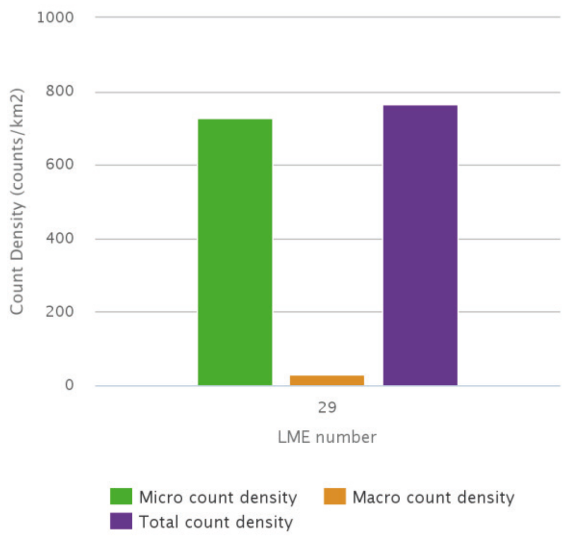
	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk

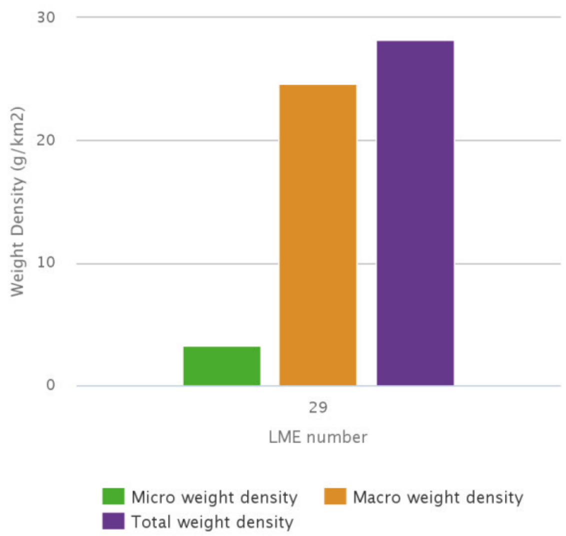
Legend:

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 low 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 low values are due to the relative remoteness of this LME from significant sources of plastic. The abundance of floating plastic in this category is estimated to be on average over 40 times lower that those LMEs with the highest values. There is very limited evidence from sea-based direct observations and towed nets to support this conclusion.





Ecosystem Health

Mangrove and coral cover

0.03% of this LME is covered by mangroves (US Geological Survey, 2011).

Reefs at risk

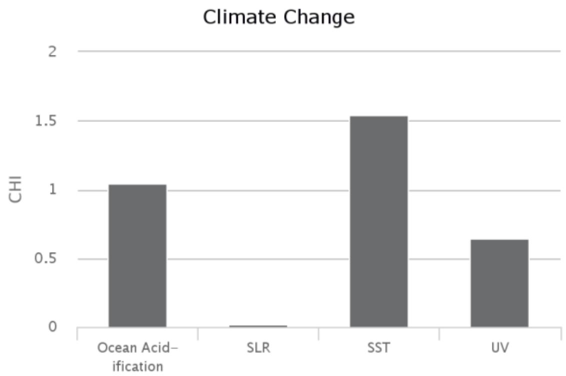
Not applicable.

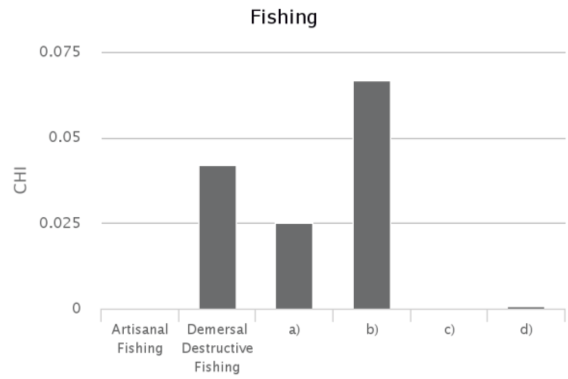
Marine Protected Area change

The Benguela Current LME experienced an increase in MPA coverage from 92 km^2 prior to 1983 to 20,855 km^2 by 2014. This represents an increase of 22,668%, within the high category of MPA change.

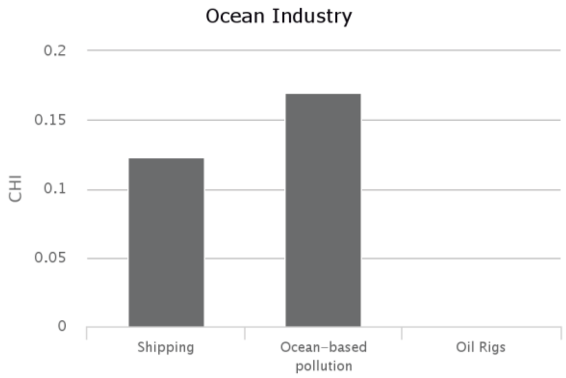
Cumulative Human Impact

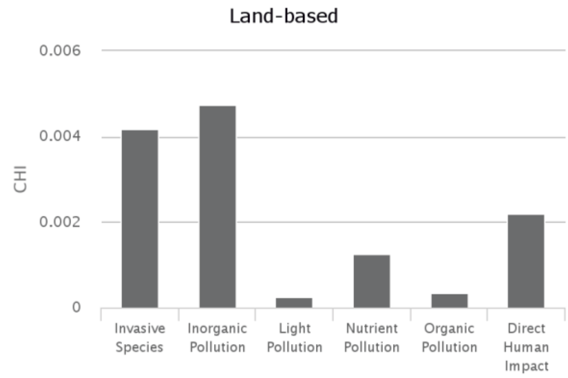
The Benguela Current LME experiences an above average overall cumulative human impact (score 3.70; maximum LME score 5.22), which is also well above the LME with the least cumulative impact. It falls in risk category 3 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, 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 (0.64; maximum in other LMEs was 0.76), and sea surface temperature (1.54; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, ocean based pollution, and demersal non-destructive low-bycatch commercial fishing.





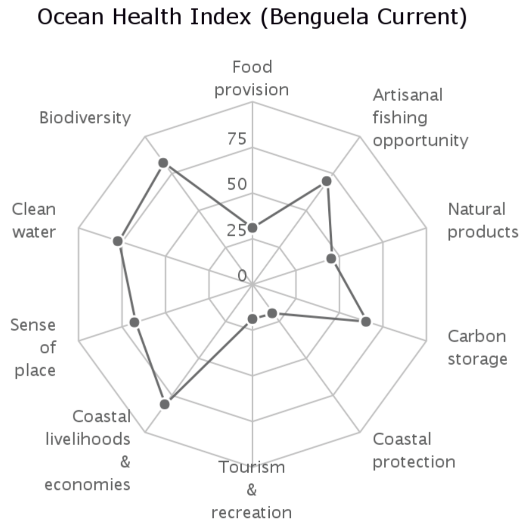
a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing





Ocean Health Index

The Benguela Current LME scores the lowest of any LME on the Ocean Health Index (score 57 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 increase 2 points compared to the previous year, due in large part to changes in the score for coastal economies. This LME scores lowest on food provision, natural products, coastal protection, tourism & recreation, and iconic species goals and highest on the artisanal fishing opportunities goal. It falls in risk category 5 of the five risk categories, which is the highest level of risk (1 = lowest risk; 5 = highest risk).



OHI: 57.53

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 364 147 km^2. A current population of 9 720 thousand in 2010 is projected to increase to 24 515 thousand in 2100, with a density of 27 persons per km^2 in 2010 increasing to 67 per km^2 by 2100. About 16% of coastal population lives in rural areas, and is projected to increase in share to 49% in 2100.

Total population		Rural population	
2010	**2100**	**2010**	**2100**
9,719,997	24,515,118	1,562,959	11,908,854

Legend: Very low, Low, Medium, High, Very high

Coastal poor

The indigent population makes up 29% of the LME's coastal dwellers. This LME places in the very high-risk category based on percentage and in the medium-risk category using absolute number of coastal poor (present day estimate).

Coastal poor
2,791,168

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. This LME ranks in the high-revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $1 202 million for the period 2001-2010. Fish protein accounts for 16% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013 $6 131 million places it in the low-revenue category. On average, LME-based tourism income contributes 8% 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 very high risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
1,202,281,658	16.4	6,130,545,447	7.8	0.8670

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 0.576, this LME has an HDI Gap of 0.424, 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 low risk category (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
0.5757	0.7730	0.3015

Legend: Very low, Low, Medium, High, Very high

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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 medium, and increases to very high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	Contemporary Threat	SSP1	SSP3
0.6758	0.4208	0.5203	0.7584

Legend: Very low, Low, Medium, High, Very high

Governance

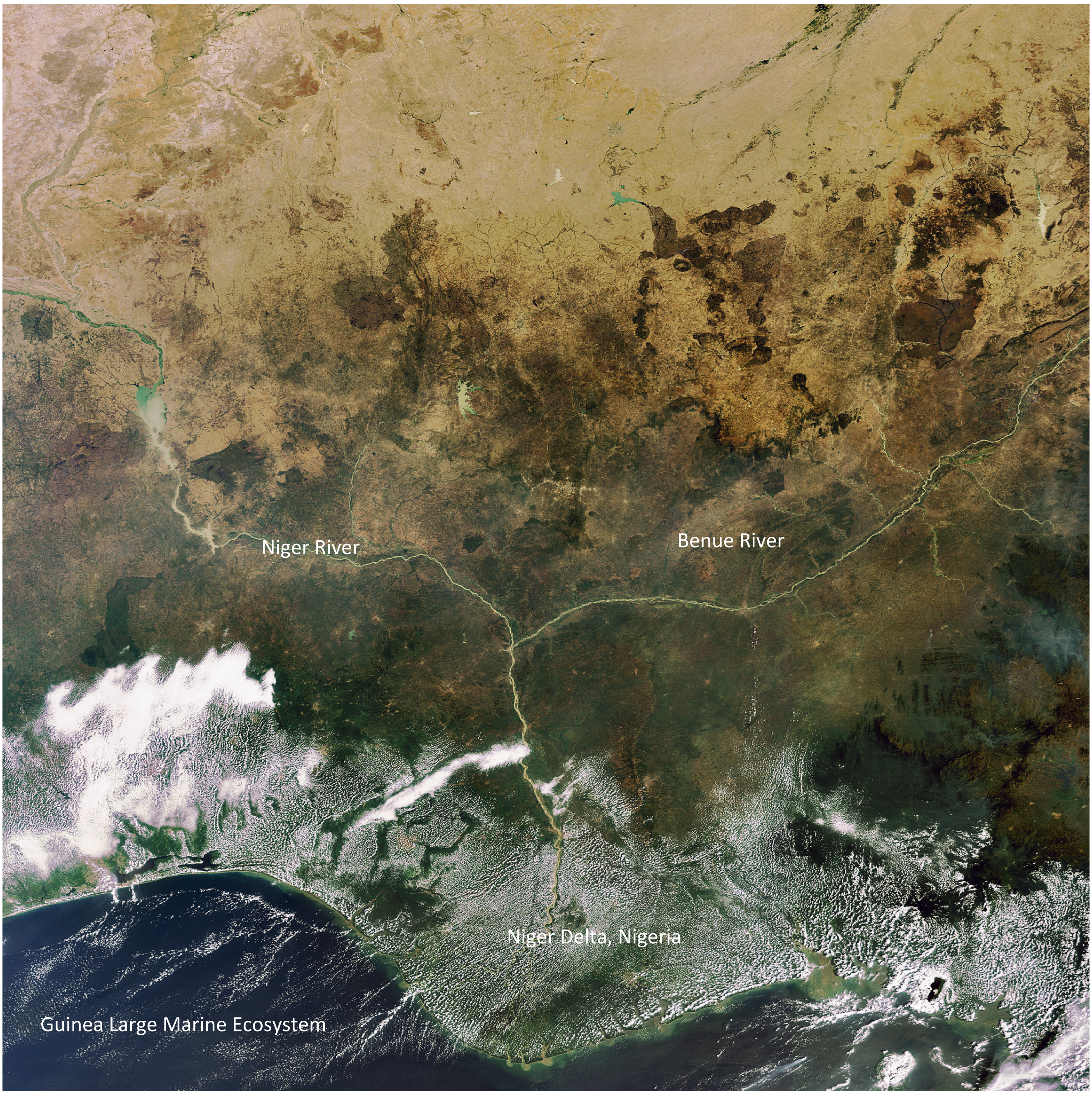
Governance architecture

In this LME the Benguela Current Commission provides for full integration across issues in the EEZs that it covers. It is the integration between the highly migratory species arrangement (ICCAT) and the area beyond national jurisdiction arrangement (SEAFO) and between those arrangements and the Benguela Current Comission (BCC) that are unclear. In the broader assessment, the presence of the BCC arrangement that is clearly designed to integrate issues for the LME is overriding and a score of 1 is assigned for integration due to the presence of this arrangement.

The overall scores for ranking of risk were:

Engagement	Completeness	Integration
93	80	1

Legend: Very low, Low, Medium, High, Very high



Niger River
Benue River
Niger Delta, Nigeria
Guinea Large Marine Ecosystem

UNEP-DHI PARTNERSHIP
Centre on Water and Environment

UNEP DHI

UNESCO
United Nations
Educational, Scientific and
Cultural Organization

International
Hydrological
Programme

UNESCO
United Nations
Educational, Scientific and
Cultural Organization

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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: Western & Middle Africa, Volume 6-Annex F -- 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. On the long term, it is envisioned that these baseline information sheets 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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