TWAP
TRANSBOUNDARY WATERS ASSESSMENT PROGRAMME

Transboundary Waters: A Global Compendium

Water System Information Sheets: Eastern & Southern Africa

Volume 6 - Annex G: Eastern & Southern Africa

UNEP

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Volume 6-Annex G

Transboundary Waters: A Global Compendium

Water System Information Sheets: Eastern & Southern Africa

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GOOS – Global Ocean Observing System

WCRP – World Climate Research Programme

GACS – Global Alliance of CPR Surveys

PML – Plymouth Marine Laboratory

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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.

Transboundary Waters: A Global Compendium

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:

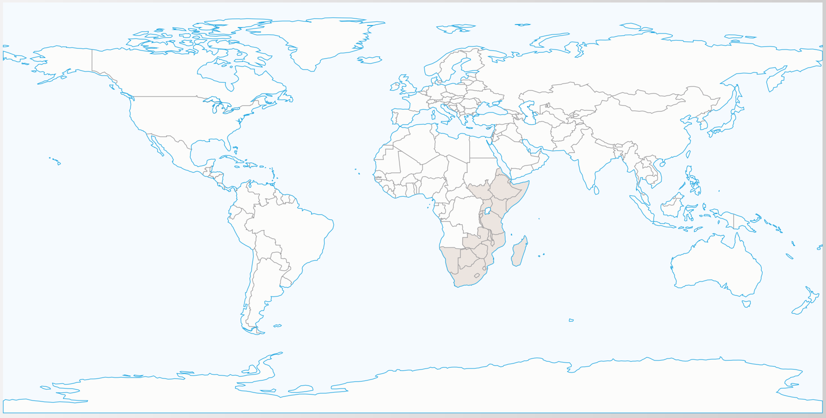
Transboundary Aquifers: http://twapviewer.un-igrac.org
Transboundary Lakes/ Reservoirs: http://ilec.lakes-sys.com/
Transboundary River Basins: http://twap-rivers.org
Large Marine Ecosystems: http://onesharedocean.org
Open Ocean: http://onesharedocean.org

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

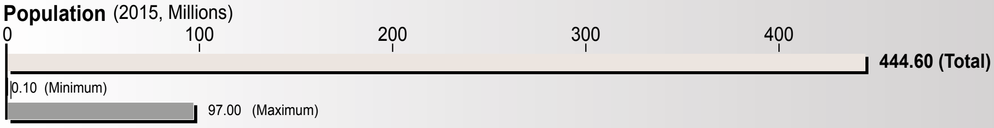
Over the long term, it is envisioned that these baseline information sheets will continue to be updated by future assessments at multiple spatial and temporal scales to better track the changing states of transboundary waters that are essential in sustaining human wellbeing and ecosystem health.

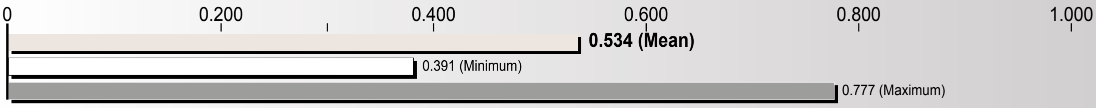
Regional Risks by Theme

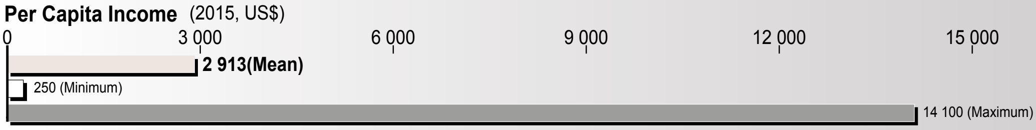
TRANSBOUNDARY WATERS: EASTERN & SOUTHERN AFRICA



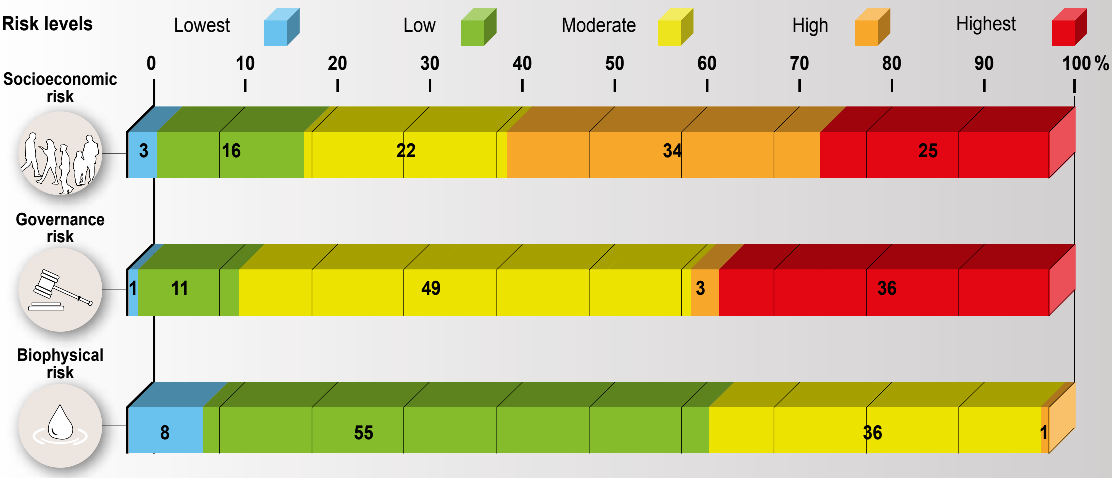
The region belongs to the Low HDI Group with a regional HDI average of 0.534, and a population of 445 million in 2015. Contemporary risks of water systems by water category and theme expressed as percentages are shown at top right. Examining how 67 transboundary waters are distributed by risk level and by risk theme (bottom left), 60% are threatened by high to highest socioeconomic risk, 88% by moderate to highest governance risk, and 92% by low to high biophysical risk with 55% experiencing low risk. On average, this region is similar to Western & Middle Africa region. Its 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 for all risk themes, on average.





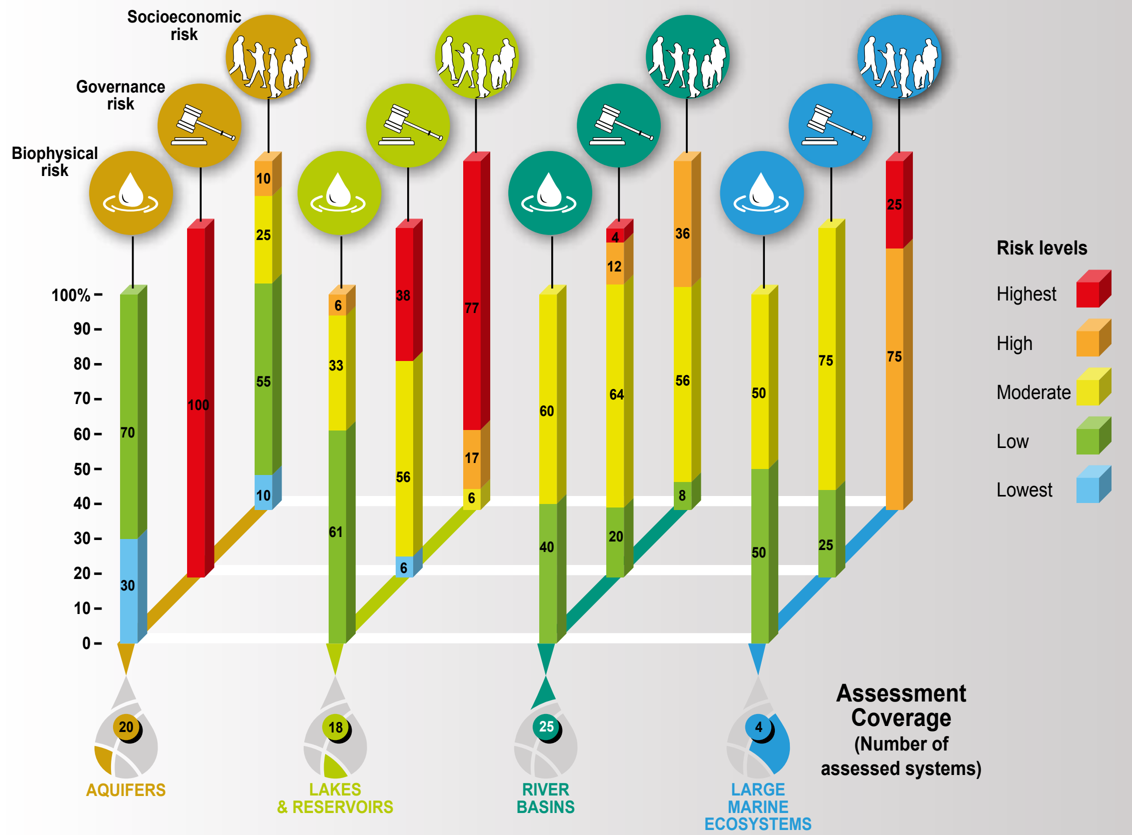


Contemporary Risks by Theme

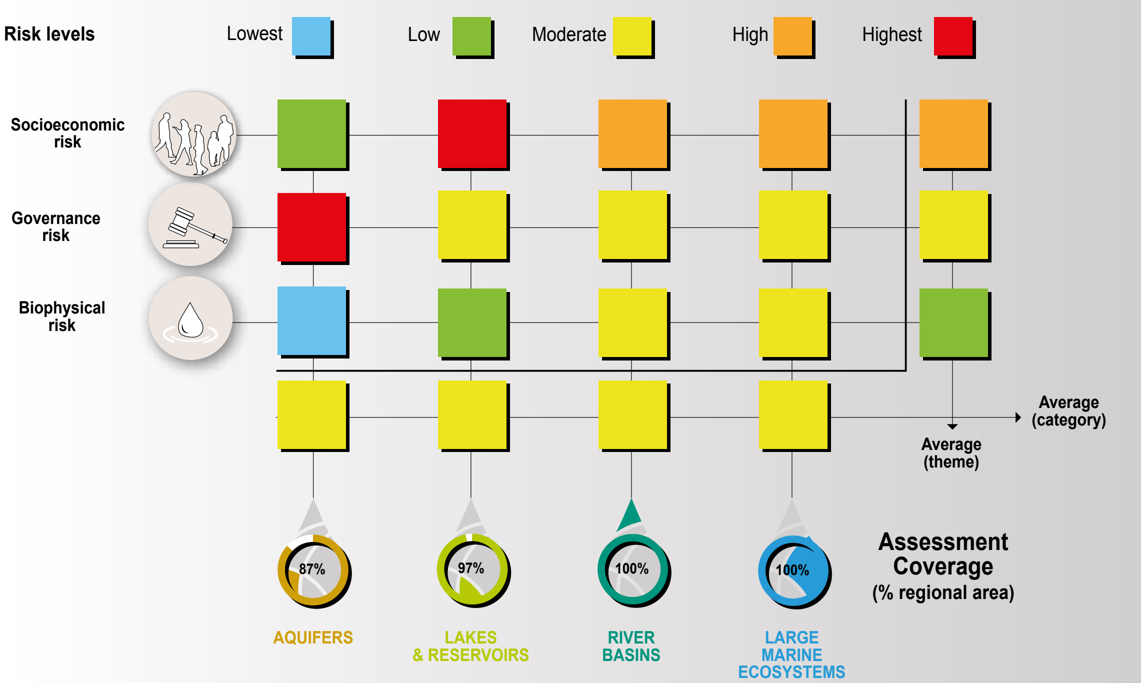


Regional Risks by Water Category

Contemporary Risks by Water Category



Average Risks



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United Nations Educational, Scientific and Cultural Organization · International Hydrological Programme
igrac International Groundwater Resources Assessment Centre
GOETHE UNIVERSITÄT FRANKFURT AM MAIN
SFU SIMON FRASER UNIVERSITY ENGAGING THE WORLD

AF59 – Afar Rift Valley / Afar Triangle Aquifer

Geography

Total area TBA (km^2): 51 000

No. countries sharing: 3

Countries sharing: Djibouti, Eritrea Ethiopia

Population: 780 000

Climate Zone: Arid

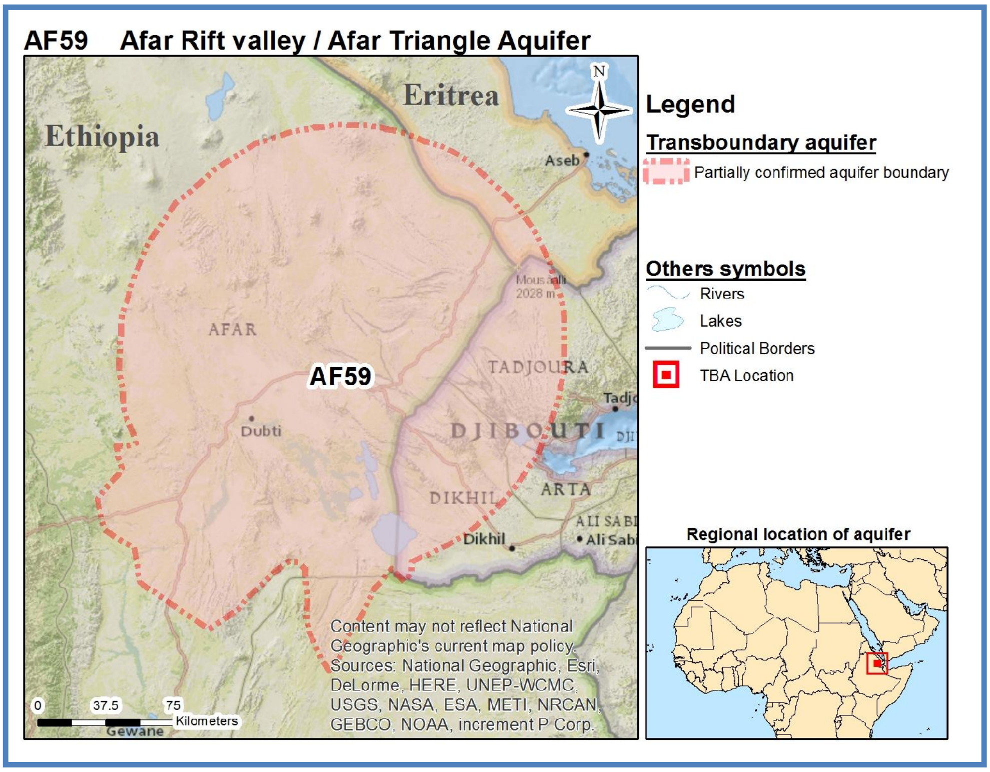
Rainfall (mm/yr): 220

Hydrogeology

Aquifer type: Multiple-layered hydraulically connected

Degree of confinement: Mostly unconfined, some parts confined

Main Lithology: Crystalline rocks - volcanics



No cross-section available

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

AF59 – Afar Rift Valley / Afar Triangle 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)
Djibouti	2	240	35				7	20	D	C
Eritrea							8			
Ethiopia	4	260	35		0		17	<5	D	D
TBA level							**16**			

(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)				
Djibouti	120	8400	-28	-43	15	96	4	7
Eritrea	3	390	-12	-35	79	80	2	18
Ethiopia	81	4400	-28	-40	3	80	0	1
TBA level	**86**	**4900**	**-28**	**-40**	**4**	**83**	**0**	**7**

	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)
Djibouti	0	14	42	81	<1	0	2
Eritrea	0	9	54	110	4	2	25
Ethiopia	0	18	43	75	<1	1	3

AF59 – Afar Rift Valley / Afar Triangle 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)
TBA level	**0**	**17**	**43**	**76**	<1	**1**	**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)
Djibouti				Aquifer Mostly unconfined, but some parts confined	Crystalline rocks - volcanics	Low Primary porosity inter-granular porosity	Secondary porosity: Fractures	
Eritrea								
Ethiopia	12	<5	55	Aquifer Mostly unconfined, but some parts confined	Crystalline rocks - volcanics	Low Primary porosity inter-granular porosity	Secondary porosity: Fractures	1800
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 (2 layers within Ethiopia) that is mostly unconfined, but some parts are confined. The average depth to the water table is 12 m (Ethiopia). The average depth to the top of the aquifer is <5 m and the average thickness of the aquifer system 55 m in Ethiopia.

Hydrogeological aspects

The lithology, that comprises mainly crystalline rocks - volcanics with some granites, is characterized with a low primary porosity and with secondary porosity: fractures. It is furthermore characterized by a high horizontal and vertical connectivity. Transmissivity values reported from Ethiopia are high with an average value of 1800 m^2/d. The mean average annual recharge is 195 Mm^3/yr over an area in excess of 6300 km^2 (Djibouti, Ethiopia). The area is subject to cyclical droughts and the annual average amount of recharge decreases to 43Mm^3/yr within Ethiopia.

Linkages with other water systems

The predominant source of recharge is from surface water runoff, while discharge is mainly from the aquifer into the surrounding lakes.

AF59 – Afar Rift Valley / Afar Triangle Aquifer

Environmental aspects
About 65 % of the natural water quality does not satisfy drinking quality standards due to natural salinity and high fluoride contents. Limited anthropogenic pollution, mainly due to nitrates from domestic sources, has been reported but the data is not available to determine the percentage of the aquifer area that has been affected.

Socio-economic aspects
Annual groundwater abstraction from the aquifer is in the order of 7.1 Mm^3 /yr (Ethiopia, Djibouti). Data is not available on the fresh water abstraction within the aquifer area.

Legal and Institutional aspects
No formal Transboundary Agreement has been made. Within Djibouti the National Institution has a full mandate and capacity whereas both of these are limited within Ethiopia.

Priority Issues
The main issue for this TBA is water quality and about 65 % of the aquifer has high natural salinity content. Excessive amounts of fluoride also are problematic in certain areas. The extent and frequency of water quality monitoring must be reviewed.

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Dessie Habtemariam	Addis Ababa University	Ethiopia	dessienedaw@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.

2 of the 3 TBA countries contributed to the information. The information was adequate to describe the aquifer in general terms. Some quantitative information was also available, and this was sufficient for calculating some of the indicators with.

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

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

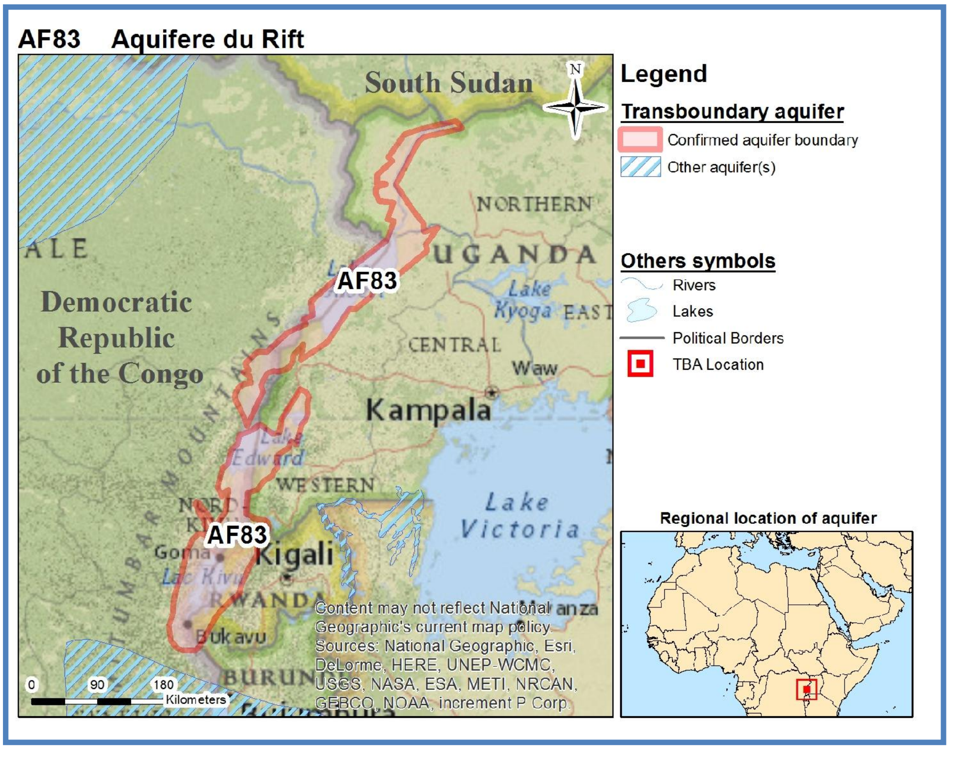
Rainfall (mm/yr): 1200

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

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.

AF83 - AQUIFERE DU RIFT

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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

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

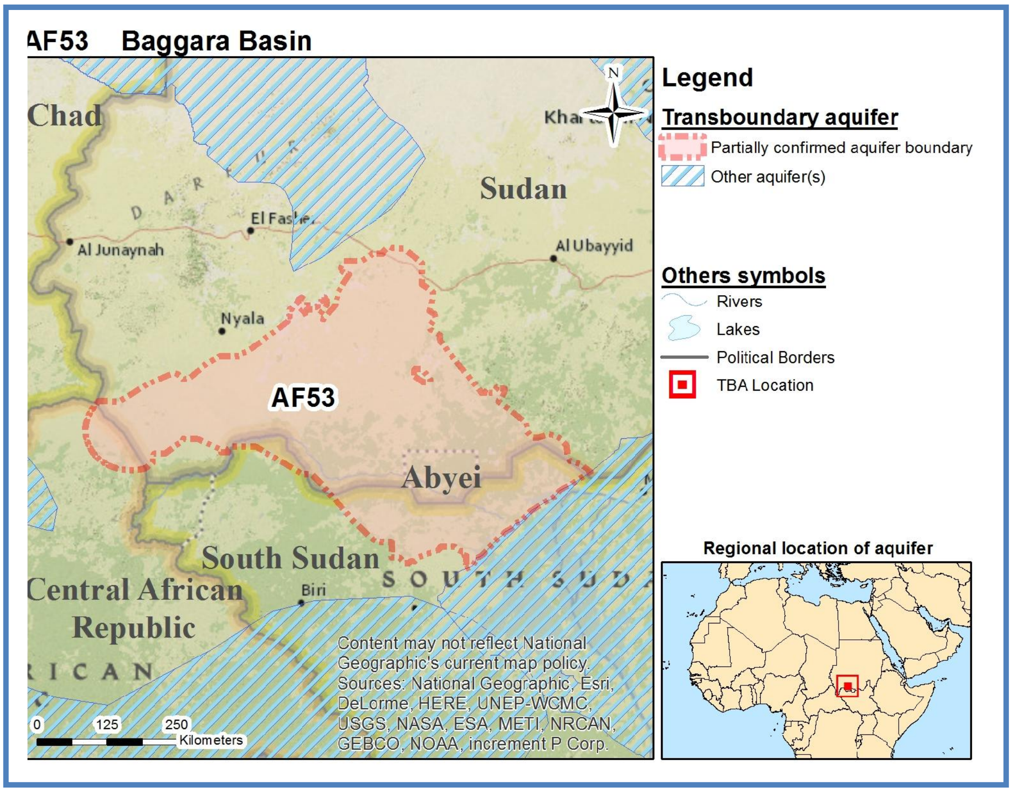
Rainfall (mm/yr): 620

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.

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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

AF31 - Coastal Sedimentary Basin 1

Geography

Total area TBA (km^2): 15 000

No. countries sharing: 2

Countries sharing: Kenya, Tanzania

Population: 2 700 000

Climate Zone: Semi-arid

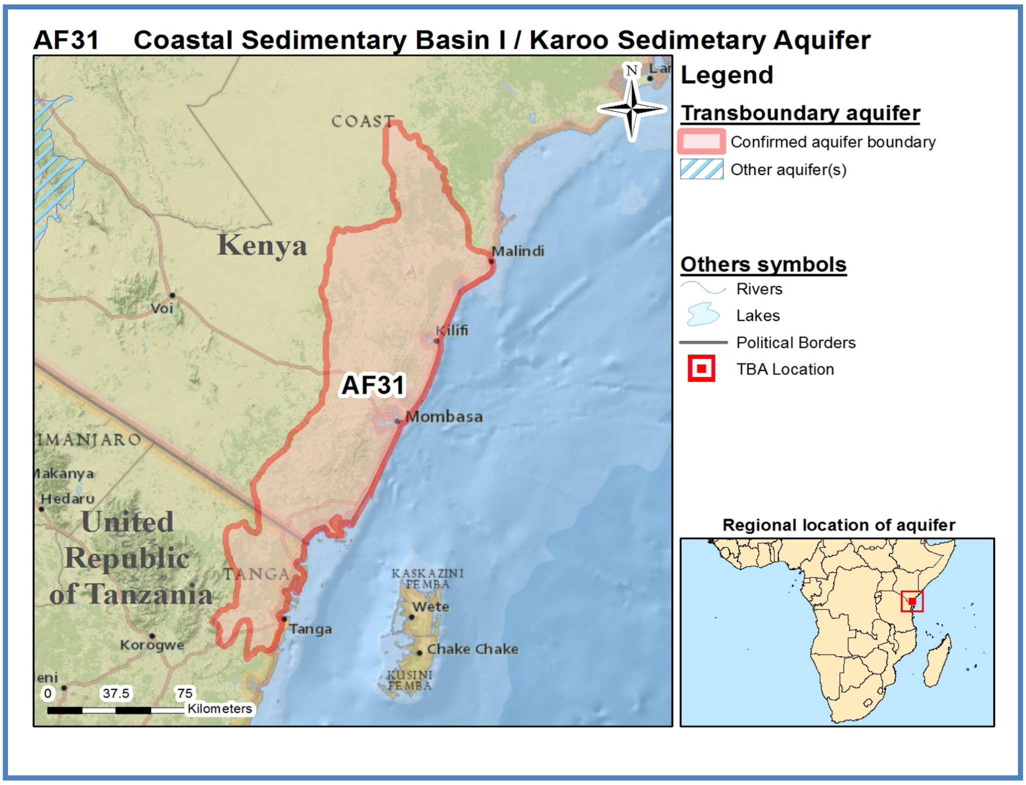
Rainfall (mm/yr): 950

Hydrogeology

Aquifer type: Multi-layered system

Degree of confinement: Confined, but some parts are unconfined

Main Lithology: Sedimentary rocks - limestone



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

No Cross-section provided

AF31 - Coastal Sedimentary Basin 1

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)
Kenya							190			
Tanzania	200	1300	50			B	150		A	A
TBA level							**180**			

(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)
Kenya								
Tanzania	10	15	30	Aquifer mostly confined, but some parts unconfined	Sedimentary rocks - Limestone	High primary porosity fine/ medium sedimentary deposits	Secondary porosity; dissolution	
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.

AF31 - Coastal Sedimentary Basin 1

Aquifer description

Aquifer geometry
Within Tanzania it is a multi 6-layered system that is mostly confined, but some parts are unconfined. The average depth to the water table is 10 m, and the average depth to the top of the aquifer is 15 m within while the average thickness of the aquifer system is 30 m (within Tanzania).

Hydrogeological aspects
The predominant lithology comprises sedimentary rocks - limestone that is characterized by a high primary porosity with secondary porosity: dissolution, with a low horizontal and a high vertical connectivity. The total groundwater volume within Tanzania is 190 km^3. The mean annual recharge, that is 100% due to natural processes, is 456 Mm^3/yr over an area of about 3800 km^2 (Tanzania). The area is generally not characterized by extreme recharge events.

Linkages with other water systems
The predominant source of recharge is from precipitation over the aquifer area. The predominant natural discharge mechanism is into river base flow.

Environmental aspects
Within Tanzania about 50% of the natural water quality does not satisfy drinking quality standards due to natural salinity. Around 50% of the aquifer has been polluted over significant parts due to mining, agriculture, and urban development. Shallow water levels comprise 30% of the aquifer area within Tanzania and groundwater dependent ecosystems cover around 70% of the area.

Socio-economic aspects
No data was available on the amounts of groundwater abstraction from the system, nor on the total amount of fresh water abstraction over the aquifer area.

Legal and Institutional aspects
From the information provided by Tanzania there is a signed full scope bilateral agreement and a there is a dedicated Transboundary Institute with a full mandate and capacity. No information was provided on the mandate or capacity of the National Institute.

Priority Issues and Hotspots
The area is relatively densely populated and around 50% of the TBA is polluted and an effort to control and improve on the current situation is of utmost importance. The vulnerability and risk to pollution is increased due to the abundance of shallow groundwater. Furthermore around 50% of the aquifer is brackish to saline and therefore un-potable. From the assessment it shows a high pollution stress. This must receive priority attention.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
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Alloice Jackson Kaponda	Ministry of Water - Tanzania	United Republic of Tanzania	alloicekaponda@yahoo.com	Lead National Expert
Mtoi Kanyawana	Pangani Basin	United Republic of Tanzania	mkanyawana@yahoo.co.uk	Contributing national expert

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

AF31 - Coastal Sedimentary Basin 1

Considerations and recommendations

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Only 1 of the 2 TBA countries have provided 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 with.

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:
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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: May 2017

AF20 - Coastal Sedimentary Basin III

Geography

Total area TBA (km^2): 20 000

No. countries sharing: 2

Countries sharing: Mozambique, Tanzania

Population: 1 100 000

Climate Zone: Tropical Dry

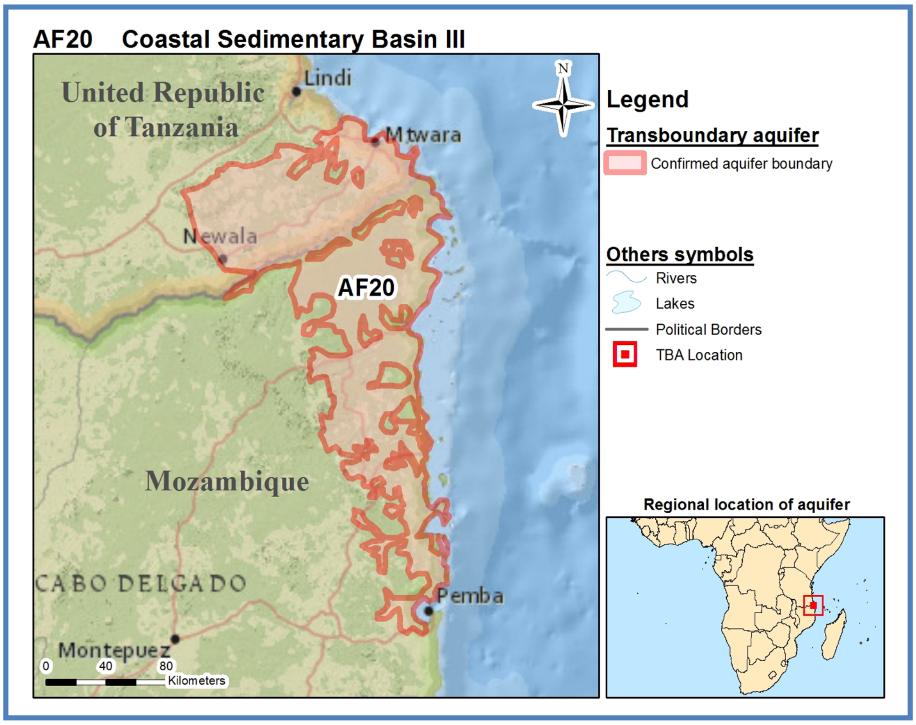
Rainfall (mm/yr): 1100

Hydrogeology

Aquifer type: Multiple-layered hydraulically connected system

Degree of confinement: Mainly unconfined – confined in places

Main Lithology: Sediments - sands and sedimentary rocks - limestone



No Cross-section provided

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

AF20 - Coastal Sedimentary Basin III

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)
Mozambique							32		A	A
Tanzania	83	980	95	85			85	<5	A	A
TBA level							**52**			

(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)				
Mozambique	210	5700	-39	-59	28	33	4	0
Tanzania	200	2600	-46	-68	8	25	7	0
TBA level	**210**	**3900**	**-43**	**-65**	**11**	**29**	**7**	**0**

	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)
Mozambique	4	37	58	130	<1	0	1
Tanzania	2	78	81	210	<1	0	1
TBA level	**3**	**53**	**72**	**180**	**<1**	**0**	**1**

AF20 - Coastal Sedimentary Basin III

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)
Mozambique				Aquifer Mostly unconfined, but some parts confined	Sediment - Sand	High Primary porosity fine/ medium sedimentary deposits	Secondary porosity: Fractures	
Tanzania	25	6	120	Aquifer Mostly confined, but some parts unconfined	Sedimentary rocks - Sandstone	High Primary porosity fine/ medium sedimentary deposits	Secondary porosity: Fractures	840
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, also known as the Ruvuma Delta Coastal Sedimentary Basin Aquifer within Mozambique, is a multiple-layered hydraulically connected system, that varies from confined to semi-confined through to unconfined The average water level is 25 m, and the average depth to the top of the aquifer is 6m while the average thickness of the aquifer system is 120 m (in Tanzania).

Hydrogeological aspects

The predominant lithology is sedimentary rocks – sandstone, with some limestone and sediment – sands and alluvial deposits that are characterized by a high primary porosity, with secondary porosity fractures in the consolidated formations. There is generally a high horizontal and vertical connectivity. The alluvium along the main rivers, crossing the sedimentary terrains, includes the most productive aquifers of the basin. The transmissivity values are relatively high with an average value of 840 m^2/d and the total groundwater volume within the Tanzanian side is 57 km^3. The mean annual recharge, that is 100 % through natural processes, is 646 Mm^3/yr over an area of about 5300 km^2 (in Tanzania).

Linkages with other water systems

The predominant source of recharge is through precipitation over the aquifer area. The predominant discharge mechanism is through discharge from springs.

Environmental aspects

Tertiary to Quaternary age alluvial sands and gravels with fresh groundwater of the Ruvuma Delta, overlie Cretaceous-age marlstones with brackish to saline water. Zones along the coast can also be brackish in places. Within Tanzania around 5% of the aquifer is not suitable for drinking water purposes mainly due to high salinity within the superficial layers. Some anthropogenic groundwater pollution within the superficial layers has been observed but data is not available on the extent to determine the percentage of the aquifer area that has been affected. In Tanzania 45 % of the aquifer area consists of shallow groundwater with 60 % containing groundwater dependent ecosystems.

AF20 - Coastal Sedimentary Basin III

Socio-economic aspects

During 2010 the annual groundwater abstraction on the Tanzanian side was 11 Mm^3, and this was an estimate based on expert judgment. The water was mainly used for agricultural purposes. The estimated of fresh water abstraction over the aquifer area was 13 Mm^3/yr.

Legal and Institutional aspects

Tanzania reports on a signed TBA agreement with full scope and a dedicated Transboundary Institute, the Ruvuma Basin board that exists with a full mandate and full capacity. Within Tanzania the National Institute has a full mandate and capacity.

Emerging Issues

Cross-border flow through the alluvium is unlikely as drainage to the river will prevent groundwater from flowing beneath the river in either direction so major issues in this regard are unlikely to arise. Possible saline intrusion through over-abstraction along the coast should be reviewed. From the assessment the population density and the aquifer shows a high use and it is vulnerable to pollution. This aspect must be collectively reviewed.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
Lucas Chairuca	Department of Water Resources Management	Mozambique	chairuca@yahoo.com	Lead National Expert
Alloice Jackson Kaponda	Ministry of Water - United Republic of Tanzania	United Republic of Tanzania	alloicekaponda@yahoo.com	Lead National Expert
Lazaro Msaru	Ruvuma Basin	United Republic of Tanzania	lamsaru59@gmail.com	Contributing national expert

Considerations and recommendations

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

Only 1 of the 2 TBA countries have provided information. Aspects of the aquifer geometry and most of the parameters have been addressed with consistent and realistic information, allowing for most indicator estimates at the country 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.

AF20 - Coastal Sedimentary Basin III

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

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

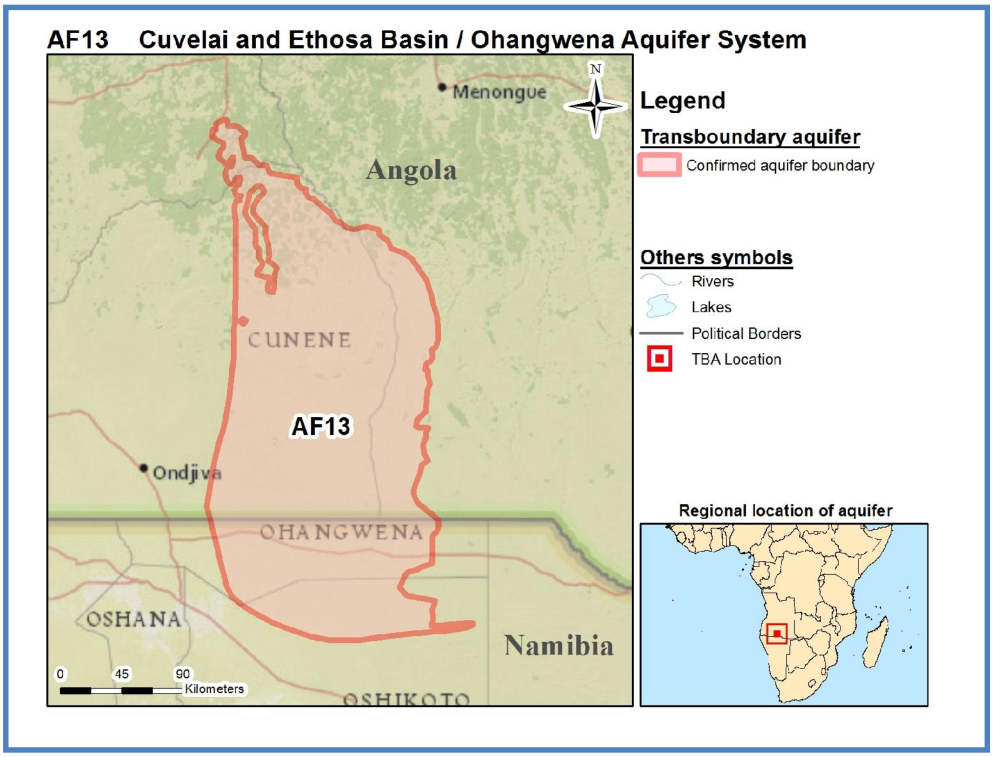
Rainfall (mm/yr): 650

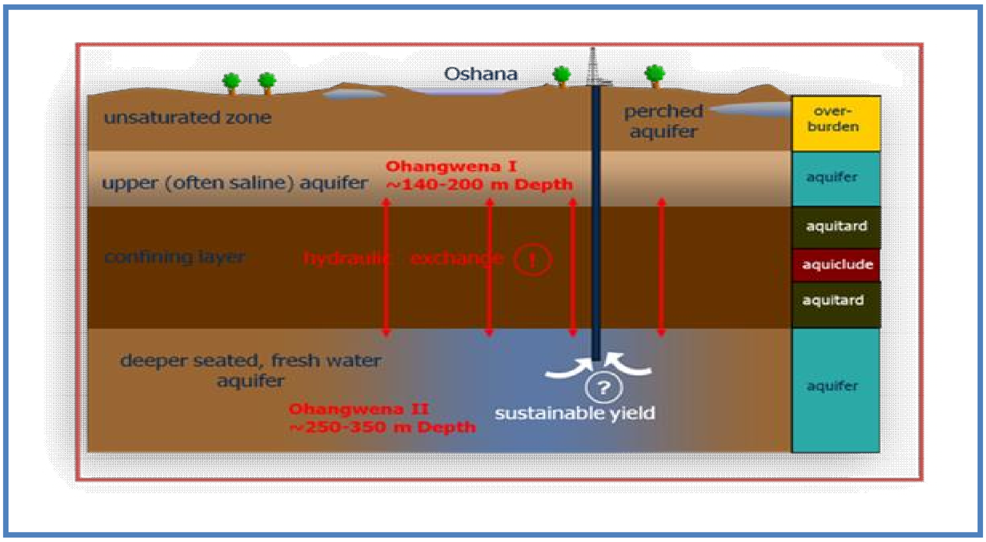
Hydrogeology

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**

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
Martin Quinger	DWAF-BGR project "Groundwater Management in the CEB"	Namibia	martin.quiger@bgr.de	Contributing national expert

Considerations and recommendations

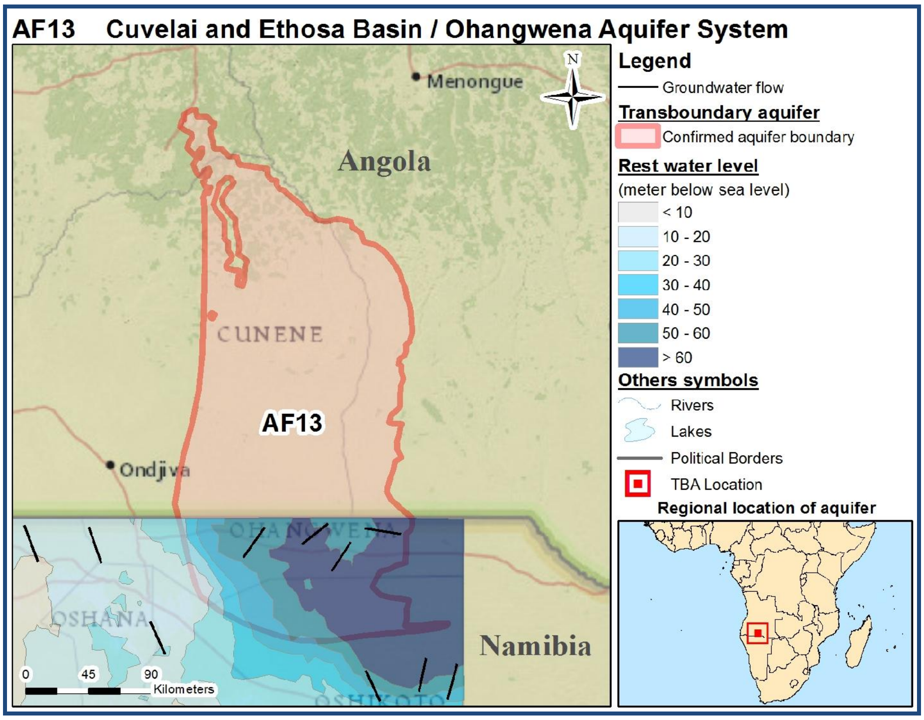
Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

Only 1 of the 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.

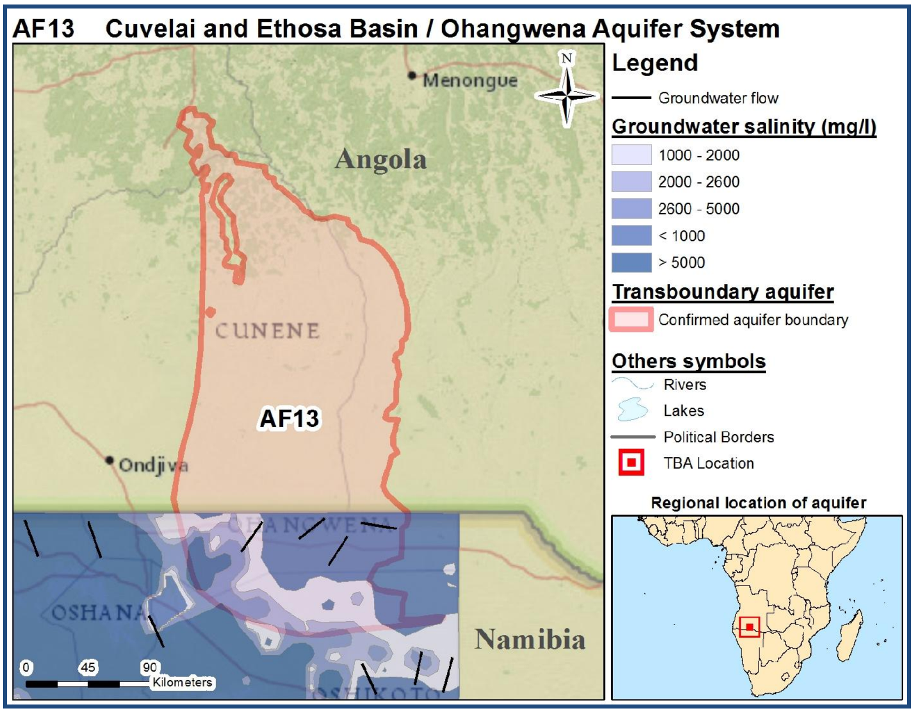
AF13 - Cuvelai And Etosha Basin / Ohangwena Aquifer System

Appendix 1: AF13



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

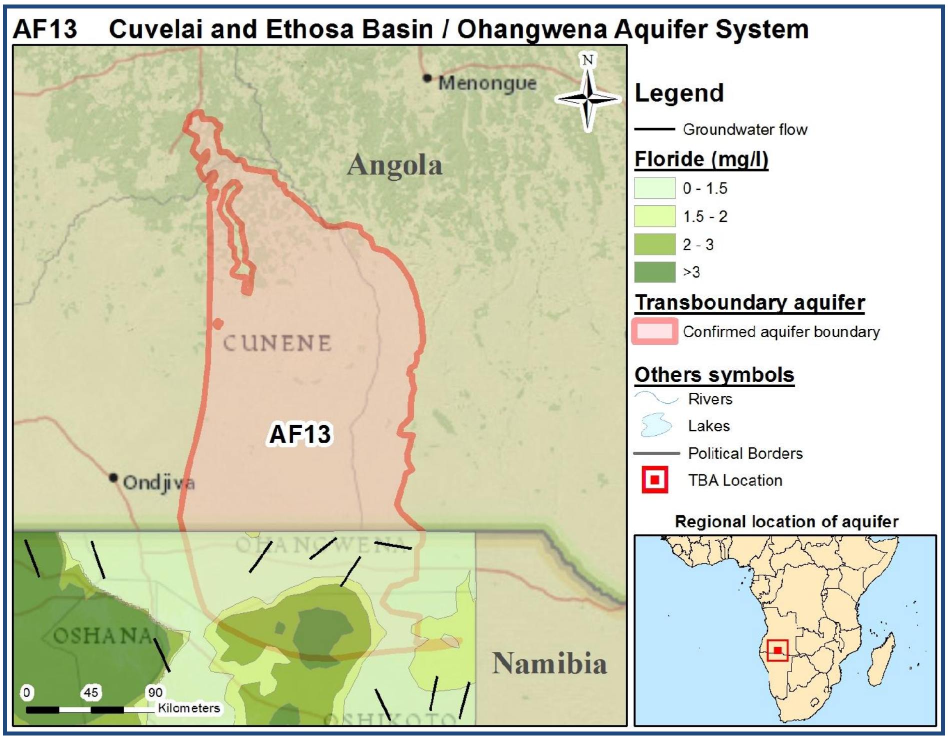
Appendix 2: AF13



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

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

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Request:

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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

AF13 - Cuvelai And Etosha Basin / Ohangwena Aquifer System

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

Groundwater desalination plant, northern Namibia

ISOE Wikom

AF43 - Dawa

Geography

Total area TBA (km^2): 31 000

No. countries sharing: 3

Countries sharing: Ethiopia, Kenya, Somalia

Population: 370 000

Climate Zone: Arid

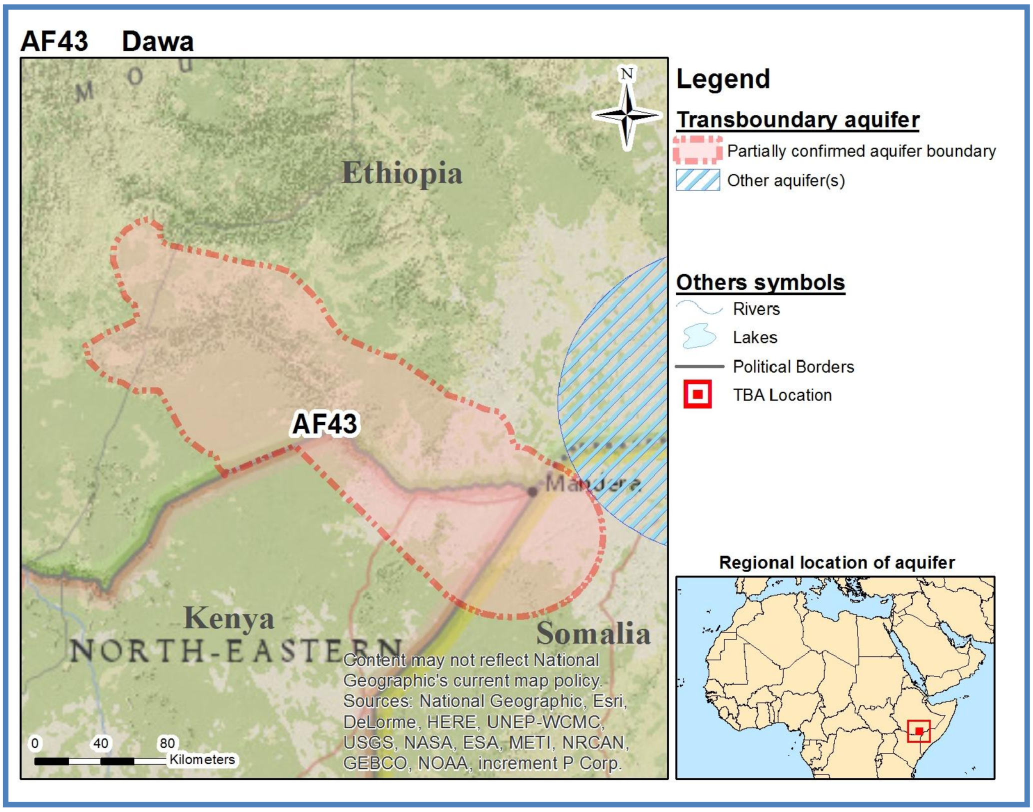
Rainfall (mm/yr): 370

Hydrogeology

Aquifer type: Multi-layered system

Degree of confinement: Semi-confined, mixed

Main Lithology: Sedimentary rocks – limestones



Cross-section

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

AF43 - Dawa

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Ethiopia	2	240	50	50	0		8	<5	D	C
Kenya	2	110	80				17		D	C
Somalia							27			
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).

(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)				
Ethiopia	21	2600	-9	-12	12	78	0	0
Kenya	7	370	-25	-36	3	41	0	0
Somalia	16	810	-17	-30	0	70	0	0
TBA level	**18**	**1500**	**-12**	**-19**	**5**	**66**	**0**	**0**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Ethiopia	0	8	46	85	1	2	4
Kenya	0	20	53	120	2	6	12
Somalia	0	20	32	70	<1	0	0

AF43 - Dawa

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
TBA level	**0**	**12**	**45**	**91**	**1**	**2**	**4**

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Ethiopia	100	<5	200	Aquifer mostly semi-confined, but some parts unconfined	Sedimentary rocks - Limestone	Low primary porosity inter-granular porosity	Secondary porosity: Fractures	50
Kenya	6	8	110	Aquifer Mostly unconfined, but some parts confined	Sediment - Gravel	High Primary porosity fine/ medium sedimentary deposits	Secondary porosity: Fractures	
Somalia								
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-3-layered system in Ethiopia and a 2-layered system in Kenya that is hydraulically connected. In Ethiopia it is mostly semi-confined with some unconfined parts but in Kenya it is mostly unconfined with some confined parts. The average water level within Kenya is 6 m and this increases to 100m within Ethiopia. The average depth to the top of the aquifer varies from <5 m within Ethiopia to 8 m within Kenya and the average aquifer thickness of the aquifer system varies from 110 m within Kenya to 200 m within Ethiopia.

Hydrogeological aspects

The major lithology is predominantly sedimentary rocks – limestones (Ethiopia) that have a low primary porosity and secondary porosity: fractures. They have a relatively high horizontal connectivity. Within Kenya the predominant lithology is sedimentary gravel. The gravels have a high primary porosity. The average transmissivity value within Ethiopia is 50 m^2 /d. The mean annual recharge was 48 Mm^3/yr over an area of about 2500 km^2. During prolonged drought periods within Ethiopia the annual recharge amount decreases by around 20 Mm^3/yr.

AF43 - Dawa

Linkages with other water systems

Within Kenya the predominant source of recharge is through runoff into the aquifer, whereas the discharge mechanism is mainly through groundwater flow into another aquifer.

Environmental aspects

Within Ethiopia 50% of the aquifer does not satisfy local drinking standards, over a significant part of the aquifer due to natural salinity. In Kenya this is reduced to 20 % of the aquifer, mainly over superficial layers that are not suitable due to high salinity. Some pollution within the superficial layers has been observed but data are not available to determine the extent of the aquifer area that has been affected.

Socio-economic aspects

During 2010 the annual groundwater abstraction on the Ethiopian side was 0.90 Mm^3/yr. The total fresh water abstraction from the same area, including the groundwater was 1.70 Mm^3 /yr.

Legal and Institutional aspects

There is no Transboundary Agreement in place, and the National Institutes have a full capacity and mandate.

Emerging Issues

Essential aspects of water quality and quantity and the likely issues in need of cooperation must be reviewed between the Aquifer States. Recharge seems to be very low and long-terms trends must be more closely followed.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
Dessie Habtemariam	Addis Ababa University	Ethiopia	dessienedaw@yahoo.com	Lead National Expert
Agatha Wanjiru Njuguna	Water Resources Management Authority	Kenya	agathathuita@yahoo.com, agatha.wanjiru@wrma.or.ke	Lead National Expert
Agnes Wanjiru Mbugua	Ministry of Environment , Water and Natural Resources	Kenya	mbuguaagnes@yahoo.co.uk	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.

2 of the 3 countries have provided the information. . Some quantitative information was also available, and some of the indicators could be calculated on the national levels.

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

Colophon

This Transboundary Aquifers information sheet has been produced as part of the Groundwater Component of the GEF Transboundary Water Assessment Programme (GEF TWAP). **GEF TWAP** is the first truly global comparative assessment of transboundary groundwater, lakes, rivers, large marine ecosystems and the open ocean. More information on TWAP can be found on: www.geftwap.org . **The Groundwater component** of TWAP carried out a global comparison of 199 transboundary aquifers and the groundwater systems of 41 Small Island Developing States. The data used to compile this

AF43 - Dawa

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

AF12 - Eastern Kalahari Karoo Basin

Geography

Total area TBA (km^2): 34 000

No. countries sharing: 2

Countries sharing: Botswana, Zimbabwe

Population: 240 000

Climate Zone: Semi-arid

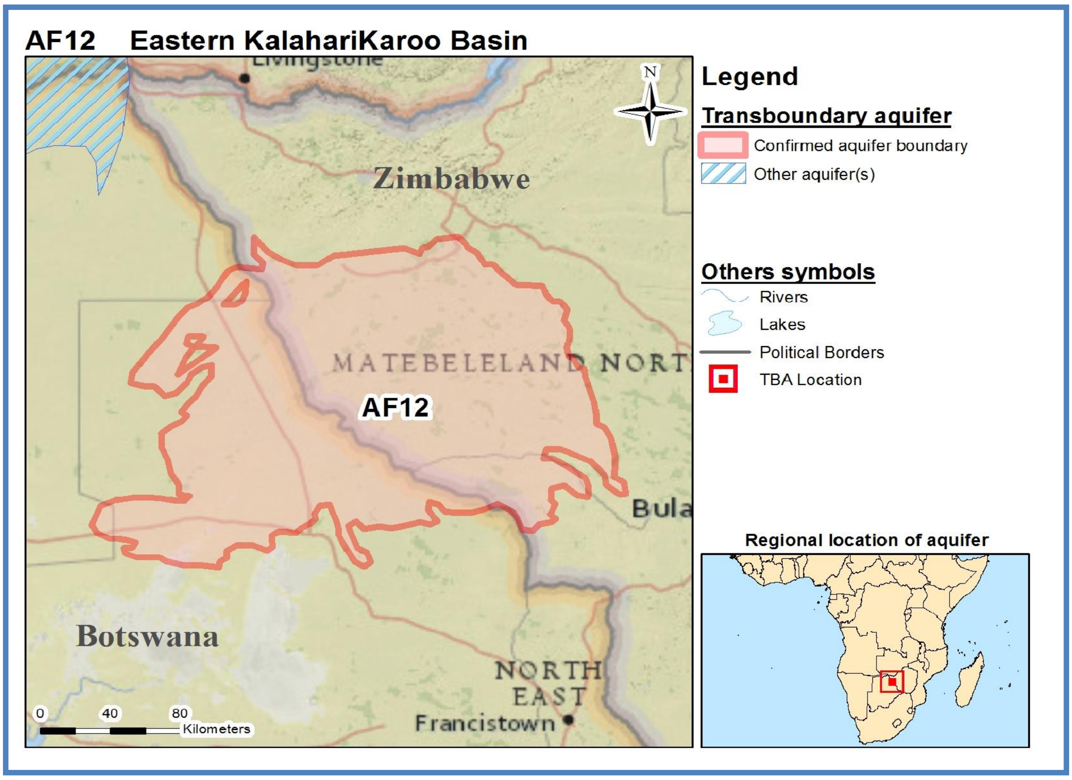
Rainfall (mm/yr): 490

Hydrogeology

Aquifer type: Multi-layered system

Degree of confinement: Mostly confined with some semi-confined parts

Main Lithology: Sedimentary rocks – sandstones and shales; Crystalline rocks - basal



No cross-section available

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

AF12 - Eastern Kalahari Karoo 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)
Botswana							3			
Zimbabwe							10		D	D
TBA level							**7**			

(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)				
Botswana	29	7700	41	10	45	41	0	67
Zimbabwe	19	2400	23	-3	20	17	0	67
TBA level	**23**	**3800**	**28**	**2**	**36**	**31**	**0**	**67**

	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)
Botswana	0	4	30	58	1	1	8
Zimbabwe	0	8	40	63	<1	0	2
TBA level	**0**	**6**	**37**	**62**	**<1**	**1**	**5**

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

AF12 - Eastern Kalahari Karoo 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)
Botswana								
Zimbabwe				Whole aquifer confined	Sedimentary rocks – sandstones and shale	Low Primary porosity intergranular porosity	Secondary porosity: Fractures	200
TBA level								

* Including aquitards/aquicludes

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

Aquifer description

Aquifer geometry

This is a multi-layered system that is mostly confined with some semi-confined aquifers. Data is not available on the aquifer geometry.

Hydrogeological aspects

The main lithology is sedimentary rocks - Karoo sandstones and shales, and crystalline rocks - basalts. It is characterized by some primary porosity with secondary porosity: fractures that have a high vertical connectivity. The TBA receives short seasonal rains and often experiences prolonged droughts. In the eastern areas transmissivity values of up to 200 m^2/d are reported. Recharge has been estimated at 2.5 mm/yr in the Maitengwe River area, decreasing to 0.5 mm/yr in the thinner basalts.

Linkages with other water systems

The predominant source of recharge is from precipitation on the aquifer area and specifically in Botswana at the Ntane sub-outcrop area and through thin basalt cover along major drainage courses.

Environmental aspects

Data is not available on the environmental information. The groundwater quality is generally good but deteriorates towards the northwest in Botswana. There is a potential for cross border flow in the Karoo aquifer, and degradation on the one side can result in pollution on the other side of the border.

Socio-economic aspects

Data is not available with regard to the groundwater and fresh water abstraction within the system.

Legal and Institutional aspects

No agreement exists, nor is it under preparation. The National institutions are in place, but are not fully operational.

Hotspots

The hydraulic continuity and potential flow across the border, coupled with likely enhanced demand in the future, makes this TBA a priority for monitoring.

AF12 - Eastern Kalahari Karoo Basin

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
Robert Mutepfa	Ministry of Environment, Water and Climate	Zimbabwe	mutepfar@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.

More information for this TBA should be obtained through the National Experts of the 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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- All other data: TWAP Groundwater (2015).

Version: September 2015

AF61 - Gedaref

Geography

Total area TBA (km^2): 51 000

No. countries sharing: 3

Countries sharing: Eritrea, Ethiopia, Sudan

Population: 1 600 000

Climate Zone: Semi-arid

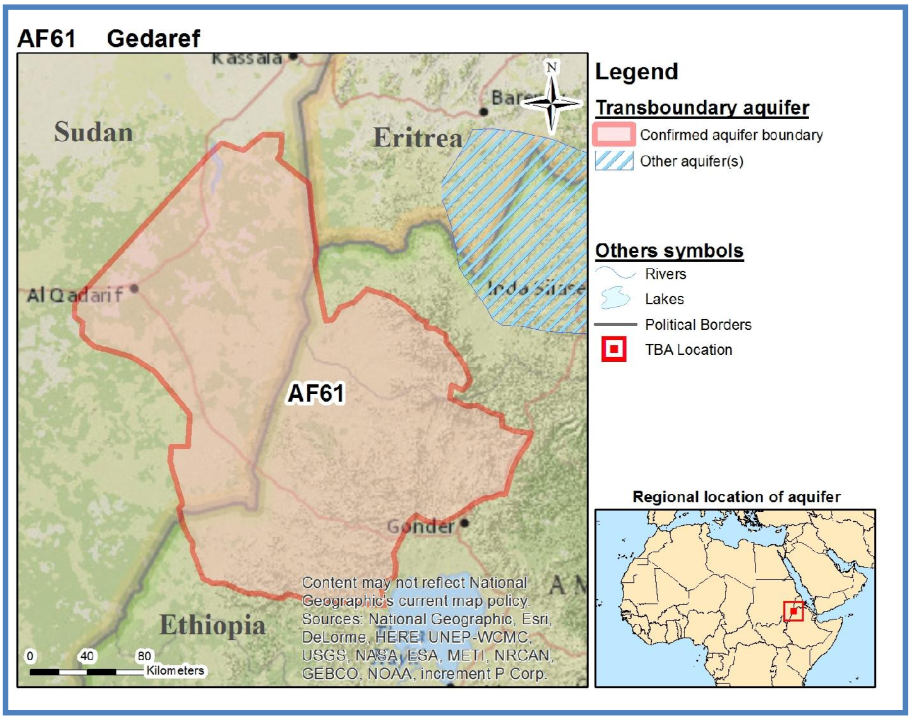
Rainfall (mm/yr): 790

Hydrogeology

Aquifer type: Multiple 3-layered hydraulically connected

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

Main Lithology: Sedimentary rocks - Sandstone



No cross-section available

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

AF61 - Gedaref

TWAP Groundwater Indicators from Global Inventory

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

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

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

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

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

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

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

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

TWAP Groundwater Indicators from WaterGAP model

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

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

AF61 - Gedaref

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

Key parameters table from Global Inventory

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

* Including aquitards/aquicludes

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

Aquifer description

Aquifer geometry

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

Hydrogeological aspects

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

Linkages with other water systems

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

Environmental aspects

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

AF61 - Gedaref

Socio-economic aspects

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

Legal and Institutional aspects

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

Emerging Issues

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

Contributors to Global Inventory

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

Considerations and recommendations

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

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

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

Colophon

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AF61 - Gedaref

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

Version: September 2015

AF44 - Jubba

Geography

Total area TBA (km^2): 31 000

No. countries sharing: 2

Countries sharing: Ethiopia, Somalia

Population: 310 000

Climate Zone: Arid

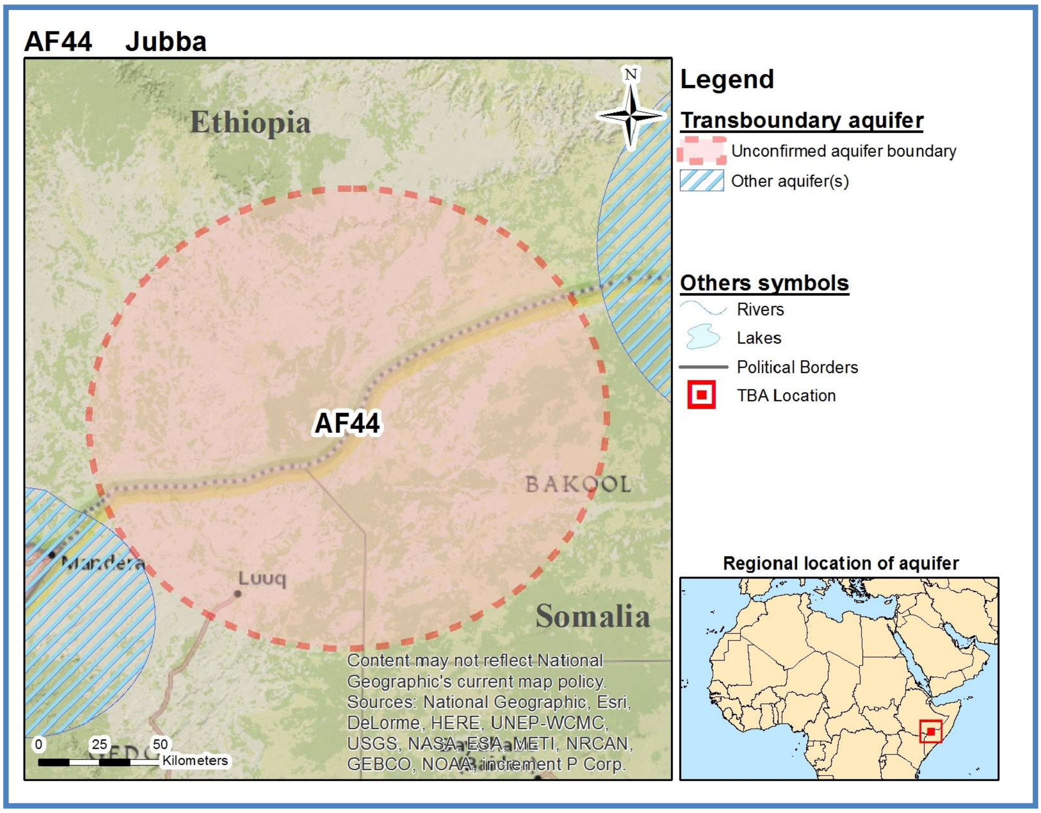
Rainfall (mm/yr): 330

Hydrogeology

Aquifer type: Data not available

Degree of confinement: Data not available

Main Lithology: Precambrian and intrusive rocks



No cross-section available

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

AF44 - Jubba

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)				
Ethiopia	10	1600	-16	-16	10	80	0	0
Somalia	12	1300	14	42	2	80	0	0
TBA level	**11**	**1400**	**1**	**14**	**6**	**80**	**0**	**0**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Ethiopia	0	6	31	53	1	2	5
Somalia	0	10	0	-5	<1	0	1
TBA level	**0**	**8**	**11**	**16**	<1	**1**	**3**

Key parameters table from Global Inventory

No data available.

Aquifer description

Aquifer geometry

The extent of this transboundary aquifer is inferred and limited data and information could be located. It is a fairly extensive aquifer which extends to the Upper Giuba in the south. On average, depth to water table ranges from <5m to 15 m.

Hydrogeological aspects

The predominant aquifer lithology is Precambrian and intrusive rocks. No further information with regard the hydrogeology and interlinkages was located.

Environmental aspects

Water quality can be problematic as the TDS amounts can be excessive. From the shallow water table it is assumed that there is a relatively high ratio of groundwater-dependant ecosystems.

Socio-economic aspects

Data is not available with regard to groundwater abstraction from the system.

Legal and Institutional aspects

No Transboundary Agreement is in place.

AF44 - Jubba

Emerging Issues

Recharge seems to be very low as assessed through available information. The groundwater level monitoring set-up must be reviewed and introduced if necessary.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@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

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.

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

AF36 - Kagera Aquifer

Geography

Total area TBA (km^2): 5200

No. countries sharing: 3

Countries sharing: Rwanda, Tanzania, Uganda

Population: 530 000

Climate Zone: Tropical Dry

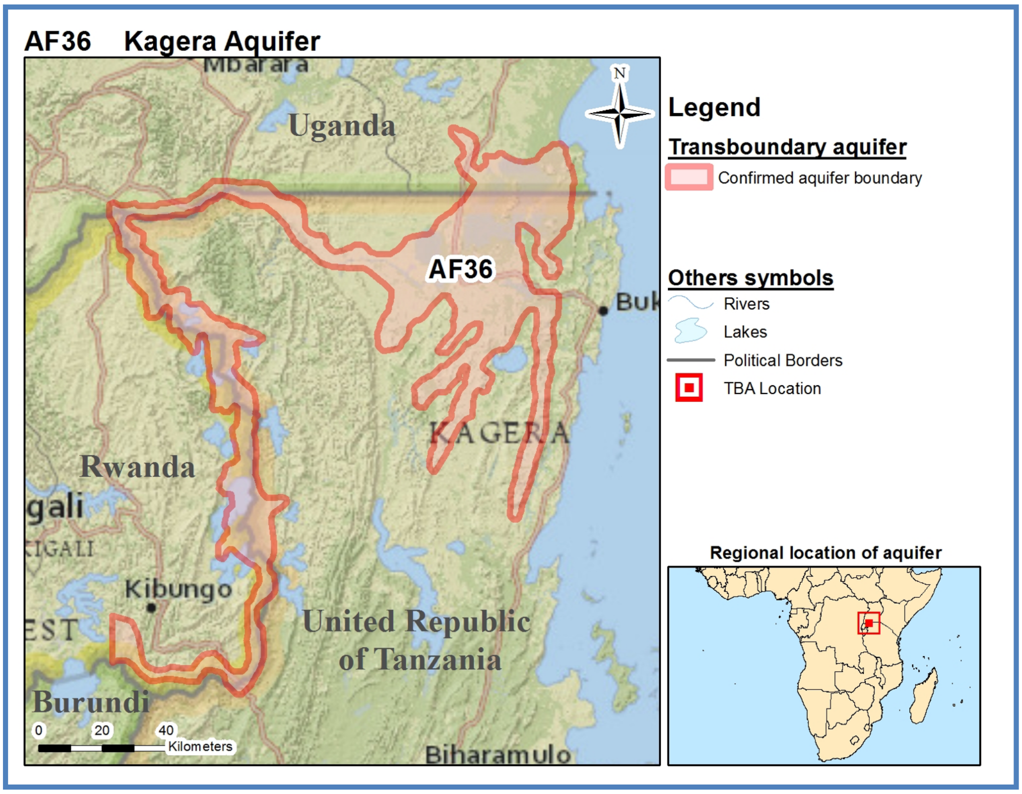
Rainfall (mm/yr): 1200

Hydrogeology

Aquifer type: Single-layered and multiple-layered

Degree of confinement: Mostly unconfined but some parts confined

Main Lithology: Consolidated sandstones with some unconsolidated formations



No Cross-section Provided

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

AF36 - Kagera 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)
Rwanda			99				120		B	D
Uganda			45				100		D	D
Tanzania	8	80	95			B	95	10	A	A
TBA level							**100**		**E**	**F**

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

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Rwanda				Aquifer Mostly unconfined, but some parts confined	Sedimentary rocks - sandstone	High Primary porosity fine/ medium sedimentary deposits	Secondary porosity: Fractures	3600
Uganda	25	51		Aquifer Mostly unconfined, but some parts confined	Sedimentary rocks - sandstone	Low Primary porosity inter-granular porosity	Secondary porosity: Fractures	

AF36 - Kagera 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)
Tanzania	8	25	37	Aquifer Mostly unconfined, but some parts confined	Sedimentary rocks - sandstone	High Primary porosity fine/ medium sedimentary deposits	Secondary porosity: Fractures	600
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 system varies regionally between a single-layered and multiple-layered hydraulically connected system that is mostly unconfined, but some parts are confined. The average water level varies between 8 m in Tanzania and 25 m within Uganda. The average depth to the top of the aquifer varies between 25m within Tanzania to 51 m within Uganda. The average thickness of the aquifer system is 37m within Tanzania.

Hydrogeological aspects

The predominant lithology consists of consolidated sedimentary rocks - sandstones with some unconsolidated formations. It is characterized by a high primary porosity, with secondary porosity: fractures that have a low to high horizontal and vertical connectivity. The transmissivity values are high varying from an average value of 600 m^2/d to 3600 m^2/d (Rwanda, Tanzania). The total groundwater volume is 21.4 km^3 (Rwanda, Tanzania). With regard to recharge, that is 100% through natural recharge, there is a difference in recharge between years within the Rwandan part of the aquifer but this has not been quantified. The average amount of recharge is 270 Mm^3/yr within the Tanzanian part and recharge occurs over an area of 10 300 km^2 (Tanzania and Rwanda).

Linkages with other water systems

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

Environmental aspects

The natural groundwater quality that does not satisfy local drinking water standards varies from <5 % in Rwanda to 5 % in Tanzania, and to 55% in Uganda. This is mainly due to natural salinity and high fluorides in places. Some anthropogenic groundwater pollution over the system has been identified mainly in the superficial layers. This covers about 5 % of the aquifer (Tanzania). Around 60 % of the aquifer area is covered by shallow groundwater and around 80 % of the area is covered with groundwater dependent ecosystems (Tanzania).

Socio-economic aspects

During 2010 the annual groundwater abstraction was estimated to be around 4.6 Mm^3/yr (Rwanda, Tanzania). This was used mainly for domestic purposes. The total amount of freshwater that was abstracted over the aquifer area was not quantified.

Legal and Institutional aspects

Tanzania has reported that a ratified Agreement exists with full scope exists (Nile Basin Initiative), whereas Rwanda has reported on a limited scope Agreement that exists. According to Tanzania a dedicated Transboundary Institution exists with full mandate and capacity (Lake Victoria Basin). The National Institutions have a limited mandate and capacity (Rwanda, Uganda) whereas in Tanzania the National Institute has a full mandate and capacity.

AF36 - Kagera Aquifer

Emerging Issues
The Transboundary Agreement and Institutional set-up needs to be reviewed by all partners with regard to joint management of the resource. There is a relatively high population density over the aquifer and the favourable hydraulic conditions increase its vulnerability to pollution. This must be taken into account.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
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Carolyne Nakalyango	Ministry of Water & Environment	Uganda	caroline.nakalyango@mwe.go.ug	Contributing national expert
Dr. Callist Tindimugaya	Ministry of Water & Environment	Uganda	callist.tindimugaya@mwe.go.ug	Lead National Expert
Gwendolyn Kyoburungi	Ministry of Water & Environment	Uganda	gwendolyn.kyoburungi@mwe.go.ug	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.

The information was provided by all of the TBA countries. . Some quantitative information was also available, but not enough to calculate all of the indicators with.

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.

AF36 - Kagera 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.

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

Version: May 2017

AF21 - Karoo Sandstone Aquifer

Geography

Total area TBA (km^2): 36 000

No. countries sharing: 2

Countries sharing: Mozambique, Tanzania

Population: 430 000

Climate Zone: Tropical Dry

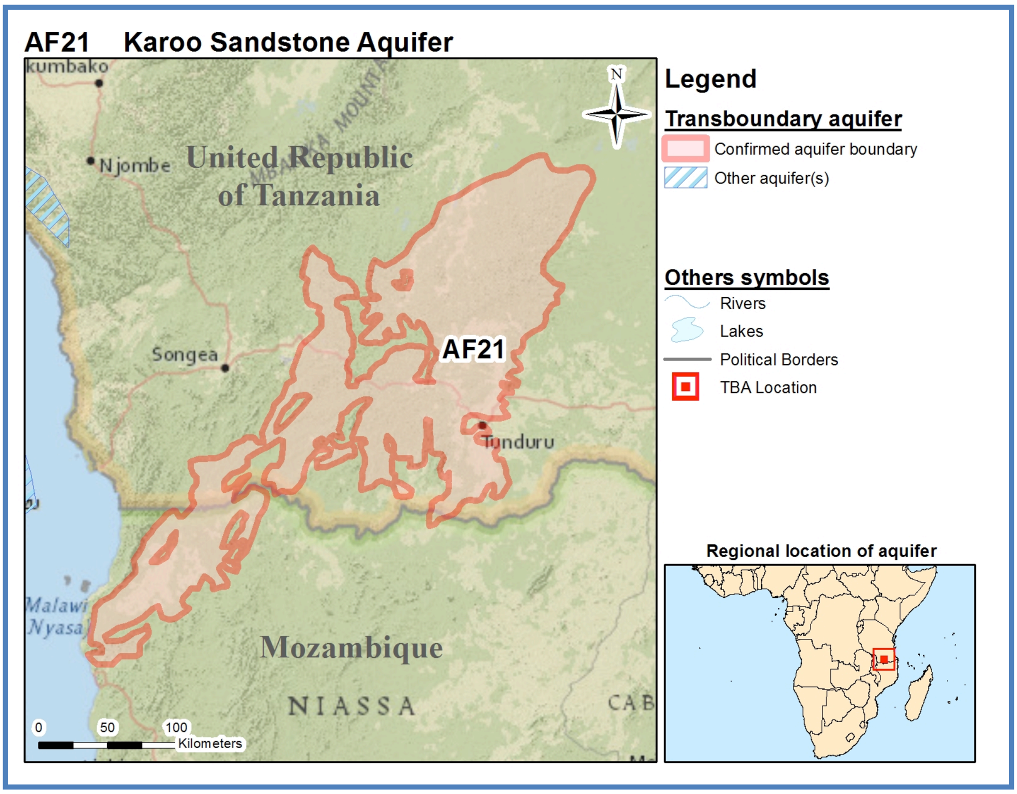
Rainfall (mm/yr): 1200

Hydrogeology

Aquifer type: Multi-layered hydraulically connected

Degree of confinement: Unconfined / confined

Main Lithology: Karoo Sandstones underlying basalts



No Cross-section Provided

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

AF21 - Karoo Sandstone 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)
Mozambique							6		A	A
Tanzania	47	3600	100				13		A	A
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).
(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)				
Mozambique	240	37 000	-43	-64	33	33	3	0
United Republic of Tanzania	210	15 000	-49	-70	19	25	7	0
TBA level	**210**	**17 000**	**-48**	**-70**	**20**	**26**	**7**	**0**

	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)
Mozambique	0	7	66	160	<1	0	0

AF21 - Karoo Sandstone 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)
United Republic of Tanzania	2	14	82	210	<1	0	0
TBA level	**2**	**13**	**81**	**210**	<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)
Mozambique				Aquifer mostly semi-confined, but some parts unconfined	Sedimentary rocks - Sandstones	Low Primary porosity inter-granular porosity	Secondary porosity: Fractures	
Tanzania	<5	10	50	Aquifer Mostly confined, but some parts unconfined	Sedimentary rocks - Sandstones	Low Primary porosity inter-granular 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 Transboundary Aquifer, also known as the Tunduru/ Maniamba Basin Karoo Sandstone Aquifer, is a multi-layered hydraulically connected system (3-layered within Tanzania). It is and unconfined to semi-confined whereas within Tanzania it is confined and some parts are unconfined. The average depth to the water table is >5 m. The average depth to the top of the aquifer is 10 m whereas the average thickness of the aquifer system is 50 m.

Hydrogeological aspects

The Karoo Sandstones that underlie basalts have moderate yields and are artesian in part. The aquifer has some primary porosity with secondary porosity fractures. Data is not available on transmissivity values. The total groundwater volume within Tanzania is 175 km^3. There is no extreme recharge events and the average recharge, that is 100% due to natural conditions, within the Tanzanian side is 1 400 Mm^3/yr. Data is not available on the long-term trend of the water level.

Linkages with other water systems

AF21 - Karoo Sandstone Aquifer

The predominant source of recharge is through precipitation over the aquifer area. The main discharge mechanism is through springs that feed the River base flow and the Ruvuma River acts as the base level in the Karoo aquifer where the water table coincides with the valley bottom and the aquifer discharges to the river.

Environmental aspects
Within Tanzania the water is generally of a good quality. Some pollution within the superficial layers has been observed but the extent has not been specified. In Tanzania 60 % of the area consists of shallow groundwater with 80 % containing groundwater dependent ecosystems.

Socio-economic aspects
The amount of water that was abstracted from the aquifer was not specified.

Legal and Institutional aspects
There is a ratified Transboundary Agreement with full scope. There is a dedicated Transboundary Institute with full mandate and capacity (the Ruvuma Basin Water Board). The National Institutions have a full mandate and capacity.

Emerging Issues
Cross border interference is also moderated by the river which acts in the manner of a constant head boundary that coincides with a linear groundwater sink. Other aspects that need to be considered for joint management need to be discussed between the Aquifer States.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
Lucas Chairuca	Department of Water Resources Management	Mozambique	chairuca@yahoo.com	Lead National Expert
Alloice Jackson Kaponda	Ministry of Water - United Republic of Tanzania	United Republic of Tanzania	alloicekaponda@yahoo.com	Lead National Expert
Lazaro Msaru	Ruvuma Basin	United Republic of Tanzania	lamsaru59@gmail.com	Contributing national expert

Considerations and recommendations

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

Only 1 of the 2 TBA countries has provided information. Some quantitative information was also available, that was sufficient to calculate some of the indicators on a national level. No information was provided on groundwater use and this must be followed up.

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.

AF21 - Karoo Sandstone Aquifer

Colophon

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- All other data: TWAP Groundwater (2015).

Version: May 2017

AF1 – Karoo Sedimentary Aquifer

Geography

Total area TBA (km^2): 135 000

No. countries sharing: 2

Countries sharing: Lesotho, South Africa

Population: 4 700 000

Climate Zone: Marine

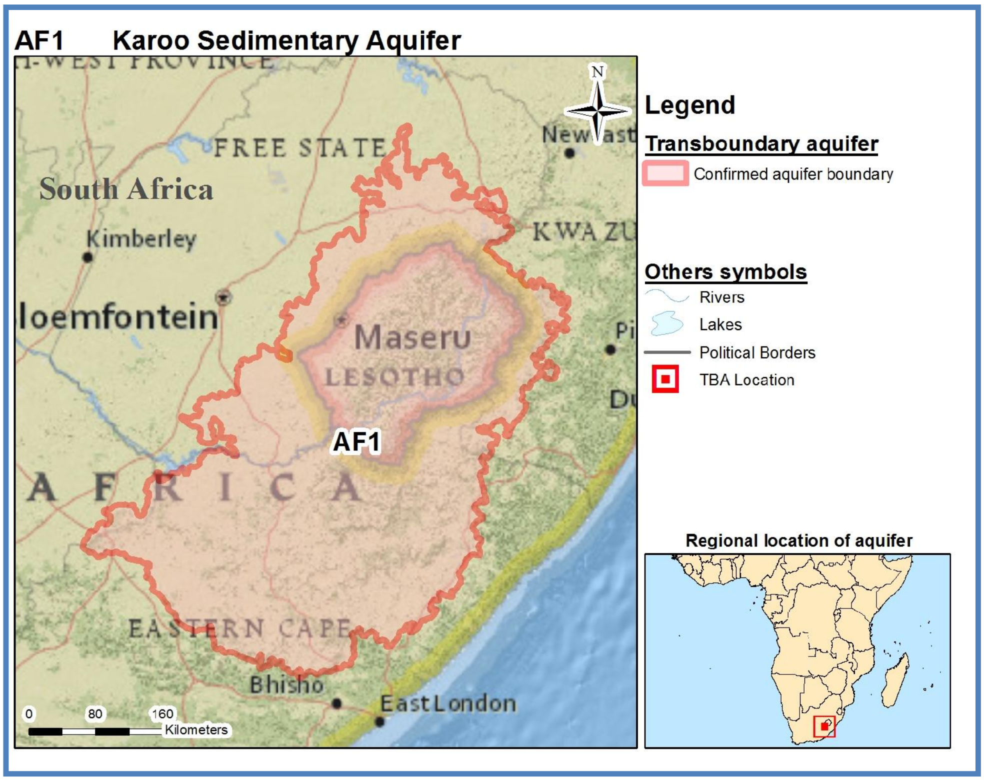
Rainfall (mm/yr): 680

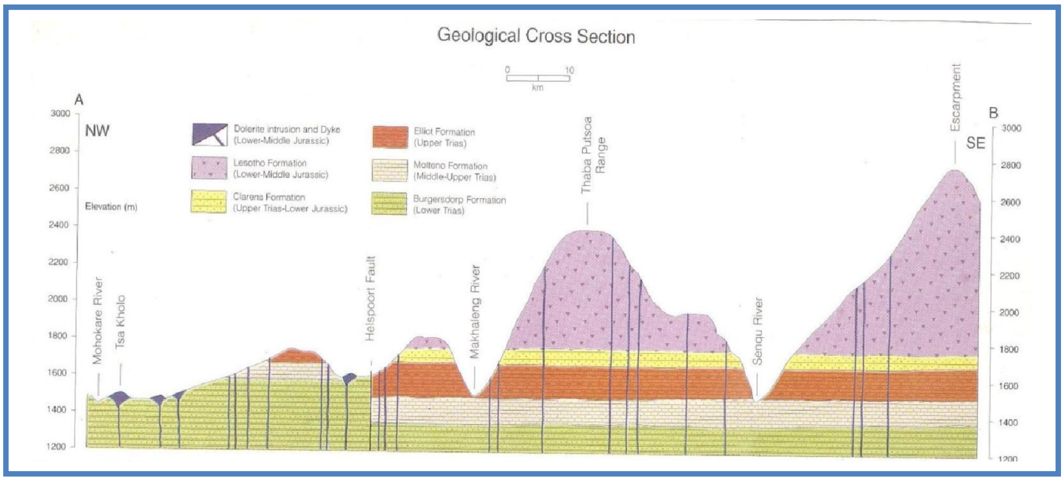
Hydrogeology

Aquifer type: Multiple layered hydraulically connected system

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

Main Lithology: Sedimentary rocks – sandstone





Geological Cross-section showing the geological setting in which the main aquifers are situated

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

AF1 – Karoo Sedimentary 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)
Lesotho	21	320	90	10			66	<5	B	D
South Africa	<1	1		<5			26	100	B	C
TBA level							**35**		**B**	**F**

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

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)				
Lesotho	16	240	-13	-21	25	49	6	0
South Africa	41	1400	-9	-14	8	14	6	13
TBA level	**35**	**930**	**-11**	**-17**	**10**	**18**	**6**	**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)
Lesotho	0	69	17	25	4	2	21
South Africa	0	29	10	14	2	1	2
TBA level	**0**	**38**	**13**	**18**	**2**	**1**	**4**

AF1 – Karoo Sedimentary Aquifer

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)
Lesotho	33	22	2250	Aquifer mostly semi-confined, but some parts unconfined	Sedimentary rocks - sandstone	High primary porosity fine/ medium sedimentary deposits	Secondary porosity: Fractures	43
South Africa	20	10	630	Aquifer mostly semi-confined, but some parts unconfined	Sedimentary rocks - sandstone	Low primary porosity inter-granular porosity	Secondary porosity: Fractures	20
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 (5 layers within Lesotho and 4 layers within South Africa) that is mostly semi-confined, but some parts are unconfined. The average rest water level is between 20m and 33m and the average depth to the top of the aquifer is 22m within Lesotho. The thickness of the aquifer system within Lesotho is 2 250m whereas in South Africa this is reduced to 630m (Lesotho is the so-called mountain kingdom, with the Drakensberg – Maluti range peaking at nearly 3500 m above sea level). Appendix 1 shows the Drakensberg basalts and Clarens sandstones (within the South African part of the TBA) which make up the high mountain peaks and the lower plateaus respectively.

Hydrogeological aspects

The predominant lithology is sedimentary sandstones that are characterized by a low to high primary porosity, with secondary porosity (fractures) and there is generally a low horizontal and vertical connectivity. The transmissivity values are low with an average value varying between 20 m^2/d (South Africa) and 43 m^2/d (Lesotho). The mean annual recharge is 650 Mm^3/annum. The size of the recharge area over the aquifer is 76 078 km^2.

Linkages with other water systems

The predominant source of recharge is through precipitation over the aquifer area. The predominant discharge mechanism is through springs within Lesotho.

Environmental aspects

Within Lesotho about 10 % of the aquifer is not suitable for human consumption; mainly in the superficial layers; due to high fluoride contents. Within South Africa there are localities with brackish water but this has not been quantified. Some pollution within the superficial layers has been observed but the extent has not been specified. No information was recorded on shallow

AF1 – Karoo Sedimentary Aquifer

groundwater or on groundwater dependent ecosystems. A number of South Africa's major rivers have their source in the high-altitude peat lands in Lesotho (see Appendix 2).

Socio-economic aspects

During 2010 the total annual groundwater abstraction from the aquifer was 25 Mm^3. The information that was supplied by Lesotho was based on a summation based on data from a database and/ or through a dedicated study. The total amount of fresh water abstraction over the aquifer area within Lesotho over the same period was 223 Mm^3.

Legal and Institutional aspects

A ratified multi-lateral River Basin Agreement with limited scope does exist through ORASECOM. Although a dedicated Transboundary River Basin Institute is in place, this does not currently include the aquifer management. The National Institutes have a full mandate but the capacity is limited within Lesotho.

Emerging Issues

Although ORASECOM does have a ratified multilateral agreement with limited scope, a committee that will focus on the groundwater requirements needs to be formed in order to make this effective.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
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Kwazikwakhe Majola	Department of Water Affairs (South Africa)	South Africa	MajolaK@dwa.gov.za	Contributing national expert
Wilhelm Ernst Bertram	Department of Water Affairs (South Africa)	South Africa	bertrame@dwa.gov.za	Lead National Expert

Considerations and recommendations

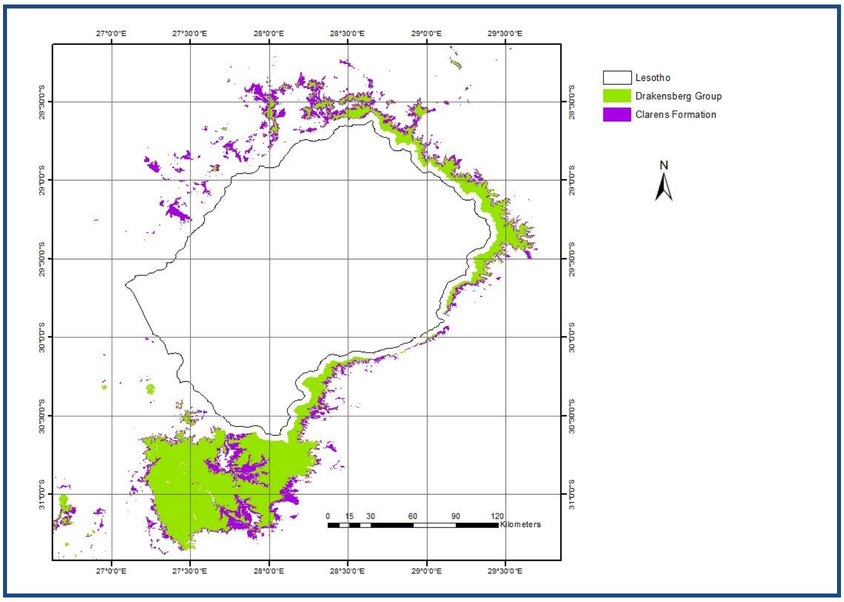
Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.

AF1 – Karoo Sedimentary Aquifer

Both TBA countries contributed to the information. Information was adequate to describe the aquifer in general terms. Some quantitative information was also made available, but this was insufficient to calculate the indicators at the TBA level.

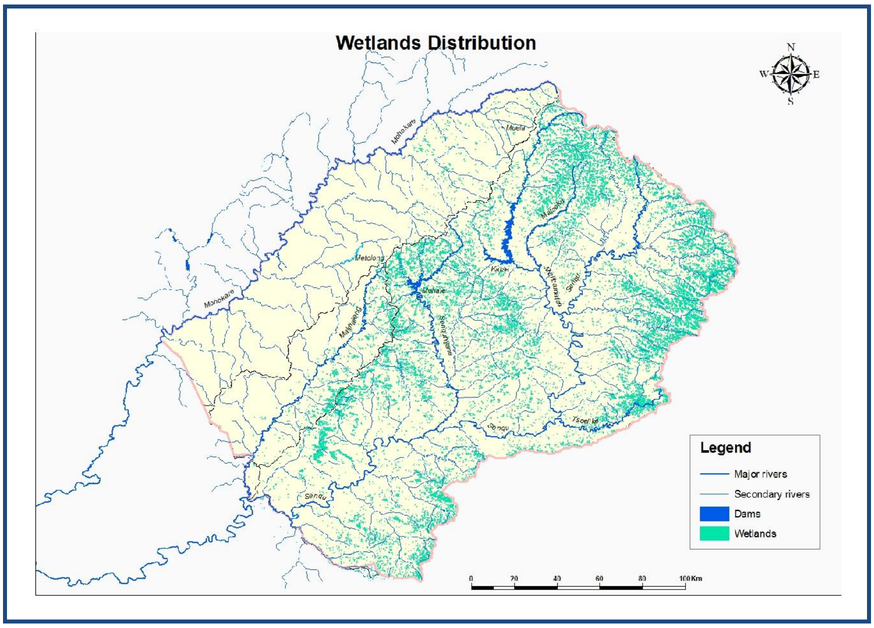
Data gaps and also differences between data from national experts (Global Inventory) and data derived from WaterGAP highlight the need for further research on transboundary aquifers.

Appendix 1: AF1



Karoo Sedimentary Aquifer: Map showing some Geological formations of the Drakensberg-Maluti range
(Please note: Information on this map has only been provided for the South African part of the aquifer)

Appendix 2: AF1



Karoo Sedimentary Aquifer: Map showing major wetlands on the mountain escarpment in Lesotho

AF1 – Karoo Sedimentary 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: September 2015

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

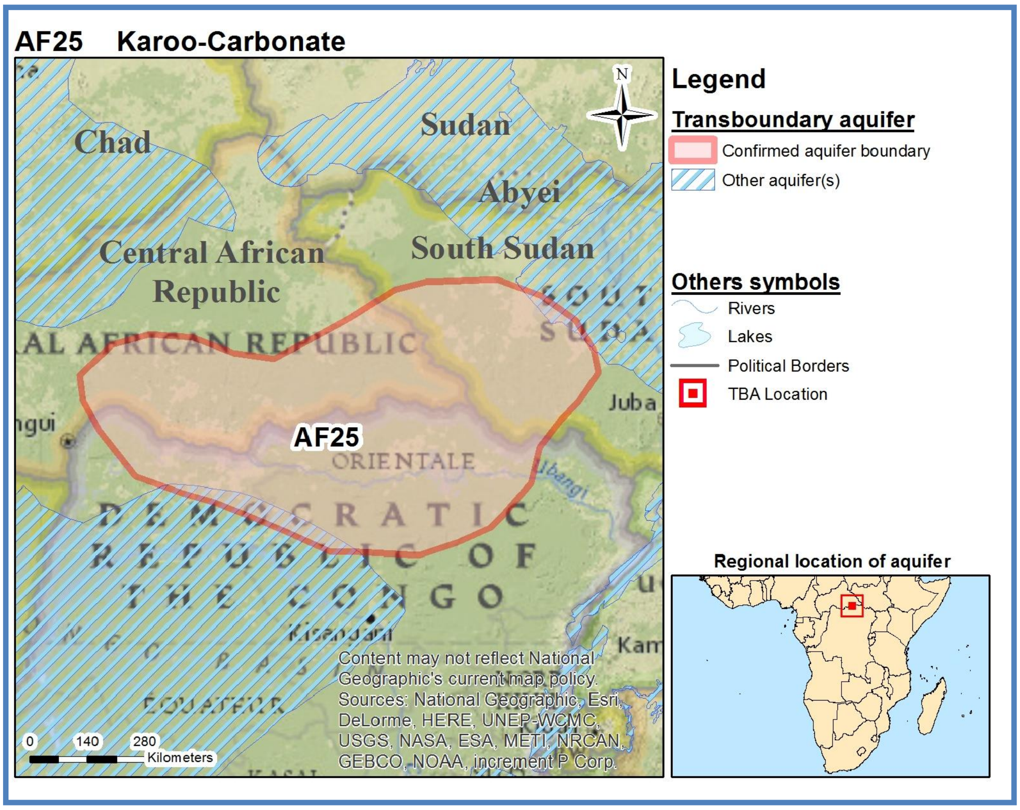
Rainfall (mm/yr): 1600

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

AF25 - KAROO-CARBONATE

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**

AF25 - KAROO-CARBONATE

	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 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

Name	Organisation	Country	E-mail	Role
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Considerations and recommendations

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

Only 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.

AF25 - KAROO-CARBONATE

Colophon

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

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- 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

AF6 - Khakhea/ Bray Dolomite

Geography

Total area TBA (km^2): 25 000

No. countries sharing: 2

Countries sharing: Botswana, South Africa

Population: 31 000

Climate Zone: Semi-arid

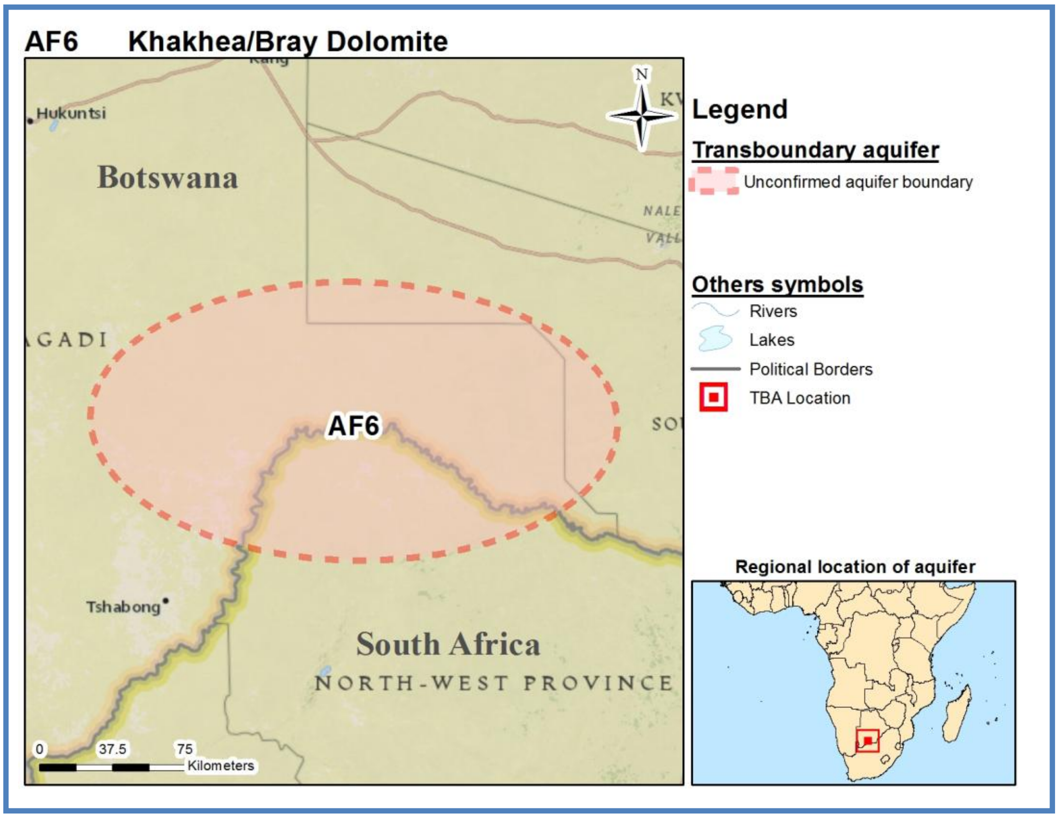
Rainfall (mm/yr): 340

Hydrogeology

Aquifer type: A multiple-layered hydraulically connected system

Degree of confinement: Mostly unconfined, but some parts confined

Main Lithology: Sedimentary rocks - dolostone



No cross-section available

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

AF6 - Khakhea/ Bray Dolomite

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)
Botswana							1			
South Africa	4	3200					1	5	D	C
TBA level							**1**			

(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)				
Botswana	9	4900	29	-12	42	40	6	67
South Africa	9	5400	59	22	13	18	6	0
TBA level	**9**	**5000**	**37**	**-7**	**34**	**35**	**6**	**67**

	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)
Botswana	0	2	27	54	1	250	54
South Africa	0	2	12	19	<1	0	0
TBA level	**0**	**2**	**24**	**47**	**1**	**61**	**35**

AF6 - Khakhea/ Bray Dolomite

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)
Botswana								
South Africa				Aquifer Mostly unconfined, but some parts confined	Sedimentary rocks - Dolostone	Low Primary porosity intergranular porosity	Secondary porosity: Dissolution	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.

Aquifer description

Aquifer geometry

The exact boundaries of this Transboundary aquifer are still unclear and further work in this regard between the countries is necessary. The aquifer is a multiple layered hydraulically connected system that is mostly unconfined, but some parts confined. Data is not available for the average thickness of the aquifer system.

Hydrogeological aspects

The predominant lithology is sedimentary rocks - dolomites that are characterized by a low primary porosity, and with secondary porosity through dissolution that has a high horizontal and vertical connectivity. The transmissivity values are relatively low with an average value on the South African side of 22 m^2/d. The total groundwater volume within the South African side of the TBA is 2.39 km^3 and this is based on expert judgment. There is a significant difference in recharge between years and recharge occurs over the entire aquifer area. In South Africa the mean annual recharge of the aquifer is 21 Mm^3/yr. During extreme events the average annual recharge rises to 35 Mm^3/yr.

Linkages with other water systems

The predominant source of recharge is through precipitation over the aquifer area. The main discharge mechanism was not recorded.

Environmental aspects

Within South Africa some superficial layers are characterized with high level of Fluoride concentrations but the data is not available to determine the percentage of the aquifer area that has been affected . No data is available on the extent of groundwater pollution, on shallow groundwater, and groundwater dependent ecosystems.

Socio-economic aspects

During 2010 the annual groundwater abstraction on the South African side was 1.4 Mm^3 and this was an estimation based on expert judgment. Data is not available to determine the total amount of fresh water abstraction over the aquifer area.

Legal and Institutional aspects

No Agreement exists, nor is one currently under preparation. The National Groundwater Institute within South Africa is fully operational.

AF6 - Khakhea/ Bray Dolomite

Emerging Issues

No Transboundary management is in place and the legal and institutional matters in this regard must be followed up.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
Wilhelm Ernst Bertram	Department of Water Affairs (South Africa)	South Africa	bertrame@dwa.gov.za	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 South Africa provided information. This information was also inconsistent and did not allow for an adequate description of some aspects such as the status of groundwater pollution and shallow groundwater. Some quantitative information did allow for the calculation of 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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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

AF6 - Khakhea/ Bray Dolomite

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

AF32 - Kilimanjaro Aquifer

Geography

Total area TBA (km^2): 13 000

No. countries sharing: 2

Countries sharing: Kenya, Tanzania

Population: 1 700 000

Climate Zone: Semi-arid

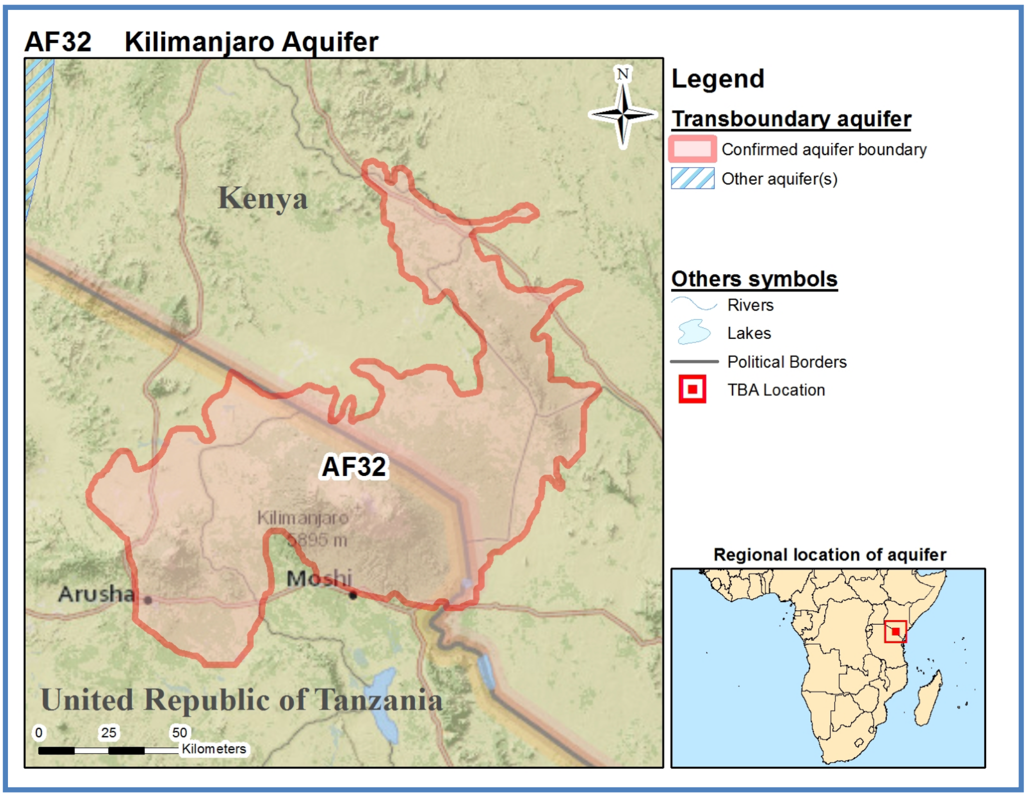
Rainfall (mm/yr): 910

Hydrogeology

Aquifer type: Multiple layered hydraulically connected system

Degree of confinement: Unconfined to semi-confined – confined in places

Main Lithology: Crystalline rocks - basalt



No Cross-section provided

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

AF32 - Kilimanjaro 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)
Kenya							50		B	C
Tanzania	140	770	90			B	180		B	A
TBA level							**130**			**F**

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

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

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

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

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

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

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

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Kenya				Whole Aquifer semi-confined	Crystalline rocks - basalt	Very high Primary porosity gravels/ pebbles	Secondary porosity: Fractures	
Tanzania	7	15	40	Aquifer Mostly unconfined, but some parts confined	Crystalline rocks - basalt	Very high Primary porosity gravels/ pebbles	Secondary porosity: Fractures	16 000
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.

AF32 - Kilimanjaro Aquifer

Aquifer description

Aquifer geometry

This is a multiple layered hydraulically connected system. Within Kenya the whole aquifer is semi-confined whereas in Tanzania it is mostly unconfined, but some parts are confined. The average depth to the water table is 7 m within the Tanzanian side. The average depth to the top of the aquifer is 15 m and the average thickness of the aquifer system is 40 m.

Hydrogeological aspects

The predominant lithology is crystalline rocks - basalt that is characterized by a very high primary porosity, secondary porosity fractures, and a high horizontal and vertical connectivity. The transmissivity values are very high with an average value of 16 000 m^2/day on the Tanzanian side. The total groundwater volume within the Tanzanian part is 440 km^3. The mean annual recharge, that is 100% through natural processes, is 1050 Mm^3/annum over an area of about 8 500 km^2 (within Tanzania).

Linkages with other water systems

The predominant source of recharge is through precipitation over the aquifer area and the predominant discharge mechanism is through springs.

Environmental aspects

Within Tanzania around 10% of the aquifer within the superficial layers is not suitable for drinking water purposes. Anthropogenic groundwater pollution is prevalent is around 10 % of the aquifer system mainly within the superficial layers. Around 5% of aquifer consists of shallow groundwater (<5 m depth) and 60 % of the area is covered by groundwater dependent ecosystems.

Socio-economic aspects

Data is not available with regard to the groundwater abstraction within the system, nor on the fresh water abstraction over the aquifer area.

Legal and Institutional aspects

From the information provided by Tanzania there is a signed memorandum of understanding with limited scope that is in place and a dedicated Transboundary Institute exists with a full mandate and full capacity (Pangani Basin Water Board). Within both countries the National Institute has a full mandate and capacity.

Emerging Issues

The signed MOU must be reviewed to see the Transboundary groundwater and management thereof is fully covered. With its very high transmissivity values this aquifer system is vulnerable to pollution and as there is a relatively high population density over the aquifer this also increases the risk for pollution. This aspect must be monitored.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
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AF32 - Kilimanjaro Aquifer

Name	Organisation	Country	E-mail	Role
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Considerations and recommendations

Most data in the tables and text above have been provided by national and regional experts (listed above) or have been derived from the global WaterGAP model. See colophon for more information, including references to data from other sources.
Although both countries did provide some information, this was insufficient to describe all of the main aspects such as the socio-economic aspects. Only some of the indicators could therefore be calculated.
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: May 2017

AF73 - MEREB AQUIFER

Geography

Total area TBA (km^2): 34 000

No. countries sharing: 2

Countries sharing: Eritrea, Ethiopia

Population: 3 400 000

Climate Zone: Semi-arid

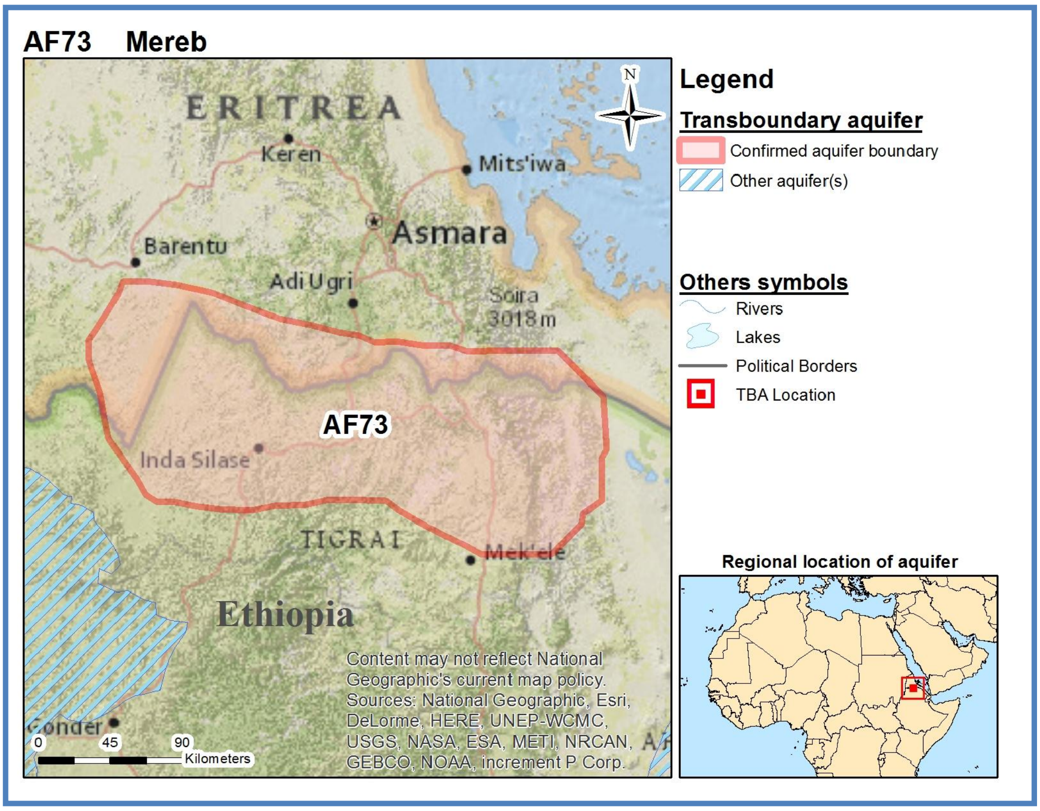
Rainfall (mm/yr): 650

Hydrogeology

Aquifer type: Multiple-layered hydraulically connected system

Degree of confinement: Unconfined

Main Lithology: Granites with some volcanics and alluvial deposits



No cross-section available

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

AF73 - MEREB 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)
Eritrea							57		D	
Ethiopia							110			
TBA level							**100**			

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

TWAP Groundwater Indicators from WaterGAP model

	Recharge, incl. recharge from irrigation (mm/yr)	Renewable groundwater per capita			Human dependency on groundwater (%)	Human dependency on groundwater for domestic water supply (%)	Human dependency on groundwater for irrigation (%)	Human dependency on groundwater for industrial water use(%)
		Current state (m^3/y/capita)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)				
Eritrea	28	440	-13	-30	53	80	12	75
Ethiopia	47	410	-20	-35	52	80	1	74
TBA level	**43**	**420**	**-20**	**-34**	**52**	**80**	**3**	**74**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Eritrea	1	65	55	110	4	4	27
Ethiopia	1	110	44	77	4	17	57
TBA level	**1**	**100**	**45**	**81**	**4**	**15**	**52**

AF73 - MEREB AQUIFER

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Eritrea			40	Whole Aquifer unconfined	Granites with some volcanics and alluvial deposit	Low Primary porosity inter-granular porosity	Secondary porosity: Fractures	
Ethiopia								
TBA level								

* Including aquitards/aquicludes

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Aquifer description

Aquifer geometry

The aquifer is multiple layered hydraulically connected system that is unconfined. The average aquifer thickness is in the order of 40 m.

Hydrogeological aspects

The predominant lithology is granites with some volcanics and alluvial deposits. They are characterized by a low primary intergranular porosity with secondary porosity: fractures. They have a low horizontal and a high vertical connectivity. No data is available on groundwater recharge that is 100% due to natural recharge processes.

Linkages with other water systems

The predominant source of recharge is through precipitation on the aquifer area and discharge is through groundwater flow into another aquifer system.

Environmental aspects

The water quality is generally good with no major natural quality issues or anthropogenic pollution has been identified.

Socio-economic aspects

The aquifer is currently being utilized on a very small scale.

Legal and Institutional aspects

No Transboundary Agreement is currently in place. No further information with regard to the institutional settings was located.

Emerging Issues

The relatively high population density on the TBA together with its low mean annual rainfall results in it being a potentially vulnerable aquifer. Annual renewable resources are probably low.

Contributors to Global Inventory

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

AF73 - MEREB 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.

The national experts of both countries must be contacted to provide more quantitative information with regard to this TBA aquifer.

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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- 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

AF19 - Sand And Gravel Aquifer

Geography

Total area TBA (km^2): 23 000

No. countries sharing: 3

Countries sharing: Malawi, Mozambique, Zambia

Population: 3 000 000

Climate Zone: Tropical Dry

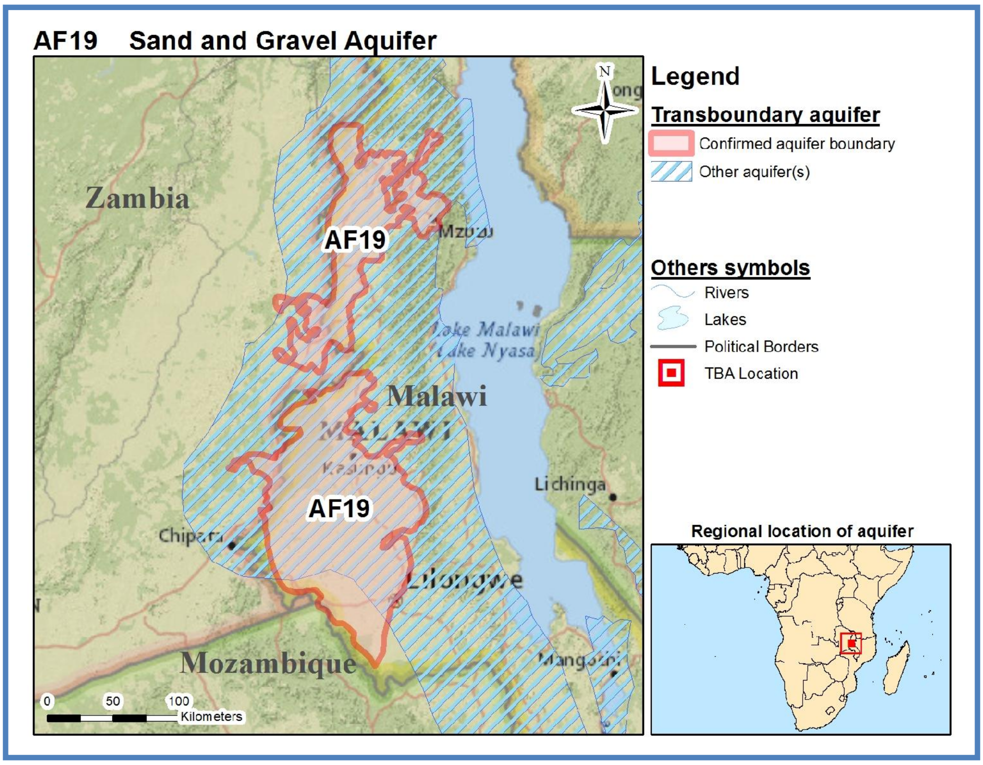
Rainfall (mm/yr): 980

Hydrogeology

Aquifer type: Single-layered system

Degree of confinement: Unconfined to semi-confined

Main Lithology: Sediments – sands and gravels, crystalline rocks – weathered basement - metamorphic



No cross-section available

AF19 - Sand And Gravel 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)
Malawi	33	230	100	100	2	B	140	35	D	D
Mozambique							150			
Zambia	11	360	95		540	B	30	50		D
TBA level							**130**			

(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)
Malawi	9	18	60	Whole aquifer semi-confined	Sedimentary rocks - Sandstone	Low Primary porosity inter-granular porosity	Secondary porosity: Weathering	<5
Mozambique								
Zambia	20	20	20		Sediment - Gravel	Low Primary porosity inter-granular porosity	Secondary porosity: Weathering	26
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.

AF19 - Sand And Gravel Aquifer

Aquifer description

Aquifer geometry

The aquifer is a single-layered system that is largely unconfined to semi-confined. The average water level varies from 9 m in Malawi to 20 m within Zambia. The average depth to the top of the aquifer varies from 18m to 20 m and the average thickness of the aquifer system varies from 20 m to 60 m (Malawi, Zambia).

Hydrogeological aspects

The predominant lithology is alluvium and weathered metamorphic basement that is characterized by a low to high primary porosity, with secondary porosity developed in the basement through fractures. It is also characterized by a low horizontal and a low to high vertical connectivity in the consolidated formations. The average transmissivity values are low and range from <5 m^2/d to 26 m^2/d, and the total groundwater volume within is 48.7 km^3 (Malawi, Zambia). The mean annual recharge, that is 100% due to natural conditions, is 20 Mm^3/yr in Zambia and this increases over 100 fold in Malawi due to the large extent of the weathered basement that forms an integral part of the system, but the total amount must be reviewed. During extreme events the total recharge increases by about 20 % above the average recharge. The predominant recharge mechanism, that is 100 % due to natural conditions, is through precipitation on the aquifer area.

Linkages with other water systems

The predominant recharge mechanism is through precipitation over the aquifer area The predominant discharge mechanism is through river base flow and through groundwater flow into surrounding aquifers.

Environmental aspects

The groundwater is generally of a good quality and <5 % of the aquifer in Malawi is not suitable for drinking purposes mainly due high salinity in the superficial layers and this increases to 5 % within Zambia. High iron concentrations make it unpalatable in places. Some anthropogenic groundwater pollution within the superficial layers has been observed and that ranges from 1 % to 5 % within Malawi and Zambia and this is mainly due to household and agricultural practices. In Malawi <5 % of the area is covered with shallow groundwater and groundwater dependent ecosystems.

Socio-economic aspects

During 2010 the annual estimated groundwater abstraction on the Malawian side was 237 Mm^3 while this was in the order of 10 Mm^3 in Zambia. The aquifer supports rural domestic supplies forming an extensive source of protected safe water. In Malawi this is the predominant source that is used and no additional amount of fresh water is used over the aquifer area.

Legal and Institutional aspects

A Transboundary Agreement with limited scope is under preparation within Zambia. No dedicated Transboundary Institute exists. Within Malawi and Zambia the National Institute has limited mandate and capacity.

Emerging Issues

There is some potential for cross-border flow to take place. The results of the assessment show that it has a high use relative to mean annual recharge that is occurring. It is furthermore relatively densely populated in places and local pollution due to sanitation may be higher than is currently anticipated.

Contributors to Global Inventory

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

AF19 - Sand And Gravel Aquifer

Name	Organisation	Country	E-mail	Role
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Dr Howard MPAMBA	Ministry of Mines Energy and Water Development	Zambia		Contributing national expert
Andrew Kangomba	Ministry of Mines Energy and Water Development	Zambia		Contributing national expert
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 3 TBA countries have provided information. Information was adequate to describe the aquifer in general terms. Quantitative information was sufficient to calculate the indicators for the 2 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

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

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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.

AF19 - Sand And Gravel Aquifer

- 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

AF24 - Weathered Basement

Geography

Total area TBA (km^2): 110 000

No. countries sharing: 4

Countries sharing: Malawi, Mozambique, Tanzania, Zambia

Population: 12 000 000

Climate Zone: Tropical Dry

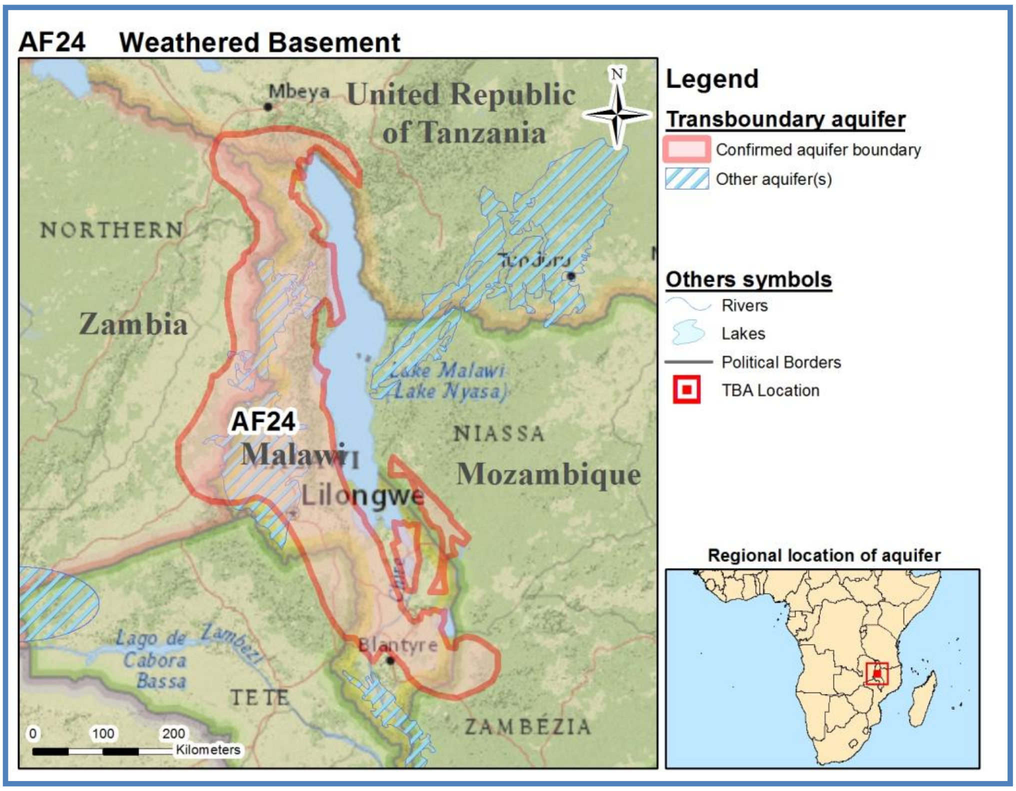
Rainfall (mm/yr): 1100

Hydrogeology

Aquifer type: Mainly single-layered system - multi-layered in the northern part

Degree of confinement: Semi-confined with some parts unconfined

Main Lithology: Crystalline - metamorphic basement rocks



No cross-section available

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

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

AF24 - Weathered Basement

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)
Malawi	1	8	100	100	0	B	140	95	D	D
Mozambique							74			
Tanzania			95				83		D	D
Zambia	1	36	95		46	B	27	50	D	D
TBA level							**110**			

(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)
Malawi	8	18	45	Whole aquifer semi-confined	Crystalline rocks - metamorphic	Low Primary porosity inter-granular porosity	Secondary porosity: Weathering	<5
Mozambique								
Tanzania	20	7	40	Aquifer Mostly confined, but some parts unconfined	Crystalline rocks - metamorphic	Low Primary porosity inter-granular porosity	Secondary porosity: Fractures	<5

AF24 - Weathered Basement

	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)
Zambia	19	20	30	Whole aquifer semi-confined	Crystalline rocks - metamorphic	Low Primary porosity inter-granular porosity	Secondary porosity: Weathering	6
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 weathered basement is extensive throughout Malawi and it extends underneath the Sand and Gravel Aquifer. It is generally a single-layered system although in Tanzania it is seen as a multi 3-layered system that is hydraulically connected. The aquifer is generally semi-confined with some parts being unconfined. The average depth to the rest water level varies from 8 m to 20 m (Malawi, Tanzania). The average depth to the top of the aquifer varies from 7 m to 20 m (Tanzania, Zambia) and the average thickness of the aquifer system varies from 30 m to 45 m within (Malawi, Zambia).

Hydrogeological aspects

The predominant lithology is crystalline - metamorphic basement rocks that are characterized by a low primary porosity, with secondary porosity fractures. It also shows a low horizontal and vertical connectivity. The transmissivity values are low with an average value ranging from <5 m^2/d to 6 m^2/d (Malawi, Tanzania). The total groundwater volume, excluding the part within Mozambique, is 183 km^3. The amount of recharge is approximately 103 Mm^3/yr over an area of about 2000 km^2 (Tanzania, Zambia). The long-term trend of the water level seems to indicate a significant decline within Zambia.

Linkages with other water systems

The predominant source of recharge is through precipitation on the aquifer area. The predominant discharge mechanism is through springs in Tanzania whereas a significant amount is discharged into Lake Malawi in Malawi, while the remainder within Zambia, and the rest of Malawi, is generally discharged into neighbouring groundwater systems.

Environmental aspects

Within Tanzania and Zambia around 5% of the aquifer is not suitable for domestic consumption mainly due to high salinity in the superficial layers while in Malawi this is reduced to <5% of the aquifer. Groundwater pollution varies from <5 % in Malawi to 5% in Tanzania and this is normally within the superficial layers. Within Zambia this is more extensive and increases to 10 % of the aquifer area. Around 10% of the system has shallow groundwater and the area is covered with around 10% by groundwater dependent ecosystems.

Socio-economic aspects

During 2010 the annual groundwater abstraction throughout the entire system was around 110 Mm^3/yr (excludes Mozambique). The total amount of fresh water abstraction is 78 Mm^3/yr within Malawi.

AF24 - Weathered Basement

Legal and Institutional aspects
There is no Transboundary Agreement currently in place. The National Institutes have a full mandate and capacity in Tanzania but these are limited within Malawi and Zambia.

Emerging Issues
From the assessment there seems to be a high use relative to the mean annual recharge that is occurring and the abstraction use is high. It may be showing signs of stress in places and this must be further assessed.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
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Dr Howard MPAMBA	Ministry of Mines Energy and Water Development	Zambia		Contributing national expert
Andrew Kangomba	Ministry of Mines Energy and Water Development	Zambia		Contributing national expert
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 3 of the 4 TBA countries have provided information. Information from 2 of the countries (Malawi, Zambia) was sufficient to calculate most of the indicators on a national level. The technical information must still be provided by Mozambique through the lead national expert.

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.

AF24 - Weathered Basement

Colophon

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

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- All other data: TWAP Groundwater (2015).

Version: 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

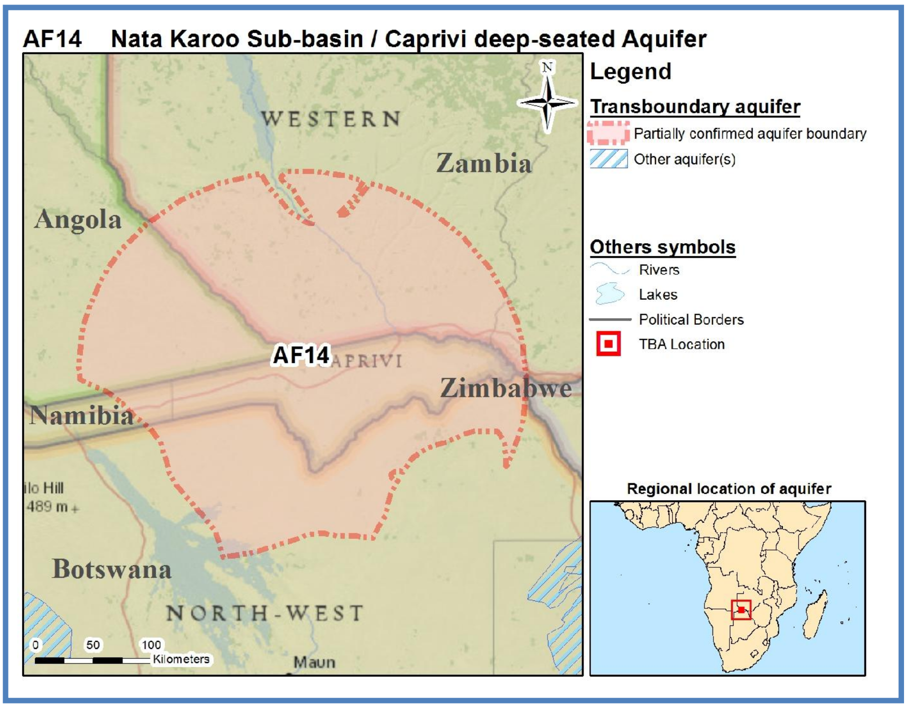
Rainfall (mm/yr): 630

Hydrogeology

Aquifer type: Single to multi-layered aquifer

Degree of confinement: Mainly unconfined – confined in places

Main Lithology: Sediments - sands and sedimentary rocks - sandstone



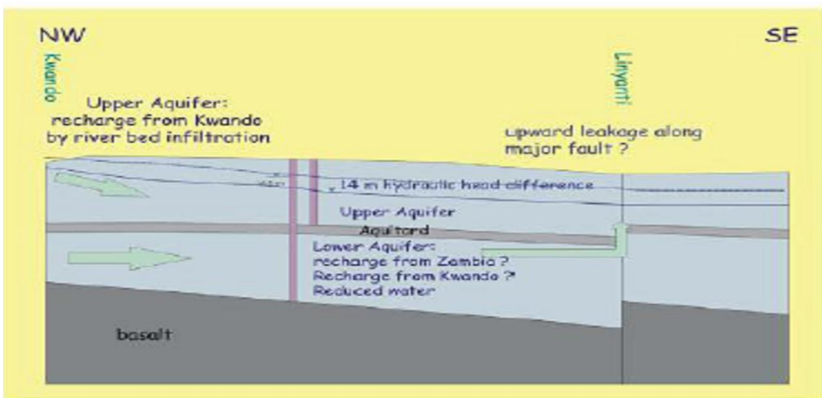


Figure 41: Schematic Concept showing the Structure of the Aquifer System in the Eastern Caprivi

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

Name	Organisation	Country	E-mail	Role
Cheikh Becaye Gaye	Université Cheikh Anta Diop	Senegal	cheikhbecayegaye@gmail.com	Regional coordinator
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Henry Beukes	Ministry of Agriculture, Water and Forestry	Namibia	henryb@mawf.gov.na	Contributing national expert
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Beatrice Kanyamula Pole	Ministry of Mines Energy and Water Development	Zambia		Contributing national expert

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

Name	Organisation	Country	E-mail	Role
Dr Howard MPAMBA	Ministry of Mines Energy and Water Development	Zambia		Contributing national expert
Andrew Kangomba	Ministry of Mines Energy and Water Development	Zambia	kangomba@yahoo.com	Contributing national expert
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

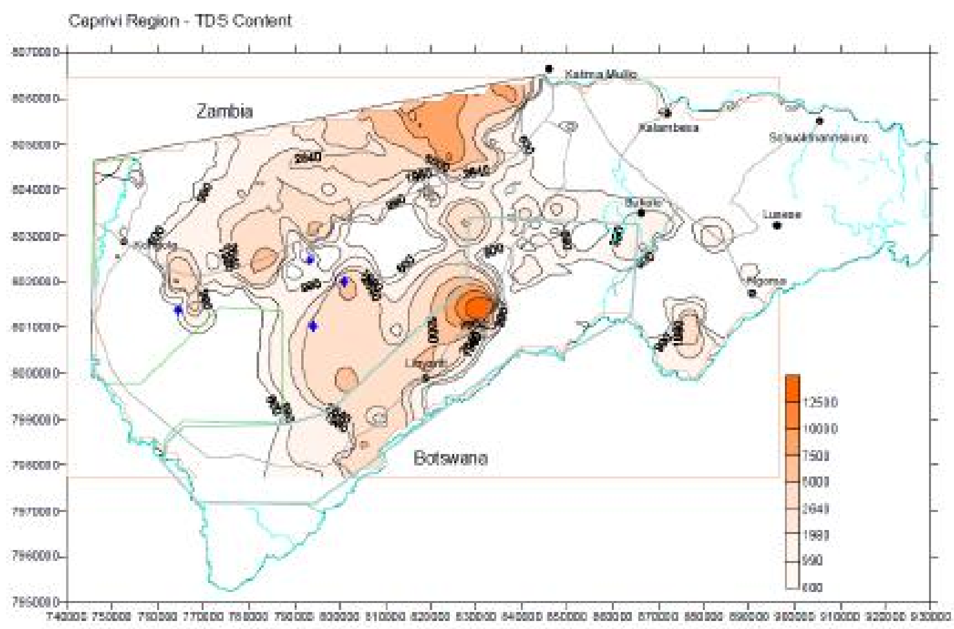

Figure 38: Distribution of Total Dissolved Solids (TDS; in mg/l) in the Upper Aquifer
(grey line: HEM survey area; blue symbols: new DWA-BGR boreholes)

Groundwater salinity contours within the Namibia side

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

Colophon

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- All other data: TWAP Groundwater (2015).

Version: September 2015

AF4 - Rhyolite-Breccia Aquifer

Geography

Total area TBA (km^2): 4 100

No. countries sharing: 3

Countries sharing: Mozambique, South Africa, Swaziland

Population: 330 000

Climate Zone: Tropical Dry

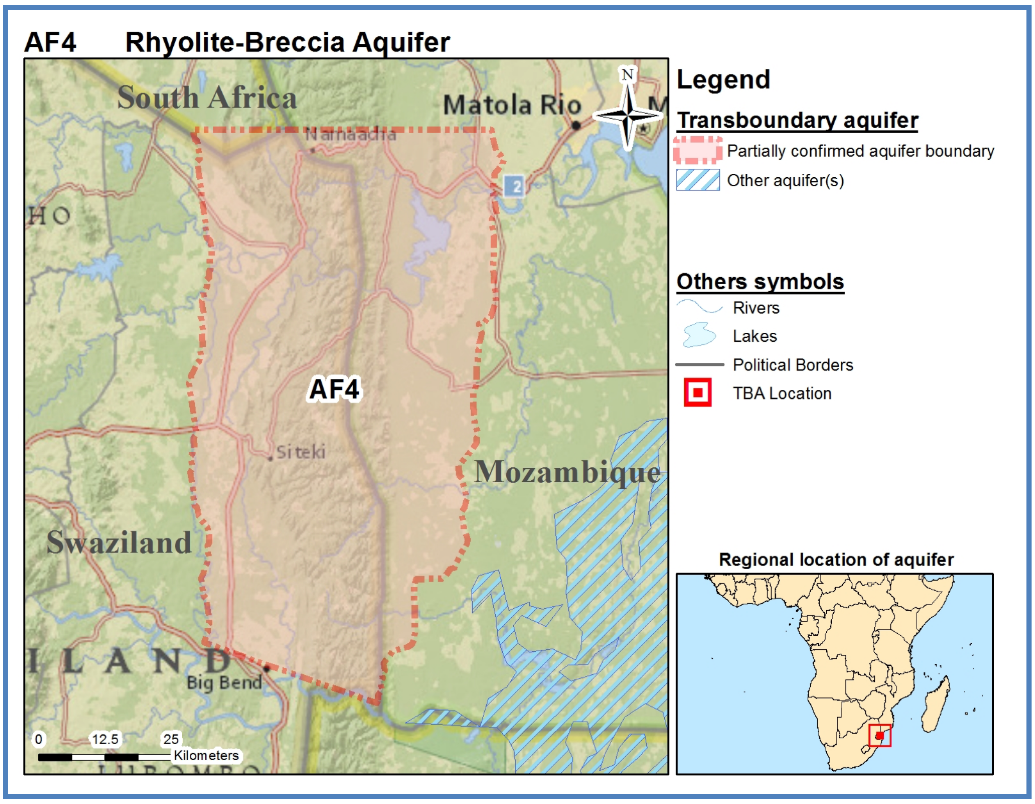
Rainfall (mm/yr): 690

Hydrogeology

Aquifer type: Multiple-layered hydraulically connected system

Degree of confinement: Mostly confined

Main Lithology: Crystalline basalts and rhyolites



No Cross-section provided

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

AF4 - Rhyolite-Breccia 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)	Transbounday legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Mozambique							160			
South Africa							67			
Swaziland	6	203	30	5	19		29	100	D	C
TBA level							**76**			

(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)
Mozambique								
South Africa								
Swaziland	9	17	94	Whole aquifer confined	Crystalline rocks - Rhyolites	Low primary porosity intergranular porosity	Secondary porosity: Fractures	<5
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.

AF4 - Rhyolite-Breccia Aquifer

Aquifer description

Aquifer geometry

The aquifer is a multi-layered system that is mostly confined. The average depth of the rest water level within Swaziland is 9 m. The average depth to the top of the aquifer within Swaziland is 17 m and the aquifer system has an average thickness of 94m.

Hydrogeological aspects

The dominant lithology is crystalline basalts and rhyolites that are characterized by a low primary porosity, with secondary porosity fractures that generally have a low horizontal and vertical connectivity. The transmissivity values are low with an average value on the Swaziland side of <5 m^2/d. The total groundwater volume within Swaziland is 10km^3. There is a significant difference in the volume of recharge events and the mean annual recharge within Swaziland is 14 Mm^3/yr over an area of about 810 km^2, and the annual recharge rises to 35 Mm^3/yr during extreme recharge events. The long-term trend of the water level shows signs of groundwater depletion and this has been estimated at 0.045 km^3/y.

Linkages with other water systems

The predominant source of recharge is through precipitation over the aquifer area although uncertainties exist as to how much comes from other sources. Within Swaziland the predominant discharge mechanism is through river base flow.

Environmental aspects

Within Swaziland around 70% of the aquifer is not suitable for human consumption mainly due to high salinity and fluorides. Some pollution is taking place over a significant part of the aquifer but the data is not available to determine the percentage of the aquifer area that has been affected (Swaziland). The data is not available for the amount of shallow groundwater but about 80% of the area within Swaziland is covered by groundwater dependent ecosystems.

Socio-economic aspects

During 2010 the annual groundwater abstraction on the Swaziland side was 14 Mm^3, and this was mainly used for domestic purposes (based on the summation of data from a database and/ or on a dedicated study). The mean annual fresh water abstraction from the aquifer area within Swaziland was 250 Mm^3 (based on an estimate from expert judgment).

Legal and Institutional aspects

There is no Transboundary Legal Agreement or Transboundary Institute in place. The National Institute within Swaziland has full capacity and a full mandate.

Priority Issues and Hotspots

The adequate understanding of recharge mechanism and amounts must be further investigated and the water quality deterioration must also receive attention. It appears to be a stressed system – renewable resources seem to be limited. Its groundwater abstraction already represents a significant part relative to the mean annual groundwater recharge, and there are indications of groundwater depletion. Furthermore, significant pollution is occurring from sources indicating a high level of urbanization/ industrialization. The impacts of irrigation through farming on the water quality should also be investigated.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
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AF4 - Rhyolite-Breccia Aquifer

Name	Organisation	Country	E-mail	Role
Victoria Thulisile Dlamini	Ministry of Natural Resources and Energy	Swaziland	dlaminivt@yahoo.co.uk / dlaminivt@gov.sz	Contributing national expert
Obed M. Ngwenya	Ministry of Natural Resources and Energy	Swaziland	wrb-wcon@realnet.co.sz	Contributing national expert
Tom Titus Dlamini	Ministry of Natural Resources and Energy	Swaziland	dlaminitomtitus@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.

Only 1 of the 3 TBA countries has provided information. Information was adequate to describe the aquifer in general terms. Some quantitative information was also made available that was sufficient to calculate the indicators for that country (Swaziland). Information to measure groundwater depletion must be further investigated

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: May 2017

AF5 – Se Kalahari Karoo Basin / Stampriet Artesian Aquifer System

Geography

Total area TBA (km^2): 72 000

No. countries sharing: 3

Countries sharing: Botswana, Namibia, South Africa

Population: 28 000

Climate Zone: Arid

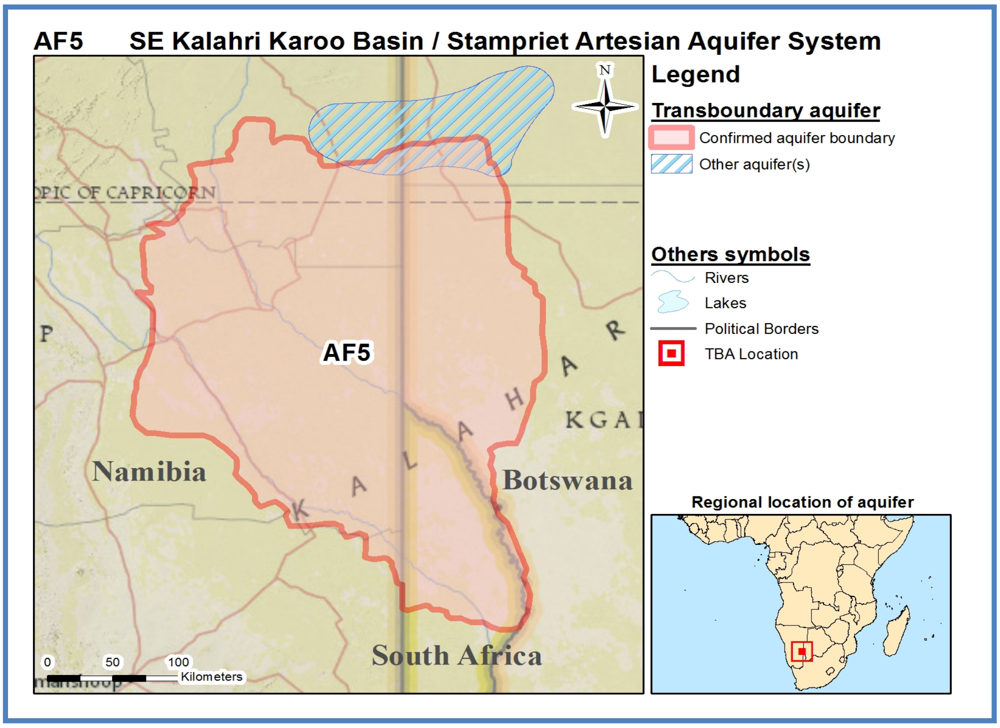
Rainfall (mm/yr): 250

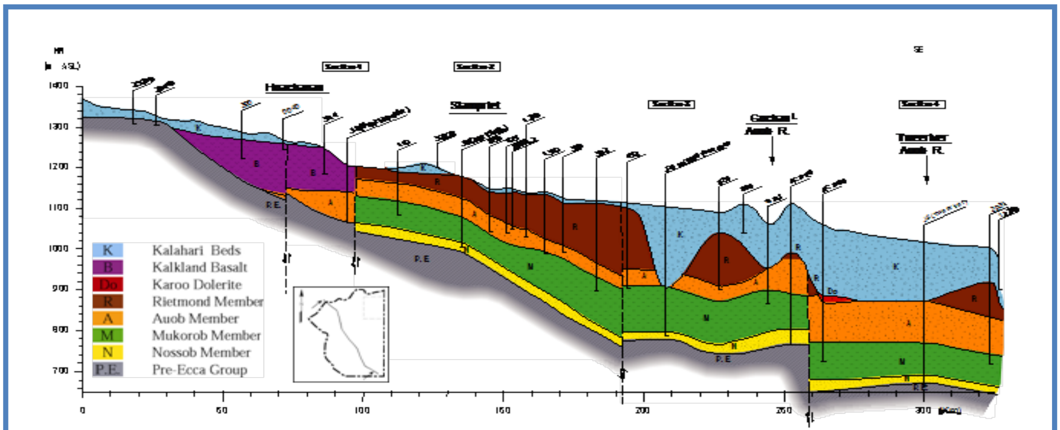
Hydrogeology

Aquifer type: Multiple-layered hydraulically connected

Degree of confinement: Mostly confined, but unconfined in the upper layer

Main Lithology: Sedimentary sandstones and shales, overlain by Kalahari sediments.





< Fig.2-1 Geological Cross Section of Study Area >

AF5 – Se Kalahari Karoo Basin / Stampriet Artesian Aquifer System

Geological Cross-section of part of the SE Kalahari Karoo Basin

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

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)
Botswana							<1			
Namibia	3	5800	80	100	0	A	1	15	B	D
South Africa							<1			
TBA level							<1			

(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)				
Botswana	3	11 000	74	570	41	41	0	0
Namibia	3	5200	54	55	69	37	96	0
South Africa	2	26 000	58	130	15	15	0	0
TBA level	**3**	**6700**	**51**	**44**	**65**	**37**	**96**	**0**

r d e p	Population density	Groundwater development stress

AF5 – Se Kalahari Karoo Basin / Stampriet Artesian Aquifer System

		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)
Botswana	0	<1	28	57	<1	-510	-1200
Namibia	0	1	33	57	2	3	-15
South Africa	0	<1	10	16	<1	19	53
TBA level	**0**	<1	**32**	**56**	**1**	**15**	**-20**

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)
Botswana								
Namibia	25	20	300	Aquifer Mostly confined, but some parts unconfined	Sedimentary rocks - Sandstone	High Primary porosity fine/ medium sedimentary deposits	Secondary porosity: Fractures	20
South Africa								
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 largely a multi 3-layered hydraulically connected system that is mostly confined but is unconfined in the upper layer (in the Kalahari). The average piezometric water level within the Namibian side is 25 m. The average depth to the top of the aquifer is 20m while the average thickness of the aquifer system is 300 m within (Namibia). Although the aquifer size is recorded as 72 000 km^2 it is much larger and probably in the order of 140 000 km^2 and the eastern boundary probably extends a lot further to the east than is currently shown but this still needs to be confirmed through further investigations.

Hydrogeological aspects

The predominant aquifer lithology is sedimentary sandstones and shales that are overlain by the Kalahari sediments. Dolerite sills and dykes are more frequent towards the central parts of the basin where the level of fracturing within the country rock is generally higher. The sandstones are characterized by a high primary porosity, and by secondary porosity fractures. There is a high horizontal connectivity while the vertical connectivity is generally low. The average transmissivity values are relatively low although the variation is relatively large. The average transmissivity is 20 m^2/d, and the total groundwater volume within the Namibian part of the Aquifer is 340 km^3. The mean annual recharge is 130 Mm^3/yr over an area of about 30 000 km^2 and this increases by around

AF5 – Se Kalahari Karoo Basin / Stampriet Artesian Aquifer System

10 fold during extreme events that occur every 20 to 30 years with a mean value of 1500 Mm^3/yr. Recharge maps are available (see Appendix 1).

Linkages with other water systems

Although the main recharge mechanism is through precipitation in the recharge areas along the NW edge of the basin, a certain amount of the recharge does also comes through major runoff from the ephemeral rivers that flow across the system. The predominant discharge mechanism is through evapo-transpiration.

Environmental aspects

Around 20 % of the aquifer within Namibia is not suitable for drinking water due to high salinity, fluoride and nitrates and this occurs towards the point of discharge of the system (see Appendix 2). There is generally little to no pollution that effects the aquifer. Within Namibia around 10 % of the area contains shallow groundwater and around 20 % of the area is covered with groundwater dependent ecosystems.

Socio-economic aspects

During 2010 the annual groundwater abstraction within Namibia was 17 Mm^3 that was mainly used for domestic and agricultural purposes and this is based on expert judgment. Groundwater is the sole source of water that is utilised within the aquifer area.

Legal and Institutional aspects

There is a signed Transboundary Groundwater Agreement under preparation with limited scope. There is a dedicated Transboundary Institute in place that is currently mainly focusing on the surface water and groundwater management still needs to be developed. The National institutes exist with limited mandate and capacity.

Emerging Issues

The recharge area is situated in Namibia and joint management of the system by the Aquifer States, concentrating on utilization and protection of the water resources within the system, should be jointly undertaken. From the assessment it shows a high use relative to the mean annual recharge that is occurring and groundwater stress seems to be increasing within the Namibia side.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
Jurgen Kirchner	Ground-Water Investigation Consultants	Namibia	g-wi@hotmail.de	Contributing national expert
Martin Penda Amukwaya	Ministry of Agriculture, Water and Forestry	Namibia	amukwayam@mawf.gov.na	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 1 of the 3 TBA countries (Namibia) has provided information. All aspects of the aquifer geometry and parameters have been addressed with consistent and realistic information and it was adequate to describe the aquifer in general terms and also sufficient to calculate the indicators for Namibia part.

AF5 – Se Kalahari Karoo Basin / Stampriet Artesian Aquifer System

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: AF5

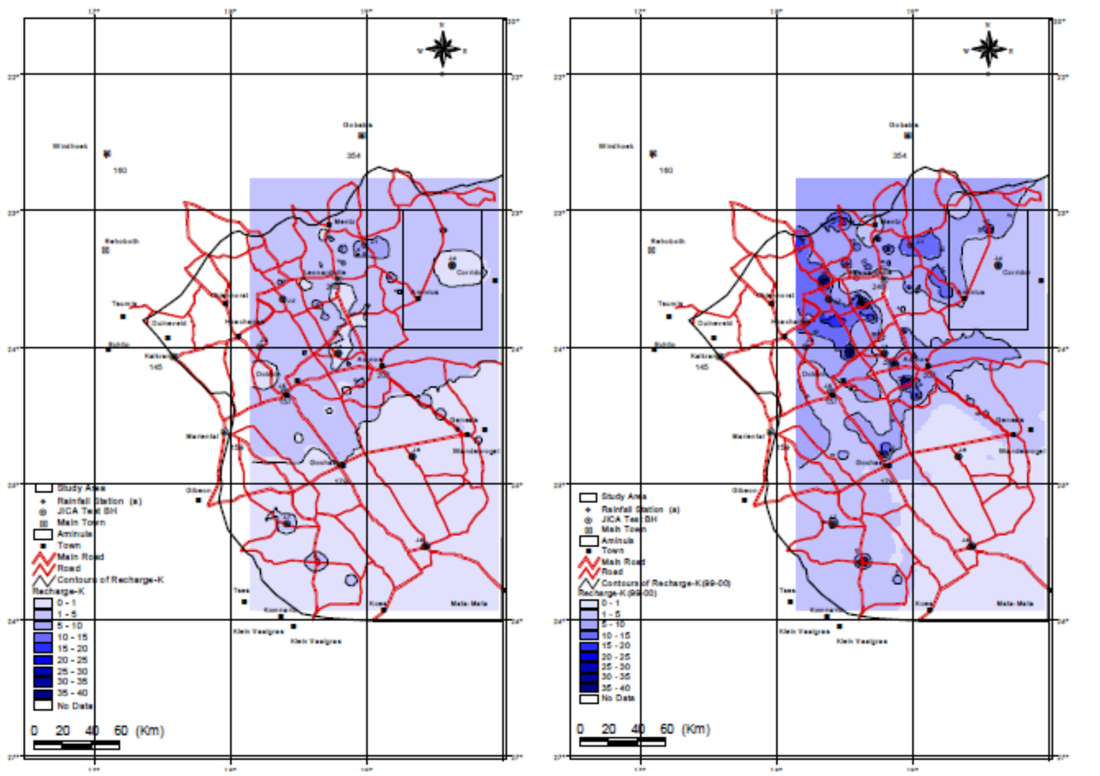


Fig. 3.10-5 Recharge of Kalahari Aquifer in Ordinary Year by CDBM Fig. 3.10-6 Recharge of Kalahari Aquifer in '99-00 Rainy Season Year by CDBM

Maps showing Seasonal recharge variation within the SE Kalahari Karoo Basin / Stampriet Artesian Aquifer System

(Please note: Information on these maps have only been provided for the Namibian part of the aquifer)

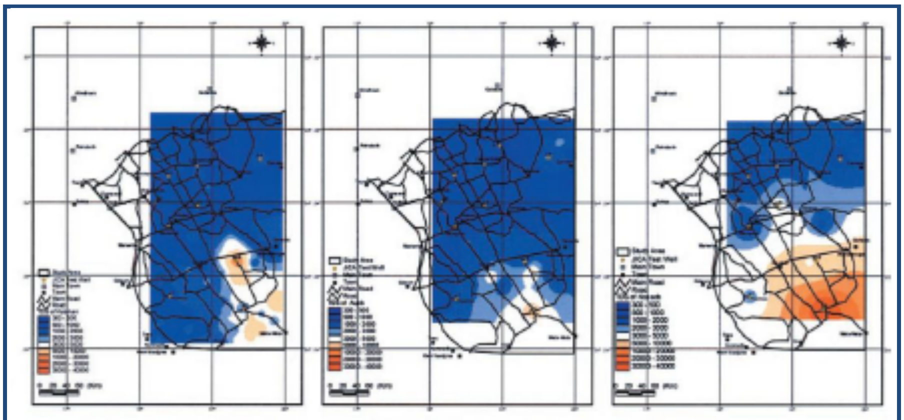


Fig. 3.8-1 TDS of Groundwater in Kalahari Aquifer Fig. 3.8-2 TDS of Groundwater in Auob Aquifer Fig. 3.8-3 TDS of Groundwater in Nossob Aquifer

AF5 – Se Kalahari Karoo Basin / Stampriet Artesian Aquifer System

Maps showing the Total Dissolved Solids (TDS) in the different aquifer layers of the SE Kalahari Karoo Basin / Stampriet Artesian Aquifer System. Water quality deteriorates towards the south-east

(Please note: Information on these maps have only been provided for the Namibian part of the 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

AF45 - Shabelle

Geography

Total area TBA (km^2): 28 000

No. countries sharing: 2

Countries sharing: Ethiopia, Somalia

Population: 280 000

Climate Zone: Arid

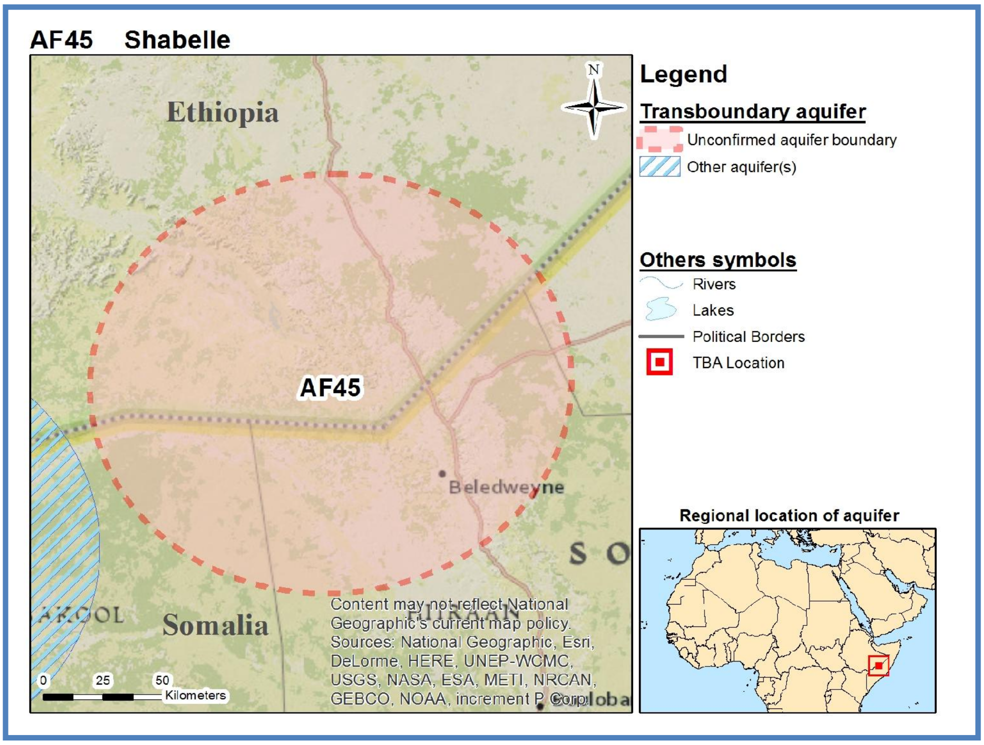
Rainfall (mm/yr): 280

Hydrogeology

Aquifer type: Single layer

Degree of confinement: Mostly unconfined, but some parts confined

Main Lithology: Sedimentary rocks – sandstones and limestones



No cross-section avalaible

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

AF45 - Shabelle

TWAP Groundwater Indicators from Global Inventory

	Recharge (mm/y) (1)	Renewable groundwater per capita (m^3/y/capita)	Natural background groundwater quality (%) (2)	Human dependency on groundwater (%)	Groundwater depletion (mm/y)	Groundwater pollution (%) (3)	Population density (Persons/km2)	Groundwater development stress (%) (4)	Transboundary legal framework (Scores) (5)	Transboundary institutional framework (Scores) (6)
Ethiopia							8			
Somalia							12			
TBA level							**10**			

(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)				
Ethiopia	80	9400	-24	-34	2	80	0	0
Somalia	150	18 000	5	18	2	80	0	0
TBA level	**120**	**14 000**	**-12**	**-15**	**2**	**80**	**0**	**0**

	Groundwater depletion (mm/y)	Population density			Groundwater development stress		
		Current state (Persons/km2)	Projection 2030 (% change to current state)	Projection 2050 (% change to current state)	Current state (%)	Projection 2030 (% point change to current state)	Projection 2050 (% point change to current state)
Ethiopia	0	8	38	65	<1	1	1
Somalia	0	9	1	-3	<1	0	0
TBA level	**0**	**9**	**20**	**32**	**<1**	**0**	**0**

AF45 - Shabelle

Key parameters table from Global Inventory

	Distance from ground surface to groundwater table (m)	Depth to top of aquifer formation (m)	Full vertical thickness of the aquifer (system)* (m)	Degree of confinement	Predominant aquifer lithology	Predominant type of porosity (or voids)	Secondary Porosity	Transmissivity (m^2/d)
Ethiopia								
Somalia	110	114	78	Aquifer Mostly unconfined, but some parts confined	Sedimentary rocks – sandstones and limestones	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

The aquifer is a multiple-layered hydraulically connected system that is mostly unconfined, but some parts confined. The average depth to the water table is 110 m, and the average depth to the top of the aquifer is 114 m while the average thickness of the aquifer system is 78 m (Somalia).

Hydrogeological aspects

The predominant lithology is sedimentary rocks - sandstones and limestones that are characterized by a high primary porosity, with secondary porosity fractures. The limestones are among the most productive aquifers due to fractures and dissolution cavities, though their productivity varies considerably depending on proximity to rivers

Linkages with other water systems

The predominant source of recharge is through perennial rivers that flow across the system into Somalia where they tend to dry up. The predominant discharge mechanism is through evapo-transpiration and through springs.

Environmental aspects

Within Somalia some of the water is unsuitable for drinking water purposes within the superficial layers. This is mainly due to elevated levels of natural and fluoride but the data is not available to determine the percentage of the aquifer area that has been affected. Some anthropogenic pollution has been detected that is sometimes over significant parts of the aquifer but the data is not available to determine the percentage of the aquifer area that has been affected.

Socio-economic aspects

No efforts to date have been made to develop the transboundary aquifer for larger-scale use such as for agricultural and industrial activities. No information with regard to the total annual abstraction from the aquifer during 2010 was made available.

Legal and Institutional aspects

No formal Transboundary Agreement is in place. The National Institute within Somalia has a limited mandate and capacity.

Emerging Issues

AF45 - Shabelle

This area is sometimes susceptible for conflict due to the nomadic nature of the people. From the assessment information, recharge seems to be very limited and annual renewable resources are low. The status of groundwater monitoring within the system must be reviewed and introduced/ upgraded as necessary.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
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Abdullahi Roble	Ministry of Energy & Water Resources	Somalia	aaroble@hotmail.com	Contributing national expert
Omar Shurie	Ministry of Energy & Water Resources	Somalia	omarshurie@gmail.com	Contributing national expert

Considerations and recommendations

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

Some quantitative information was provided by 1 of the countries. . Some quantitative information was also 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.

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

AF46 - Sudd Basin

Geography

Total area TBA (km²): 330 000

No. countries sharing: 5

Countries sharing: Ethiopia, Kenya, South Sudan, Sudan

Population: 5 000 000

Climate Zone: Semi-arid

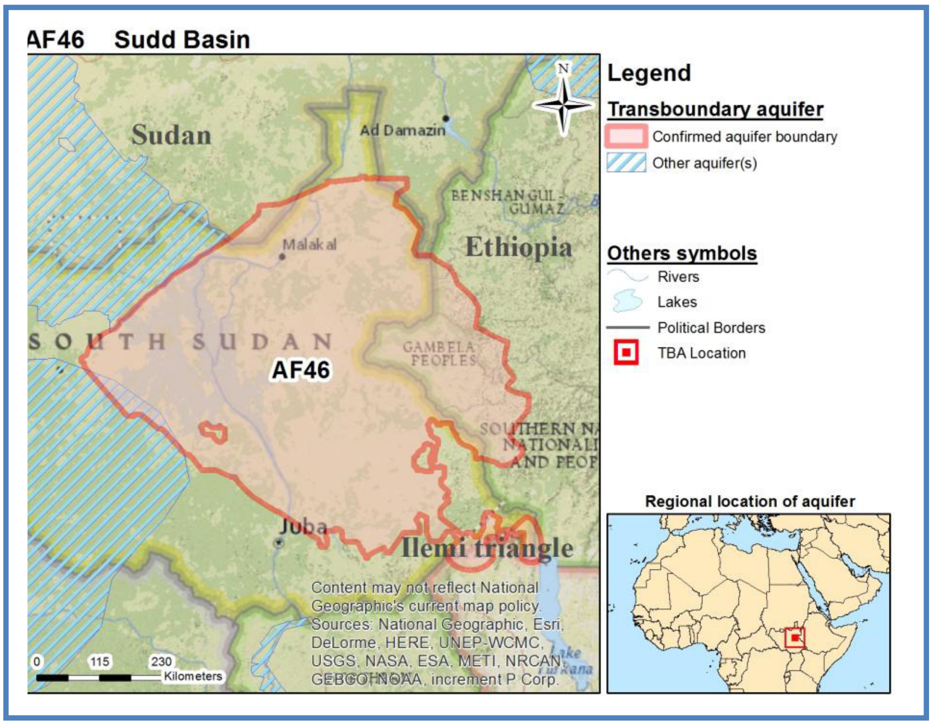
Rainfall (mm/yr): 890

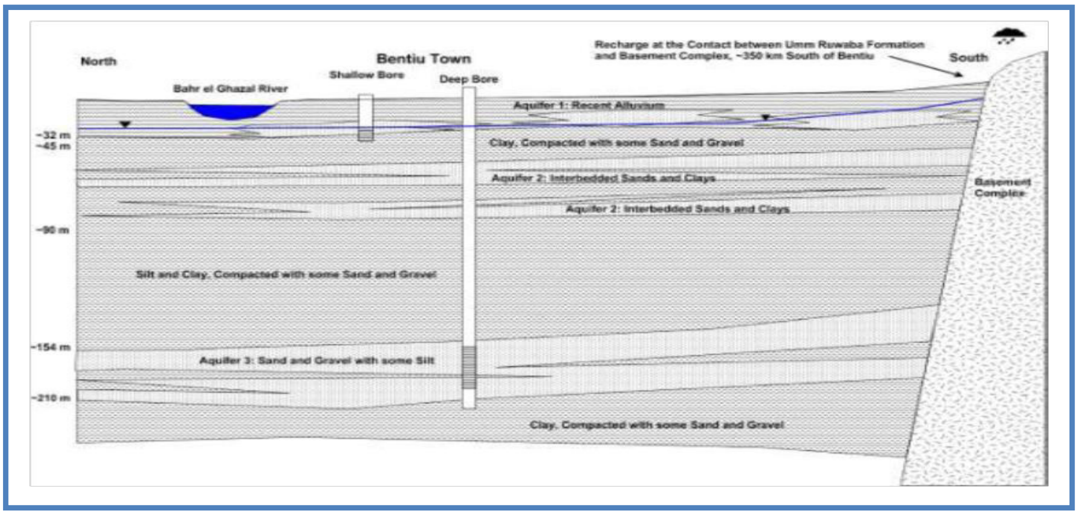
Hydrogeology

Aquifer type: Multi-layered system

Degree of confinement: Mostly confined but some parts are unconfined

Main Lithology: Sedimentary deposits and sedimentary rocks - sandstone





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

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

AF46 - Sudd 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)
Ethiopia	3	120	100	40	0	B	22	<5	C	D
Kenya							4			
South Sudan	4	290	80	<5		B	14	<5		D
Sudan							12			
Disputed land*							4			
TBA level							**15**			

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

TWAP Groundwater Indicators from WaterGAP model

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

AF46 - Sudd Basin

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

Key parameters table from Global Inventory

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

* Including aquitards/aquicludes

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

Aquifer description

Aquifer geometry

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

AF46 - Sudd Basin

Hydrogeological aspects

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

Linkages with other water systems

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

Environmental aspects

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

Socio-economic aspects

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

Legal and Institutional aspects

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

Emerging Issues

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

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
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Yusuf Al-Mooji		Lebanon	mooji46@yahoo.com	Regional coordinator
Dessie Habtemariam	Addis Ababa University	Ethiopia	dessienedaw@yahoo.com	Lead National Expert
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Charles Lopero Mario	Ministry of Electricity, Dams, Irrigation and Water Resources	South Sudan	charlesonly2002@yahoo.com , onlylopero@gmail.com	Lead National Expert

AF46 - Sudd Basin

Name	Organisation	Country	E-mail	Role
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Nyasigin Deng Makor	Ministry of Electricity, Dams, Irrigation and Water Resources	South Sudan	nyasiginpeter@ymail.com	Contributing national expert
Albert Eluzai Moni	Ministry of Electricity, Dams, Irrigation and Water Resources	South Sudan	alberteluzaimoni@gmail.com	Contributing national expert

Considerations and recommendations

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

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

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

Colophon

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

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AF46 - Sudd Basin

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- All other data: TWAP Groundwater (2015).

Version: April 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

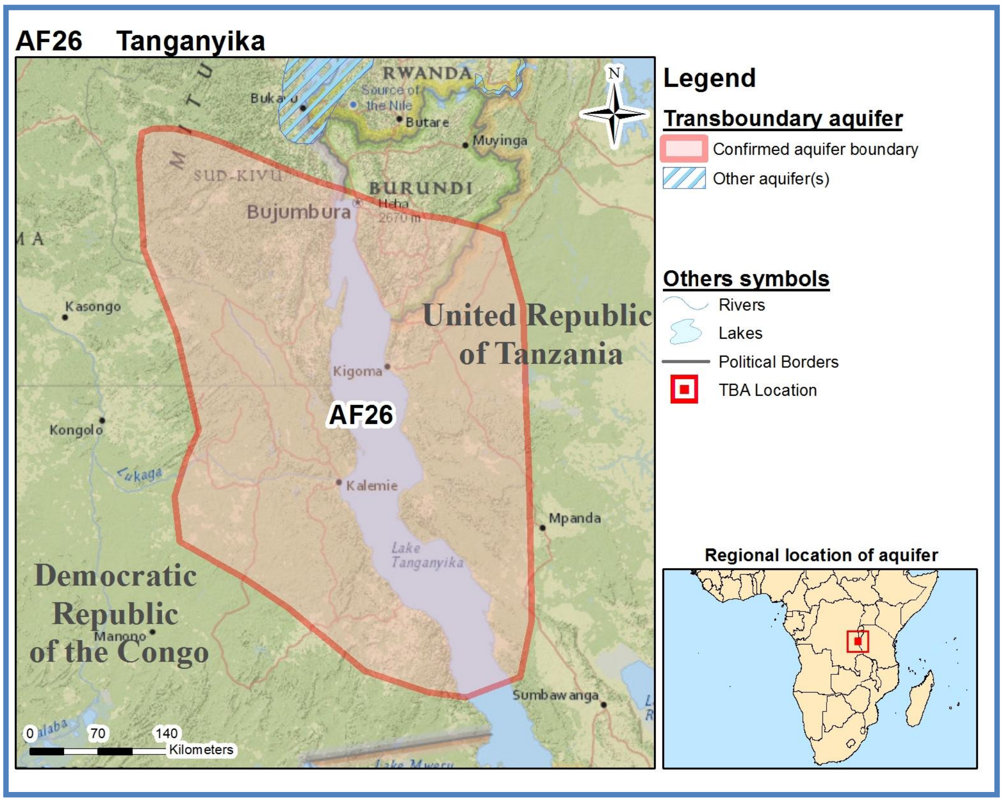
Rainfall (mm/yr): 1200

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
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
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Tamimu Said Mlimbo	Ministry of Water	United Republic of Tanzania	ltbwateroffice@yahoo.com	Contributing national expert

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

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

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

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- Rainfall: Average rainfall per TBA has been calculated based on the aquifer map and grid data for precipitation. Source precipitation data: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978. Grid data download from www.worldclim.org (2015): Data for current conditions (~1950-2000), ESRI grids, 30 arc seconds, Precipitation.
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- All other data: TWAP Groundwater (2015).

Version: September 2015

AF7 - Zeerust/ Lobatse/ Ramotswa Dolomite Basin Aquifer

Geography

Total area TBA (km^2): 300

No. countries sharing: 2

Countries sharing: Botswana, South Africa

Population: 20 000

Climate Zone: Semi-arid

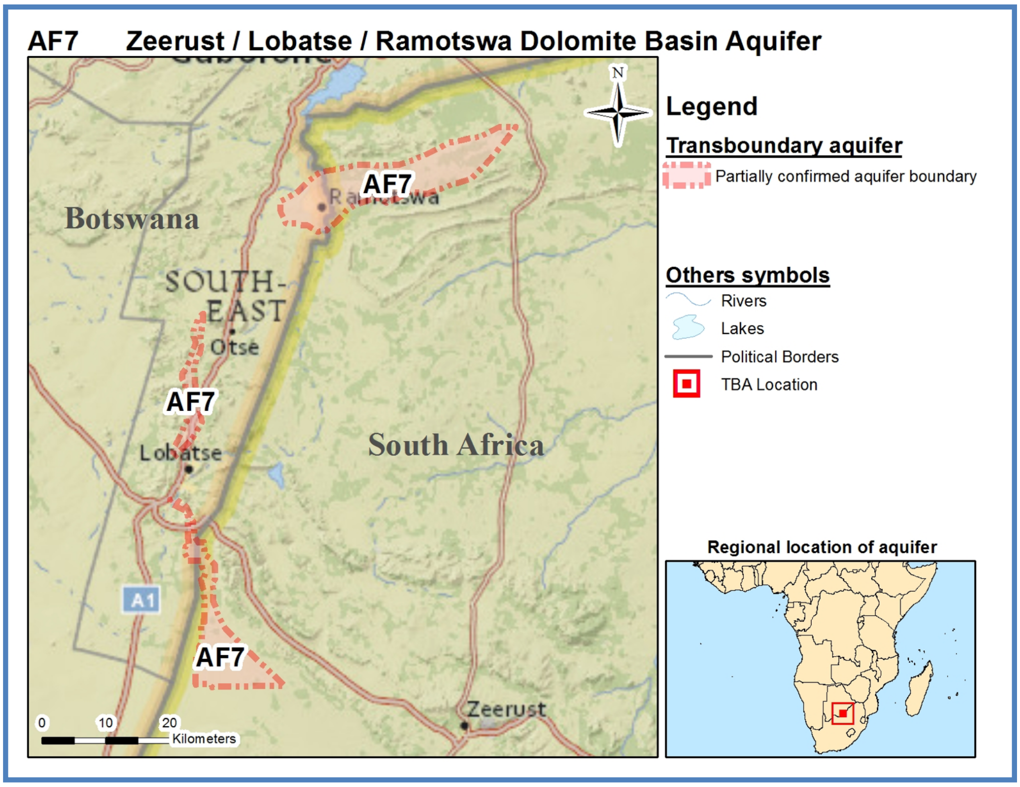
Rainfall (mm/yr): 480

Hydrogeology

Aquifer type: Multiple layered hydraulically connected system

Degree of confinement: Mostly unconfined to semi-confined

Main Lithology: Sedimentary rocks - karst sandstone



No Cross-section provided

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

AF7 - Zeerust/ Lobatse/ Ramotswa Dolomite Basin 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)
Botswana							78			
South Africa	76	1200					62		D	D
TBA level							**67**			

(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

	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)
Botswana								
South Africa	25	24	210	Semi-confined, to unconfined	Sedimentary rocks - Dolostone	Low Primary porosity intergranular porosity	Secondary porosity: Dissolution	1000
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 multiple 2-layered hydraulically connected system (South Africa) that is mostly unconfined to semi-confined. The average rest water level is 25 m and the average depth to the top of the aquifer is 24 m while the full thickness of the aquifer system is 210 m (South Africa).

AF7 - Zeerust/ Lobatse/ Ramotswa Dolomite Basin Aquifer

Hydrogeological aspects

The predominant lithology is sedimentary rocks - karst limestone that are characterized by a low primary porosity, with secondary porosity through dissolution and there is generally a high horizontal and vertical connectivity. The transmissivity values in South Africa are relatively high with an average value of 1000 m^2/d while this seems to be less within the Botswana side. The total groundwater volume within the South African side of the system is 0.87 km^3. The mean annual recharge potential is high and periodic, comprising 7.5 % of the mean annual rainfall. The mean recharge amount is 16.2 Mm^3/yr (in the South Africa part). There is a significant difference in recharge between years and during extreme recharge events this rises to 110 Mm^3/yr.

Linkages with other water systems

The predominant source of recharge is through precipitation over the aquifer area and the predominant discharge mechanism is through springs and this amounts to 4.5 Mm^3/yr within South Africa and this is based on dedicated discharge studies.

Environmental aspects

The natural water quality is generally good. In Botswana anthropogenic pollution is quite extensive in places whereas in South Africa some pollution within the superficial layers has been observed but data is not available on the extent of the percentage of the aquifer that has been affected. Within Botswana the main cause was through excessive nitrates through uncontrolled sanitation whereas in South Africa it is through households and through agricultural practices where irrigation is associated with high amounts of pesticides and fertilizers. Data is not available on shallow groundwater systems and on groundwater dependent ecosystems.

Socio-economic aspects

During 2010 the annual groundwater abstraction from the aquifer on the South African side was 40 Mm^3, which was mainly used for domestic purposes. Data is not available on the total amount of freshwater abstraction over the aquifer area.

Legal and Institutional aspects

No Transboundary Groundwater Agreement or Institute currently exists, although within the Limpopo River Basin (LIMCOM) in which part of this aquifer is situated, the Limpopo River Basin Commission does have a Multi-lateral Agreement in place that can be utilised and adopted for the Transboundary groundwater. Within South Africa the National Institute has limited mandate and capacity.

Priority Issues

The aquifer is known to be seriously polluted with nitrates on the Botswana side. It is potentially an important part of the water supply for Gaborone, the capital, of Botswana. The aquifer was abandoned on the Botswana side due to pollution, but rehabilitation is under consideration. Natural cross border flow and degradation are unlikely as groundwater flow is essentially local with valley bottom springs in the wet season. There is a minor risk of localised cross-border pollution. The LIMCOM Agreement should be reviewed as to whether groundwater management is fully covered and catered for.

Contributors to Global Inventory

Name	Organisation	Country	E-mail	Role
Greg Christelis	CHR Water Consultants	Namibia	gregchristelis@gmail.com	Regional coordinator
Wilhelm Ernst Bertram	Department of Water Affairs (South Africa)	South Africa	bertrame@dwa.gov.za	Lead National Expert

AF7 - Zeerust/ Lobatse/ Ramotswa Dolomite Basin 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 South Africa contributed to the information. Information was adequate to describe the aquifer in general terms. Some quantitative information was also available, but this was insufficient 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

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.

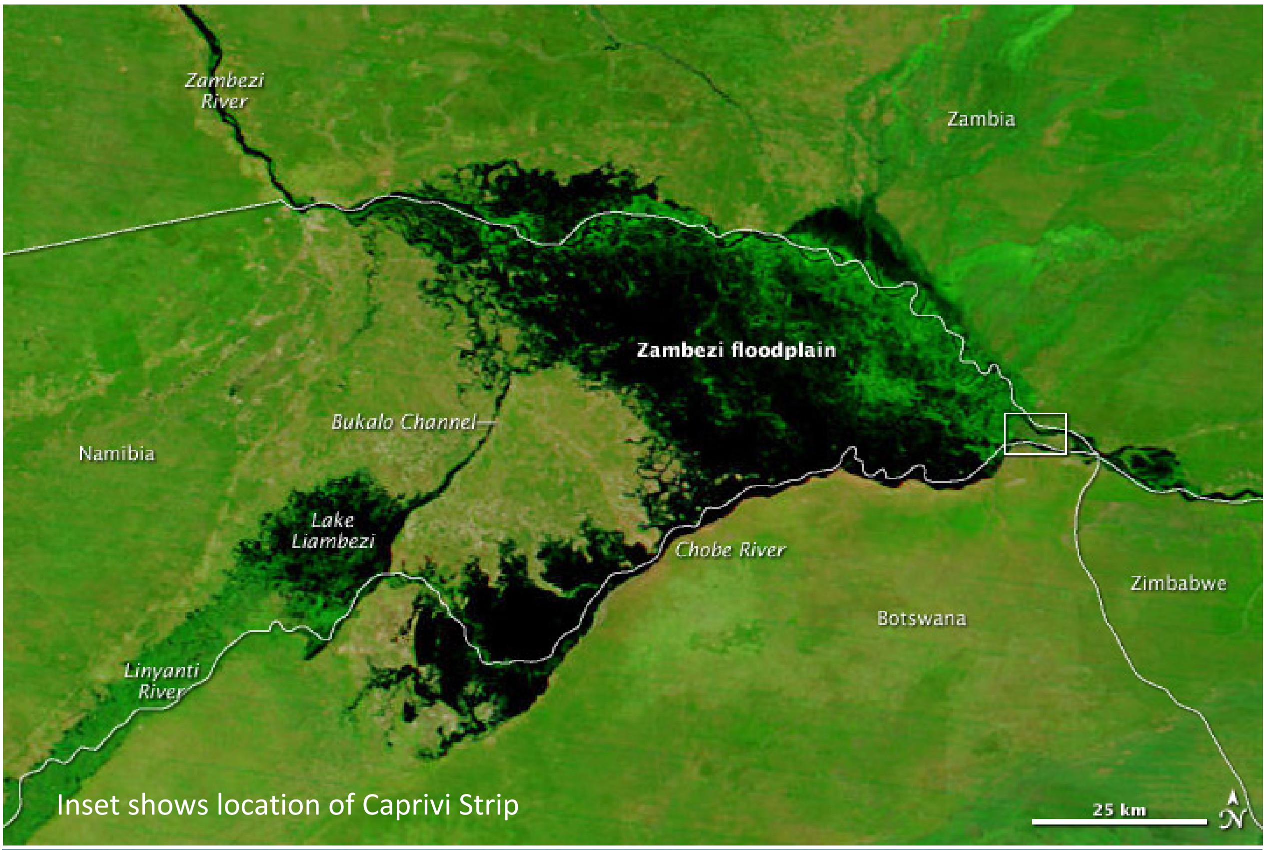
For more information on TWAP Groundwater and for more data, please have a look at the TWAP Groundwater Information Management System which is accessible via www.twap.isarm.org or www.un-igrac.org.

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



Inset shows location of Caprivi Strip

MODIS Rapid Response Team, NASA Goddard Space Flight Center

A village in the eastern Caprivi flood plains

Flythefish

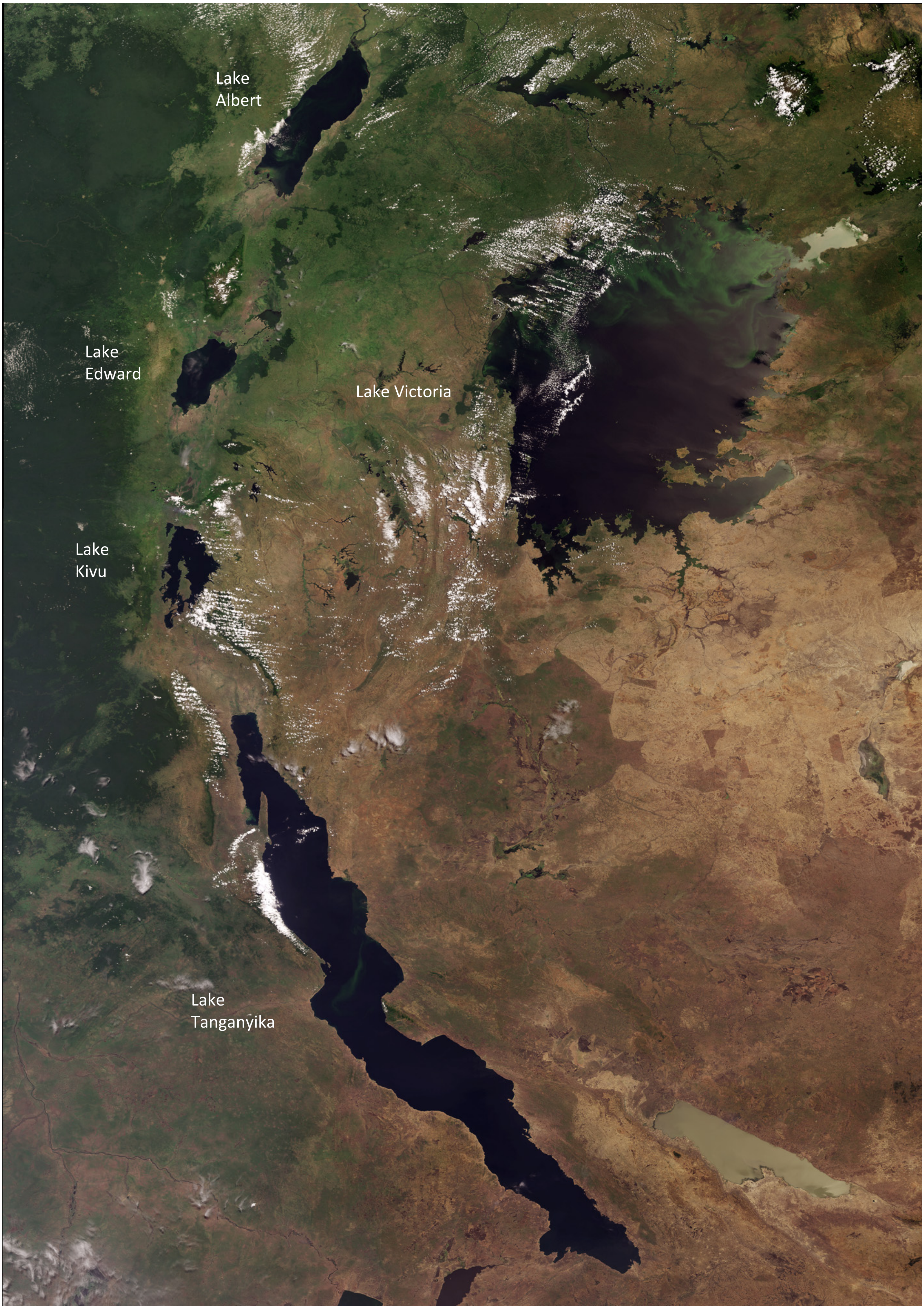
Transboundary Lakes/ Reservoirs Of Eastern & Southern Africa

1. Abbe/ Abhe
2. Albert
3. Cahora Bassa
4. Chilwa
5. Chiuta
6. Cohoha
7. Edward
8. Ihema
9. Josini/ Pongolapoort Dam
10. Kariba
11. Kivu
12. Malawi/ Nyasa
13. Mweru
14. Rweru/ Moero
15. Tanganyika
16. Turkana
17. Natron/ Magad
18. Victoria

ILEC

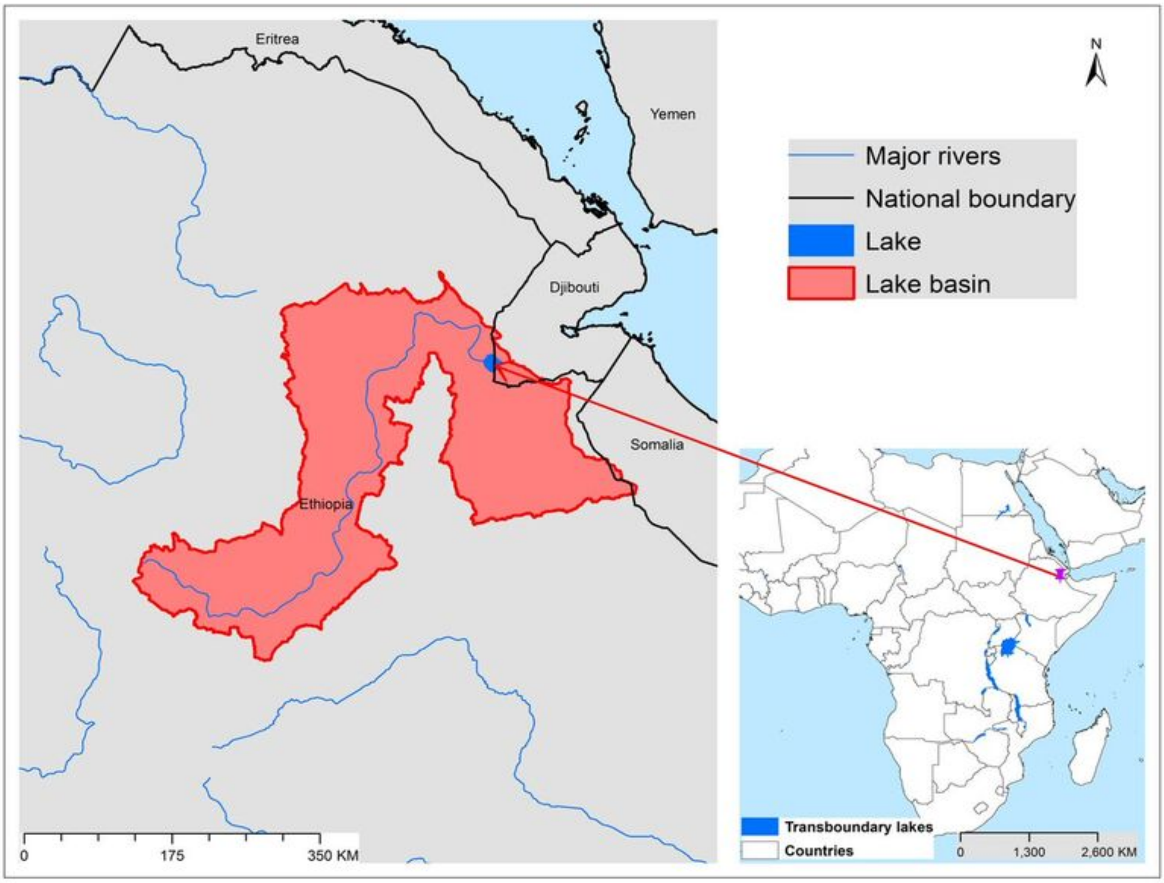
The Meadows Center for Water and the Environment
Texas State University

SHIGA UNIVERSITY


Lake
Albert
Lake
Edward
Lake Victoria
Lake
Kivu
Lake
Tanganyika

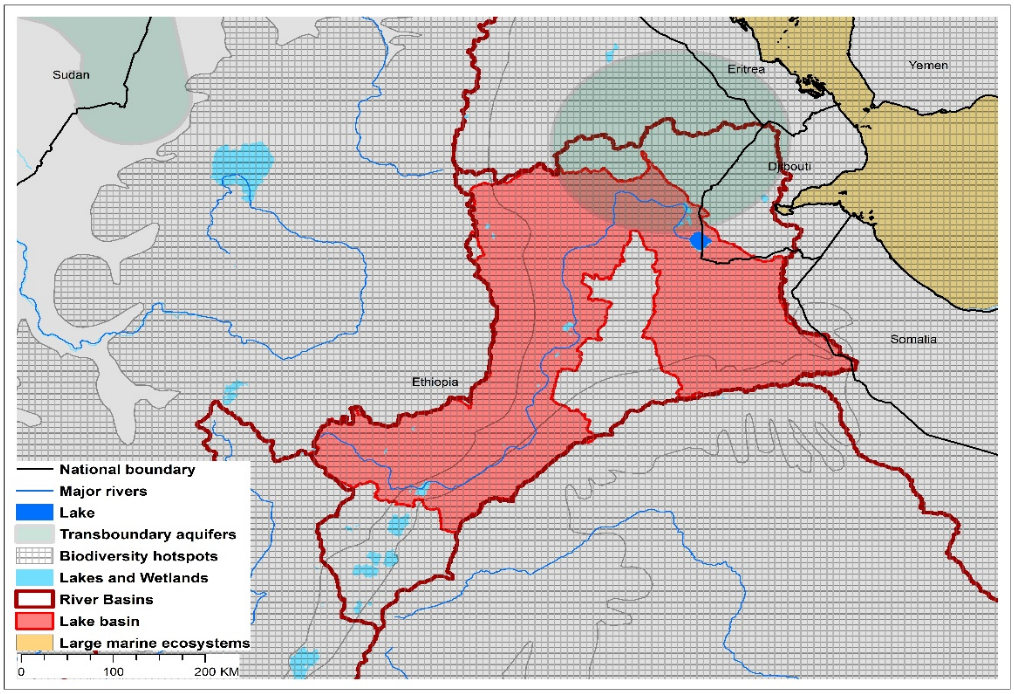
Lake Abbe/Abhe

Lake Abbe/Abhe is a saline lake in the Ethiopia and Djibouti Rift Valley highland lakes basin complex. It is a salt lake, being one of six connected lakes in the region. A dormant volcano lies on its northwest shore, and extensive salt flats on its southwestern and southern shores. It is known for its tall limestone chimneys, many venting steam. There are currently no comprehensive management plans for these lakes. Any GEF management intervention should probably consider not only Abbe/Abhe, but also the whole highland lake region, as well as the regional development programs of Ethiopia and Djibouti.

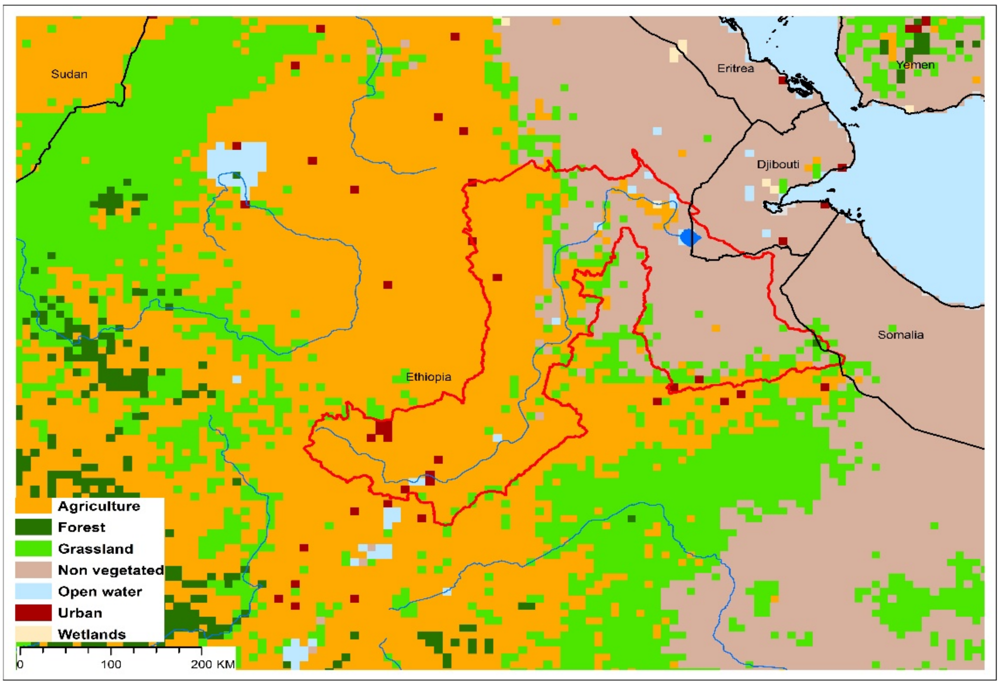


TWAP Regional Designation	Eastern & Southern Africa	Lake Basin Population (2010)	12,254,142
River Basin	Awash	Lake Basin Population Density (2010; # km^{-2})	105.3
Riparian Countries	Djibouti, Ethiopia	Average Basin Precipitation (mm yr^{-1})	629.5
Basin Area (km^2)	81,517	Shoreline Length (km)	120.1
Lake Area (km^2)	310.6	Human Development Index (HDI)	0.40
Lake Area:Lake Basin Ratio	0.003	International Treaties/Agreements Identifying Lake	No

Lake Abbe/Abhe Basin Characteristics



(a) Lake Abbe/Abhe basin and associated transboundary water systems



(b) Lake Abbe/Abhe basin land use

Lake Abbe/Abhe 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 Abbe/Abhe 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 Abbe/Abhe 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 Abbe/Abhe 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 Abbe/Abhe 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
0.93	7		0.71	7		0.40	7

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

The Reverse Biodiversity (RvBD) for Lake Abbe/Abhe, which is meant to describe its biodiversity sensitivity to basin-derived degradation, also 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 Lake Abbe/Abhe basin in a high threat rank among the priority transboundary lake basins in regard to its health, educational and economic status.

Table 2. Lake Abbe/Abhe 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
7	7	7		14	1		14	3		21	3

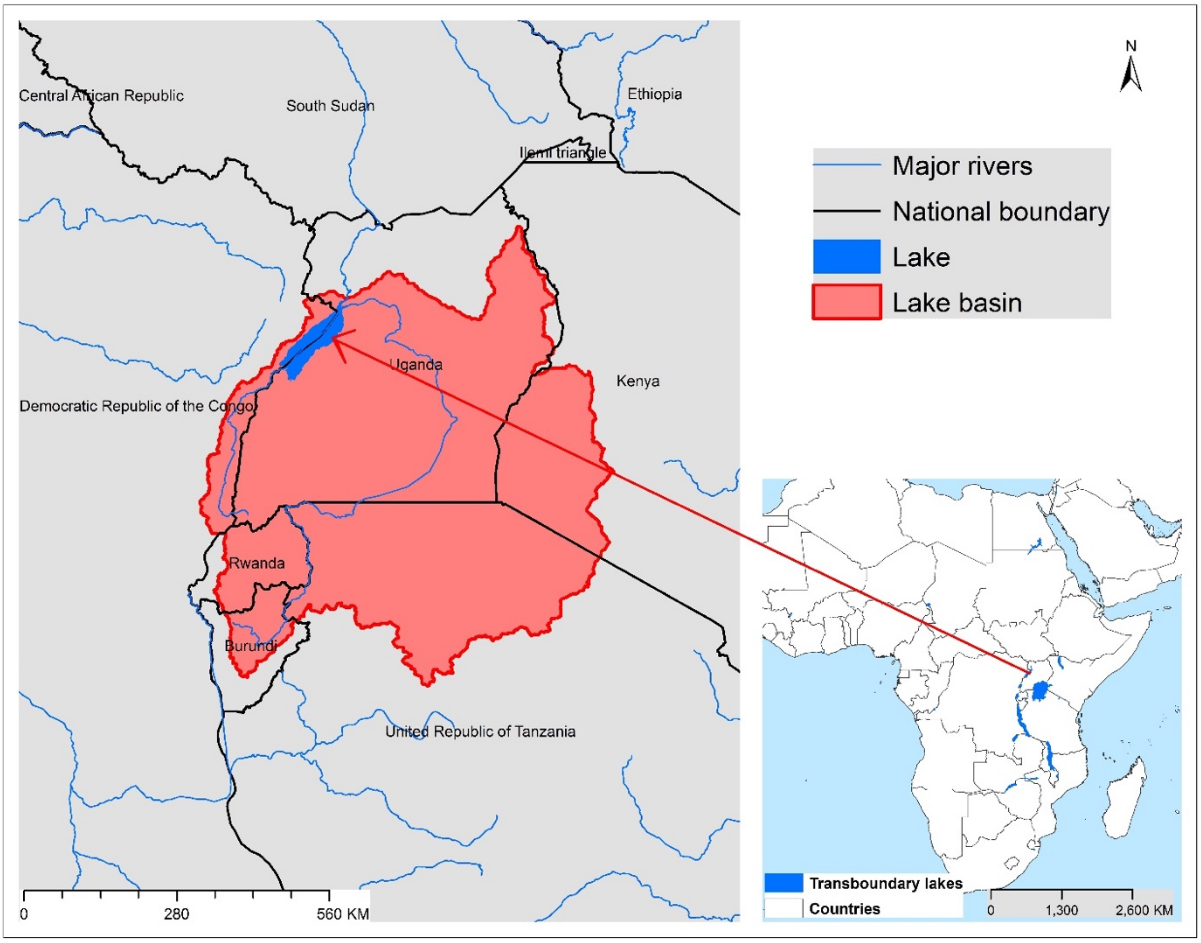
When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Abbe/Abhe in a high threat rank. The relative threat is increased when the Adj-HWS and RvBD threats are considered together. Considering all three ranking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

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

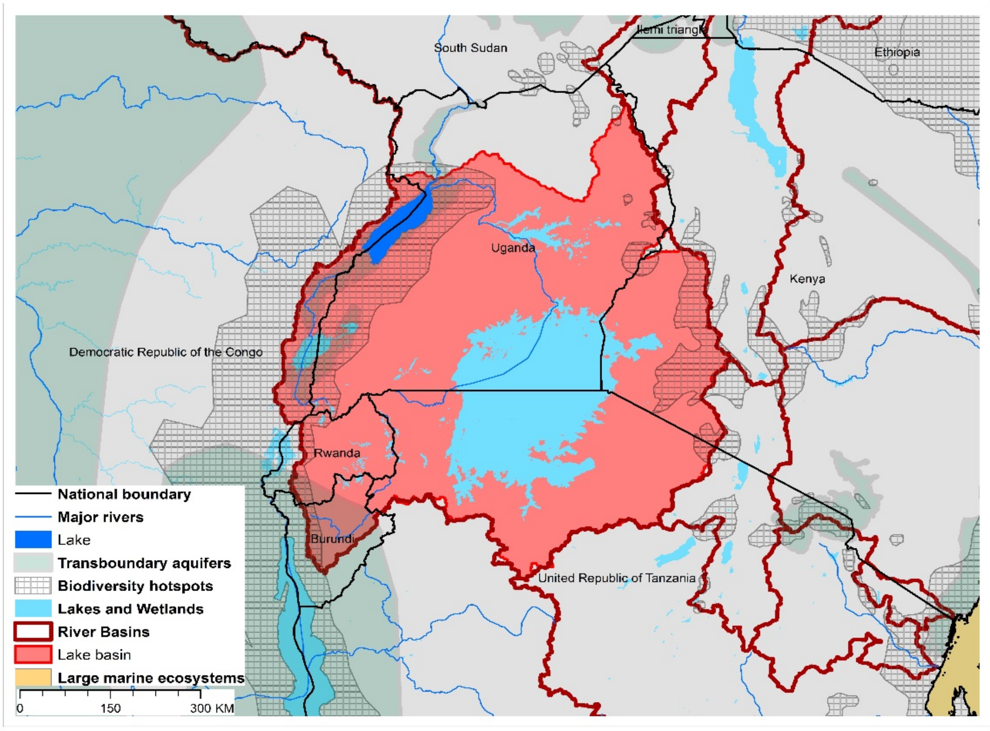
Geographic Information

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.

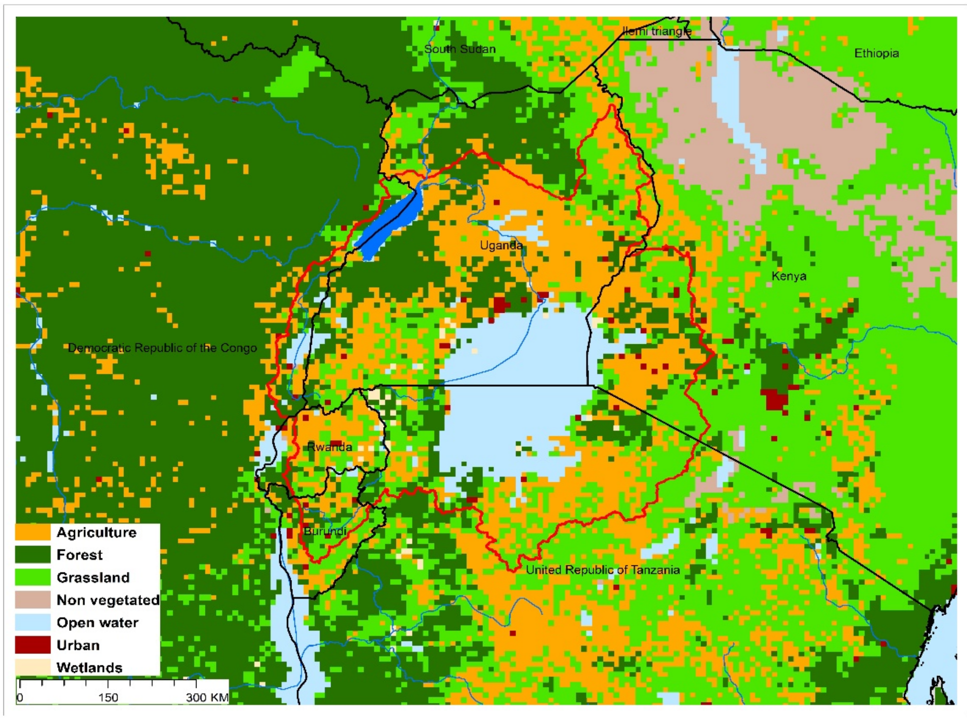


TWAP Regional Designation	Eastern & Southern Africa; Western & Middle Africa	**Lake Basin Population (2010)**	70,651,448
River Basin	Nile	**Lake Basin Population Density (2010; # km^{-2})**	186.6
Riparian Countries	Democratic Republic of Congo, Uganda	**Average Basin Precipitation (mm yr^{-1})**	1,197
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)

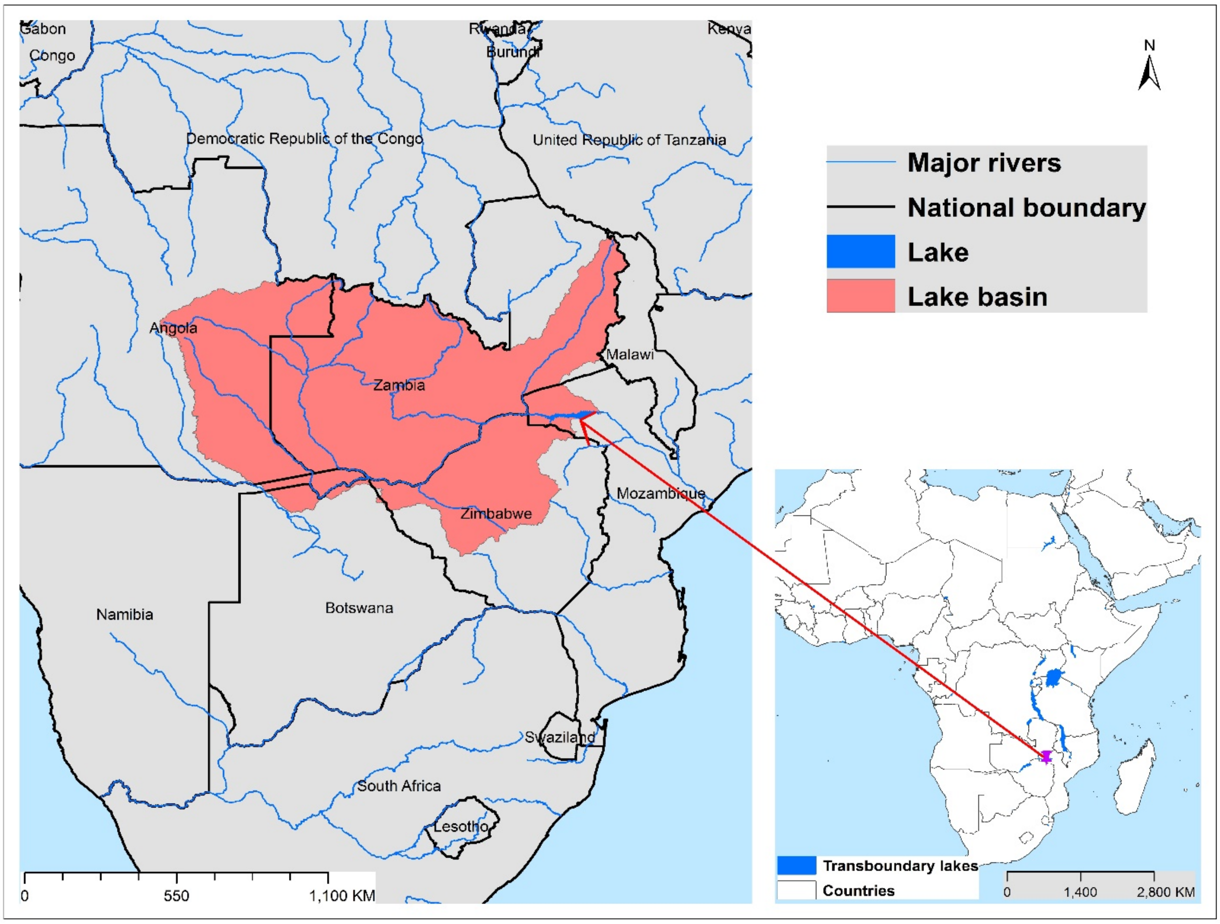
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
10	19	24		34	15		29	12		53	17

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.

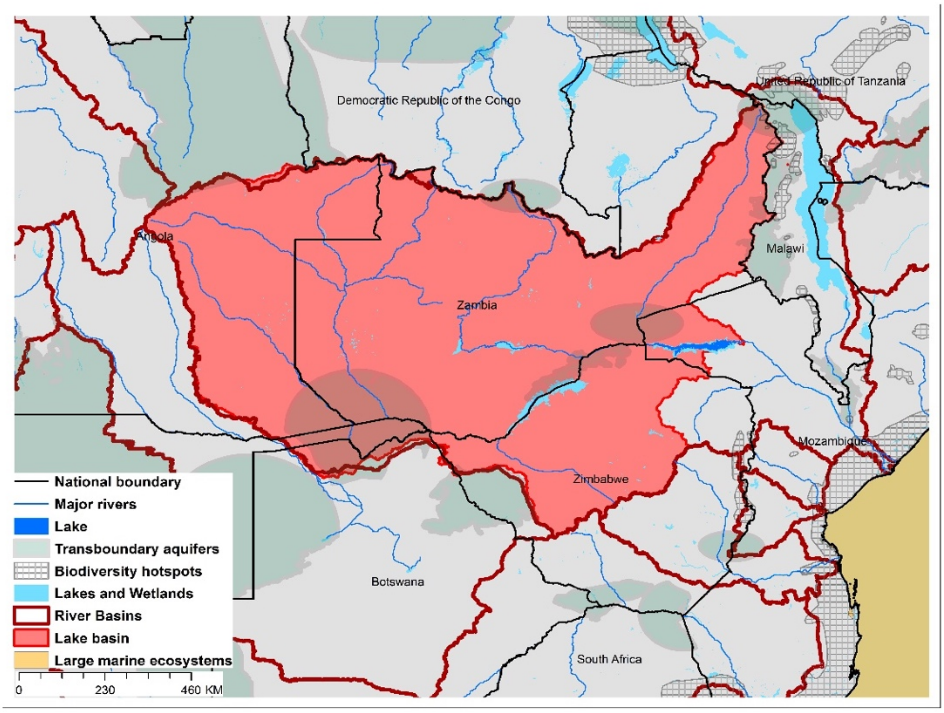
Lake Cahora Bassa — Geographic Information

Lake Cahora Bassa is one of three major reservoirs on the Zambezi River system, with the Cahora Bassa system being the largest hydroelectric complex in southern Africa. It is the fourth-largest reservoir in Africa, containing approximately 510 million m^3 of water when full. The available information suggests it does not exhibit the same resource development and conservation issues related to the lake environment, compared to Lake Kariba, another upstream reservoir constructed in the same river basin. In regard to potential management interventions, there is a need to confirm how the lake is assessed within the transboundary Zambezi River system.

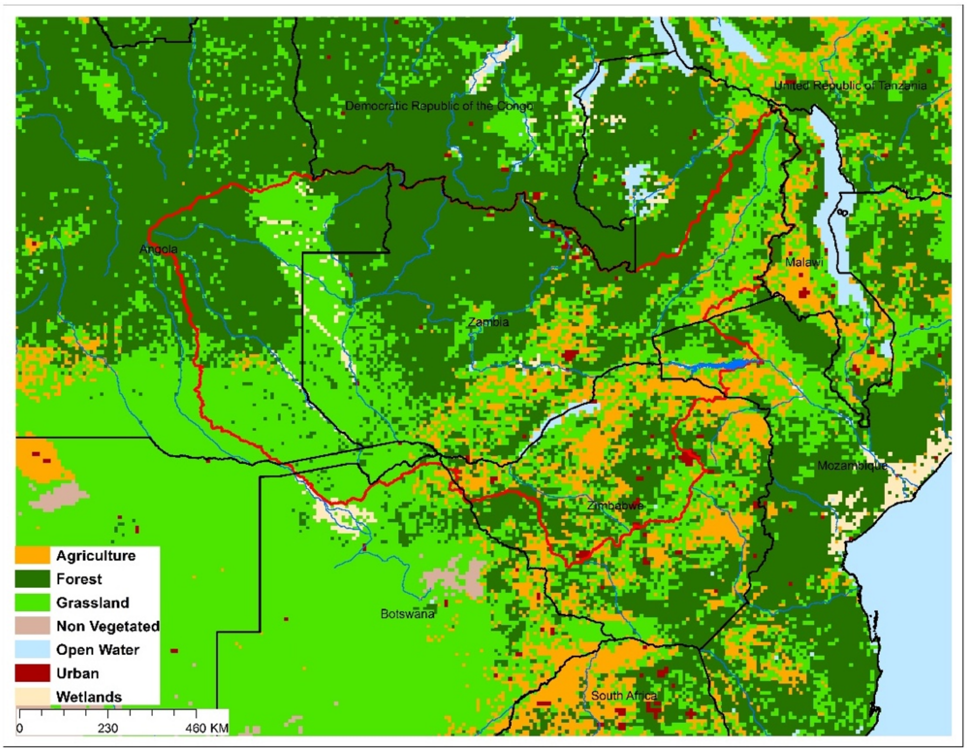


TWAP Regional Designation	Eastern & Southern Africa	**Lake Basin Population (2010)**	70,651,488
River Basin	Zambezi	**Lake Basin Population Density (2010; # km^{-2})**	186.6
Riparian Countries	Mozambique, Zambia, Zimbabwe	**Average Basin Precipitation (mm yr^{-1})**	916.4
Basin Area (km^2)	339,850	**Shoreline Length (km)**	3,233
Lake Area (km^2)	4,347	**Human Development Index (HDI)**	0.43
Lake Area:Lake Basin Ratio	0.002	**International Treaties/Agreements Identifying Lake**	Yes

Lake Cahora Bassa Basin Characteristics



(a) Lake Cahora Bassa basin and associated transboundary water systems



(b) Lake Cahora Bassa basin land use

Lake Cahora Bassa 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 Cahora Bassa 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 Cahora Bassa 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 Cahora Bassa 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 Cahora Bassa 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
0.78	34		0.69	12		0.43	15

It is emphasized that the Lake Cahora Bassa 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 Cahora Bassa indicates a moderately low threat rank compared to other priority transboundary lakes.

The Reverse Biodiversity (RvBD) for Lake Cahora Bassa, 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 Cahora Bassa basin in a moderately high threat rank in regard to its health, educational and economic status.

Table 2. Lake Cahora Bassa 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)

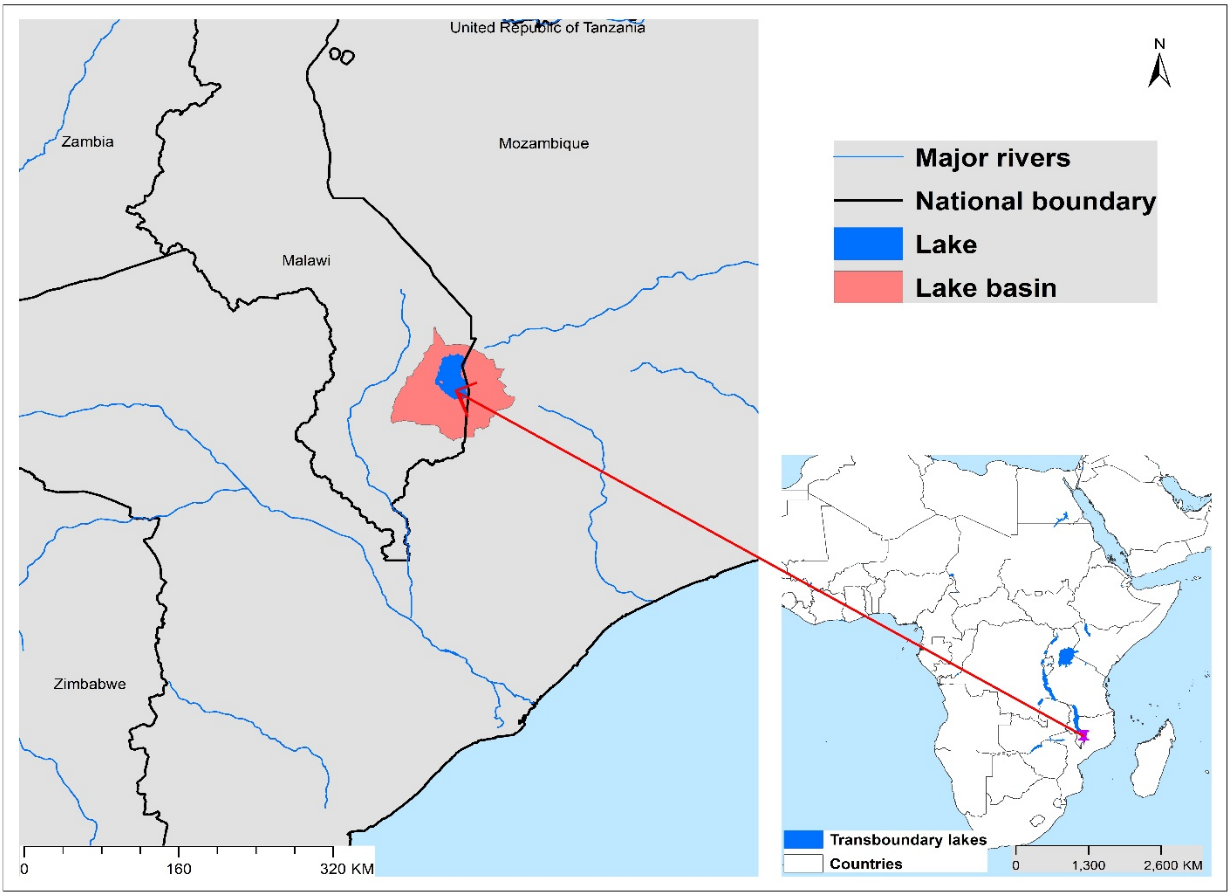
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
35	15	13		47	25		49	25		65	22

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

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

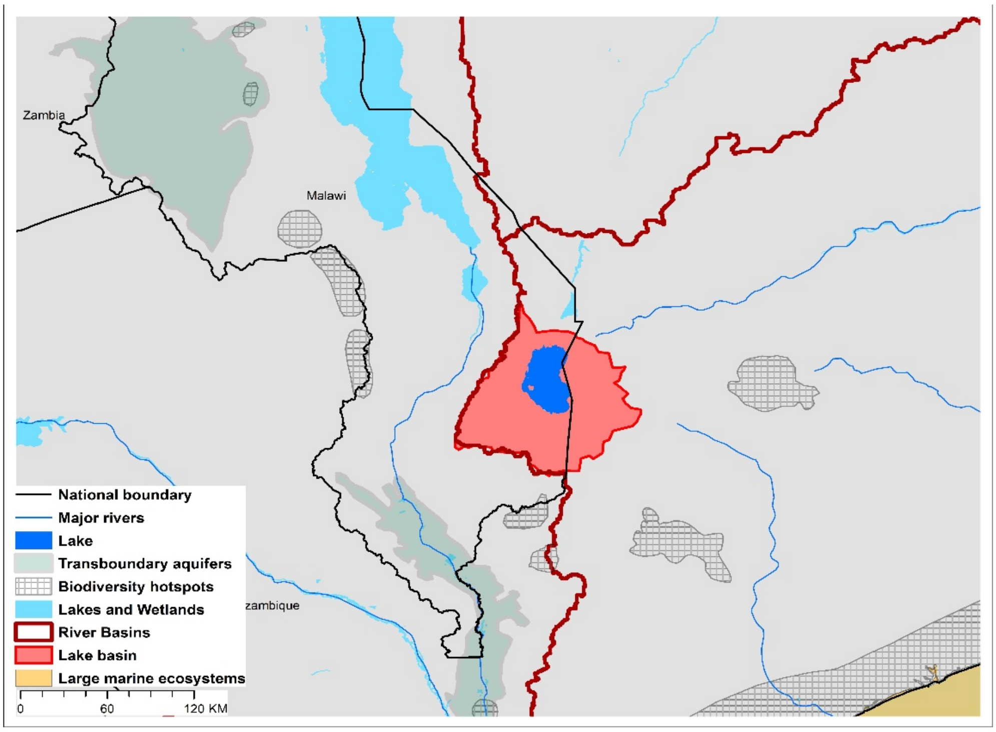
Lake Chilwa **Geographic Information**

Lake Chilwa is a terminal lake located near the border with Mozambique. Its water level is strongly influenced by seasonal rains and evaporation. It contains a large island in its middle, and is surrounded by extensive wetlands, which are important habitats for local fauna as well as a major fishery source. Lake Chilwa could be a subject for potential GEF funding consideration. However, any management interventions should be considered together with Lake Chiuta, both being located in relatively close proximity to each other, and sharing common needs regarding needed improvements in fishing practices and addressing public health hazards. The viability of relating any management interventions with Lake Malawi/Nyasa could also be considered.

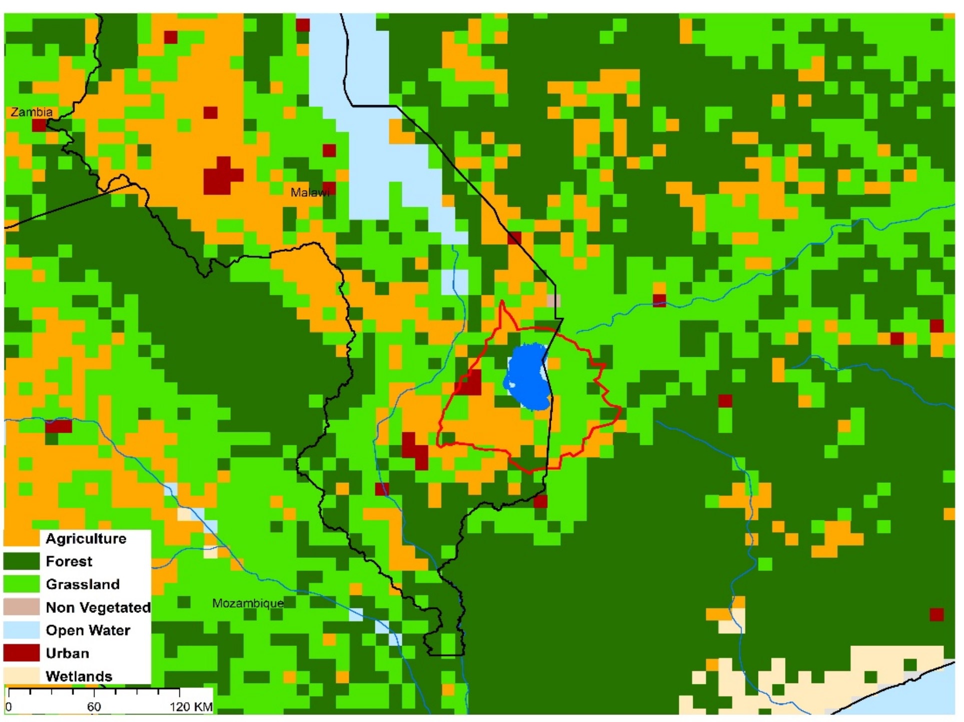


TWAP Regional Designation	Eastern & Southern Africa		**Lake Basin Population (2010)**	1,459,490
River Basin	Chilwa (endorheic)		**Lake Basin Population Density (2010; # km^{-2})**	150.3
Riparian Countries	Malawi, Mozambique		**Average Basin Precipitation (mm yr^{-1})**	1,474
Basin Area (km^2)	7,248		**Shoreline Length (km)**	488.8
Lake Area (km^2)	1,084		**Human Development Index (HDI)**	0.41
Lake Area:Lake Basin Ratio	0.126		**International Treaties/Agreements Identifying Lake**	Yes

Lake Chilwa Basin Characteristics



(a) Lake Chilwa basin and associated transboundary water systems



(b) Lake Chilwa basin land use

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

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

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank		Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank		Human Development Index (HDI) Score	Relative HDI Rank
0.86	22		0.70	9		0.41	11

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

The Reverse Biodiversity (RvBD) for Lake Chilwa, 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 Chilwa basin in a high threat rank in regard to its health, educational and economic status.

Table 2. Lake Chilwa 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)

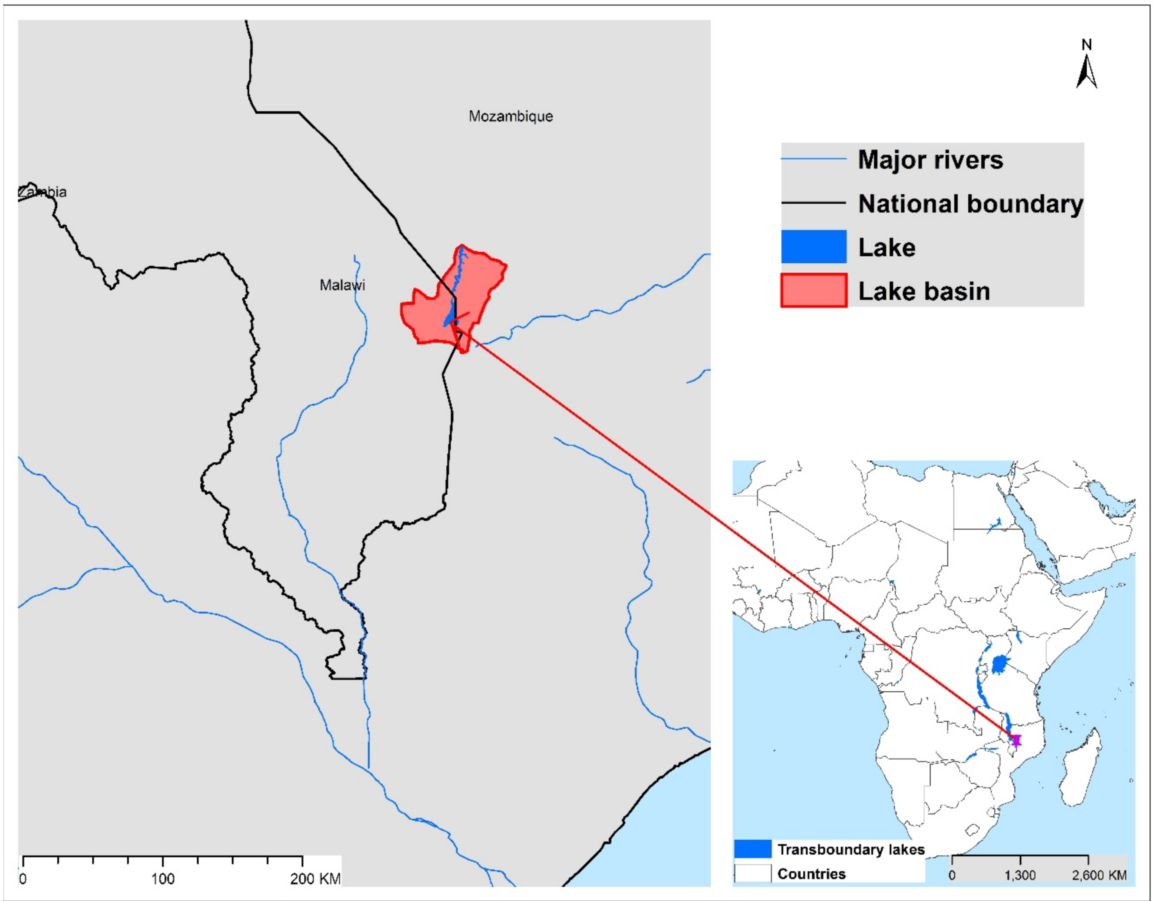
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
21	11	10		31	10		32	14		42	12

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

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

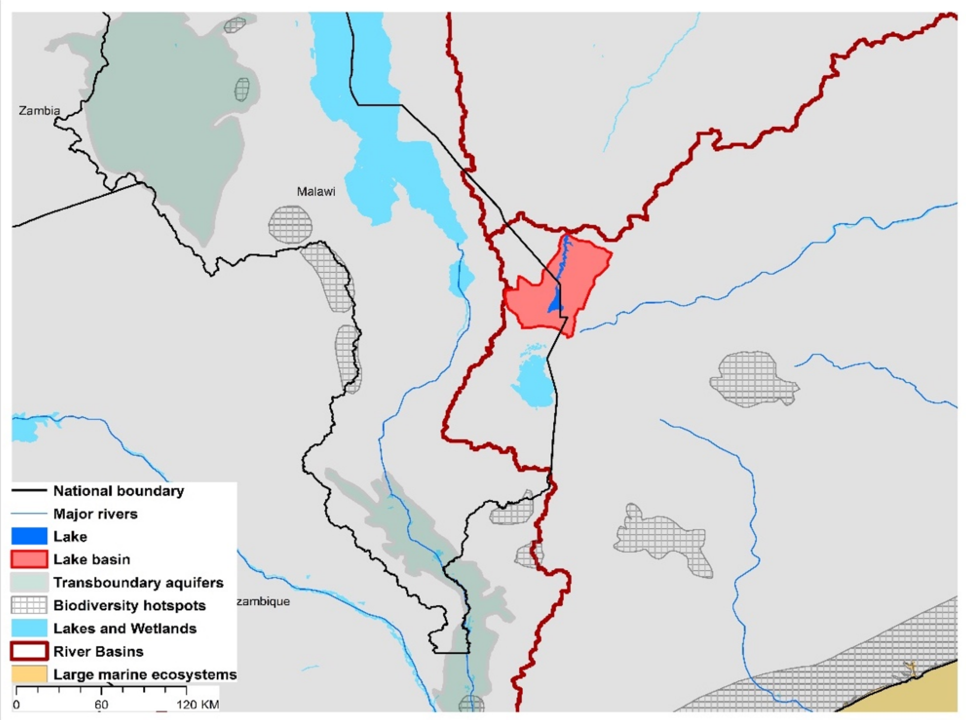
Lake Chiuta — Geographic Information

Lake Chiuta is a narrow, shallow lake lying north of Lake Chilwa and south of terminal Lake Amaramba in east Africa. The latter is separated from Lake Chiuta by a sandy ridge. The lake is intermittently linked to the Lugenda River, depending on season and rainfall, although it can dessicate completely. Lake Chiuta could be a subject for potential GEF funding consideration, along with Lakes Malawi/Nyasa and Chilwa, all being in relatively close proximity to each other. They also share common issues relating to the need for improved fishery practices, and overcoming public health hazards. In this context, joint implementation of management interventions involving all the above-noted lakes could be usefully.

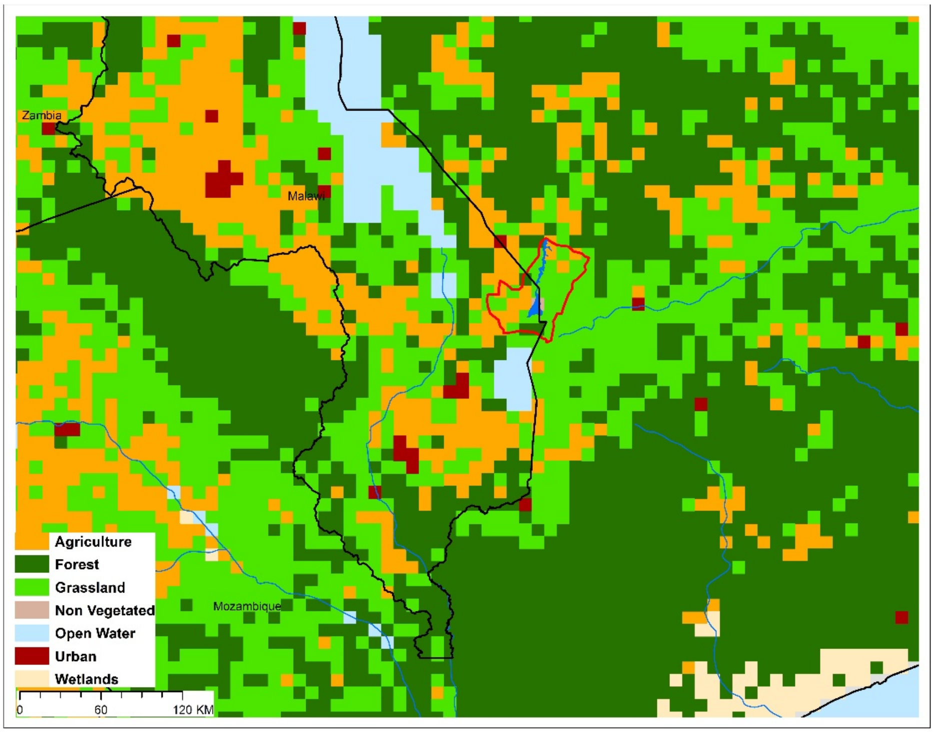


TWAP Regional Designation	Eastern & Southern Africa	**Lake Basin Population (2010)**	229,629
River Basin	Chiuta (endorheic)	**Lake Basin Population Density (2010; # km^{-2})**	70.7
Riparian Countries	Malawi, Mozambique	**Average Basin Precipitation (mm yr^{-1})**	1,063
Basin Area (km^2)	2,310	**Shoreline Length (km)**	217.9
Lake Area (km^2)	143.3	**Human Development Index (HDI)**	0.41
Lake Area:Lake Basin Ratio	0.126	**International Treaties/Agreements Identifying Lake**	No

Lake Chiuta Basin Characteristics



(a) Lake Chiuta basin and associated transboundary water systems



(b) Lake Chiuta basin land use

Lake Chiuta 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 Chiuta 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 Chiuta 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 Chiuta 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 Chiuta 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
0.85	24		0.74	3		0.41	10

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

The Reverse Biodiversity (RvBD) for Lake Chiuta, 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 Chiuta basin in a high threat rank in regard to its health, educational and economic status.

Table 2. Lake Chiuta 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)

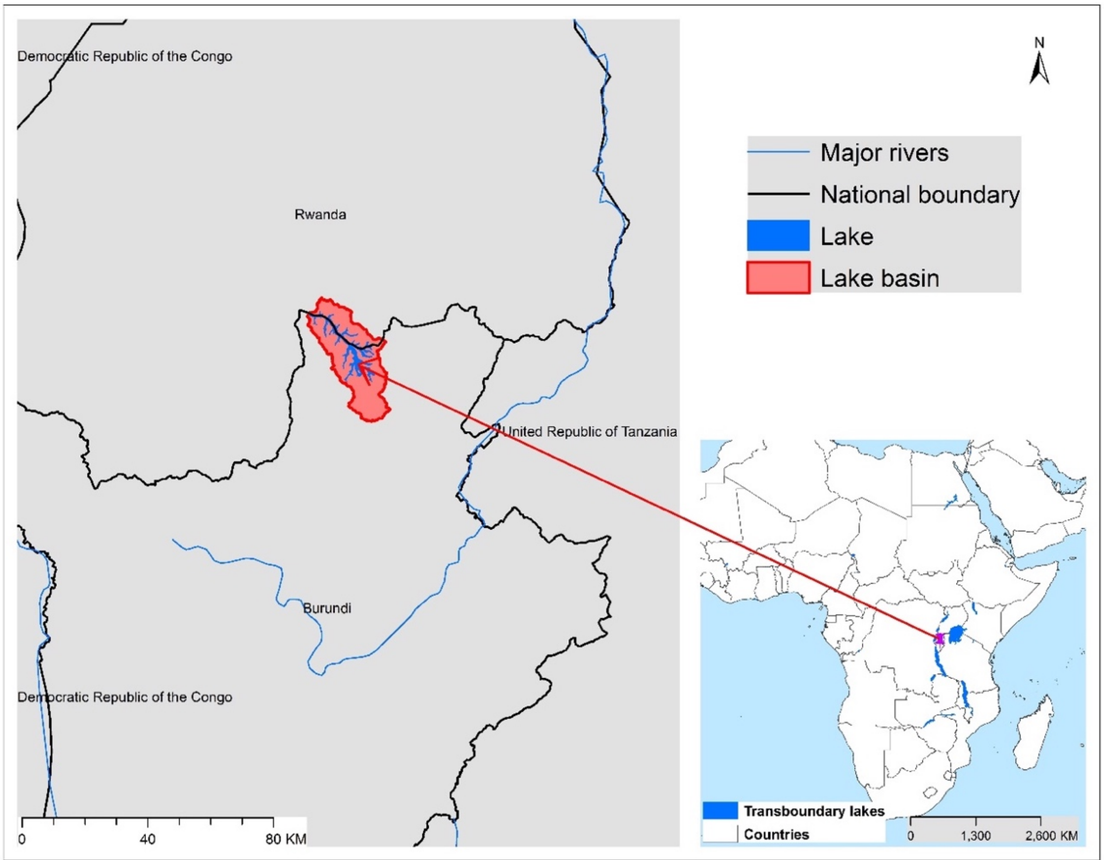
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
23	9	3		26	5		32	15		35	4

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

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

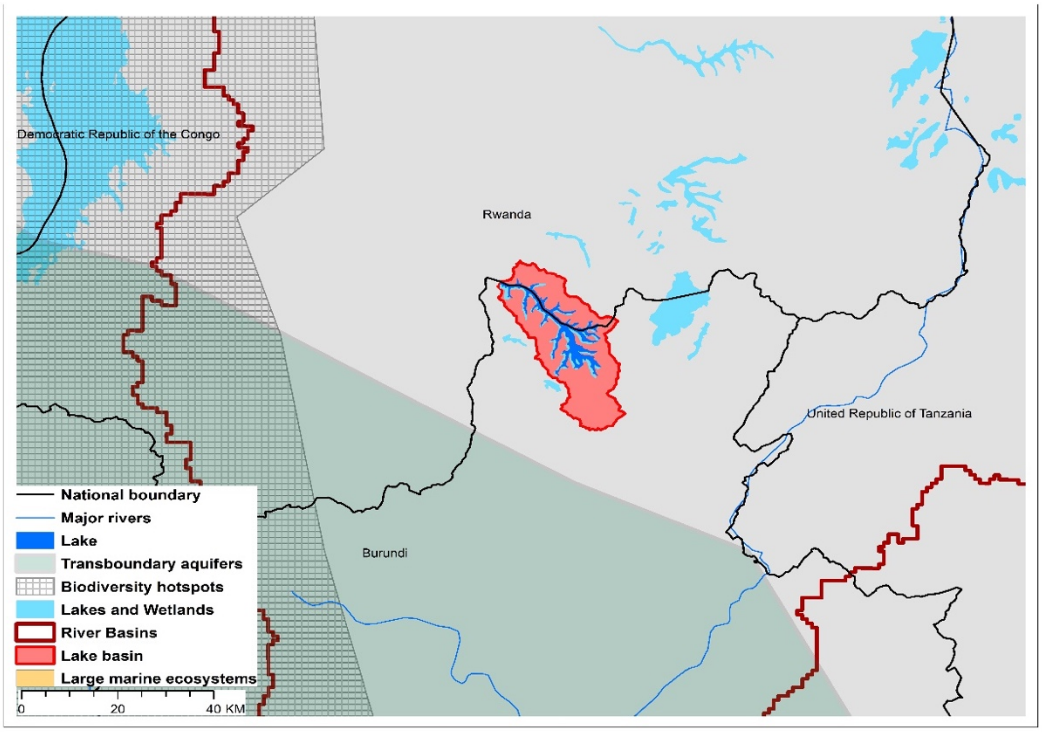
Lake Cohoha — Geographic Information

Lake Cohoha is a small lake in Central Africa, straddling the border between Burundi and Rwanda. It represents an attractive cross-border region between the two countries. The lake is located in the upper catchment region of the two countries, along with Lakes Rweru/Moero and Ihema. All three lakes exhibit share similar economic (fishery management) and environmental (progressing eutrophication) challenges. Effectively considering these lakes for GEF-catalyzed management interventions will require a new strategic approach that considers them as a lake cluster containing both transboundary and national (non-transboundary) lake basins. Thus, an option could be consideration of joint implementation of management interventions involving all three lakes.

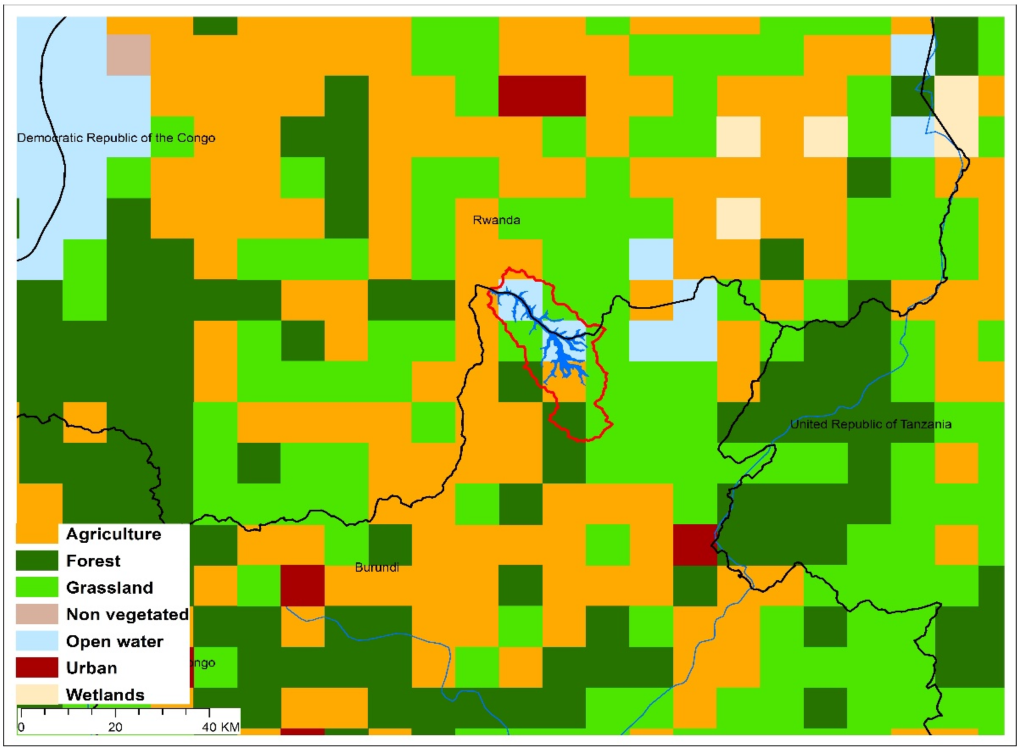


TWAP Regional Designation	Eastern & Southern Africa	**Lake Basin Population (2010)**	188,059
River Basin	Nile	**Lake Basin Population Density (2010; # km^{-2})**	322.0
Riparian Countries	Burundi, Rwanda	**Average Basin Precipitation (mm yr^{-1})**	1,007
Basin Area (km^2)	412.2	**Shoreline Length (km)**	257.2
Lake Area (km^2)	64.8	**Human Development Index (HDI)**	0.38
Lake Area:Lake Basin Ratio	0.159	**International Treaties/Agreements Identifying Lake**	No

Lake Cohoha Basin Characteristics



(a) Lake Cohoha basin and associated transboundary water systems



(b) Lake Cohoha basin land use

Lake Cohoha 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 Cohoha 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 Cohoha 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 Cohoha 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 Cohoha 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
0.96	5		0.59	28		0.38	4

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

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

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

Table 2. Lake Cohoha 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
3	4	28		31	12		7	1		35	6

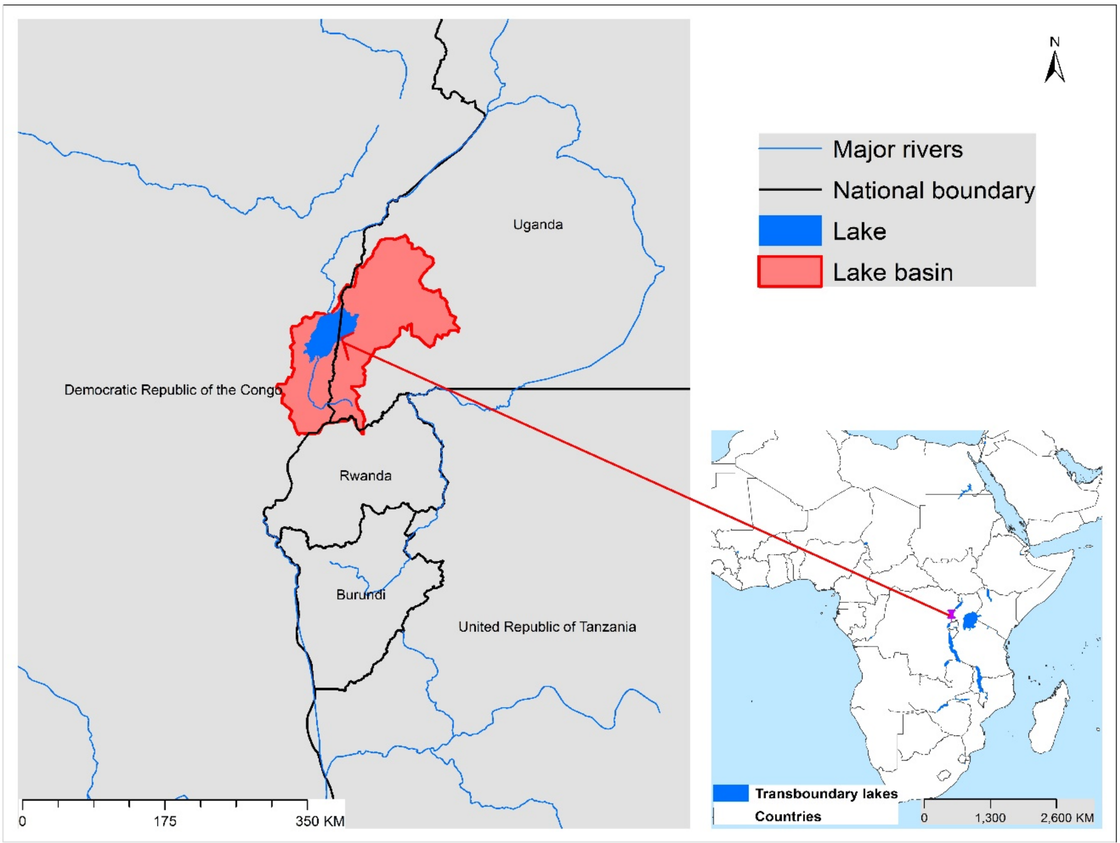
When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Cohoha in the upper quarter of the threat ranks. The relative threat is somewhat reduced when the Adj-HWS and RvBD threats are considered together. Considering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

Interactions between the ranking parameters for Lake Cohoha indicate differing sensitivity to basin-derived stresses. Identifying potential management interventions needs for Lake Cohoha 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 Cohoha basin? Accurate answers to such questions for Lake Cohoha, and other transboundary lakes, will require a case-by-case assessment approach that considers the specific lake situation and the anticipated improvements from specific management interventions, as well as interactions with water systems to which the lake is linked.

Lake Edward

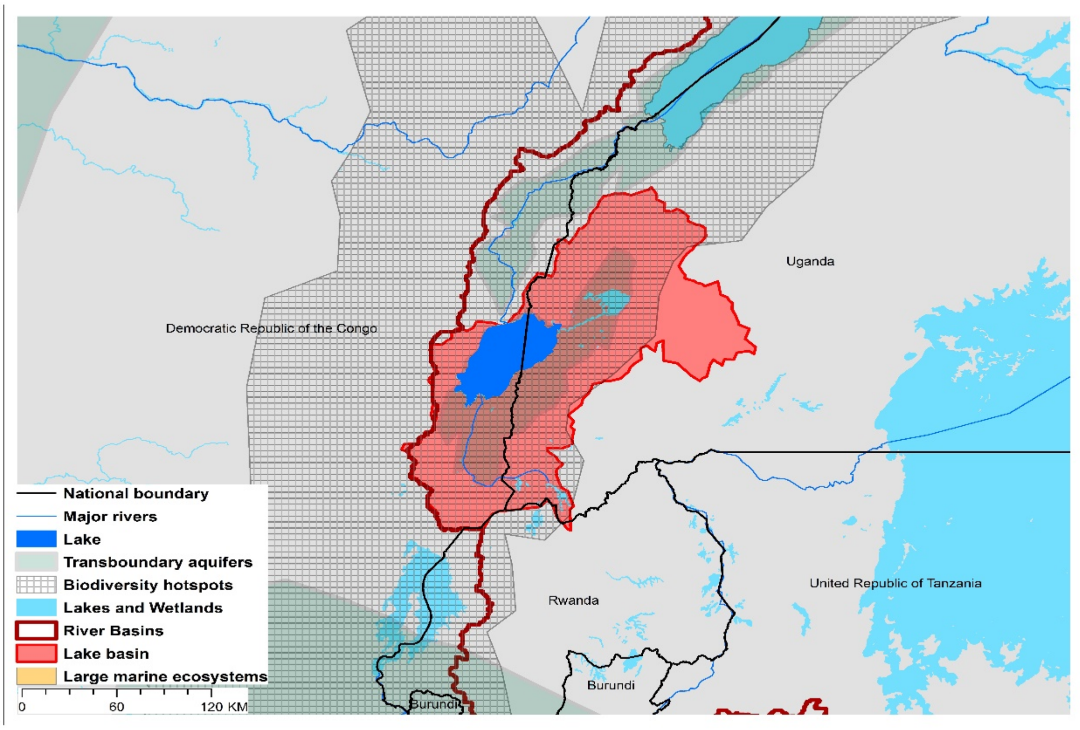
Geographic Information

Lake Edward is the smallest African Great Lakes, located along the western branch of the East African Rift between Uganda and the Democratic Republic of Congo. It is connected to the smaller Lake George to the northeast. It lies entirely with the Virunga (Democratic Republic of Congo) and Queen Elizabeth (Uganda) National Parks, and does not have extensive human habitation along its shorelines. Thus, the lake abounds in fish, with abundant wildlife along its shores. The area also is home to many perennial and migratory bird species. Compared to some other lakes in the region (e.g., Malawi/Nyasa, Tanganyika, Victoria), Lake Albert has not received as much attention as some other lakes in the region (e.g., Malawi/Nyasa, Tanganyika, Victoria), with information on its scientific and management challenges being rather sparse. In regard to possible management interventions, joint implementation with Lake Edward could be an option.

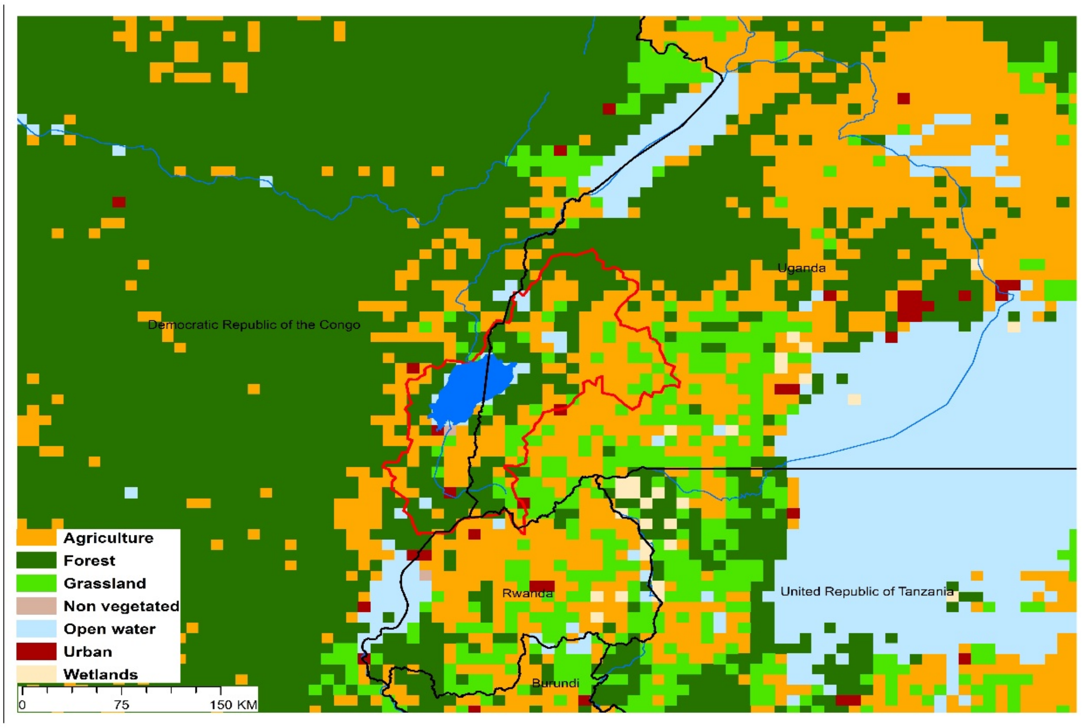


TWAP Regional Designation	Eastern & Southern Africa		**Lake Basin Population (2010)**	5,134,252
River Basin	Nile		**Lake Basin Population Density (2010; # km^{-2})**	196.8
Riparian Countries	Democratic Republic of Congo, Uganda		**Average Basin Precipitation (mm yr^{-1})**	1,159
Basin Area (km^2)	20,633		**Shoreline Length (km)**	359.6
Lake Area (km^2)	2,232		**Human Development Index (HDI)**	0.43
Lake Area:Lake Basin Ratio	0.089		**International Treaties/Agreements Identifying Lake**	No

Lake Edward Basin Characteristics



(a) Lake Edward basin and associated transboundary water systems



(b) Lake Edward basin land use

Lake Edward 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 Edward 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 Edward 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 Edward 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 Edward 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
0.94	6		0.65	21		0.43	13

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

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

Table 2. Lake Edward 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
6	13	22		28	7		19	6		41	11

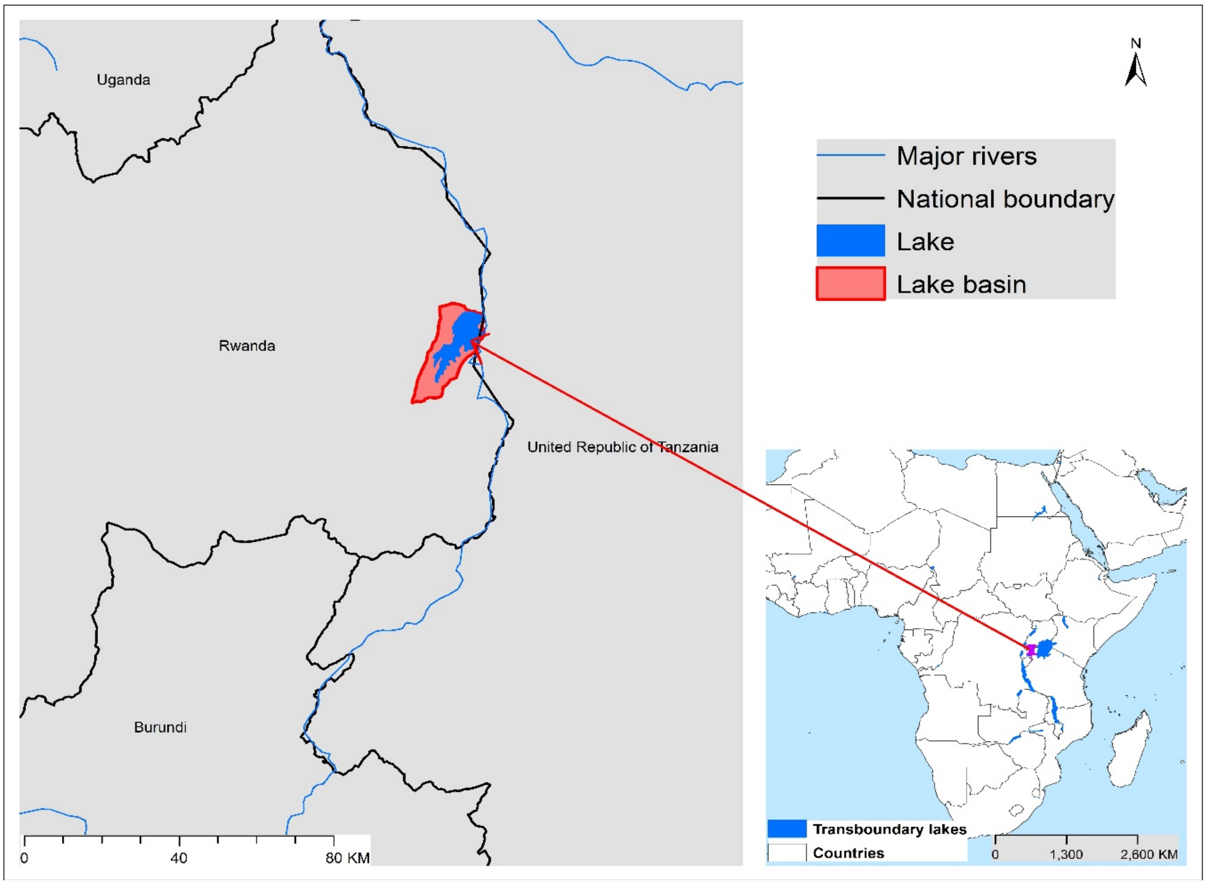
When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Edward in the upper quarter of the threat ranks. The relative threat is similar when the Adj-HWS and RvBD threats are considered together. Considering all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

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

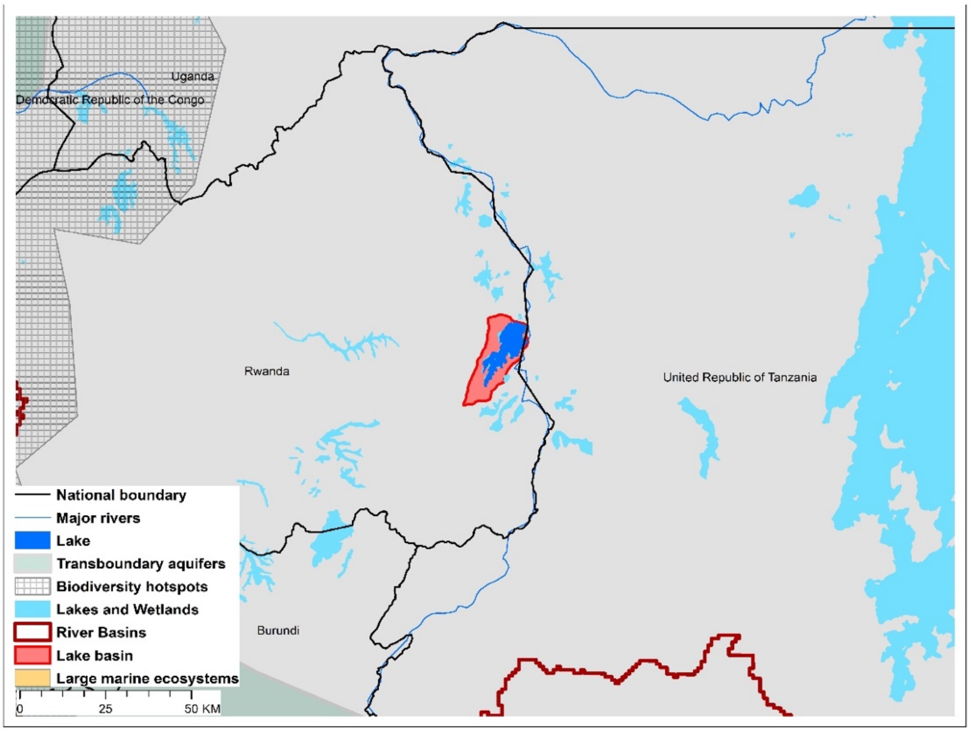
Geographic Information

Lake Ihema lies in the Akagera National Park in the eastern part of Rwanda, near its border with Tanzania. It shares similar economic (fishery management) and environmental (progressive eutrophication) challenges as Lakes Rweru/Moero and Cohoha, all three lakes being located in the same general area in upper catchment wetland regions. An effective way to consider Lake Ihema for GEf-catalyzed management interventions would be within the context of a new strategic approach that deals with Lake Ihema and the other above-noted lakes as a lake cluster containing both transboundary and national (non-transboundary) lake basins.

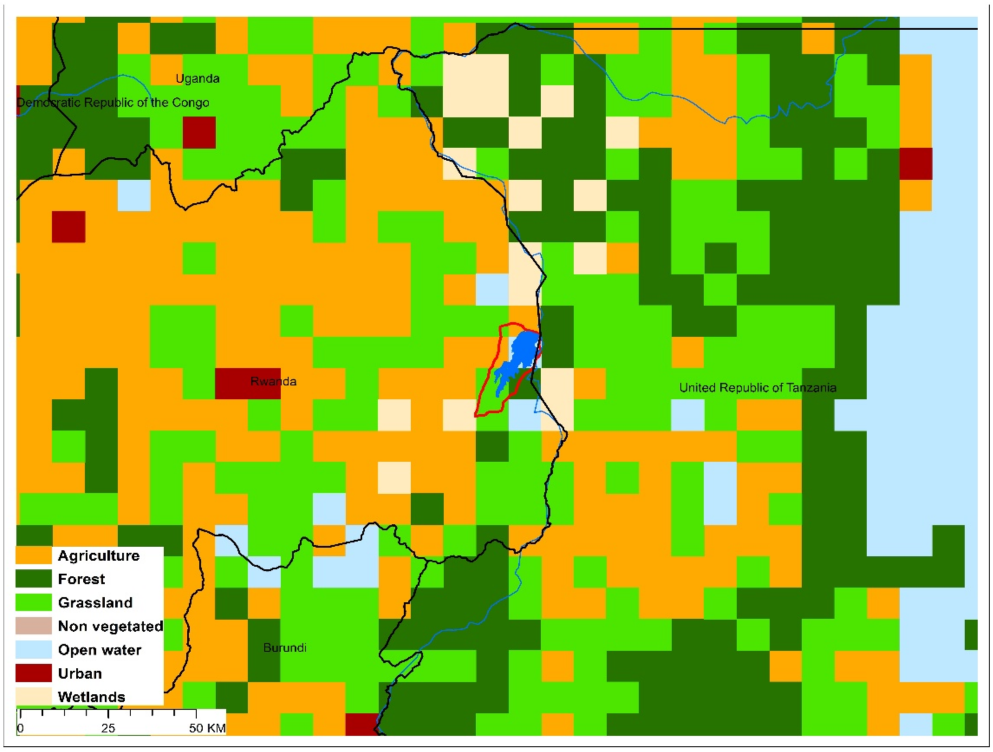


TWAP Regional Designation	Eastern & Southern Africa		**Lake Basin Population (2010)**	11,415
River Basin	Nile		**Lake Basin Population Density (2010; # km^{-2})**	46.4
Riparian Countries	Tanzania, Rwanda		**Average Basin Precipitation (mm yr^{-1})**	931.2
Basin Area (km^2)	210.3		**Shoreline Length (km)**	94.4
Lake Area (km^2)	93.2		**Human Development Index (HDI)**	0.44
Lake Area:Lake Basin Ratio	0.004		**International Treaties/Agreements Identifying Lake**	No

Lake Ihema Basin Characteristics



(a) Lake Ihema basin and associated transboundary water systems



(b) Lake Ihema basin land use

Lake Ihema 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 Ihema 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 Ihema 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 Ihema 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 Ihema 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
0.97	2		0.56	32		0.44	18

It is emphasized that the Lake Ihema 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 Ihema indicates a very 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 Ihema, which is meant to describe its biodiversity sensitivity to basin-derived degradation, places the lake in a much lower 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 Ihema basin in a moderately high threat rank in regard to its health, educational and economic status.

Table 2. Lake Ihema 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
2	18	33		35	17		20	7		53	17

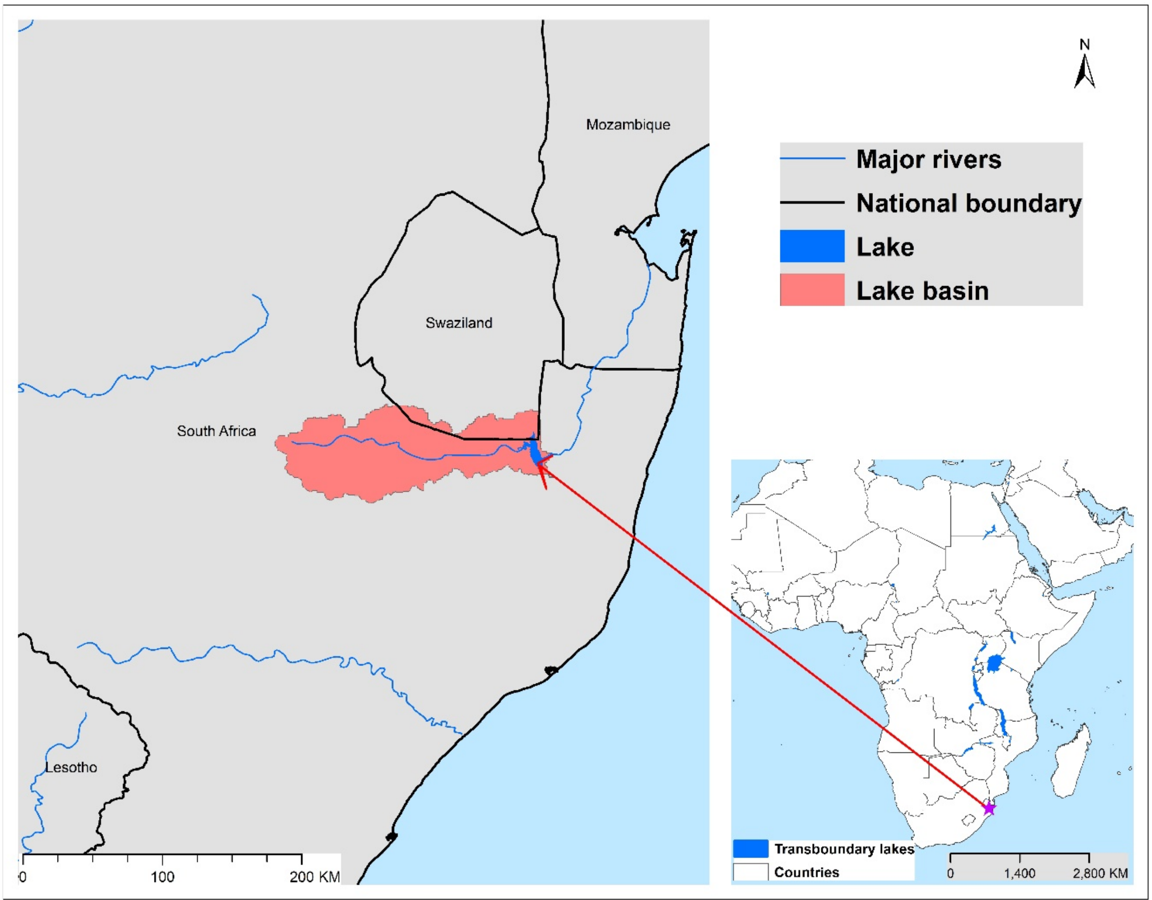
When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Ihema in the upper quarter of the threat ranks. The relative threat is notably reduced when the Adj-HWS and RvBD threats are considered together. Considering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

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

Josini/Pongolapoort Dam

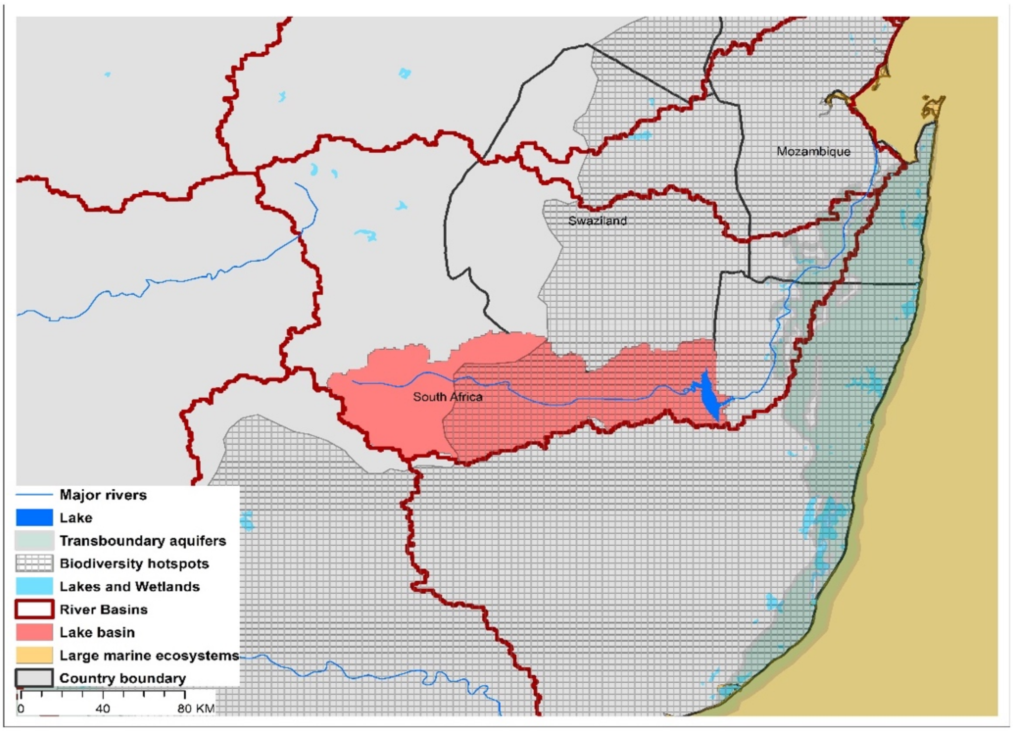
Geographic Information

Pongolapoort Dam, also referred to as Lake Josini, was the largest dam in South Africa when it was constructed. It serves mainly as a source of irrigation water. Prior to construction of the dam, the area was the first formally recognized conservation area in Africa, leading to other conservation areas, including the Kruger National Park, one of Africa's greatest wildlife conservation parks. The lake is flanked by private wildlife reserves, with wildlife and birdlife abounding in the area. There is little information regarding its environmentally-related management challenges, although there are some concerns regarding minimum environmental flow requirements in its river system. Nevertheless, it may not exhibit serious transboundary issues requiring possible GEF management interventions.

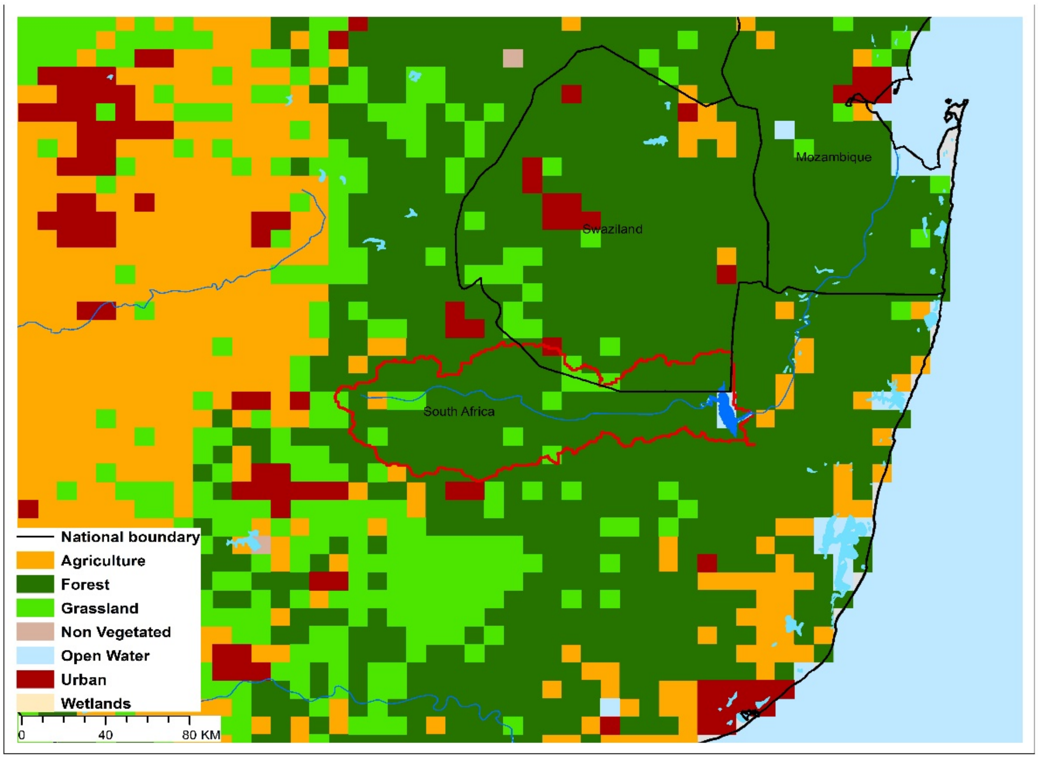


TWAP Regional Designation	Eastern & Southern Africa	**Lake Basin Population (2010)**	334,110
River Basin	Maputo	**Lake Basin Population Density (2010; # km^{-2})**	32.4
Riparian Countries	South Africa, Swaziland	**Average Basin Precipitation (mm yr^{-1})**	808.5
Basin Area (km^2)	6,982	**Shoreline Length (km)**	167.7
Lake Area (km^2)	128.6	**Human Development Index (HDI)**	0.61
Lake Area:Lake Basin Ratio	0.164	**International Treaties/Agreements Identifying Lake**	No

Josini/Pongolapoort Dam Basin Characteristics



(a) Josini/Pongolapoort Dam basin and associated transboundary water systems



(b) Josini/Pongolapoort Dam basin land use

Josini/Pongolapoort Dam 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 Josini/Pongolapoort Dam 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 Josini/Pongolapoort Dam 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 Josini/Pongolapoort Dam 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. Josini/Pongolapoort Dam 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
0.85	23		0.52	37		0.61	27

It is emphasized that the Josini/Pongolapoort Dam 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 Josini/Pongolapoort Dam indicates a moderately high threat rank compared to other priority transboundary lakes.

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

The relative Human Development Index (HDI) places the Josini/Pongolapoort Dam basin in a medium threat rank compared to the other transboundary lakes in regard to its health, educational and economic status.

Table 2. Josini/Pongolapoort Dam 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)

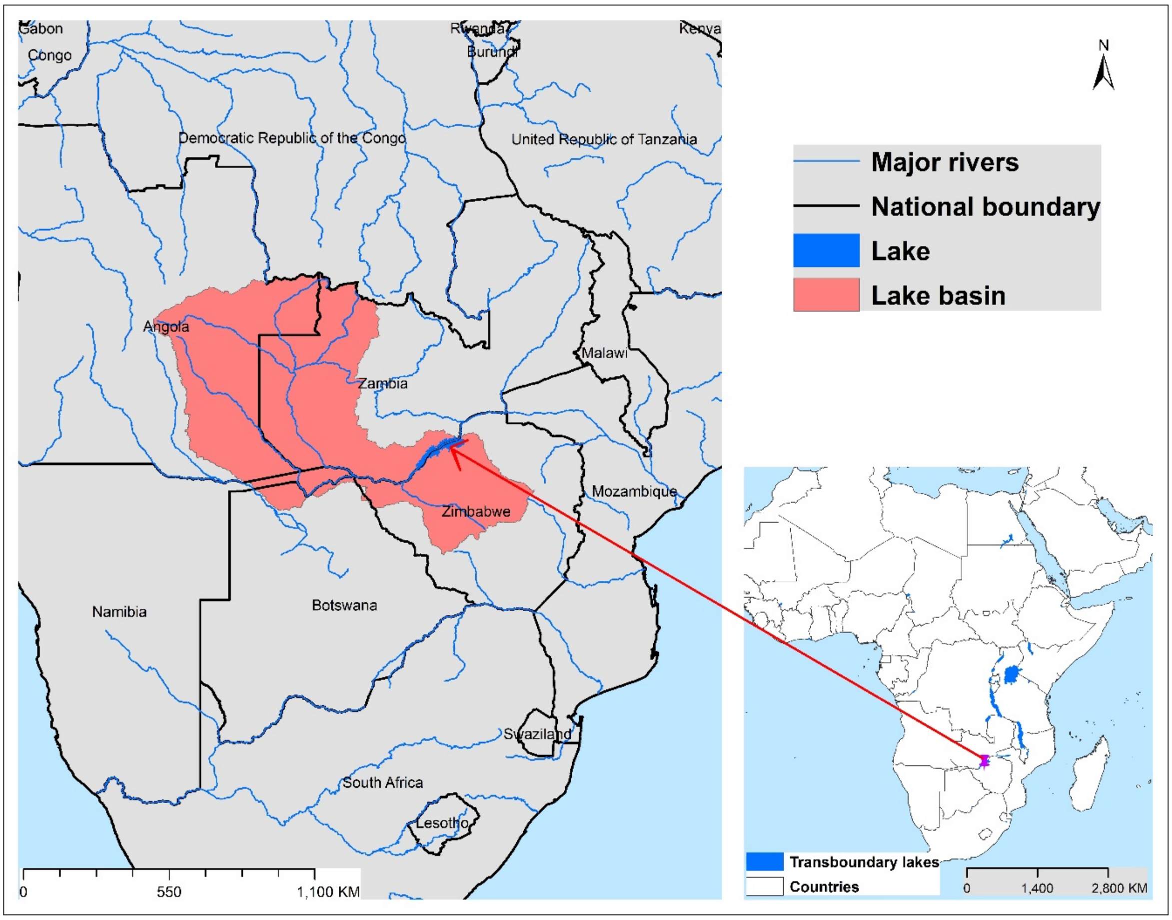
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
24	27	37		61	34		51	29		88	31

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Josini/Pongolapoort Dam 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, Josini/Pongolapoort Dam exhibits an overall medium threat ranking.

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

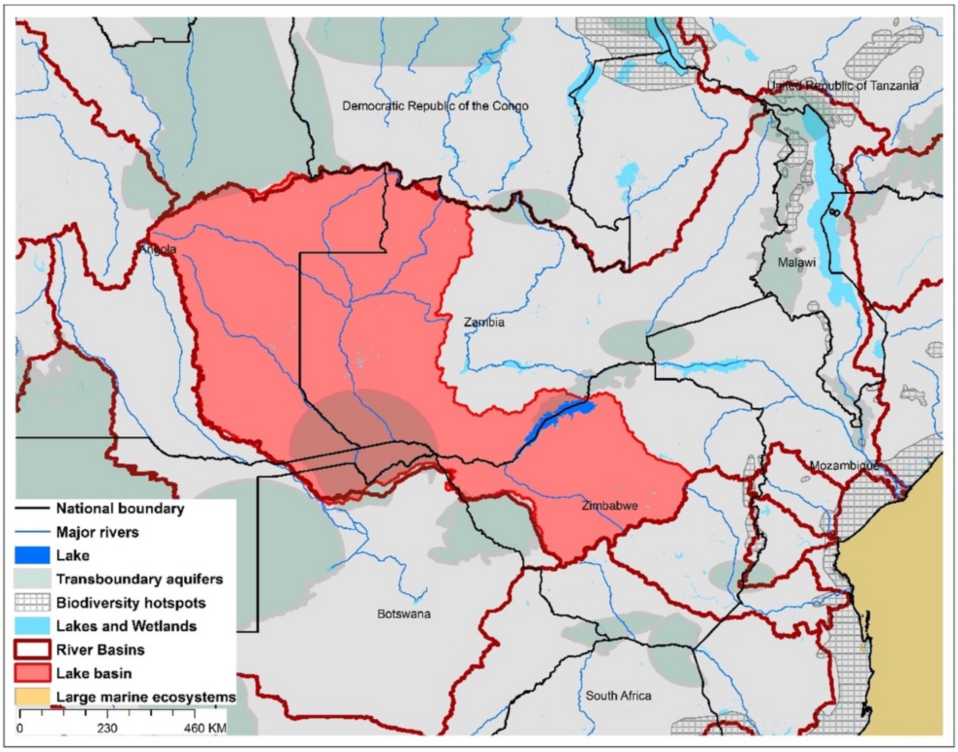
Lake Kariba — Geographic Information

Lake Kariba is the largest man-made lake in the world by volume. It was formed by damming the Zambezi River in the Kariba Gorge approximately 400 km downstream of Victoria Falls. Its functions include hydroelectric power production and fishery. It has a deeply indented shore and contains many islands. The reservoir full capacity is approximately 180 billion m^3. Lake Kariba is facing gradual deterioration of its water quality and its riparian ecosystems, potentially affecting its fishery and tourism industries. The possibility for management interventions requires confirmation of how the lake is assessed within the Zambezi River transboundary system.

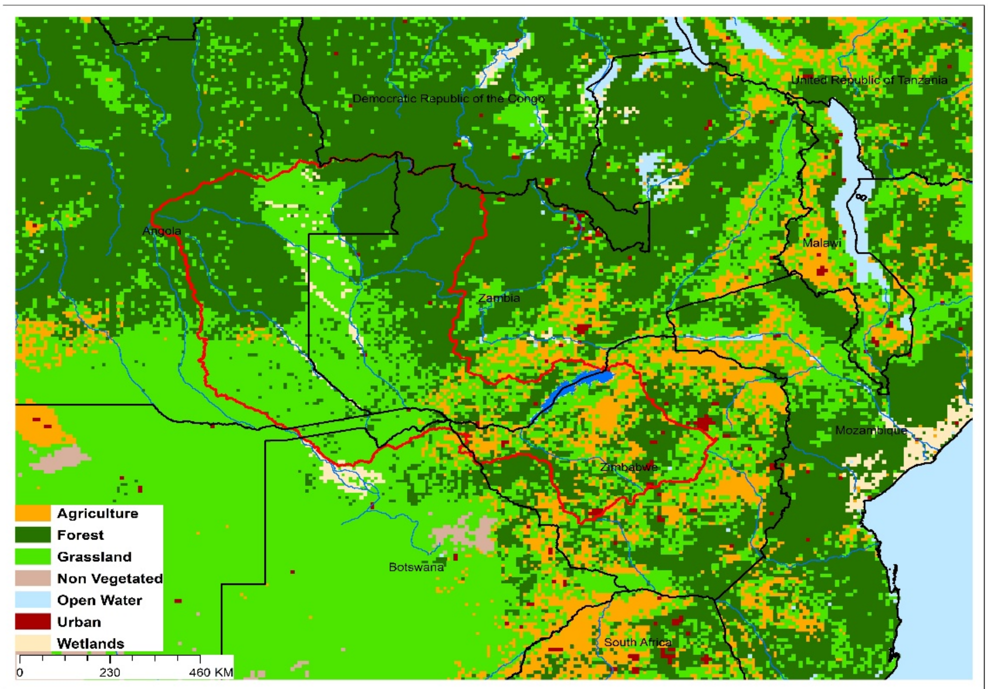


TWAP Regional Designation	Eastern & Southern Africa	**Lake Basin Population (2010)**	6,240,000
River Basin	Zambezi	**Lake Basin Population Density (2010; # km^{-2})**	7.65
Riparian Countries	Zambia, Zimbabwe	**Average Basin Precipitation (mm yr^{-1})**	906.2
Basin Area (km^2)	568,320	**Shoreline Length (km)**	1,797
Lake Area (km^2)	5,259	**Human Development Index (HDI)**	0.43
Lake Area:Lake Basin Ratio	0.008	**International Treaties/Agreements Identifying Lake**	Yes

Lake Kariba Basin Characteristics



(a) Lake Kariba basin and associated transboundary water systems



(b) Lake Kariba basin land use

Lake Kariba 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 Kariba 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 Kariba 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 Kariba 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 Kariba 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	36		0.66	20		0.43	17

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

The Reverse Biodiversity (RvBD) for Lake Kariba, 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 Kariba basin in a moderately high threat rank in regard to its health, educational and economic status.

Table 2. Lake Kariba 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
36	14	19		55	30		50	28		69	25

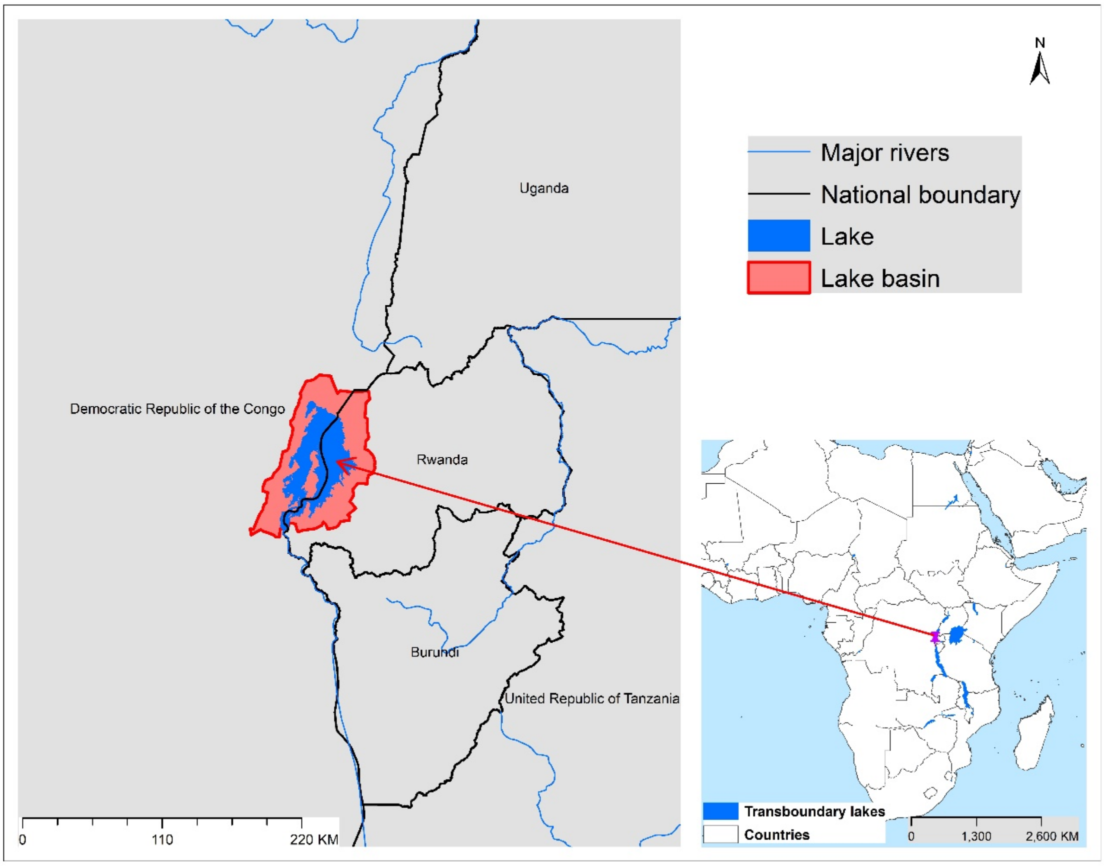
When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Kariba in the lower half of the threat ranks. The relative threat is similar when the Adj-HWS and RvBD threats are considered together. Considering all three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

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

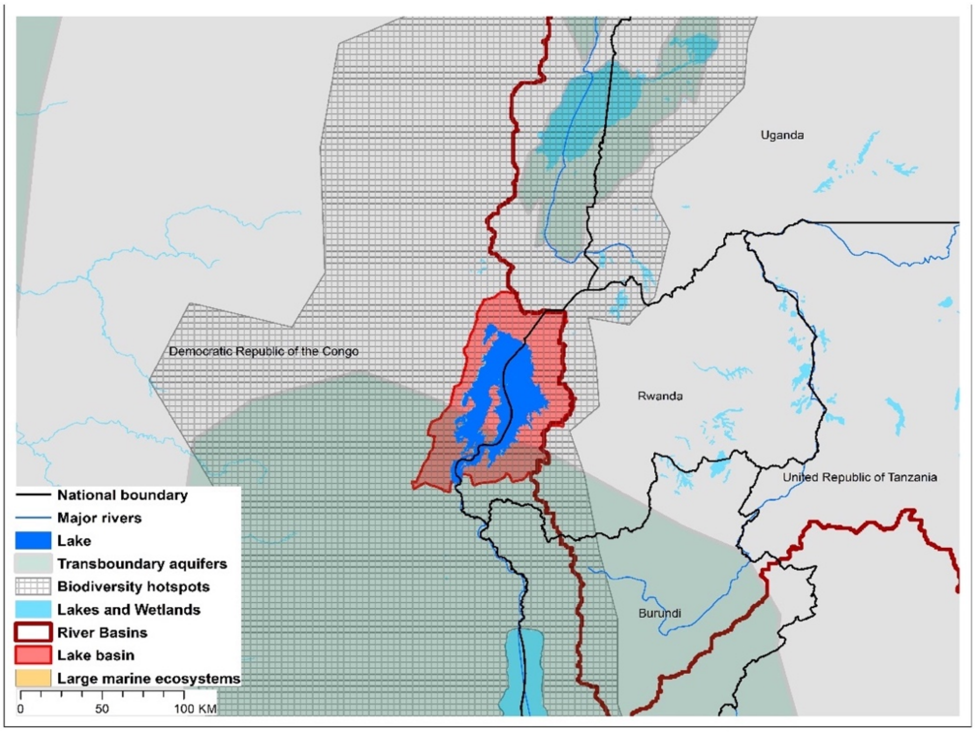
Geographic Information

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.

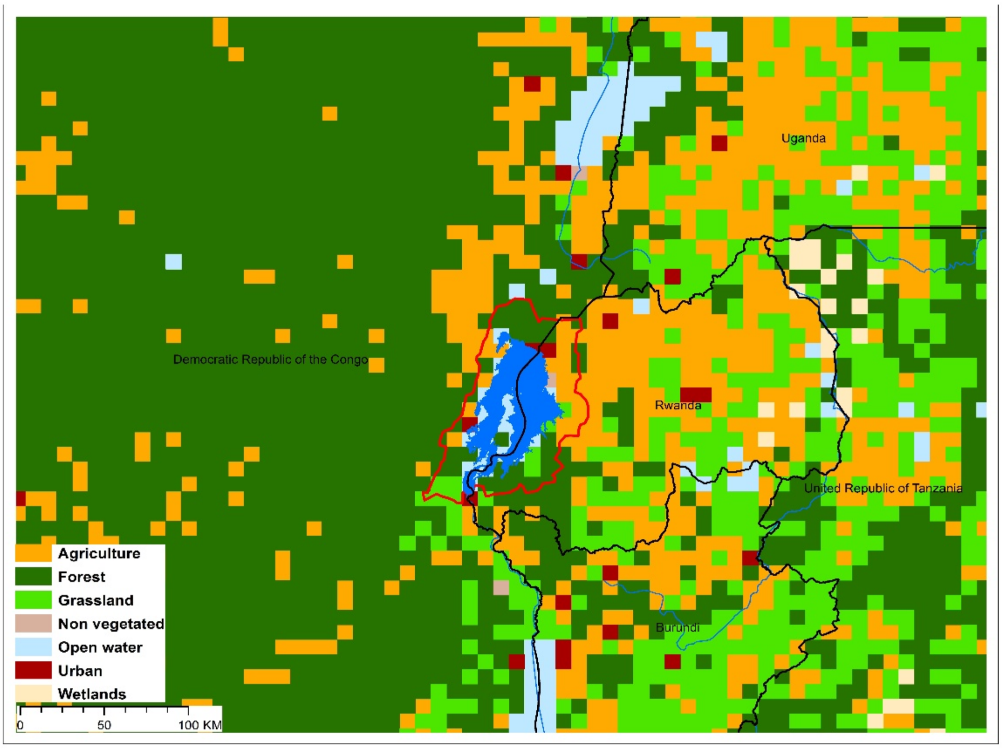


TWAP Regional Designation	Eastern & Southern Africa; Western & Middle Africa		**Lake Basin Population (2010)**	2,203,403
River Basin	Congo/Zaire		**Lake Basin Population Density (2010; # km^{-2})**	345.2
Riparian Countries	Democratic Republic of the Congo, Rwanda		**Average Basin Precipitation (mm yr^{-1})**	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)

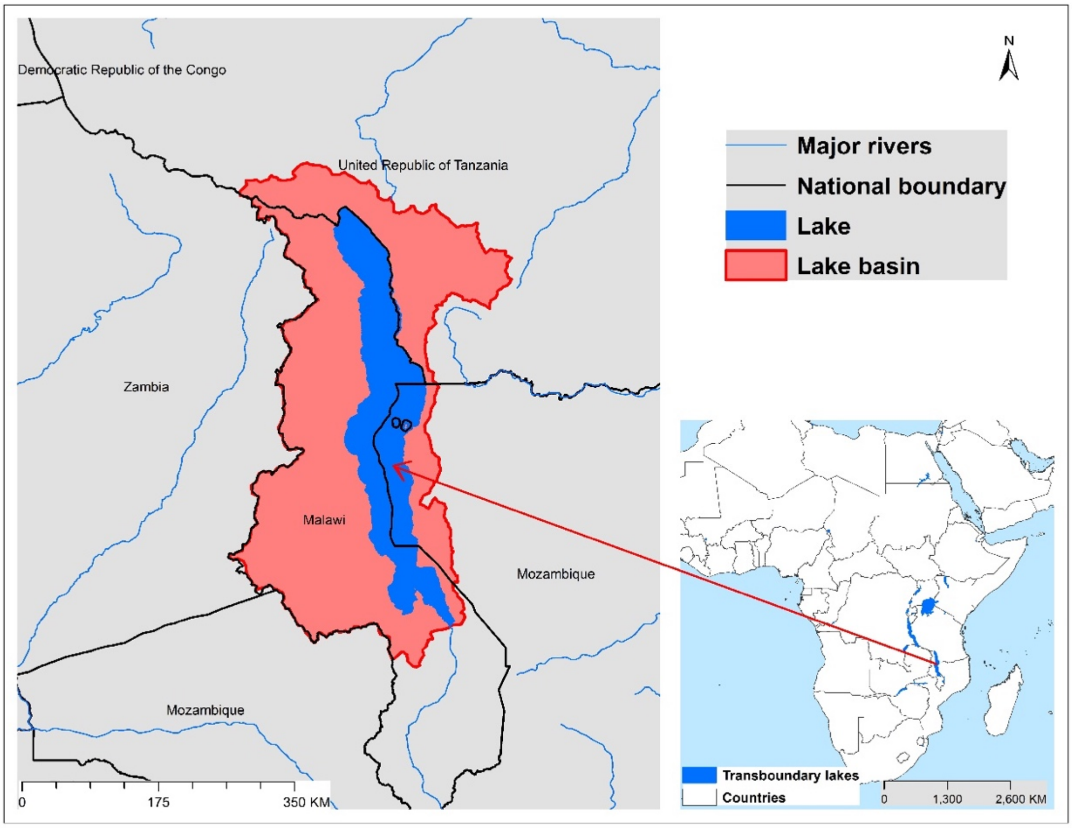
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
12	6	18		30	8		18	4		36	7

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.

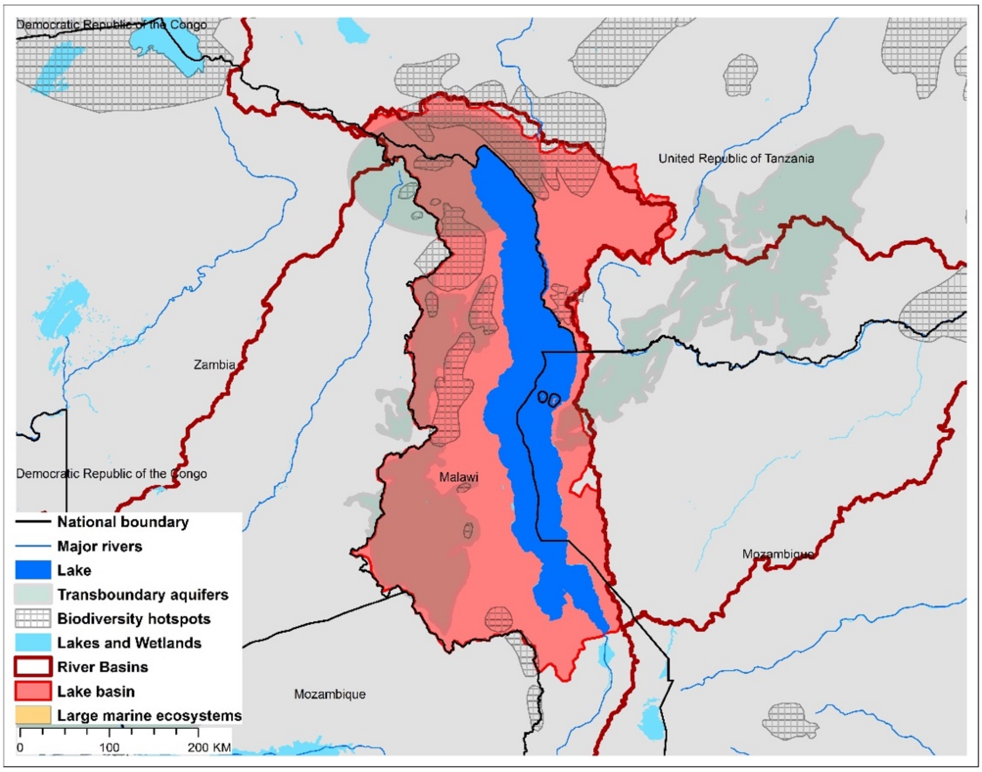
Lake Malawi/Nyasa — Geographic Information

Lake Malawi (known as Lake Nyasa in Tanzania and Lago Niassa in Mozambique) is an Eastern African Rift Valley Great Lake, being the ninth largest lake in the world, and the third largest and second deepest African lake. It contains more species of fish than any other lake, the vast majority being cichlids. The lake's surface area partitioning between Malawi and Tanzania is under dispute because of an earlier border treaty between Britain and Germany during the colonial period. Tanzania claims the international border runs through the middle of the lake, while Malawi claims the whole surface of the lake not located in Mozambique. This dispute has gained renewed importance because of recent oil exploration activities in the lake by Malawi, resulting in Tanzania demanding the exploration be halted until the dispute was settled. The Lake Malawi situation could merit GEF-catalyzed management interventions, along with Lakes Chiuta and Chilwa. All three lakes are in close proximity to each other, and share common issues regarding the need for improved fishery practices and addressing public health hazards.

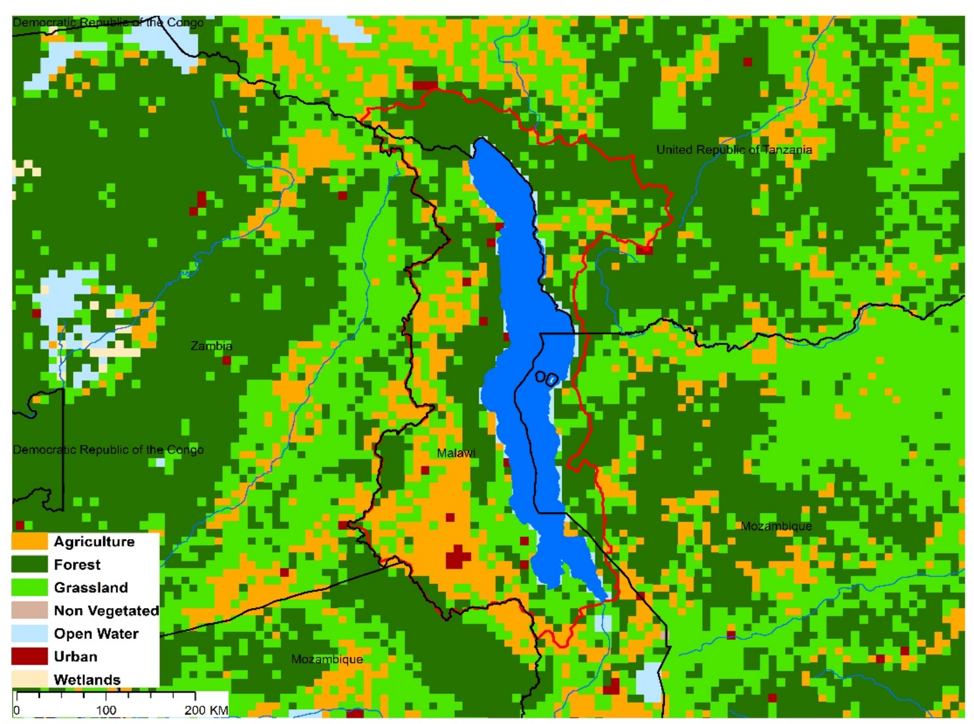


TWAP Regional Designation	Eastern & Southern Africa	**Lake Basin Population (2010)**	10,297,926
River Basin	Zambezi	**Lake Basin Population Density (2010; # km^{-2})**	88.1
Riparian Countries	Malawi, Mozambique, Tanzania	**Average Basin Precipitation (mm yr^{-1})**	1,177
Basin Area (km^2)	106,490	**Shoreline Length (km)**	1,484
Lake Area (km^2)	29,429	**Human Development Index (HDI)**	0.42
Lake Area:Lake Basin Ratio	0.276	**International Treaties/Agreements Identifying Lake**	Yes

Lake Malawi/Nyasa Basin Characteristics



(a) Lake Malawi/Nyasa basin and associated transboundary water systems



(b) Lake Malawi/Nyasa basin land use

Lake Malawi/Nyasa 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 Malawi/Nyasa 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 Malawi/Nyasa 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 Malawi/Nyasa 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 Malawi/Nyasa 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	12		0.68	14		0.42	12

It is emphasized that the Lake Malawi/Nyasa 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 Malawi/Nyasa 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 Malawi/Nyasa, 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 Malawi/Nyasa basin in a high threat rank in regard to its health, educational and economic status.

Table 2. Lake Malawi/Nyasa 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)

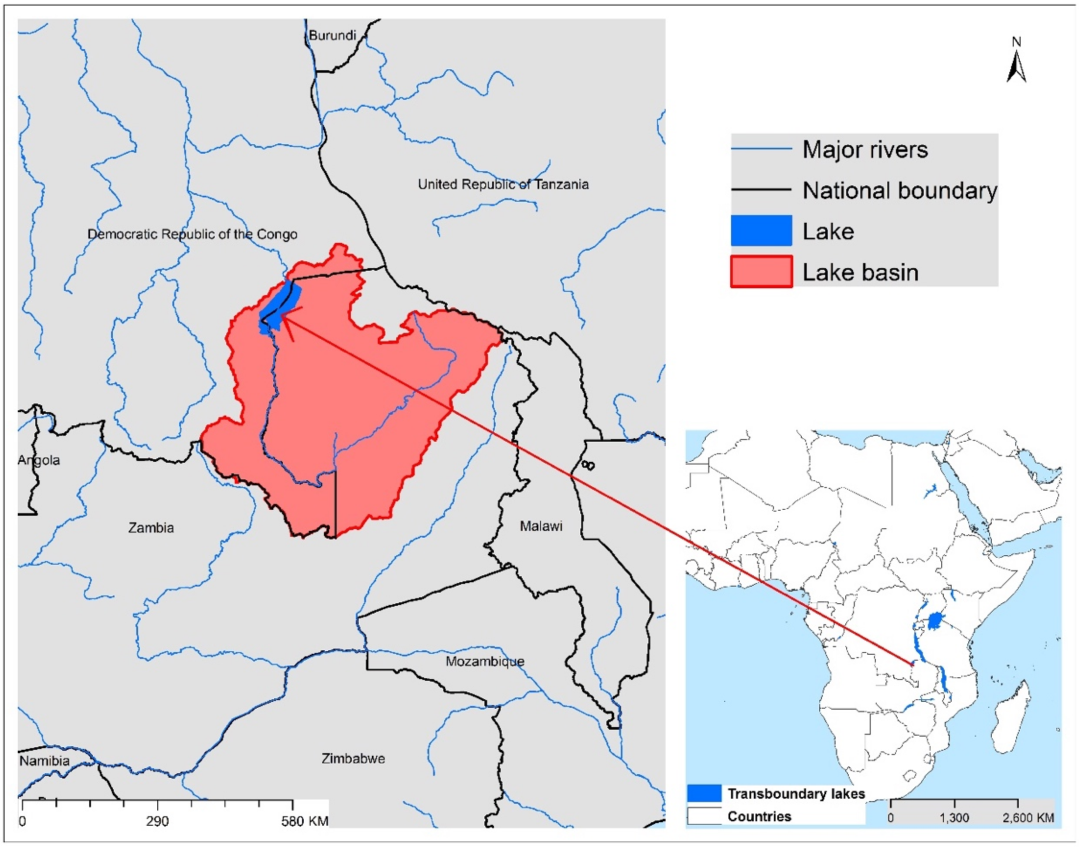
Adj-HWS Rank	HDI Rank	RvBD Rank	Sum Adj-HWS + RvBD	Relative Threat Rank	Sum Adj-HWS + HDI	Relative Threat Rank	Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
9	12	14	23	3	21	9	35	4

When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Malawi/Nyasa in the upper quarter of the threat ranks. The relative threat increases when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Lake Malawi/Nyasa exhibits a high threat ranking.

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

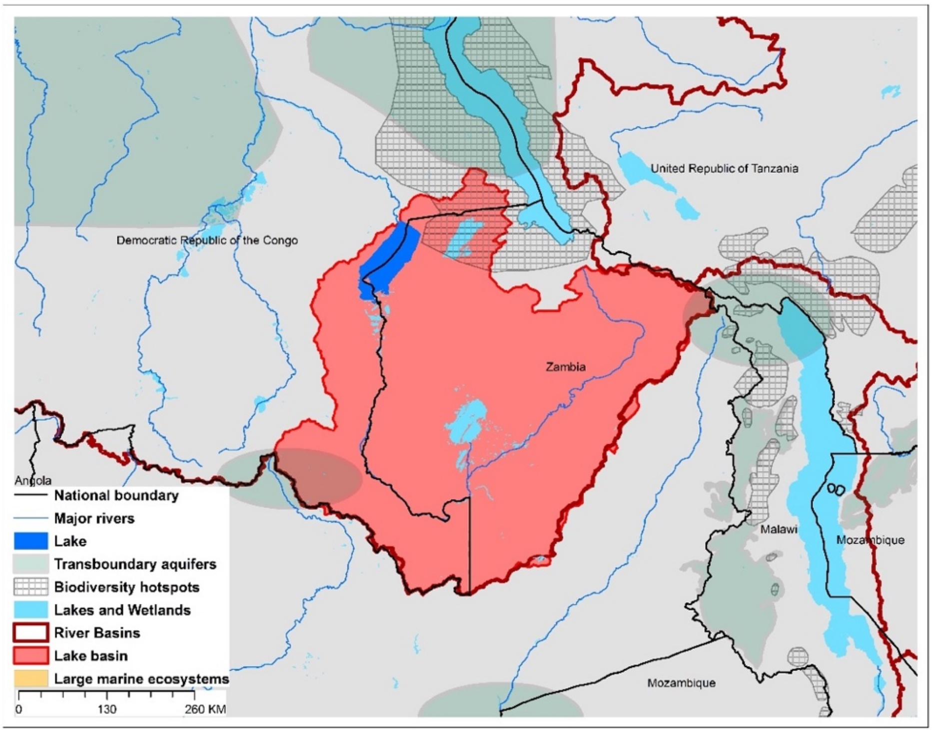
Lake Mweru **Geographic Information**

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.

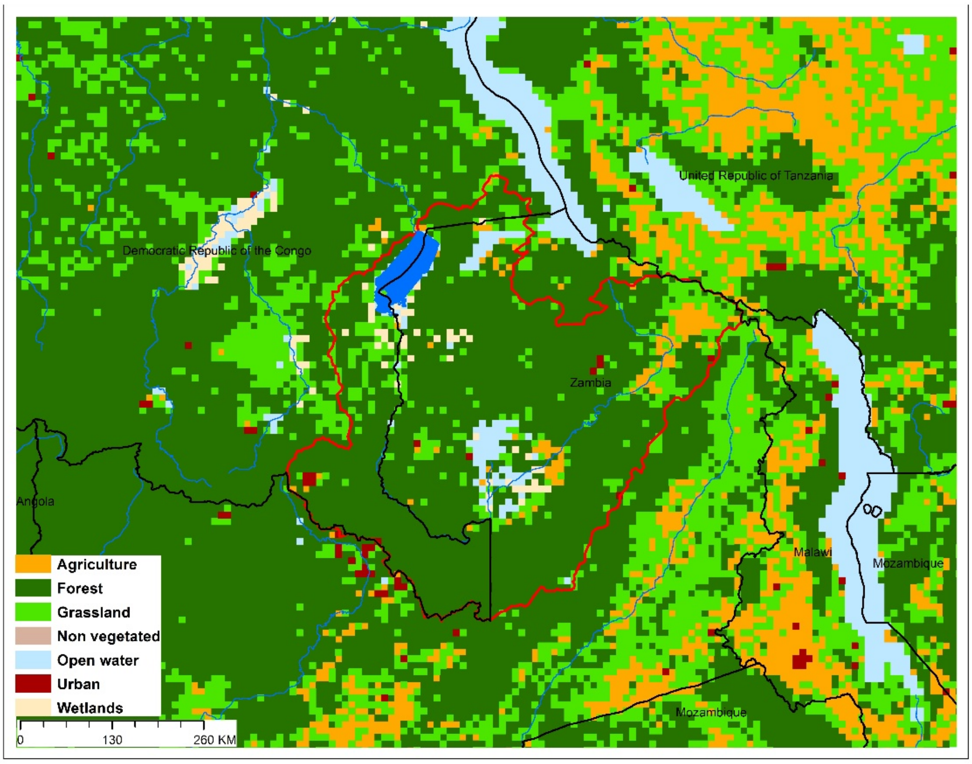


TWAP Regional Designation	Eastern & Southern Africa; Western & Middle Africa	**Lake Basin Population (2010)**	4,269,364
River Basin	Congo	**Lake Basin Population Density (2010; # km^{-2})**	17.2
Riparian Countries	Democratic Republic of Congo, Zambia	**Average Basin Precipitation (mm yr^{-1})**	1,200
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

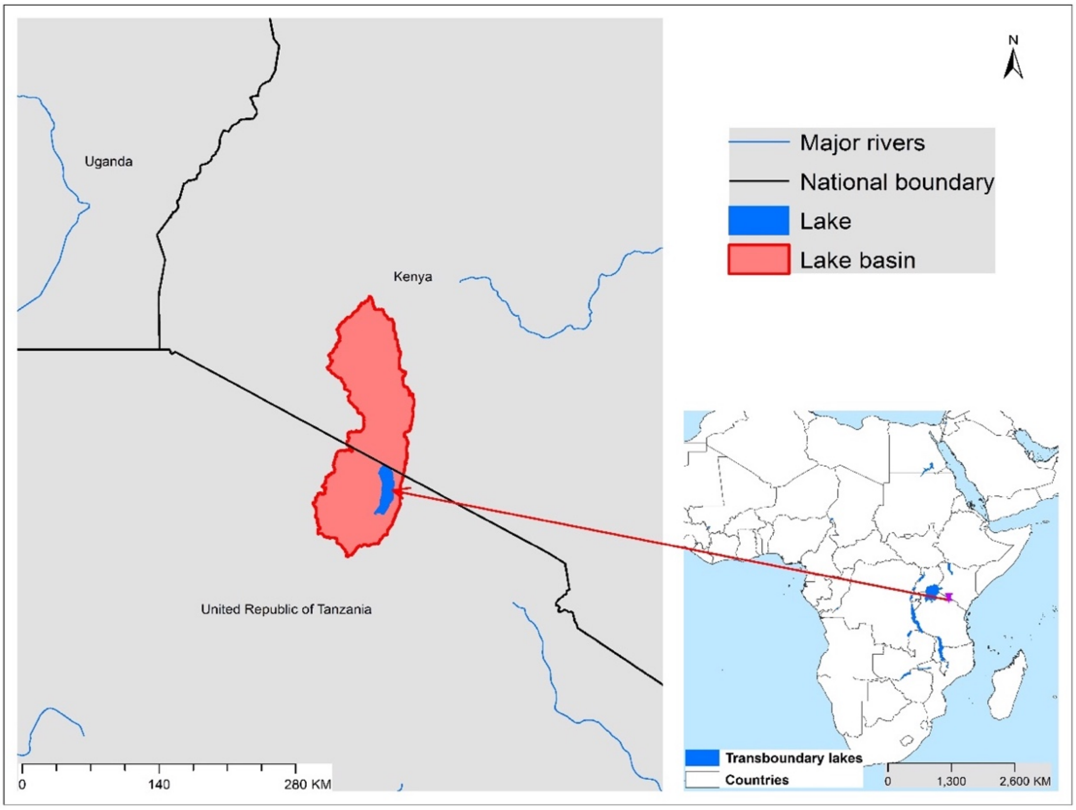
When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Mweru in the upper third of the threat ranks. The relative threat increases somewhat when the Adj-HWS and RvBD threats are considered together. Considering 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 Natron/Magadi

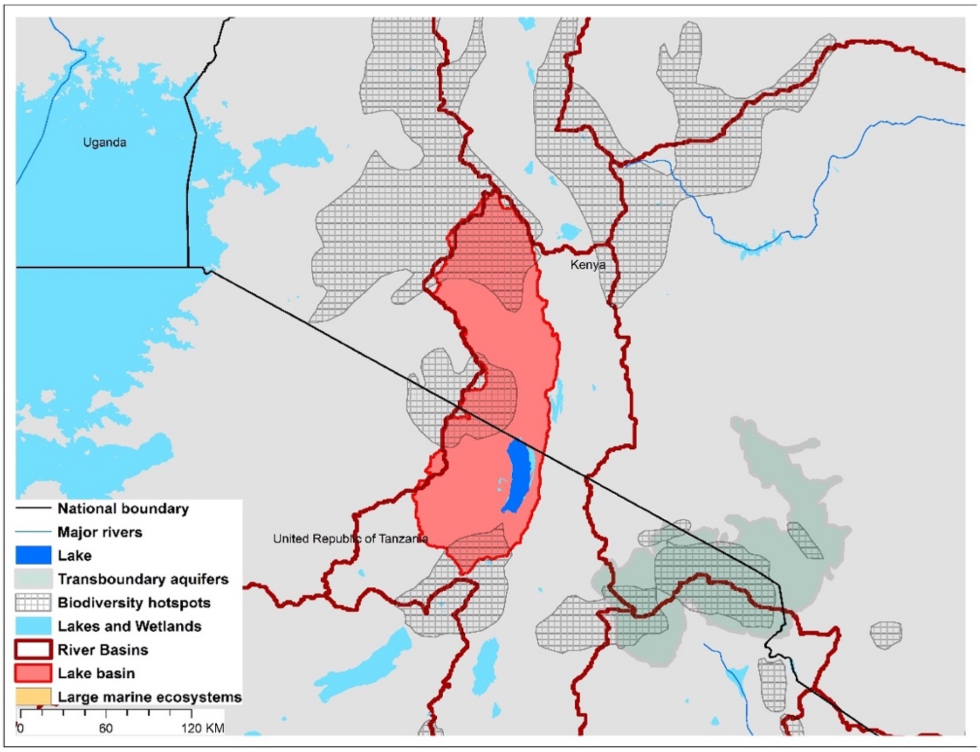
Geographic Information

Lake Natron is a terminal soda lake located in the East African Great Rift Valley surrounded by escarpments and volcanic mountains. It is located in the Lake Natron Basin, a Ramsor wetland site of international significance. It is the only regular breeding site for the East African population of Lesser Flamingos, supporting approximately 2.5 million flamingos. Potential development threats to the lake include a proposed hydropower plant for the Ewaso Ngiro River in Kenya and possible soda ash exploitation in the lake. Lake Natron and nearby Lake Magadi would benefit considerably if the two riparian countries (Kenya and Tanzania) would include them within the context of their national strategic plan for collective integrated management of the region's Rift Valley lakes. It also would have synergistic effects in terms of both GEF-catalyzed management interventions and the development and implementation of national strategic plans, suggesting the exploration of a regional transboundary/non-transboundary management framework.

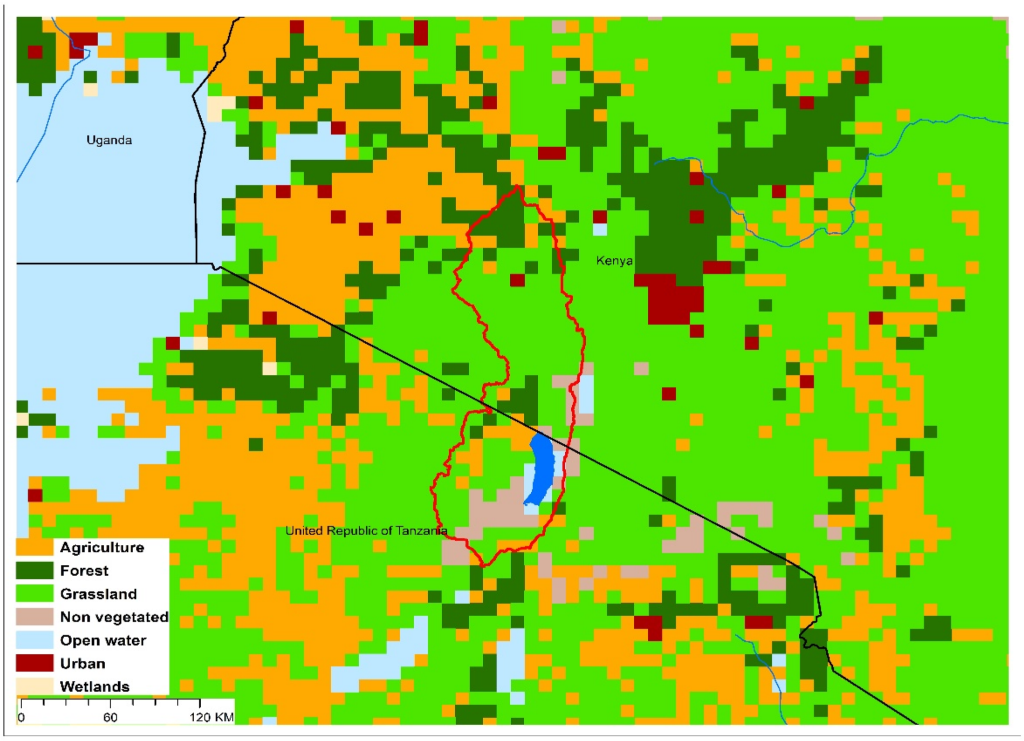


TWAP Regional Designation	Eastern & Southern Africa	**Lake Basin Population (2010)**	393,719
River Basin	Southern Ewaso Ng'iro	**Lake Basin Population Density (2010; # km^{-2})**	20.7
Riparian Countries	Kenya, Tanzania	**Average Basin Precipitation (mm yr^{-1})**	708.6
Basin Area (km^2)	13,609	**Shoreline Length (km)**	128.9
Lake Area (km^2)	560.4	**Human Development Index (HDI)**	0.51
Lake Area:Lake Basin Ratio	0.037	**International Treaties/Agreements Identifying Lake**	No (Ramsar Site

Lake Natron Basin Characteristics



(a) Lake Natron basin and associated transboundary water systems



(b) Lake Natron basin land use

Lake Natron 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 Natron 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 Natron 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 Natron 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 Natron 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
0.93	7		0.67	18		0.57	23

It is emphasized that the Lake Natron 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 Natron 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 Natron, 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 Natron basin in a moderately high threat rank in regard to its health, educational and economic status.

Table 2. Lake Natron 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)

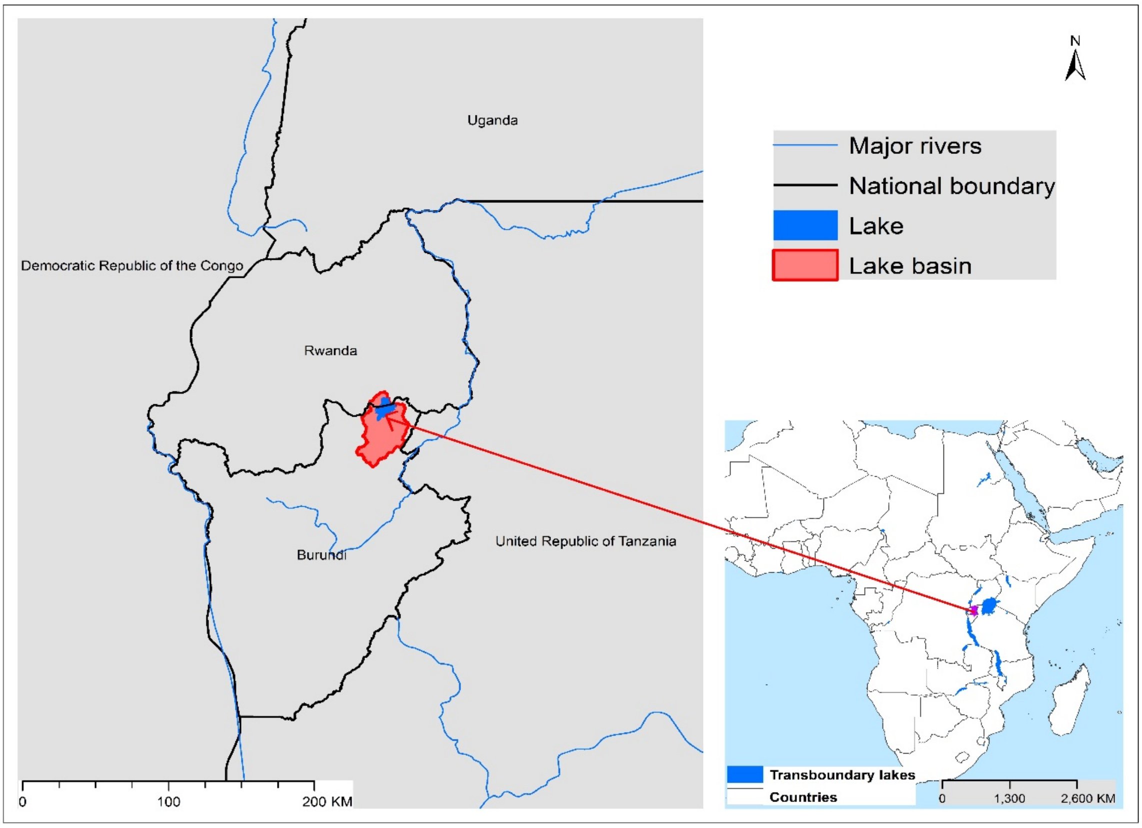
Adj-HWS Rank	HDI Rank	RvBD Rank	Sum Adj-HWS + RvBD	Relative Threat Rank	Sum Adj-HWS + HDI	Relative Threat Rank	Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
8	23	17	25	4	31	13	48	15

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

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

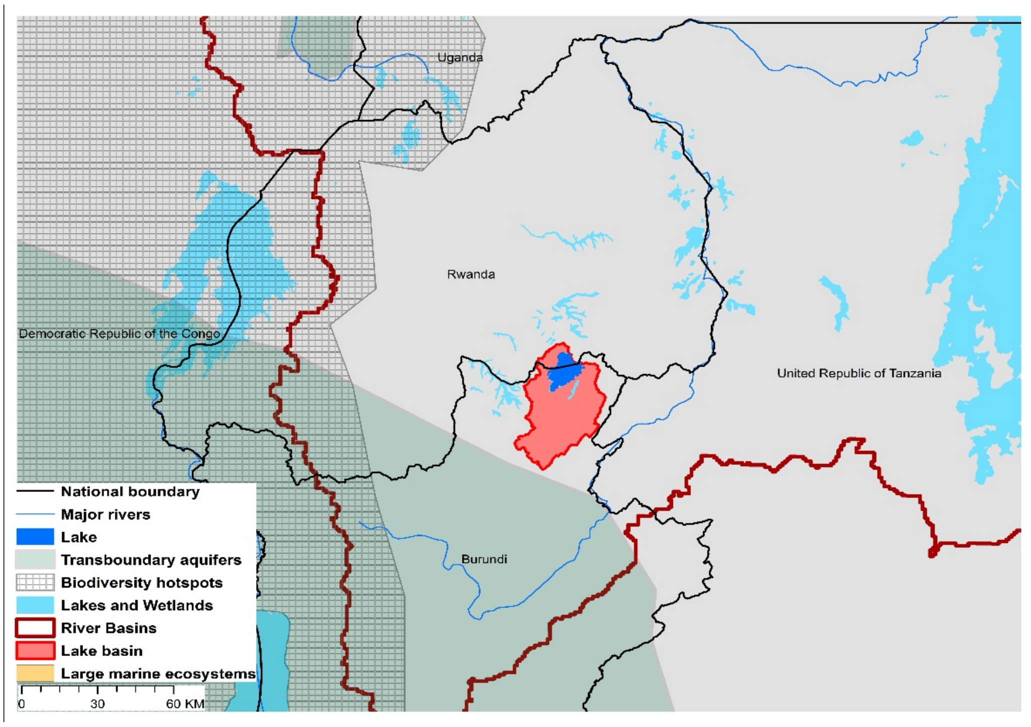
Lake Rweru/Moereo — Geographic Information

Lake Rweru is located in central Africa, close to the northernmost point of Burundi, with its northern shore forming part of the Burundi-Rwanda border. The lake is surrounded by marshes and papyrus, and contains floating islands. It is considered by many to be the most distant starting point of the Nile River, in that the Kagera River, which rises at the northern part of the lake, is considered to be the starting point of the Nile. The lake hosts limited fishing activities, and is being increasingly invaded by water hyacinth. Lake Rweru could be a subject for GEF-catalyzed management interventions, along with Lakes Cohoha and Ihema, with all three lakes located in the same general proximity in the upper catchment wetland region of the riparian countries, and sharing similar economic (fishery management) and environmental (progressing eutrophicatio) challenges. Effectively considering these lakes for such management interventions may require a new strategic approach that considers them as a lake cluster comprising both transboundary and national (non-transboundary) lake basins.

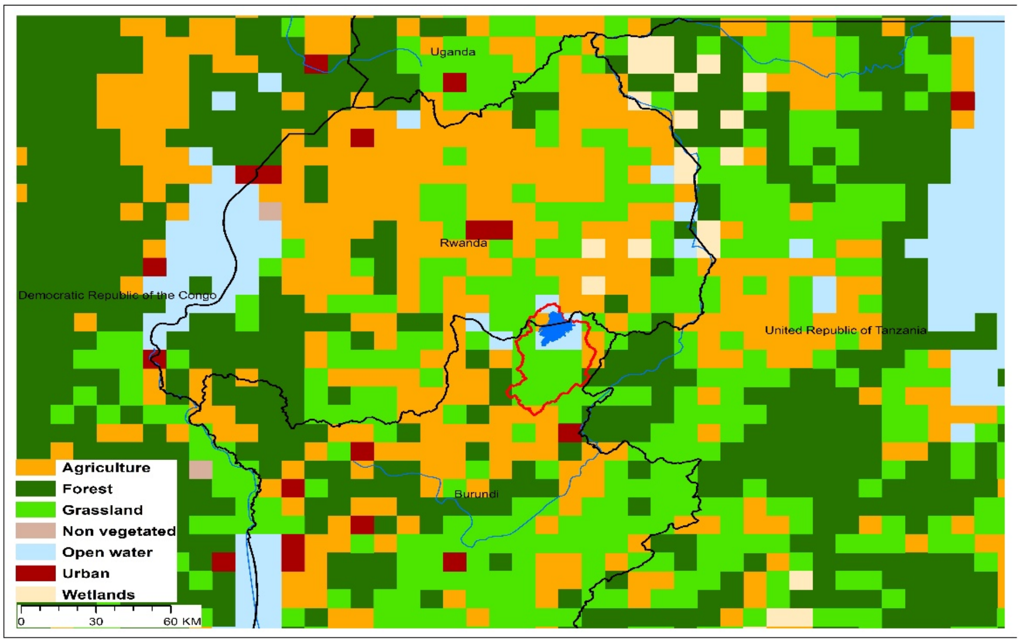


TWAP Regional Designation	Eastern & Southern Africa		**Lake Basin Population (2010)**	359,565
River Basin	Nile		**Lake Basin Population Density (2010; # km^{-2})**	284.9
Riparian Countries	Burundi, Rwanda		**Average Basin Precipitation (mm yr^{-1})**	938.7
Basin Area (km^2)	941.6		**Shoreline Length (km)**	96.7
Lake Area (km^2)	125.5		**Human Development Index (HDI)**	0.38
Lake Area:Lake Basin Ratio	0.109		**International Treaties/Agreements Identifying Lake**	No

Lake Rweru/Moero Basin Characteristics



(a) Lake Rweru/Moero basin and associated transboundary water systems



(b) Lake Rweru/Moero basin land use

Lake Rweru/Moereo 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 Rweru/Moero 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 Rweru/Moero 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 Rweru/Moero 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 Rweru/Moero 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
0.96	4		0.58	30		0.36	3

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

The relative Human Development Index (HDI) places the Lake Rweru/Moero basin in the highest quarter of the priority transboundary lake basins in regard to its health, educational and economic status.

Table 2. Lake Rweru/Moero 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
4	3	30		34	16		7	2		37	8

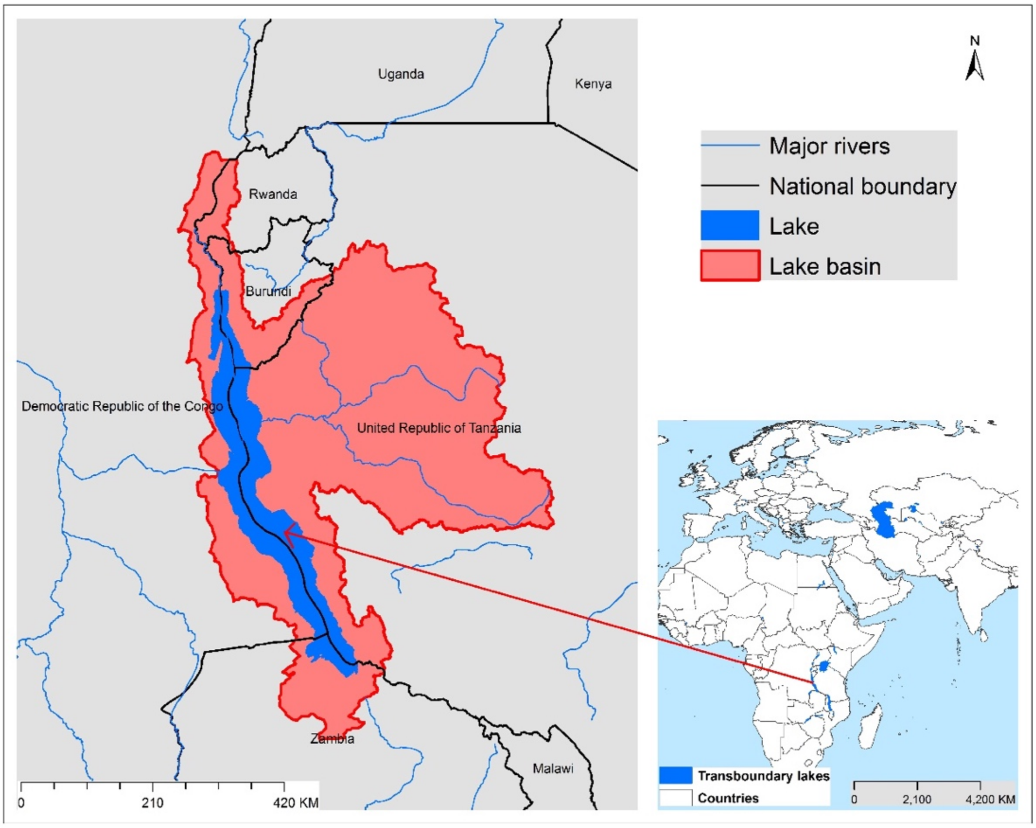
When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Rweru/Moero in the highest quarter of the threat ranks. The relative threat is somewhat reduced when the Adj-HWS and RvBD threats are considered together. Considering all three ranking criteria together, Lake Rweru/Moero exhibits an overall high threat ranking.

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

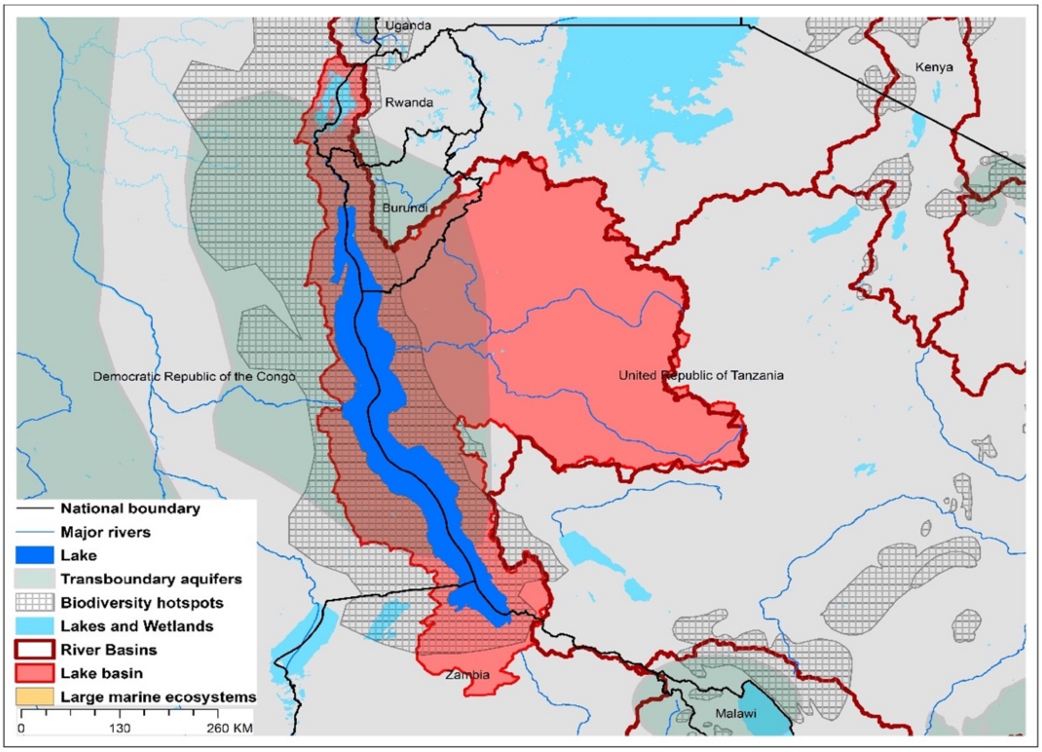
Geographic Information

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.

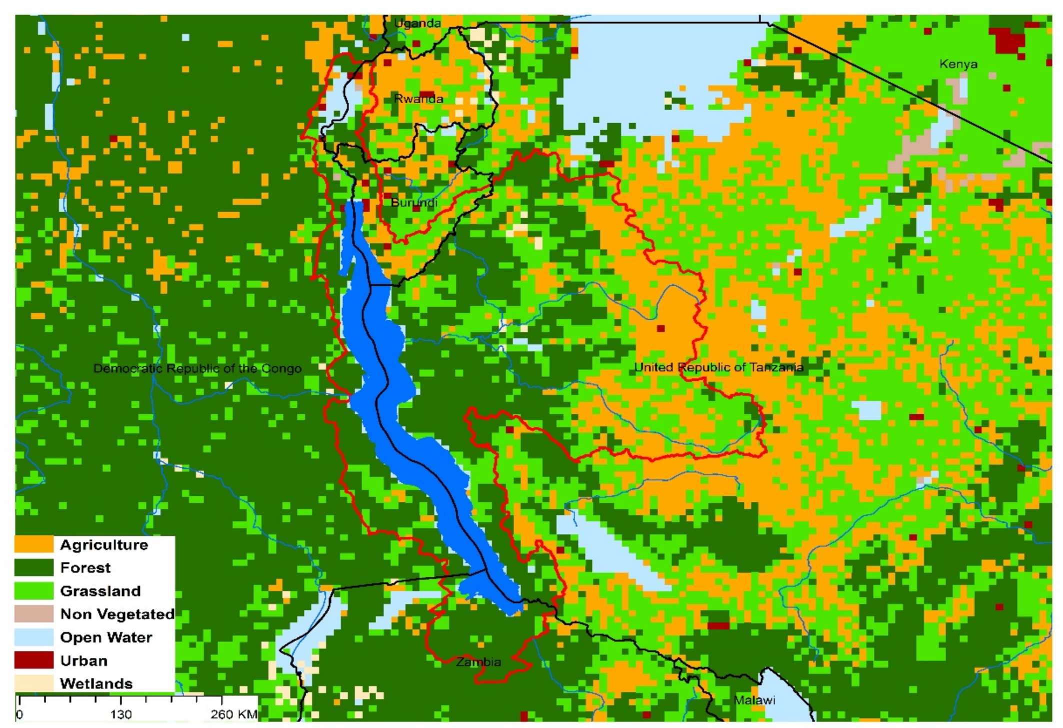


TWAP Regional Designation	Eastern & Southern Africa; Western & Middle Africa	**Lake Basin Population (2010)**	13,754,496
River Basin	Congo	**Lake Basin Population Density (2010; # km^{-2})**	57.7
Riparian Countries	Burundi, Democratic Republic of Congo, Tanzania, Zambia	**Average Basin Precipitation (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

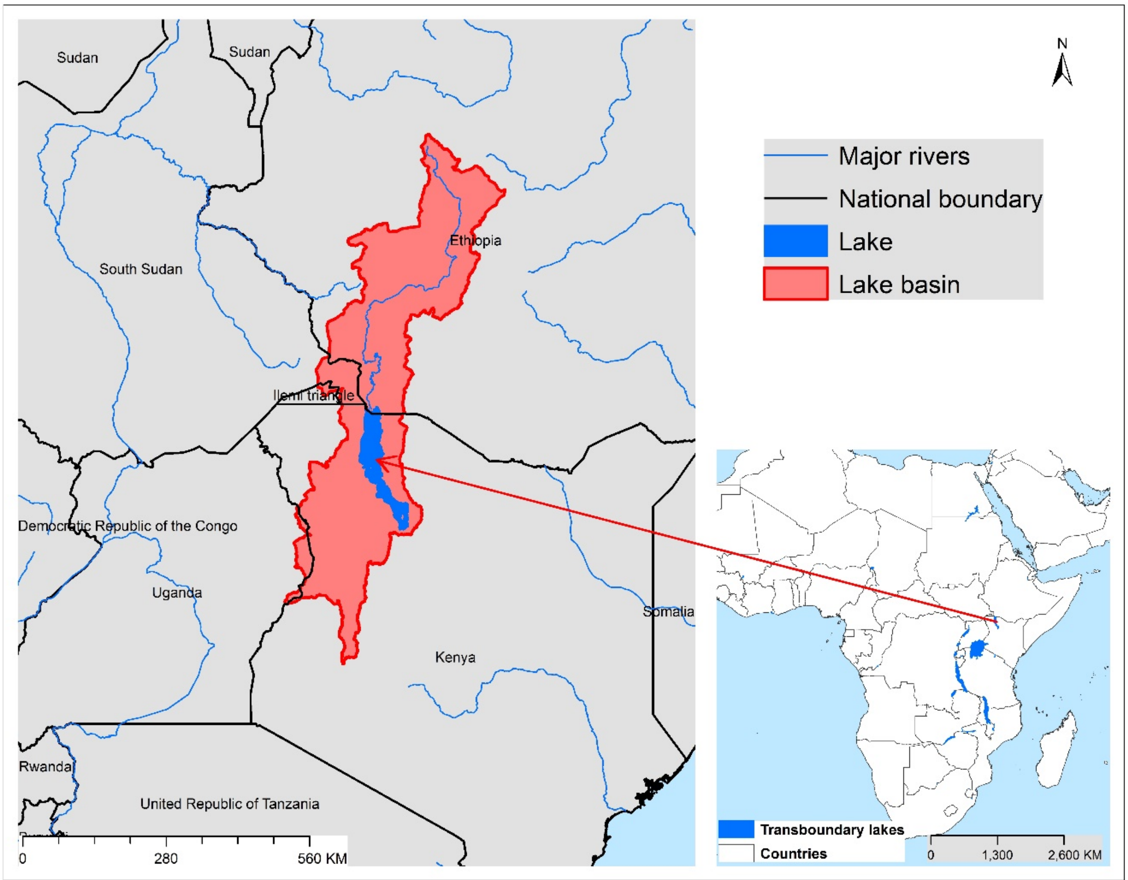
When multiple ranking criteria are considered together in the threat rank calculations, the Adj-HWS and HDI scores considered together place Lake Tanganyika in the upper third of the threat ranks. The relative threat is slightly increased when the Adj-HWS and RvBD threats are considered together. Considering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

Lake Turkana

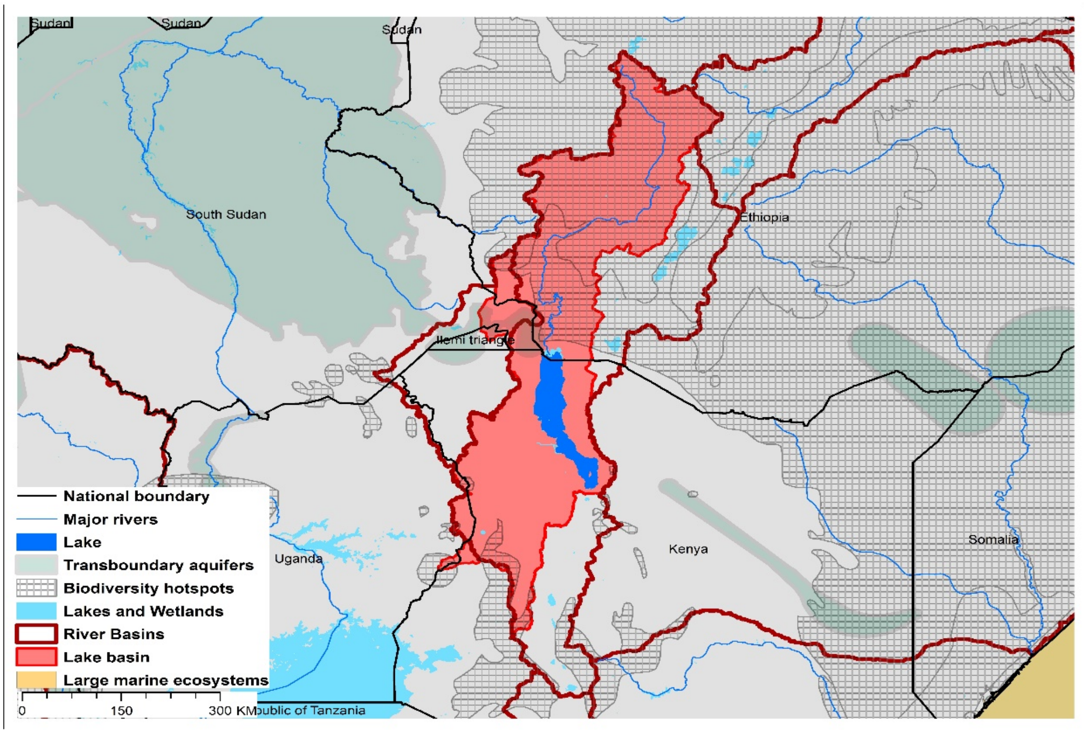
Geographic Information

Lake Turkana is located in the hot, dry Kenyan Rift Valley, with its northern end crossing into Ethiopia. Often called the Jade Sea because of its deep green alkaline color, it is the world's largest permanent desert lake and largest alkaline lake, and also contains the fourth-largest water volume of the world's salt lakes. It is located in an isolated, extremely arid region, and may receive rainfall only once every five years. The lake remains relatively isolated, receiving little tourism because of the region's high temperatures, arid conditions and geographic inaccessibility. Nevertheless, it is considered to be a seriously-challenged lake regarding its environmental condition and managerial challenges. Any possible GEF-catalyzed management interventions would depend on the politically-contended situation in the riparian countries, suggesting a review of its current GEF status.

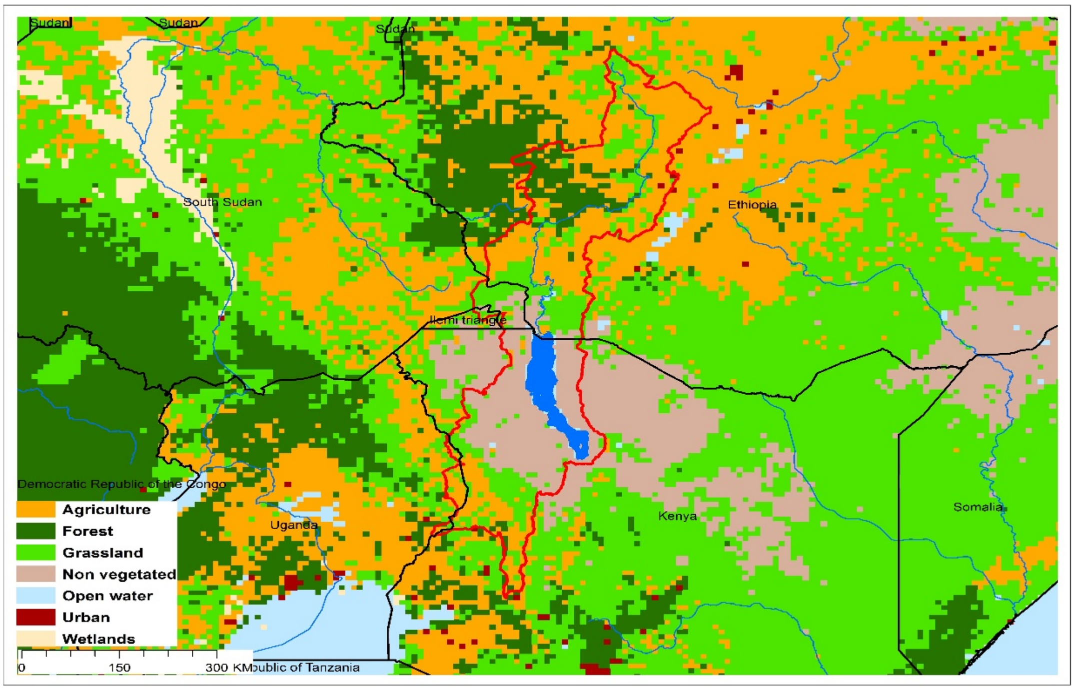


TWAP Regional Designation	Eastern & Southern Africa	**Lake Basin Population (2010)**	10,922,974
River Basin	Turkana (endorheic)	**Lake Basin Population Density (2010; # km^{-2})**	67.1
Riparian Countries	Ethiopia, Kenya	**Average Basin Precipitation (mm yr^{-1})**	850.0
Basin Area (km^2)	120,525	**Shoreline Length (km)**	1,192
Lake Area (km^2)	7,439	**Human Development Index (HDI)**	0.41
Lake Area:Lake Basin Ratio	0.051	**International Treaties/Agreements Identifying Lake**	Yes

Lake Turkana Basin Characteristics



(a) Lake Turkana basin and associated transboundary water systems



(b) Lake Turkana basin land use

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

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

Adjusted Human Water Security (Adj-HWS) Threat Score	Relative Adj-HWS Threat Rank		Reverse Biodiversity (RvBD) Threat Score	Relative RvBD Threat Rank		Human Development Index (HDI) Score	Relative HDI Rank
0.90	14		0.70	11		0.41	9

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

The Reverse Biodiversity (RvBD) for Lake Turkana, 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 Turkana basin in a high threat rank in regard to its health, educational and economic status.

Table 2. Lake Turkana 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)

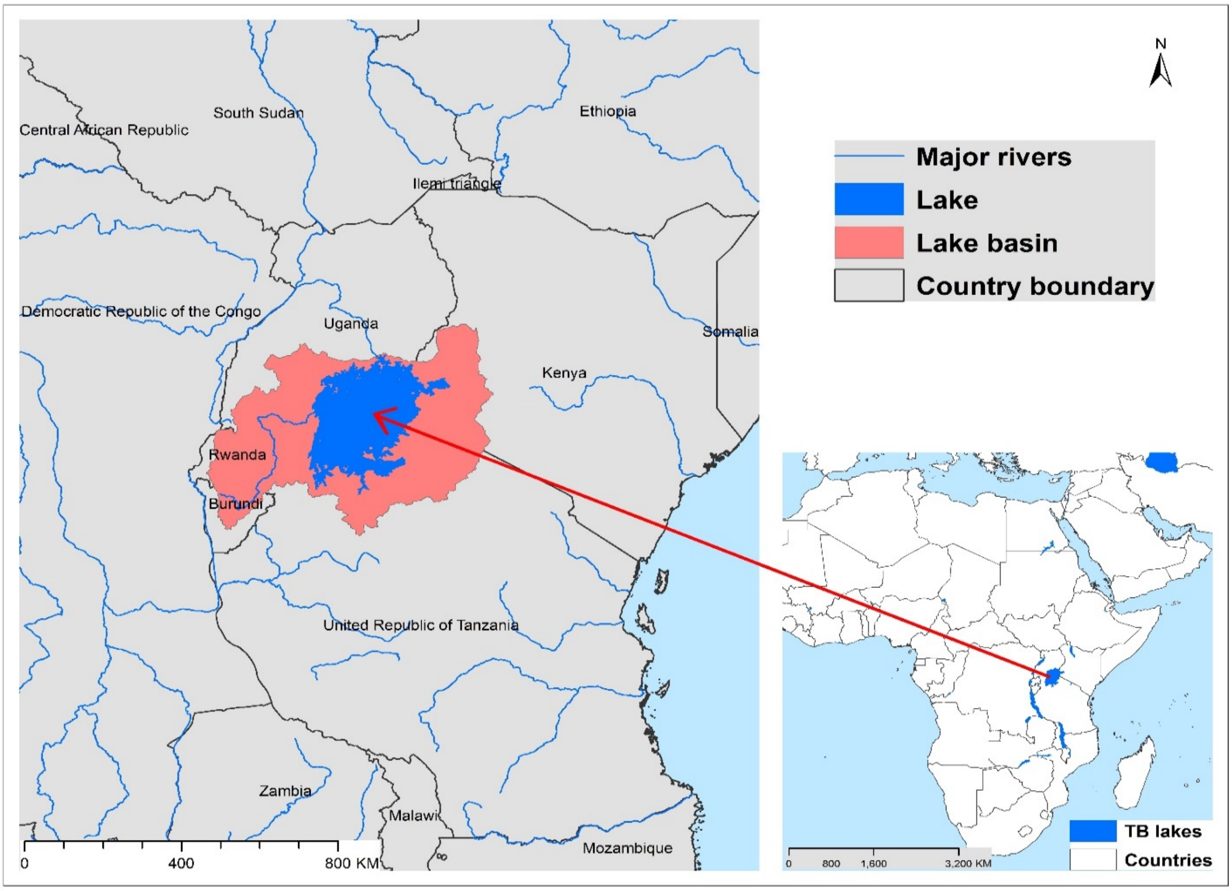
Adj-HWS Rank	HDI Rank	RvBD Rank		Sum Adj-HWS + RvBD	Relative Threat Rank		Sum Adj-HWS + HDI	Relative Threat Rank		Sum Adj-HWS + RvBD + HDI	Overall Threat Rank
14	9	11		22	2		23	10		32	2

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

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

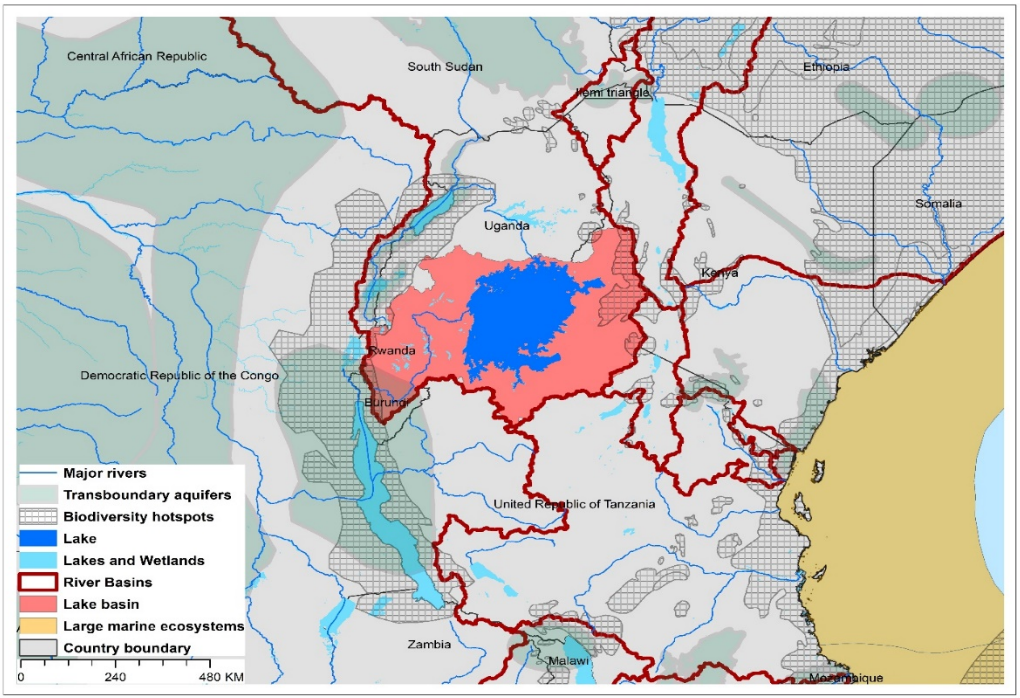
Based on area, Lake Victoria is Africa's largest lake, and the world's second largest lake. It receives about 80% of its influent water from direct rainfall, and is drained by the Nile River through an outflow at Jinja, Uganda, where it forms the White Nile. Major environmental issues include invasive species, notably Nile perch and water hyacinth, and pollution. Although the lake basin is largely rural in character, its shoreline contains many population centers, sources of the raw sewage, domestic and industrial wastes and agricultural fertilizers and chemicals that enhance its current eutrophic status. The lake has received GEF funding in the past, and a review of its GEF status should accompany future



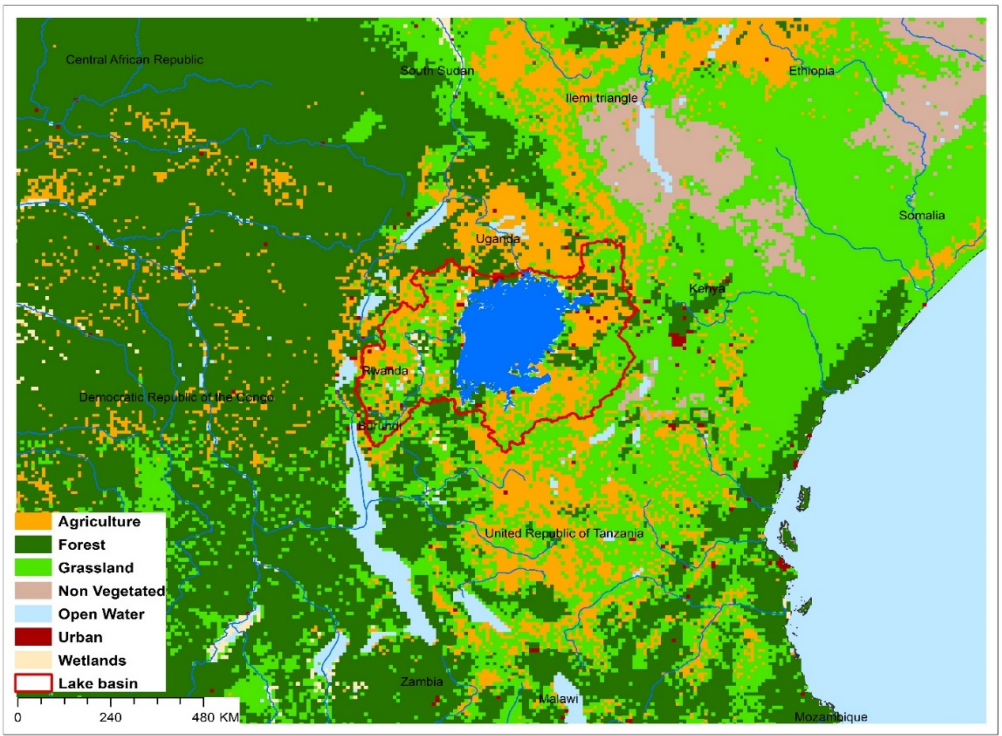
funding considerations.

TWAP Regional Designation	Eastern & Southern Africa	**Lake Basin Population (2010)**	47,436,052
River Basin	Nile	**Lake Basin Population Density (2010; # km^{-2})**	27.2
Riparian Countries	Kenya, Uganda, Tanzania	**Average Basin Precipitation (mm yr^{-1})**	1,196
Basin Area (km^2)	215,482	**Shoreline Length (km)**	8,703
Lake Area (km^2)	66,842	**Human Development Index (HDI)**	0.466
Lake Area:Lake Basin Ratio	0.254	**International Treaties/Agreements Identifying Lake**	Yes

Lake Victoria Basin Characteristics



(a) Lake Victoria basin and associated transboundary water systems



(b) Lake Victoria basin land use

Lake Victoria 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 Victoria 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 Victoria 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 Victoria 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 Victoria 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	9		0.56	33		0.47	22

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

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

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

Table 2. Lake Victoria 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
11	22	32		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 Victoria in the upper one-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 Victoria exhibits an overall moderately high threat ranking.

Interactions between the ranking parameters for Lake Victoria 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 Victoria, 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 ^oC), 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

1. Awash
2. Baraka
3. Buzi
4. Congo/ Zaire
5. Cuvelai/ Etosha
6. Gash
7. Incomati
8. Juba-Shibeli
9. Kunene
10. Lotagipi Swamp
11. Lake Natron
12. Lake Turkana
13. Limpopo
14. Maputo
15. Nile
16. Okavango
17. Orange
18. Pangani
19. Pungwe
20. Ruvuma
21. Sabi
22. Thukela
23. Umbeluzi
24. Umba
25. Zambezi

Awash Basin

Geography

Total drainage area (km²)	152,265
No. of countries in basin	4
BCUs in basin	Djibouti (DJI), Eritrea (ERI), Ethiopia (ETH), Somalia (SOM)
Population in basin (people)	16,316,581
Country at mouth	Djibouti, Ethiopia
Average rainfall (mm/year)	597

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	10
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)
AWSH_DJI		51.07			166.03	1.67
AWSH_ERI						
AWSH_ETH		178.72			1,731.27	39.59
AWSH_SOM		132.07				
Total in Basin	25.39	166.77			1,897.30	41.26

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

AWSH_DJI	34.31	3.92	3.07	9.90	6	10.96	386.24	
AWSH_ERI								
AWSH_ETH	1,419.77	798.56	64.02	1.60	281	274.93	87.55	
AWSH_SOM	9.23	6.94	1.03	0.00	0	1.25	826.87	
Total in Basin	1,463.30	809.42	68.12	11.50	287.11	287.14	89.68	5.76

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)
AWSH_DJI	11	0.07	89	8.02	1.90	0.00	100.00	0	1,668.34	0	0.00
AWSH_ERI	0	0.00	0	0.00				0	543.82	0	0.00
AWSH_ETH	141	0.93	16,217	115.02	2.21	0.50	99.50	5	498.08	4	28.37
AWSH_SOM	0	0.00	11	54.33	2.20			0	0.00	0	0.00
Total in Basin	152	1.00	16,317	107.16	2.55	0.49	99.44	5	504.11	4	26.27

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**
AWSH_DJI	2	5	2		5	3	3		2	5	3		4	3	5
AWSH_ERI					5					5	3	2	1	3	
AWSH_ETH	2	3	2		5	2	4	2	3	5	3	3	5	3	2
AWSH_SOM	1		2						1	5	3		1	5	2
River Basin	2	3	2	3	5	3	4	2	2	5	3	3	5	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**

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

AWSH_DJI	5	5	5	5			2	4	4
AWSH_ERI									4
AWSH_ETH	5	5	4	4			2	3	5
AWSH_SOM	5	5					1	2	4
River Basin	5	5	4	4	3	3	2	3	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	4				

Indicators

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

Disclaimer

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

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

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

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

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

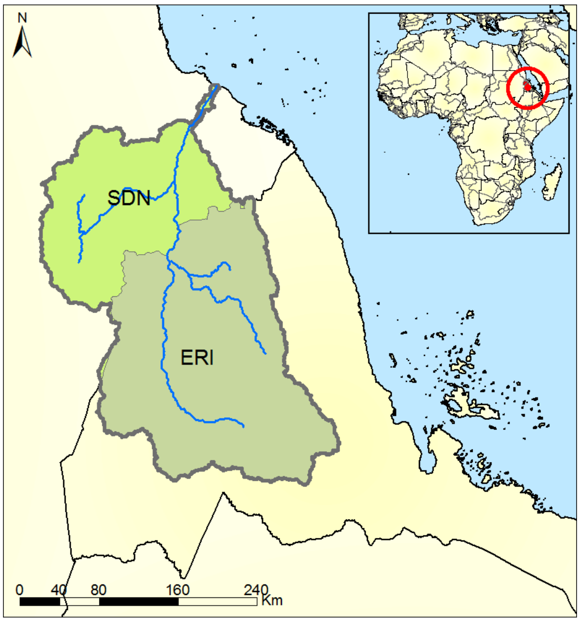
Basin Delineation
TWAP RB assessment includes 286 transboundary river basins. Information on this layer and delineation methodology can be retrieved by downloading metadata sheet for the Basins layer from TWAP Rivers Data Portal at http://twap-rivers.org/indicators/ or by direct download from http://twap-rivers.org/assets/Basin%20and%20BCU%20Creation%20Documenta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

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

For more information on data sources, indicator calculation methodologies, limitations and more consult indicator metadata sheets available on

TWAP RB Data portal on http://twap-rivers.org .

Baraka Basin



Geography

Total drainage area (km²)	63,770
No. of countries in basin	2
BCUs in basin	Eritrea (ERI), Sudan (SDN)
Population in basin (people)	2,260,349
Country at mouth	Sudan
Average rainfall (mm/year)	270

Governance

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

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	1

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

Water Resources

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

Water Withdrawals

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

[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	334.96	249.19	12.40	12.24	4.30	56.84	148.19	11.58

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)
BRKA_ERI	42	0.66	1,912	45.42	3.16	0.00	100.00	1	543.82	1	23.76
BRKA_SDN	22	0.34	349	16.08	2.51			0	1,752.90	0	0.00
Total in Basin	64	1.00	2,260	35.45	3.06	0.00	84.58	1	730.30	1	15.68

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

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

Indicators

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**
BRKA_ERI	5	5	5	5			3	5	3
BRKA_SDN	5	5	5	5			3	5	3
River Basin	5	5	5	5	5	5	3	5	3

TWAP RB Assessment results: Water System Linkages

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

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

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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Buzi Basin

Geography

Total drainage area (km^2)	28,490
No. of countries in basin	2
BCUs in basin	Mozambique (MOZ), Zimbabwe (ZWE)
Population in basin (people)	1,318,346
Country at mouth	Mozambique
Average rainfall (mm/year)	1,290

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	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)
BUZI_MOZ		329.14			183.80	2.06
BUZI_ZWE		351.57				
Total in Basin	9.49	333.23			183.80	2.06

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 (%)
BUZI_MOZ	28.87	10.17	0.52	0.00	1	17.62	25.70	
BUZI_ZWE	73.44	67.46	0.48	0.00	0	5.39	376.94	

[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	102.32	77.63	1.00	0.00	0.68	23.01	77.61	1.08

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)
BUZI_ MOZ	25	0.87	1,124	45.31	2.38	0.00	100.00	0	592.98	1	40.33
BUZI_ ZWE	4	0.13	195	52.77	0.00	0.00	100.00	0	904.76	2	541.72
Total in Basin	28	1.00	1,318	46.27	2.56	0.00	100.00	0	639.06	3	105.30

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**
BUZI_MOZ	1	1	2		5	2	3	1	2	3	3	3	1	4	3
BUZI_ZWE	2	1	2		5	1	4	2	2	3	3	2	1	3	2
River Basin	2	1	2	3	5	2	4	1	1	3	3	3	1	5	3

Indicators

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Very low	Low	Medium	High	Very high

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

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

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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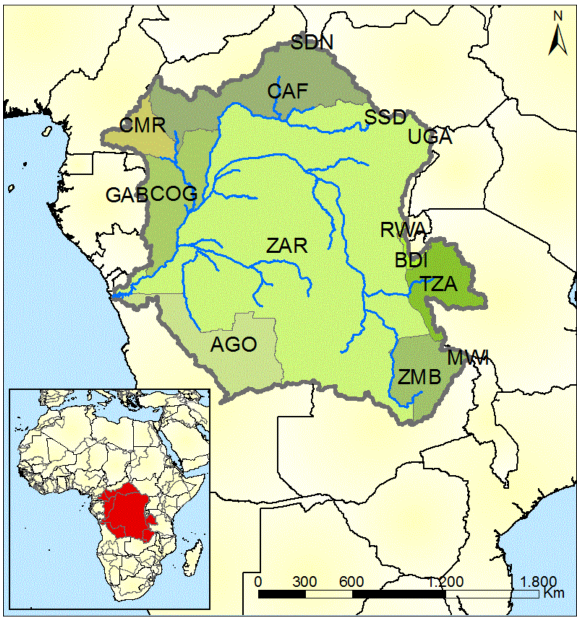
Congo/Zaire Basin



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						

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

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

Water Withdrawals

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

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
CNGO_AGO	288	0.08	2,642	9.18	2.92	8.45	91.55	0	5,668.12	0	0.00
CNGO_BDI	14	0.00	3,724	272.63	2.90	0.00	100.00	1	267.48	0	0.00
CNGO_CAF	404	0.11	3,040	7.53	1.82	0.00	100.00	1	333.20	0	0.00

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

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

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

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

Indicators

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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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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 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)
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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Gash Basin

Geography

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

Governance

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

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	0
Large Marine Ecosystems	0

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

Water Resources

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

Water Withdrawals

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

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

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

Socioeconomic Geography

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

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

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

Indicators

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

Very low | Low | Medium | High | Very high

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

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

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

TWAP RB Assessment results: Water System Linkages

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

Indicators

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Incomati Basin

Geography

Total drainage area (km²)	46,630
No. of countries in basin	3
BCUs in basin	Mozambique (MOZ), South Africa (ZAF), Swaziland (SWZ)
Population in basin (people)	2,104,987
Country at mouth	Mozambique
Average rainfall (mm/year)	860

Governance

No. of treaties and agreements[1]	5
No. of RBOs and Commissions[2]	4

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)
ICMT_MOZ		103.55			59.10	0.71
ICMT_SWZ						
ICMT_ZAF		108.07				
Total in Basin	4.96	106.37			59.10	0.71

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 (%)
ICMT_MOZ	195.69	158.89	1.11	1.06	3	31.99	330.46	

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
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ICMT_SWZ								
ICMT_ZAF	473.94	251.10	5.22	0.42	63	154.62	357.30	
Total in Basin	669.64	409.98	6.32	1.49	65.24	186.61	318.12	13.50

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/ km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
ICMT_MOZ	15	0.33	592	38.62	2.38	0.00	100.00	0	592.98	1	65.22
ICMT_SWZ	3	0.05	186	72.74	1.42	100.00	0.00	0	3,034.22	2	780.73
ICMT_ZAF	29	0.62	1,326	46.16	0.96	0.00	100.00	0	6,617.91	12	417.60
Total in Basin	47	1.00	2,105	45.14	1.67	8.85	91.15	0	4,605.70	15	321.68

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**
ICMT_MOZ	1	3	3		5	4	4	3	1	2	3	3	2	5	4
ICMT_SWZ					3				1	2	3	5	2	3	2
ICMT_ZAF	2	3	2		4	1	5	2	1	1	1	2	1	3	3
River Basin	2	3	2	3	4	2	5	2	1	2	2	3	1	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

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**
ICMT_MOZ	2	3	4	4			3	5	4
ICMT_SWZ							1	2	3
ICMT_ZAF	3	3	3	3			1	1	1
River Basin	3	3	3	3	4	5	1	2	2

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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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Juba-Shibeli Basin

Geography

Total drainage area (km²)	792,350
No. of countries in basin	3
BCUs in basin	Ethiopia (ETH), Kenya (KEN), Somalia (SOM)
Population in basin (people)	19,761,049
Country at mouth	Somalia
Average rainfall (mm/year)	597

Governance

No. of treaties and agreements[1]	5
No. of RBOs and Commissions[2]	0

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	1
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)
JUBA_ETH		79.95				
JUBA_KEN		106.03				
JUBA_SOM		35.73				
Total in Basin	58.94	74.39			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 (%)
JUBA_ETH	883.80	259.85	95.37	0.40	250	278.34	76.17	

[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/

JUBA_KEN	328.49	105.36	50.66	5.06	0	167.41	129.73	
JUBA_SOM	1,186.81	1,090.63	75.07	19.79	0	1.32	210.97	
Total in Basin	2,399.10	1,455.84	221.10	25.25	249.83	447.08	121.41	4.07

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)
JUBA_ETH	366	0.46	11,603	31.72	2.21	3.12	96.88	0	498.08	1	2.73
JUBA_KEN	209	0.26	2,532	12.12	2.58	0.00	100.00	0	994.31	0	0.00
JUBA_SOM	218	0.27	5,625	25.84	2.20	0.00	100.00	1	0.00	0	0.00
Total in Basin	792	1.00	19,761	24.94	2.67	1.83	98.17	1	419.87	1	1.26

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**
JUBA_ETH	2	1	2		5	1	3		2	5	5	3	2	3	3
JUBA_KEN	2	1	2		5	2	3	2	2	5	2	3	2	3	5
JUBA_SOM	2	4	3			3	2		2	5	4		4	5	5
River Basin	2	1	2	3		2	3	2	2	5	4		3	3	5

Indicators

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

Very low Low Medium High Very high

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

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

Geography

Total drainage area (km^2)	27,280
No. of countries in basin	2
BCUs in basin	Kenya (KEN), Tanzania, United Republic Of (TZA)
Population in basin (people)	719,709
Country at mouth	Kenya, Tanzania, United Republic Of
Average rainfall (mm/year)	780

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	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)
LKNT_KEN		81.30			114.82	1.60
LKNT_TZA		129.28			558.78	6.85
Total in Basin	2.59	95.00			673.60	8.44

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 (%)
LKNT_KEN	435.60	71.03	25.66	77.04	11	250.52	731.32	
LKNT_TZA	8.26	1.82	2.73	0.00	0	3.71	66.53	

[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	443.85	72.85	28.39	77.04	11.35	254.23	616.71	17.13

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)
LKNT_KEN	18	0.65	596	33.69	2.58	0.00	100.00	0	994.31	0	0.00
LKNT_TZA	10	0.35	124	12.92				0	694.77	0	0.00
Total in Basin	27	1.00	720	26.38	2.75	0.00	82.76	0	942.67	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
LKNT_KEN	2	1	2		5	4	2	3	3	5	3	3	2	3	5
LKNT_TZA	1	1	2		5	4	1	3	2	3	3	2	1	3	4
River Basin	2	1	2	3	5	4	1	3	2	4	3	3	1	4	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
LKNT_KEN	5	5	2	3			3	5	4
LKNT_TZA	5	5	1	1			4	5	3
River Basin	5	5	1	3	4	4	4	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				

[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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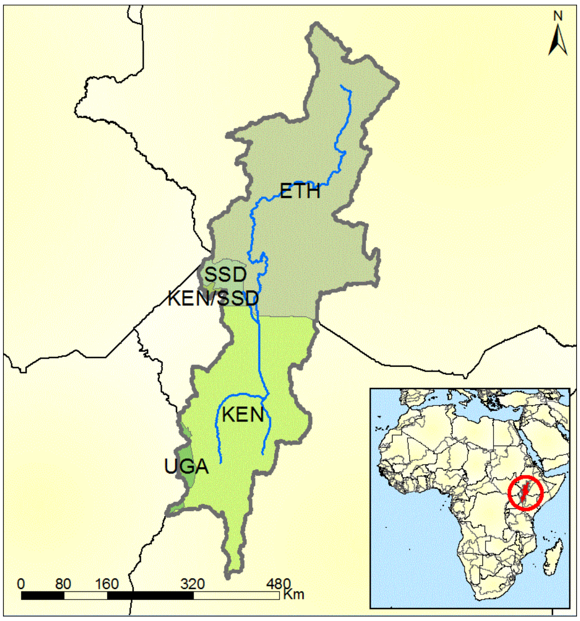
Lake Turkana Basin



Geography

Total drainage area (km^2)	173,144
No. of countries in basin	5
BCUs in basin	Ethiopia (ETH), Ilemi triangle (KEN/SSD), Kenya (KEN), South Sudan (SSD), Uganda (UGA)
Population in basin (people)	11,732,689
Country at mouth	Ethiopia, Kenya
Average rainfall (mm/year)	947

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	5
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)
LKTK_ETH		586.04			1,115.10	24.27
LKTK_KEN		160.03			7,374.50	220.33
LKTK_KEN/SSD		63.68				
LKTK_SSD		43.65				
LKTK_UGA		156.59				
Total in Basin	63.83	368.64			8,489.60	244.60

Water Withdrawals

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

BCU	Total (km³/year)	Irrigation (km³/year)	Livestock (km³/year)	Electricity (km³/year)	Manufacture (km³/year)	Domestic (km³/year)	Per capita (m³/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
LKTK_ETH	559.36	52.83	55.19	0.02	232	219.66	53.40	
LKTK_KEN	159.78	89.80	13.91	1.21	0	54.85	138.31	
LKTK_KEN/SSD	0.59	0.00	0.28	0.00	0	0.31	347.68	
LKTK_SSD	2.31	0.00	1.04	0.00	0	1.27	133.15	
LKTK_UGA	19.51	0.12	1.70	0.00	0	17.68	234.68	
Total in Basin	741.54	142.76	72.12	1.23	231.66	293.78	63.20	1.16

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)
LKTK_ETH	99	0.57	10,475	105.80	2.21	6.96	93.04	1	498.08	0	0.00
LKTK_KEN	65	0.38	1,155	17.68	2.58	0.00	100.00	0	994.31	1	15.30
LKTK_KEN/SSD	1	0.00	2	2.76				0		0	0.00
LKTK_SSD	5	0.03	17	3.27	2.51			0	1,221.35	0	0.00
LKTK_UGA	3	0.02	83	28.92	3.24			0	571.68	0	0.00
Total in Basin	173	1.00	11,733	67.76	2.57	6.21	92.92	1	548.45	1	5.78

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**
LKTK_ETH	1	1	2		5	2	2	2	2	5	5	3	1	3	2
LKTK_KEN	1	1	2		5	1	3	2	2	5	5	3	2	3	2
LKTK_KEN/SSD	1		1						1	5	3		1	4	5
LKTK_SSD	2	1	1			2	2		2		5		1	5	5
LKTK_UGA	1	1	1		5	3	4	2	2	5	3	3	1	3	2
River Basin	2	1	2	3	5	2	2	2	2	5	5	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

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

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
LKTK_ETH	5	5	1	1			2	3	5
LKTK_KEN	5	5	1	1			3	5	5
LKTK_KEN/SSD	5	5							3
LKTK_SSD	5	5	1	1					5
LKTK_UGA	5	5	1	1			4	5	4
River Basin	5	5	1	1	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	5				

Indicators

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

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Limpopo Basin

Geography

Total drainage area (km^2)	406,520
No. of countries in basin	4
BCUs in basin	Botswana (BWA), Mozambique (MOZ), South Africa (ZAF), Zimbabwe (ZWE)
Population in basin (people)	15,159,368
Country at mouth	Mozambique
Average rainfall (mm/year)	590

Governance

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

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	3
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)
LMPO_BWA		18.12				
LMPO_MOZ		67.95			402.31	2.60
LMPO_ZAF		51.10			1.69	0.01
LMPO_ZWE		41.62				
Total in Basin	19.20	47.23			404.00	2.61

Water Withdrawals

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

BCU	Total (km³/year)	Irrigation (km³/year)	Livestock (km³/year)	Electricity (km³/year)	Manufacture (km³/year)	Domestic (km³/year)	Per capita (m³/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
LMPO_BWA	677.17	34.71	8.58	489.41	38	106.57	739.94	
LMPO_MOZ	323.40	293.04	4.19	0.25	1	24.70	288.28	
LMPO_ZAF	4,750.05	2,918.89	46.33	140.29	471	1,174.00	392.27	
LMPO_ZWE	93.28	28.99	7.55	8.17	1	47.16	92.05	
Total in Basin	5,843.90	3,275.62	66.65	638.12	511.09	1,352.42	385.50	30.44

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)
LMPO_BWA	81	0.20	915	11.24	1.35	13.51	86.49	1	7,316.88	5	61.42
LMPO_MOZ	80	0.20	1,122	14.11	2.38	2.11	97.89	1	592.98	1	12.58
LMPO_ZAF	183	0.45	12,109	66.23	0.96	0.00	100.00	13	6,617.91	73	399.27
LMPO_ZWE	63	0.15	1,013	16.15	0.00	0.00	100.00	0	904.76	22	350.56
Total in Basin	407	1.00	15,159	37.29	1.51	0.97	99.03	15	5,832.35	101	248.45

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**
LMPO_BWA	2	5	2		5	1	5	2	1	3	4	3	5	3	5
LMPO_MOZ	2	1	2		5	4	4	2	1	3	3	3	3	5	5
LMPO_ZAF	5	5	3		4	1	5	2	2	3	3	2	3	3	5
LMPO_ZWE	2	5	2		5	1	5	2	1	3	4	2	1	3	4
River Basin	3	4	3	5	4	2	5	2	1	3	3	2	4	4	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

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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
LMPO_BWA	5	5	5	5			2	3	4
LMPO_MOZ	3	3	1	1			3	5	4
LMPO_ZAF	5	5	5	5			1	1	3
LMPO_ZWE	5	5	4	4			2	3	5
River Basin	5	5	4	5	5	5	1	2	3

TWAP RB Assessment results: Water System Linkages

Thematic group	Lake Influence Indicator	Delta Vulnerability Index			
Basin/Delta	17	18	19	20	21
River Basin	1	2	2	3	3

Indicators

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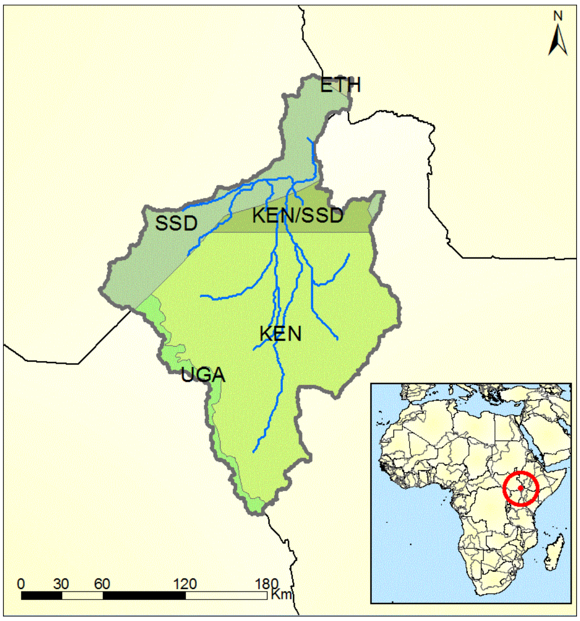
Lotagipi Swamp Basin



Geography

Total drainage area (km^2)	31,760
No. of countries in basin	5
BCUs in basin	Ethiopia (ETH), Ilemi triangle (KEN/SSD), Kenya (KEN), South Sudan (SSD), Uganda (UGA)
Population in basin (people)	333,363
Country at mouth	Kenya, Sudan
Average rainfall (mm/year)	542

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)
LGPS_ETH						
LGPS_KEN		60.81				
LGPS_KEN/SSD		0.00				
LGPS_SSD		31.23			60.40	0.35
LGPS_UGA		87.60				
Total in Basin	1.64	51.50			60.40	0.35

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 (%)
LGPS_ETH								
LGPS_KEN	9.09	0.00	1.55	0.00	0	7.54	36.43	
LGPS_KEN/SSD	0.59	0.00	0.30	0.00	0	0.29	58.52	
LGPS_SSD	1.76	0.00	0.63	0.00	0	1.13	37.53	
LGPS_UGA	1.64	0.00	0.47	0.00	0	1.18	63.51	
Total in Basin	13.08	0.00	2.96	0.00	0.00	10.13	39.24	0.80

Socioeconomic Geography

BCU	Area ('000 km^2)	BCU area in basin (%)	Population ('000 people)	Population density (people/km^2)	Annual pop. growth (%)	Rural population ratio (% pop. rural)	Urban population ratio (% pop. urban)	Large Cities (>500,000)	GDP per capita (USD)	No. of dams	Dam Density (No./000.000 km^2)
LGPS_ETH	0	0.01	1	6.61	2.21			0	498.08	0	0.00
LGPS_KEN	20	0.65	250	12.18	2.58			0	994.31	0	0.00
LGPS_KEN/SSD	3	0.08	10	3.91				0		0	0.00
LGPS_SSD	7	0.22	47	6.73	2.51			0	1,221.35	0	0.00
LGPS_UGA	2	0.05	26	16.41	3.24			0	571.68	0	0.00
Total in Basin	32	1.00	333	10.50	2.86	0.00	0.00	0	961.92	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**
LGPS_ETH					5				2	5	3	3	1	3	1
LGPS_KEN	2	2	1		5	1	4	1	1	5	3	3	1	3	5
LGPS_KEN/SSD	1	1	1			5	3	1	2	5	3		1	4	4
LGPS_SSD	1	1	1			3	3	1	2		3		1	5	5
LGPS_UGA	1	1	1		5		4	1	1	5	3	3	1	4	5
River Basin	2	1	1	3	5	1	4	1	1	5	3		1	4	5

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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

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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
LGPS_ETH									4
LGPS_KEN	5	5	1	1			3	5	4
LGPS_KEN/SSD	5	5	1	1					3
LGPS_SSD	5	5	1	1					4
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Maputo Basin

Geography

Total drainage area (km^2)	30,228
No. of countries in basin	3
BCUs in basin	Mozambique (MOZ), South Africa (ZAF), Swaziland (SWZ)
Population in basin (people)	1,334,942
Country at mouth	Mozambique
Average rainfall (mm/year)	877

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	1
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)
MPUT_MOZ		72.66				
MPUT_SWZ		114.69				
MPUT_ZAF		123.06			58.30	0.55
Total in Basin	3.50	115.63			58.30	0.55

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 (%)
MPUT_MOZ	12.71	3.48	0.84	0.00	1	7.86	657.00	

[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/

MPUT_SWZ	223.71	131.66	3.59	56.62	13	18.56	363.19	
MPUT_ZAF	215.22	56.20	11.21	2.38	21	124.20	307.62	
Total in Basin	451.64	191.34	15.64	59.00	35.04	150.62	338.32	12.92

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)
MPUT_MOZ	2	0.05	19	11.67	2.38	100.00	0.00	0	592.98	0	0.00
MPUT_SWZ	11	0.37	616	55.46	1.42	20.17	79.83	0	3,034.22	4	360.16
MPUT_ZAF	17	0.58	700	40.06	0.96	2.65	97.35	0	6,617.91	6	343.54
Total in Basin	30	1.00	1,335	44.16	1.43	12.14	87.86	0	4,877.06	10	330.82

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**
MPUT_MOZ	2	1	2		5	5	5	1	1	2	1	3	1	4	3
MPUT_SWZ	1	3	3		3	1	5	2	1	2	1	5	5	3	3
MPUT_ZAF	2	1	2		4	2	5	1	1	1	1	2	1	3	3
River Basin	2	2	2	3	3	2	5	2	1	2	1	3	3	3	3

Indicators

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Very low	Low	Medium	High	Very high

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

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

[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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Nile Basin

Geography

Total drainage area (km^2)	2,932,702
No. of countries in basin	14
BCUs in basin	Abyei (SDN/SSD), Burundi (BDI), Central African Republic (CAF), Congo, The Democratic Republic Of The (ZAR), Egypt (EGY), Eritrea (ERI), Ethiopia (ETH), Hala'ib triangle (EGY/SDN), Kenya (KEN), Rwanda (RWA), South Sudan (SSD), Sudan (SDN), Tanzania, United Republic Of (TZA), Uganda (UGA)
Population in basin (people)	174,365,405
Country at mouth	Egypt
Average rainfall (mm/year)	622

Governance

No. of treaties and agreements[1]	22
No. of RBOs and Commissions[2]	5

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	26
Large Marine Ecosystems	1

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

Water Resources

BCU	Annual Discharge (km^3/year)	Annual Runoff (mm/year)	Av. Groundwater Recharge (km^3/year)	Av. Groundwater Discharge (km^3/year)	Lake and Reservoir Surface Area (km^2)	Lake and Reservoir Volume (km^3)
NILE_BDI		311.55			146.58	1.34
NILE_CAF						
NILE_EGY		0.51			3,435.46	86.57
NILE_EGY/SDN		2.71				
NILE_ERI		57.57				
NILE_ETH		391.34			3,337.20	30.80

[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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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 (%)

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[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

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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.

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

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Orange Basin

Geography

Total drainage area (km^2)	965,647
No. of countries in basin	4
BCUs in basin	Botswana (BWA), Lesotho (LSO), Namibia (NAM), South Africa (ZAF)
Population in basin (people)	13,748,938
Country at mouth	Namibia, South Africa
Average rainfall (mm/year)	357

Governance

No. of treaties and agreements[1]	8
No. of RBOs and Commissions[2]	4

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	7
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)
ORAN_BWA		17.97				
ORAN_LSO		151.19				
ORAN_NAM		9.35				
ORAN_ZAF		30.17			1,283.98	22.08
Total in Basin	26.56	27.51			1,283.98	22.08

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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ORAN_BWA	46.98	0.63	7.11	3.67	4	31.27	207.99	
ORAN_LSO	134.71	35.42	11.82	0.07	35	51.98	64.39	
ORAN_NAM	98.84	49.29	7.65	0.10	4	38.18	617.87	
ORAN_ZAF	5,356.93	2,926.10	100.20	125.13	683	1,522.12	475.28	
Total in Basin	5,637.46	3,011.43	126.79	128.97	726.73	1,643.54	410.03	21.22

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)
ORAN_BWA	135	0.14	226	1.67	1.35	72.60	27.40	0	7,316.88	0	0.00
ORAN_LSO	30	0.03	2,092	69.24	1.00	9.60	90.40	1	1,074.85	6	198.59
ORAN_NAM	243	0.25	160	0.66	1.87	12.26	87.74	0	5,461.53	4	16.47
ORAN_ZAF	557	0.58	11,271	20.23	0.96	0.00	100.00	30	6,617.91	85	152.53
Total in Basin	966	1.00	13,749	14.24	1.31	2.80	97.20	31	5,772.54	95	98.38

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**
ORAN_BWA	2	4	2		5		5	2	1	2	1	3	1	3	5
ORAN_LSO	1	1	2		5	1	5	1	2	2	3	3	5	4	2
ORAN_NAM	2	5	2		5	1	4	2	1	1	3	3	3	3	5
ORAN_ZAF	3	4	3		4	2	5	1	2	1	3	2	3	3	5
River Basin	3	4	3	3	4	2	5	2	1	1	3	2	4	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

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

ORAN_BWA	5	5	4	3			1	2	1
ORAN_LSO	2	2	1	2			1	1	3
ORAN_NAM	5	5	5	5			2	3	3
ORAN_ZAF	5	5	4	5			1	1	3
River Basin	5	5	4	4	4	4	1	1	3

TWAP RB Assessment results: Water System Linkages

Thematic group	**Lake Influence Indicator**	**Delta Vulnerability Index**			
Basin/Delta	**17**	**18**	**19**	**20**	**21**
River Basin	3				

Indicators

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

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Pangani Basin

Geography

Total drainage area (km²)	40,317
No. of countries in basin	2
BCUs in basin	Kenya (KEN), Tanzania, United Republic Of (TZA)
Population in basin (people)	2,901,297
Country at mouth	Tanzania, United Republic Of
Average rainfall (mm/year)	916

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	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)
PANG_KEN		106.31				
PANG_TZA		140.07			216.30	2.33
Total in Basin	5.53	137.13			216.30	2.33

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 (%)
PANG_KEN	39.98	21.40	2.24	0.00	0	16.34	515.58	
PANG_TZA	507.15	419.84	11.58	5.06	3	67.22	179.60	

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

Total in Basin	547.13	441.25	13.82	5.06	3.46	83.56	188.58	9.90

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)
PANG_KEN	3	0.07	78	28.38	2.58	0.00	100.00	0	994.31	0	0.00
PANG_TZA	38	0.93	2,824	75.13		0.00	100.00	2	694.77	1	26.61
Total in Basin	40	1.00	2,901	71.96	3.02	0.00	100.00	2	702.78	1	24.80

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
PANG_KEN	1	2	2		5	4	3	3	2	5	3	3	1	4	5
PANG_TZA	2	1	2		5	4	3	3	3	3	3	2	3	3	4
River Basin	2	1	2	3	5	4	3	4	3	3	3	2	3	3	4

Indicators

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

Very low Low Medium High Very high

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

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

Geography

Total drainage area (km²)	30,925
No. of countries in basin	2
BCUs in basin	Mozambique (MOZ), Zimbabwe (ZWE)
Population in basin (people)	949,956
Country at mouth	Mozambique
Average rainfall (mm/year)	1,593

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	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)
PUNG_MOZ		660.95				
PUNG_ZWE						
Total in Basin	20.44	660.95			0.00	0.00

Water Withdrawals

BCU	Total (km^3/year)	Irrigation (km^3/year)	Livestock (km^3/year)	Electricity (km^3/year)	Manufacture (km^3/year)	Domestic (km^3/year)	Per capita (m^3/year)	Total withdrawal as a % of Total Actual Renewable Water Resources (%)
PUNG_MOZ	72.28	40.61	0.91	0.54	1	28.99	83.87	
PUNG_ZWE								

[1] For details on Treaties and Agreements please see http://www.transboundarywaters.orst.edu/
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Total in Basin	72.28	40.61	0.91	0.54	1.23	28.99	76.09	0.35

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)
PUNG_MOZ	30	0.95	862	29.19	2.38	0.00	100.00	1	592.98	1	33.87
PUNG_ZWE	1	0.05	88	63.01	0.00			0	904.76	0	0.00
Total in Basin	31	1.00	950	30.72	2.52	0.00	90.73	1	621.89	1	32.34

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**
PUNG_MOZ	2	1	2		5	2	3	3	2	3	3	3	1	5	2
PUNG_ZWE					5				2	3	3	2	1	3	1
River Basin	2	1	2	2	5	2	3	3	1	3	3	3	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
PUNG_MOZ	2	2	1	1			3	5	4
PUNG_ZWE									3
River Basin	2	2	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	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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Ruvuma Basin

Geography

Total drainage area (km²)	155,039
No. of countries in basin	3
BCUs in basin	Malawi (MWI), Mozambique (MOZ), Tanzania, United Republic Of (TZA)
Population in basin (people)	2,599,651
Country at mouth	Mozambique, Tanzania, United Republic Of
Average rainfall (mm/year)	1,192

Governance

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

Geographical Overlap with Other Transboundary Systems

(No. of overlapping water systems)

Groundwater	
Lakes	3
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)
RVMA_MOZ		383.12			61.53	0.49
RVMA_MWI		335.59			83.87	0.25
RVMA_TZA		322.88				
Total in Basin	55.94	360.84			145.40	0.74

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 (%)
RVMA_MOZ	30.59	3.09	0.67	0.67	0	25.88	47.13	

[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/

RVMA_MWI	8.69	1.48	0.15	0.00	0	7.06	21.64	
RVMA_TZA	82.45	12.67	1.37	27.37	0	40.55	53.22	
Total in Basin	121.72	17.24	2.20	28.04	0.76	73.48	46.82	0.22

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)
RVMA _MOZ	100	0.65	649	6.46	2.38	9.34	90.66	0	592.98	0	0.00
RVMA _MWI	3	0.02	402	151.33	3.00			0	226.46	0	0.00
RVMA _TZA	52	0.34	1,549	29.81		0.00	100.00	0	694.77	0	0.00
Total in Basin	155	1.00	2,600	16.77	2.86	2.33	82.22	0	597.01	0	0.00

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

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

Geography

Total drainage area (km^2)	102,291
No. of countries in basin	2
BCUs in basin	Mozambique (MOZ), Zimbabwe (ZWE)
Population in basin (people)	3,428,266
Country at mouth	Mozambique
Average rainfall (mm/year)	734

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	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)
SABI_MOZ		124.54				
SABI_ZWE		138.37			85.30	0.48
Total in Basin	13.80	134.93			85.30	0.48

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 (%)
SABI_MOZ	9.92	4.70	0.59	0.00	0	4.62	77.38	
SABI_ZWE	766.46	592.25	17.38	105.13	1	51.12	232.25	

[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	776.37	596.96	17.97	105.13	0.58	55.74	226.46	5.62

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)
SABI_MOZ	17	0.17	128	7.34	2.38	100.00	0.00	0	592.98	0	0.00
SABI_ZWE	85	0.83	3,300	38.90	0.00	0.00	100.00	1	904.76	21	247.56
Total in Basin	102	1.00	3,428	33.51	3.03	3.74	96.26	1	893.10	21	205.30

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**
SABI_MOZ	2	1	2		5	4	4	1	1	3	5	3	1	5	4
SABI_ZWE	2	1	2		5	2	5	2	1	3	5	2	3	3	3
River Basin	2	1	2	3	5	2	5	2	1	3	5	2	3	4	3

Indicators

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Very low Low Medium High Very high

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

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Thukela Basin

Geography

Total drainage area (km^2)	29,149
No. of countries in basin	2
BCUs in basin	Lesotho (LSO), South Africa (ZAF)
Population in basin (people)	1,975,380
Country at mouth	South Africa
Average rainfall (mm/year)	903

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	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)
THUK_LSO						
THUK_ZAF		149.63			111.02	0.64
Total in Basin	4.36	149.63			111.02	0.64

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 (%)
THUK_LSO								
THUK_ZAF	783.87	310.77	22.36	29.80	110	311.37	396.90	

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

Total in Basin	783.87	310.77	22.36	29.80	109.57	311.37	396.82	17.97

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)
THUK_LSO	0	0.00	0	7.61	1.00			0	1,074.85	0	0.00
THUK_ZAF	29	1.00	1,975	67.87	0.96	0.00	100.00	3	6,617.91	8	274.92
Total in Basin	29	1.00	1,975	67.77	1.34	0.00	99.98	3	6,616.85	8	274.46

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
THUK_LSO					5	5			2	3	3	3	1	3	1
THUK_ZAF	2	2	2		4	1	5	1	2	3	5	2	1	3	3
River Basin	2	2	2	4	4	1	5	2	1	3	5	2	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
THUK_LSO									3
THUK_ZAF	2	2	2	3			1	1	5
River Basin	2	2	2	3	5	5	1	1	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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Umba Basin

Geography

Total drainage area (km^2)	6,674
No. of countries in basin	2
BCUs in basin	Kenya (KEN), Tanzania, United Republic Of (TZA)
Population in basin (people)	499,314
Country at mouth	Kenya
Average rainfall (mm/year)	921

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	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)
UMBA_KEN		99.85				
UMBA_TZA		118.29				
Total in Basin	0.75	112.15			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 (%)
UMBA_KEN	18.18	4.04	0.87	0.00	0	13.27	482.46	
UMBA_TZA	104.20	89.63	1.68	0.00	0	12.54	225.72	

[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	122.38	93.67	2.55	0.00	0.35	25.81	245.09	16.35

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)
UMBA_KEN	2	0.24	38	23.61	2.58			0	994.31	0	0.00
UMBA_TZA	5	0.76	462	90.92				0	694.77	0	0.00
Total in Basin	7	1.00	499	74.82	3.00	0.00	0.00	0	717.38	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
UMBA_KEN	2	1	2		5	1	5		2	5	3	3	1	4	5
UMBA_TZA	3	4	2		5	2	4		2	3	3	2	1	3	5
River Basin	3	3	2	3	5	2	4		2	3	3	3	1	3	5

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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
UMBA_KEN	3	4	2	4			4	5	4
UMBA_TZA	4	5	4	5			4	5	3
River Basin	4	5	4	5	4	5	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				

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Umbeluzi Basin

Geography

Total drainage area (km^2)	5,492
No. of countries in basin	3
BCUs in basin	Mozambique (MOZ), South Africa (ZAF), Swaziland (SWZ)
Population in basin (people)	635,500
Country at mouth	Mozambique
Average rainfall (mm/year)	1,184

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)
UBLZ_MOZ		219.84				
UBLZ_SWZ		308.74				
UBLZ_ZAF						
Total in Basin	1.57	286.44			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 (%)
UBLZ_MOZ	13.43	0.00	0.32	0.00	1	12.08	29.11	

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UBLZ_SWZ	263.56	145.87	3.08	70.98	17	27.02	1,603.73	
UBLZ_ZAF								
Total in Basin	276.99	145.87	3.40	70.98	17.64	39.10	435.86	17.61

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)
UBLZ_ MOZ	2	0.41	461	204.96	2.38	0.00	100.00	0	592.98	1	444.19
UBLZ_ SWZ	3	0.57	164	52.15	1.42	0.00	100.00	0	3,034.22	2	634.71
UBLZ_ ZAF	0	0.02	10	108.30	0.96			0	6,617.91	0	0.00
Total in Basin	5	1.00	636	115.71	2.20	0.00	98.47	0	1,316.52	3	546.23

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
UBLZ_MOZ	1	4	1		5	5	5	2	1	3	1	3	1	4	4
UBLZ_SWZ	2	3	2		3	1	4	2	1	3	1	5	3	3	3
UBLZ_ZAF					4				1	3	1	2	1	3	1
River Basin	2	2	2	3	5	3	4	2	1	3	1	3	2	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
UBLZ_MOZ	2	2	4	5			3	5	1
UBLZ_SWZ	2	2	4	5			1	2	1
UBLZ_ZAF									1
River Basin	2	2	4	5	4	4	3	5	1

[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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Zambezi Basin

Geography

Total drainage area (km^2)	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 (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 (%)
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 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)
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]

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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
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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
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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

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
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ZAMB_TZA	2	2	1	3			4	5	3
ZAMB_ZAR									2
ZAMB_ZMB	2	2	1	1			4	5	3
ZAMB_ZWE	4	4	1	2			2	3	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	5	4	2	2	3

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Okavango River ends in the Okavango Delta inland in northern Botswana

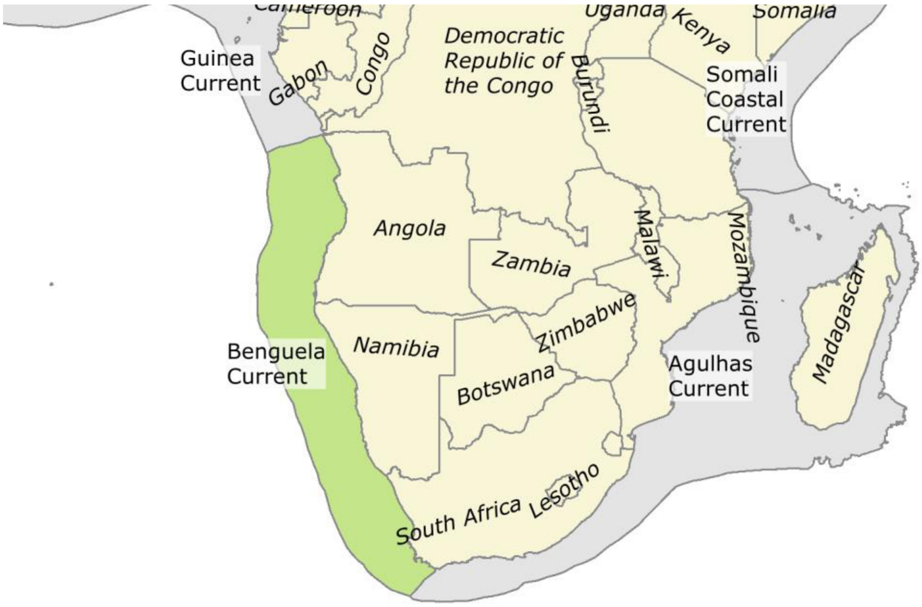
ESA

Elephants drinking in the upper reaches of the Okavango Delta.

Pavel Spindler

1. LME 29 – Benguela Current
2. LME 30 – Agulhas Current
3. LME 31 – Somali Coastal Current
4. LME 33 – Red Sea

LME 29 – Benguela Current



Bordering countries: Angola, Namibia, South Africa
LME Total area: 1,470,134 km^2

List of indicators

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LME overall risk

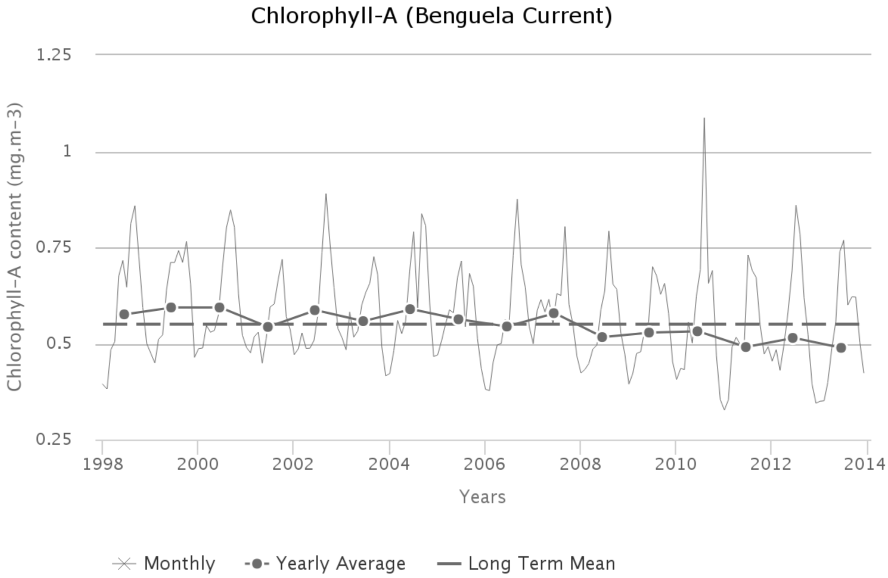
This LME falls in the cluster of LMEs that exhibit low to medium levels of economic development (based on the night light development index) and medium levels of collapsed and overexploited fish stocks.

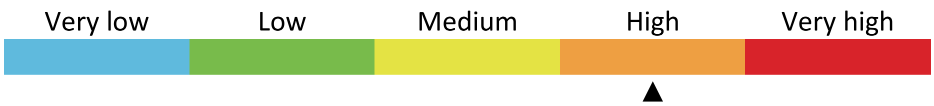
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is very high.

Productivity

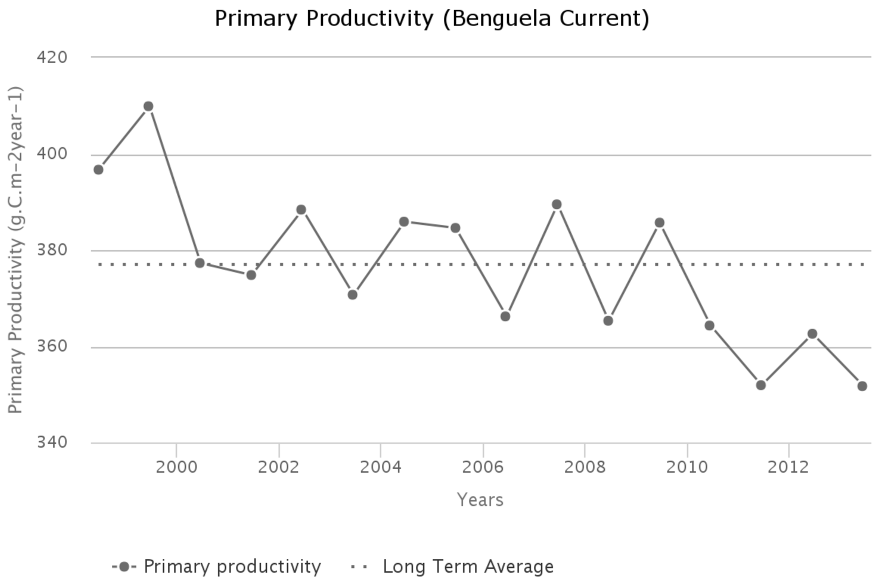
Chlorophyll-A

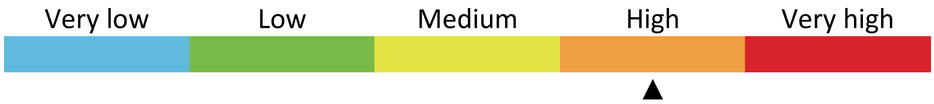
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.835 mg.m^{-3}) in September and a minimum (0.434 mg.m^{-3}) during January. The average CHL is 0.550 mg.m^{-3}. Maximum primary productivity (410 g.C.m^{-2}.y^{-1}) occurred during 1999 and minimum primary productivity (352 g.C.m^{-2}.y^{-1}) 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).





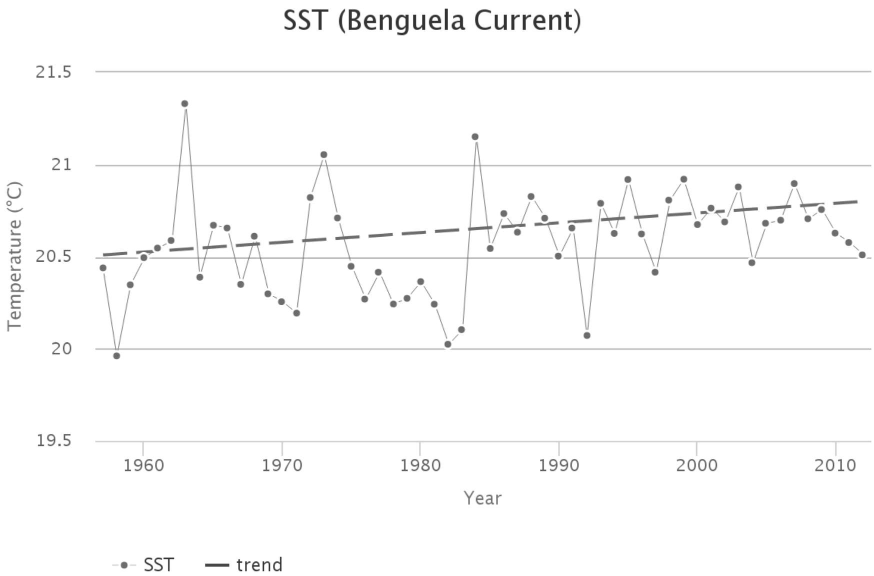
Primary productivity





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).

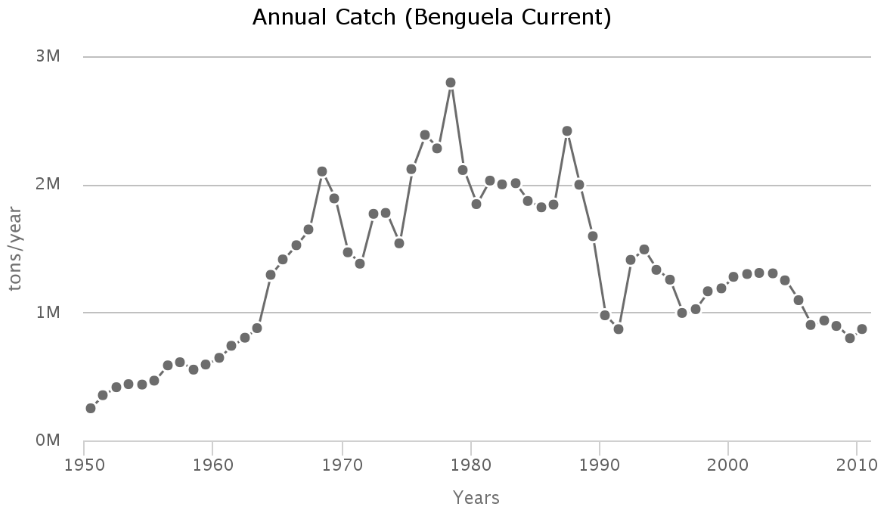


Fish and Fisheries

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.

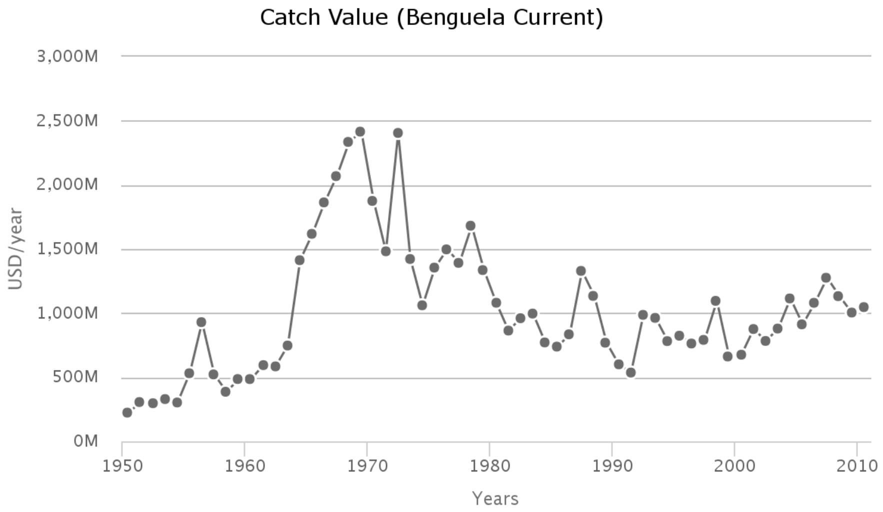
Annual Catch

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.



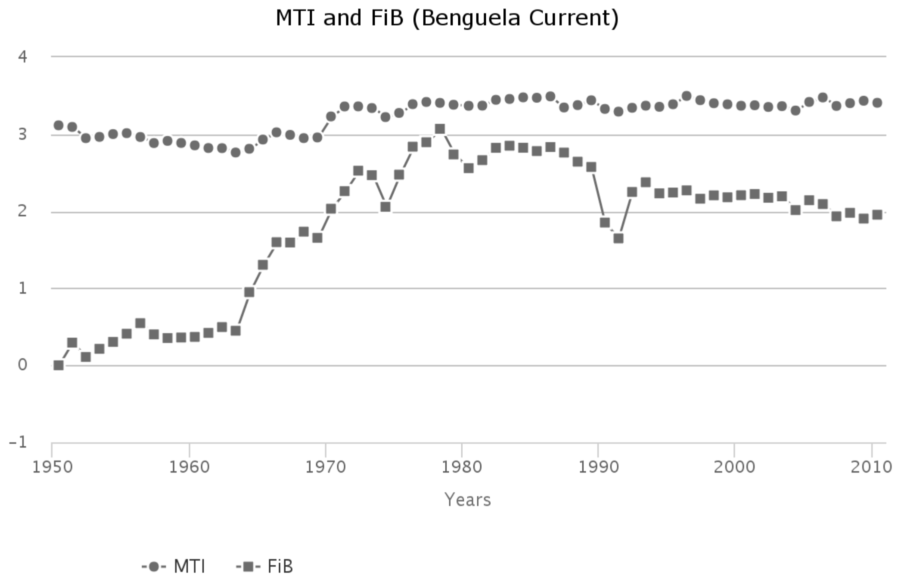
Catch value

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.



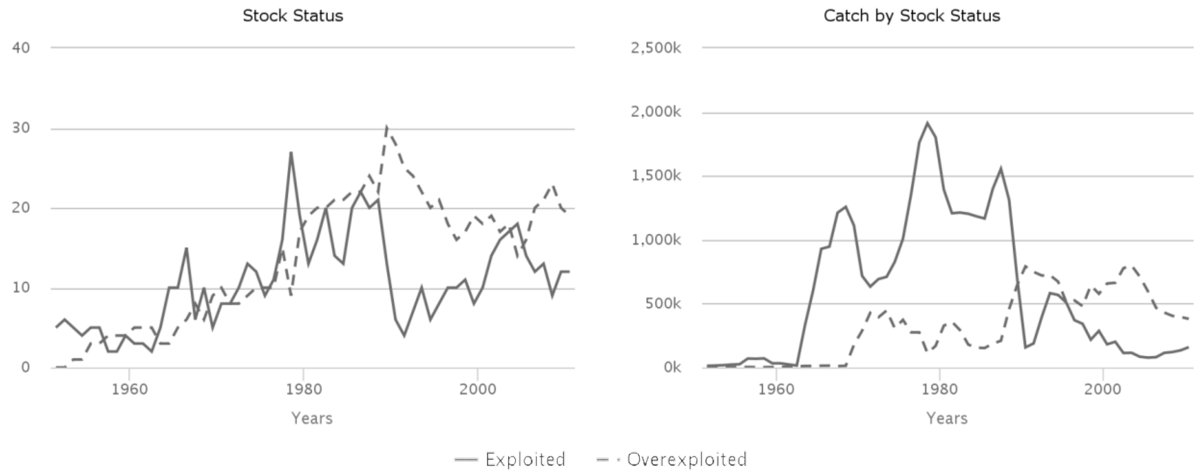
Marine Trophic Index and Fishing-in-Balance index

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.



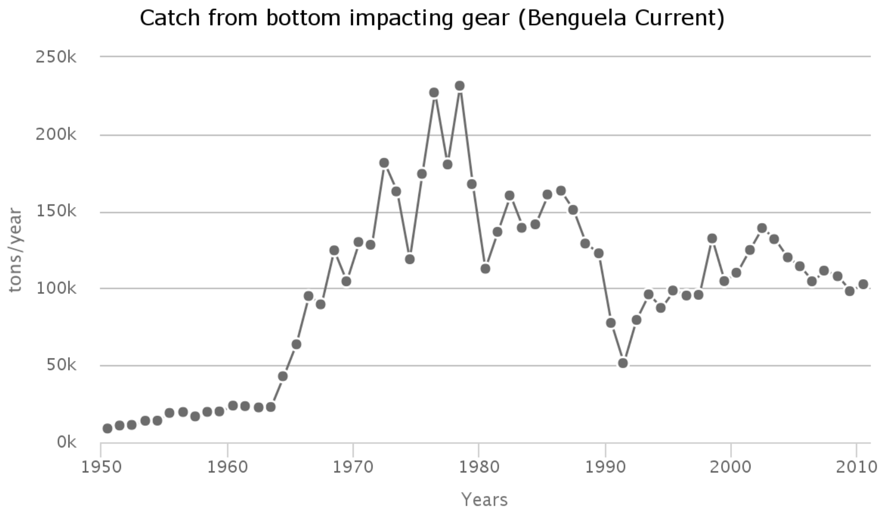
Stock status

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.

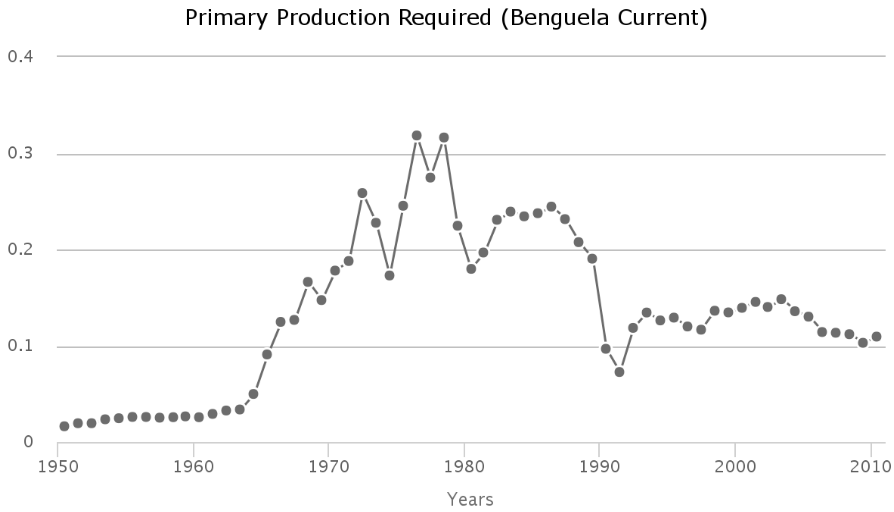


Fishing effort

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

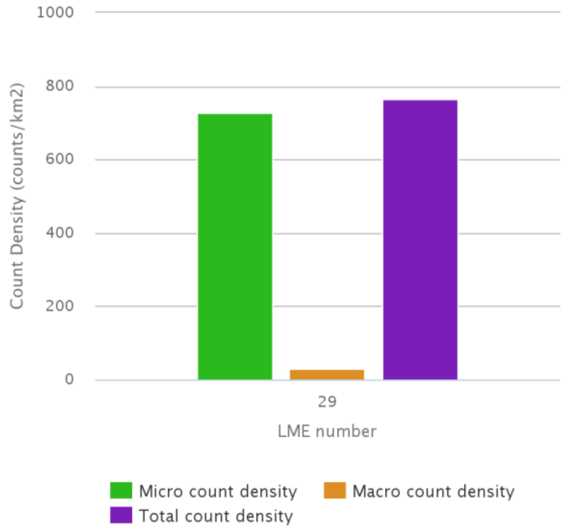
Data are available for one sample from one location near Yzerfontein. This location shows moderate concentration (ng.g-1 of pellets) of PCBs (61) and DDTs (24), and low concentration of HCHs (3.0). PCBs and DDTs concentrations at this location correspond to risk category 3, while HCHs to category 2 of 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.

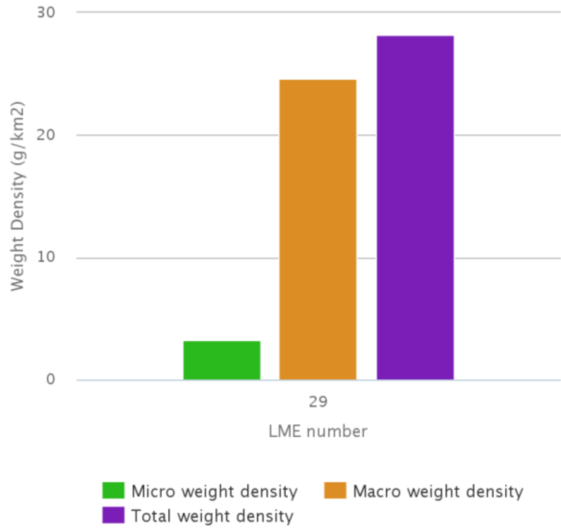
	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk

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

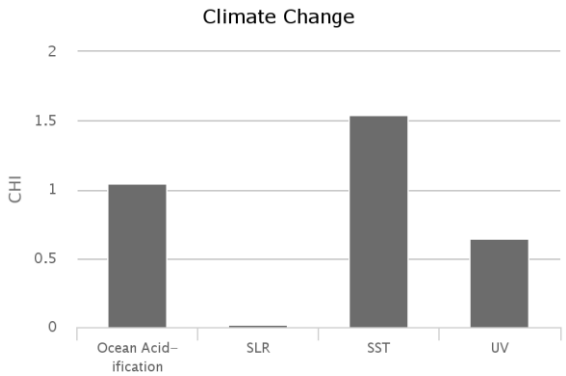
Not applicable.

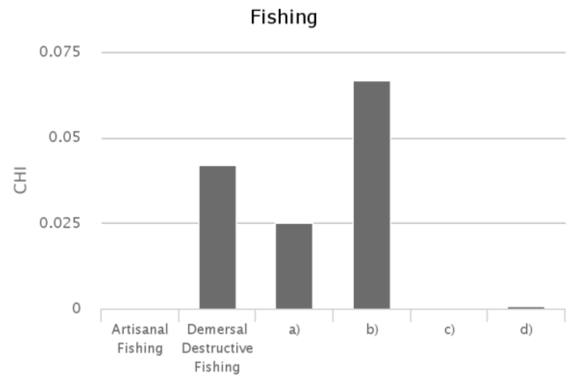
Marine Protected Area change

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.

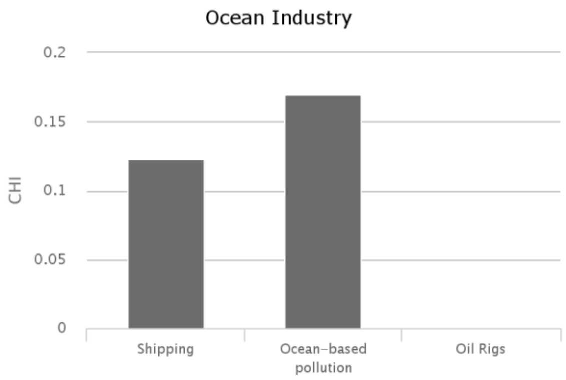
Cumulative Human Impact

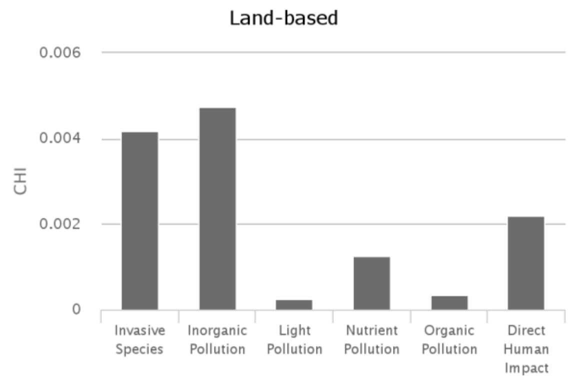
The Benguela Current LME experiences an above average overall cumulative human impact (score 3.70; maximum LME score 5.22), which is also well above the LME with the least cumulative impact. It falls in risk category 3 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most 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.

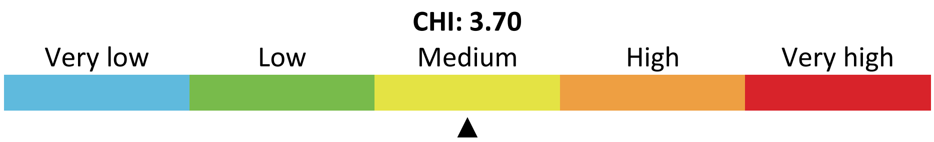




a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing

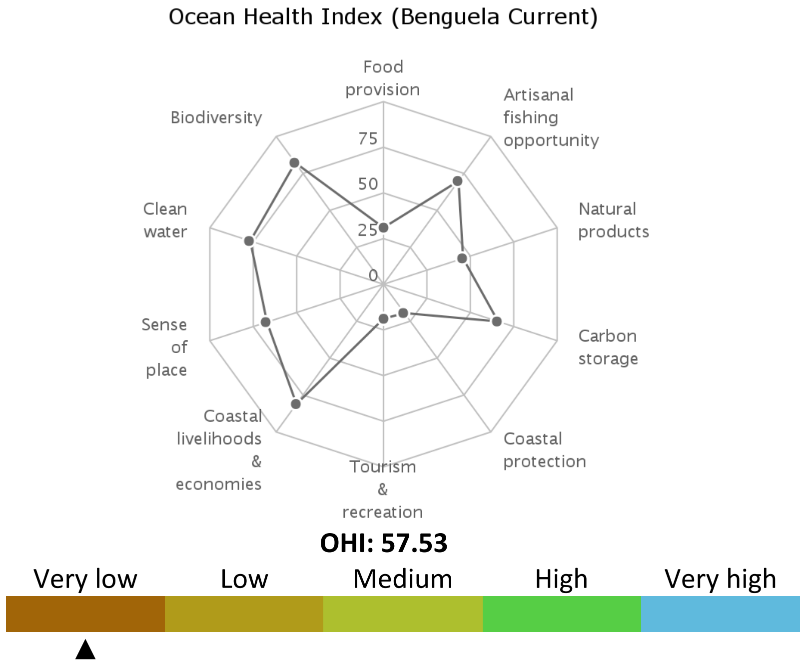






Ocean Health Index

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).



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

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (*e.g.* overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m^2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index of this LME is within the high-risk (high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is high. In a sustainable development scenario, the risk index from sea level rise in 2100 is 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.

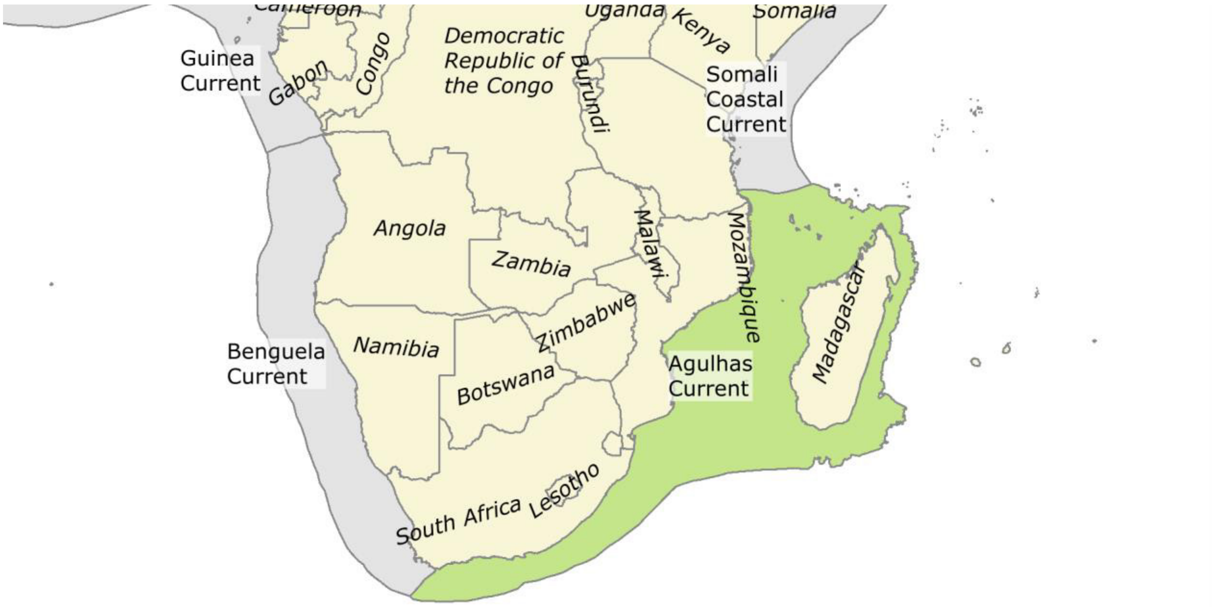
The overall scores for ranking of risk were:

Engagement	Completeness	Integration
93	**80**	**1**

Legend:

Very low Low Medium High Very high

LME 30 – Agulhas Current



Bordering countries: Comoros, Madagascar, Mayotte, Mozambique, South Africa, Swaziland, United Republic of Tanzania.
LME Total area: 2,615,294 km^2

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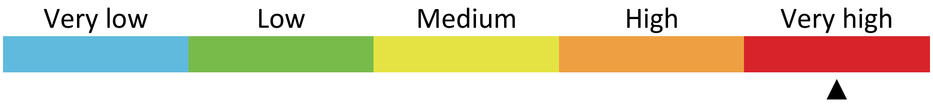
LME overall risk

This LME falls in the cluster of LMEs that exhibit high percentages of rural coastal population, high numbers of collapsed and overexploited fish stocks, as well as high proportions of catch from bottom impacting gear.

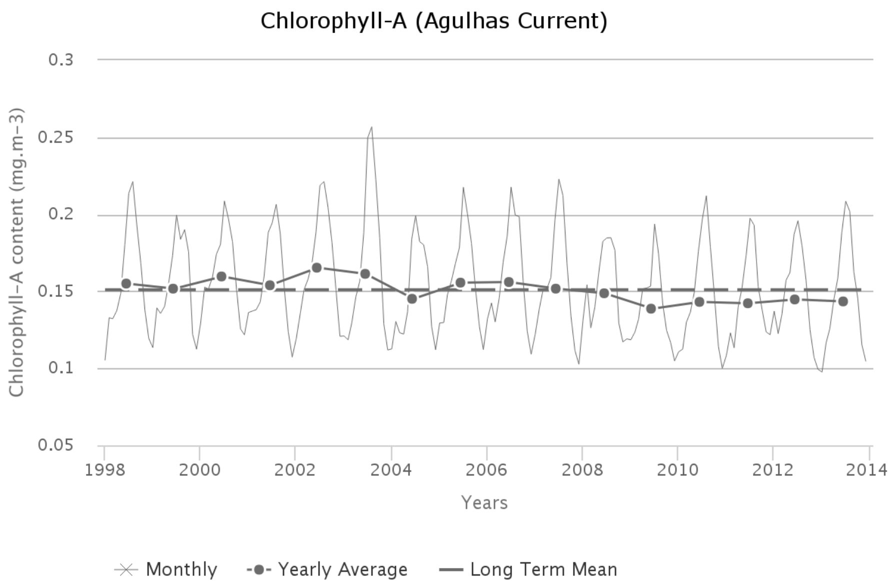
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is very high.

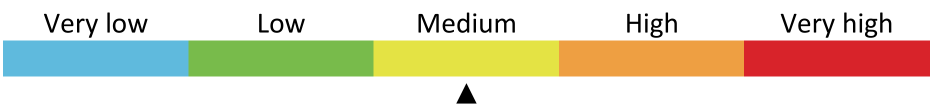


Productivity

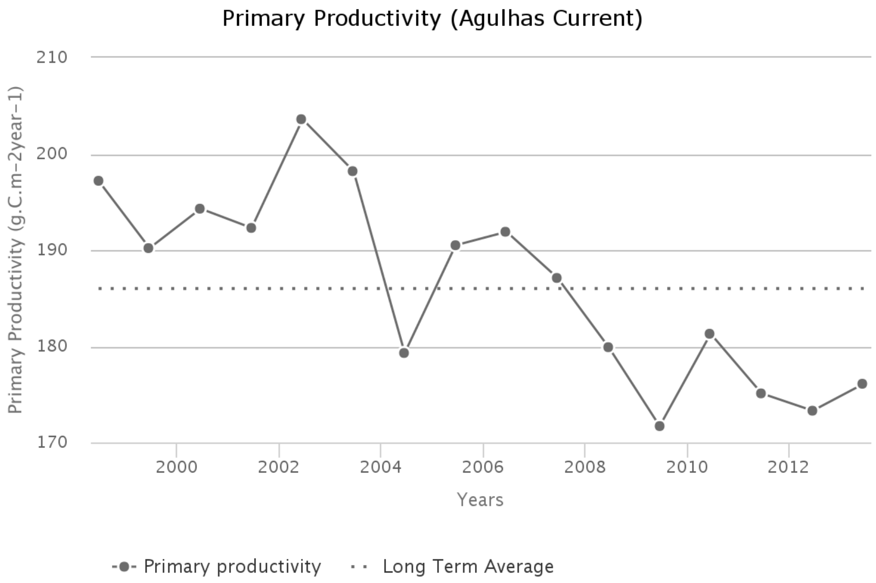
Chlorophyll-A

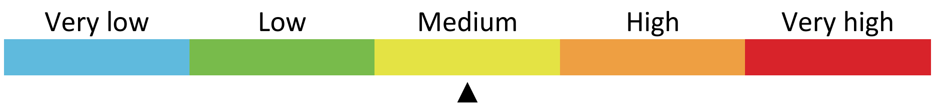
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.208 mg.m^{-3}) in July and a minimum (0.110 mg.m^{-3}) during December. The average CHL is 0.151 mg.m^{-3}. Maximum primary productivity (204 g.C.m^{-2}.y^{-1}) occurred during 2002 and minimum primary productivity (172 g.C.m^{-2}.y^{-1}) during 2009. There is a statistically insignificant decreasing trend in Chlorophyll of -11.4 % from 2003 through 2013. The average primary productivity is 186 g.C.m^{-2}.y^{-1}, which places this LME in Group 3 of 5 categories (with 1 = lowest and 5= highest).





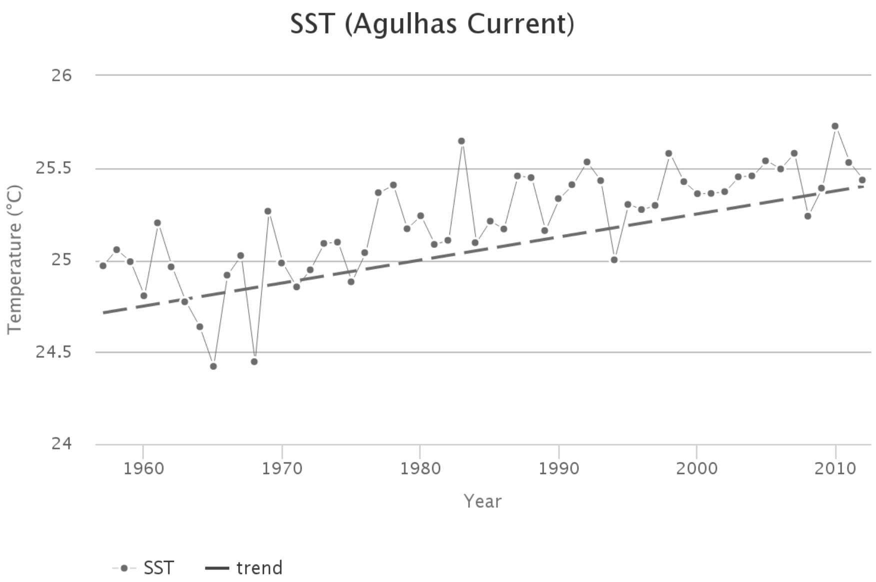
Primary productivity





Sea Surface Temperature

From 1957 to 2012, the Agulhas Current LME #30 has warmed by 0.72°C, thus belonging to Category 3 (moderate warming LME). The Agulhas Current's slow, steady long-term warming was punctuated by relatively small-scale cold/warm events with a magnitude of about 0.5°C. The Agulhas Current does not significantly affect the adjacent Benguela Current LME #29, although a certain degree of leakage can be expected from the Agulhas Current into the Benguela Current. The Agulhas Current originates in the southwestern Indian Ocean, where it is fed by the southward coastal flow from the Somali Coastal Current LME #31 and also by the South Equatorial Current and by the East Madagascar Current. The Somali-Agulhas oceanic connection explains the observed synchronism between the Somali and Agulhas LMEs. For example, the all-time minimum of 1964-1965 occurred simultaneously in the Somali and Agulhas LMEs, as well as the near-all-time maxima of 1983 in these two LMEs.

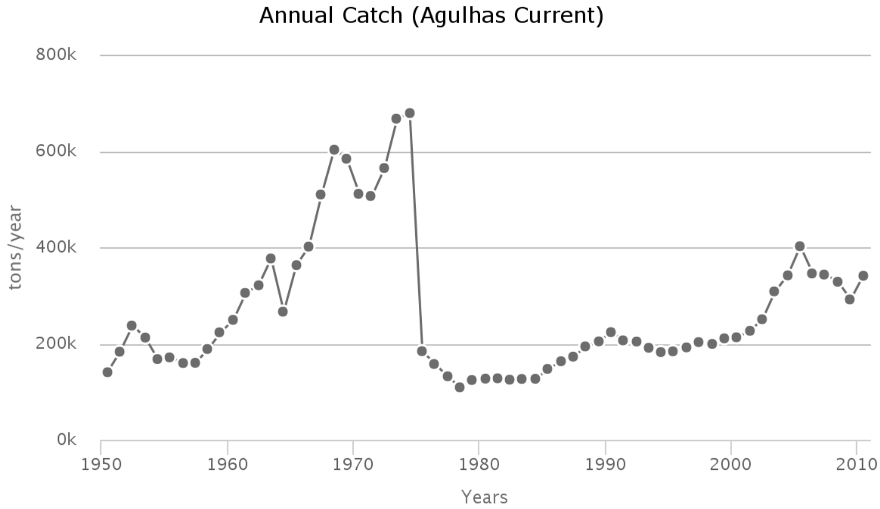


Fish and Fisheries

Total reported landings in this LME peaked at just under 700,000 t in 1974 with record landings of Cape anchovy and South American pilchard. However, with the collapse of these fisheries in the mid-1970s, the reported landings were diminished down to 180,000 t and have remained at this low level for some time. Some signs of growth can be seen in recent years, particularly in the landings of South American pilchard, and total landings reached 320,000 t in the 2000s.

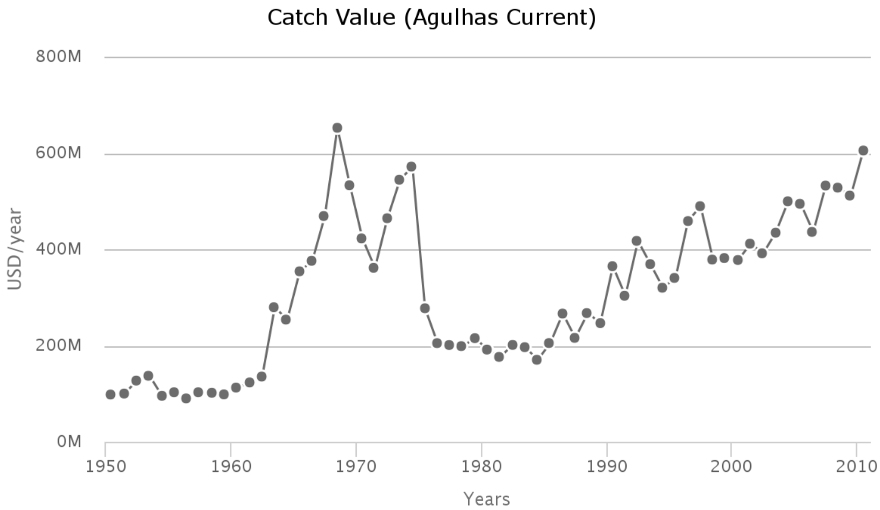
Annual Catch

The trend in the value of the reported landings has mirrored that of the landings, peaking at just over 650 million US$ (in 2005 real US$) in 1968.



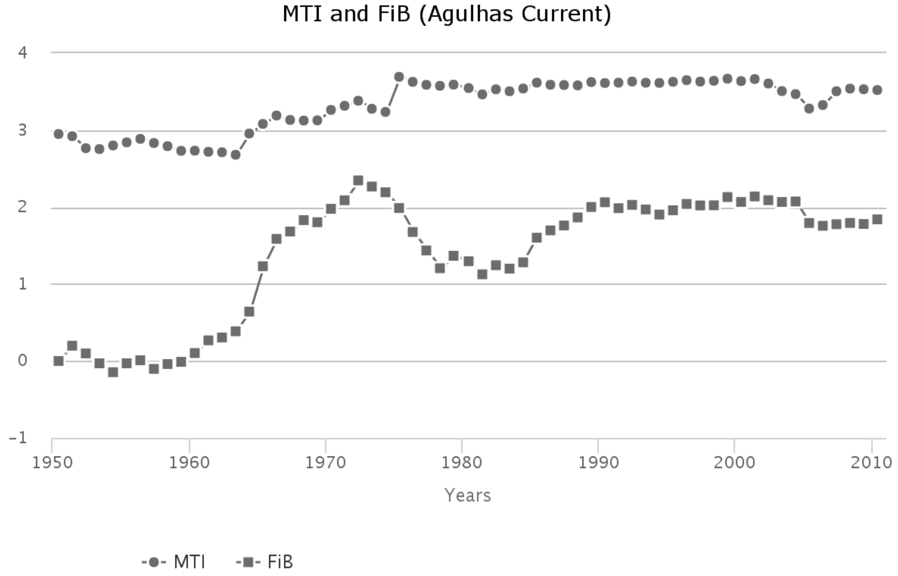
Catch value

The sharp increase in the MTI in the mid-1970s reflects the collapse of the pilchard and anchovy fisheries, two species with low trophic levels. Although the MTI has declined over the last few years, likely due to the increased pilchard landings, there is no observable decline indicative of 'fishing down' of the food web in this LME. Over the same period, the FiB index showed at best a minor decline, suggesting that the increasing catches over this period may not compensate for the decline in the MTI.



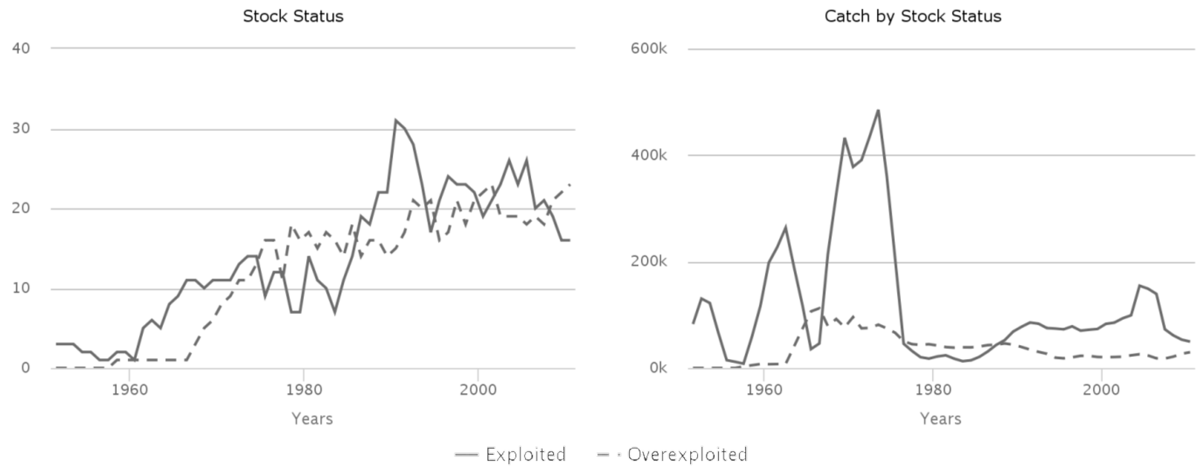
Marine Trophic Index and Fishing-in-Balance index

The sharp increase in the MTI in the mid-1970s reflects the collapse of the pilchard and anchovy fisheries, two species with low trophic levels. Although the MTI has declined over the last few years, likely due to the increased pilchard landings, there is no observable decline indicative of 'fishing down' of the food web in this LME. Over the same period, the FiB index showed at best a minor decline, suggesting that the increasing catches over this period may not compensate for the decline in the MTI.



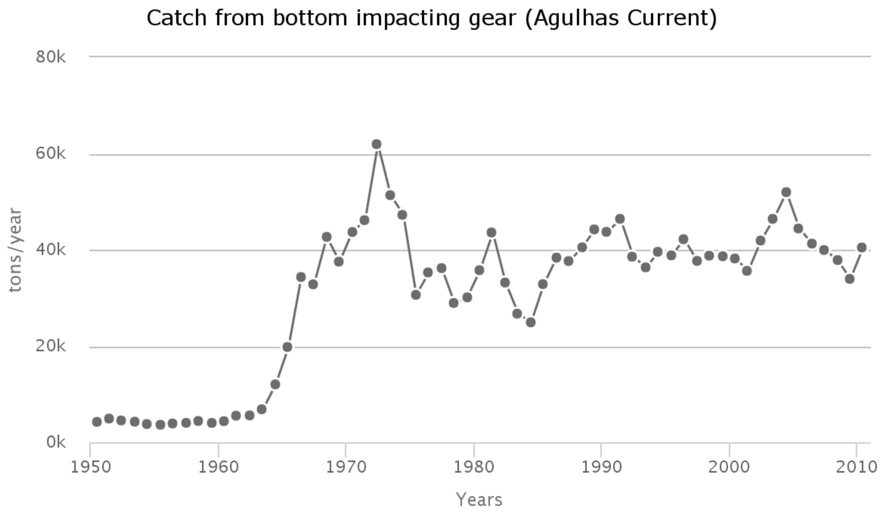
Stock status

The Stock-Catch Status Plots show that the number of collapsed stocks is about the same as overexploited (just under 30%), while the two groups altogether contribute to just under 20% of the catch biomass.



Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch increased from 2% in the 1950s to its first peak at around 34% in 1980. Then, this percentage kept decreasing and fluctuated around 13% in recent decade.

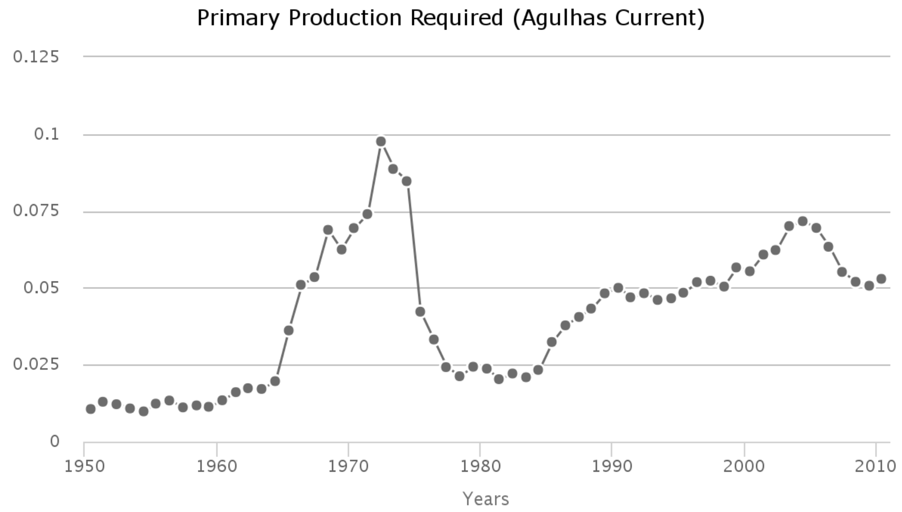


Fishing effort

The total effective effort continuously increased from around 7 million kW in the 1950s to its peak around 200 million kW in the 2000s.

Primary Production Required

The primary production required (PPR) to sustain the reported landings in the LME reached close to 8% of the observed primary production in 1968, when the highest landings was recorded. With the collapse of the Cape anchovy and South American pilchard fisheries in the mid-1970s, the PPR declined to around 2% in the 1980s; however, PPR has returned to about 5% in recent year.



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular *nitrogen load*) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the *ratio of nutrients* entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans. An overall nutrient indicator (*Merged Nutrient Indicator*) based on 2 sub-indicators: *Nitrogen Load* and *Nutrient Ratio* (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was moderate (level 3 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a “current trends” scenario (Global Orchestration), this remained the same in 2030 and 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was moderate (3). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was moderate (3). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

2000			2030			2050		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
3	3	3	3	3	3	3	3	3

Legend:
Very low Low Medium High Very high

POPs

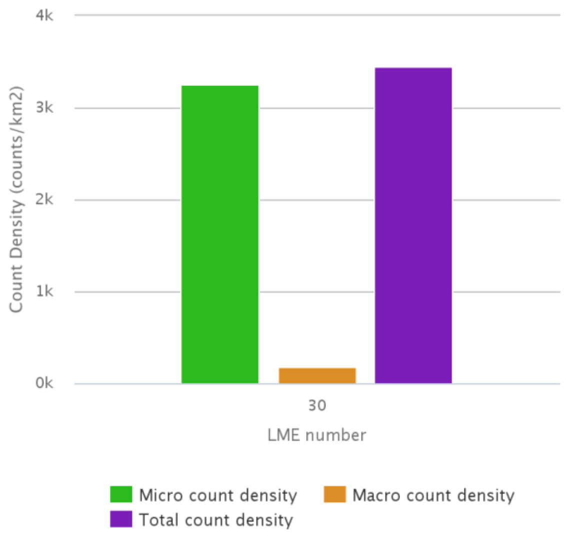
Twelve samples from 11 locations are available. Average concentrations (ng.g^{-1} of pellets) were 35 (range 1-97 ng.g^{-1}) for PCBs, 27 (range 2-129 ng.g^{-1}) for DDTs and 10 (range 0.3 -36.4 ng.g^{-1}) for HCHs, corresponding to risk categories 2, 3, and 4, respectively, of the five risk categories (1 = lowest risk; 5 = highest risk). Large spatial and temporal variations are noticeable. Average PCB concentrations were moderate in South Africa (60 ng.g^{-1}) and low (11 ng.g^{-1}) in Mozambique. This is probably due to different degrees of industrialization in these countries. High concentrations of DDTs (up to 129 ng.g^{-1} of pellets) and HCHs (up to 36.4 ng.g^{-1} of pellets) were sporadically observed. Most of them were for the samples from 2007 – 2011; such high concentrations were not observed in 2012 or later, suggesting an improvement of the pollution situation. Continuous monitoring is recommended to determine the temporal trend.

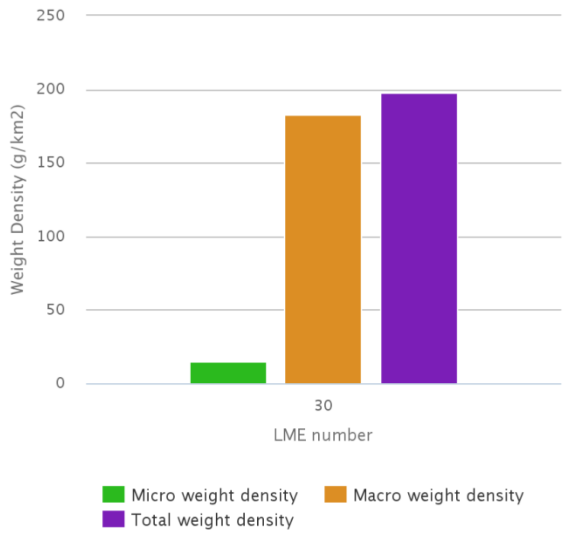
	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk
12	35	2	27	3	10.0	4

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.





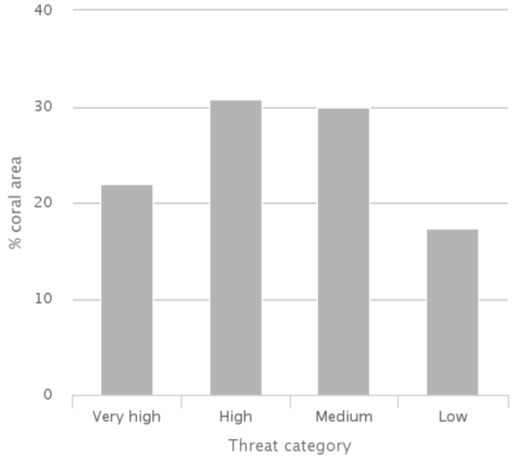
Ecosystem Health

Mangrove and coral cover

0.21% of this LME is covered by mangroves (US Geological Survey, 2011) and 0.3% by coral reefs (Global Distribution of Coral Reefs, 2010).

Reefs at risk

This LME has a present (2011) integrated threat index (combining threat from overfishing and destructive fishing, watershed-based and marine-based pollution and damage) of 257. 22% of coral reefs cover is under very high threat, and 31% under high threat (of the 5 possible threat categories, from low to critical). When combined with past thermal stress (between 1998 and 2007), these values are 36% and 31% for very high and high threat categories respectively. By year 2030, 52% of coral cover in this LME is predicted to be under very high to critical level of threat from warming and acidification; this proportion increases to 53% by 2050.

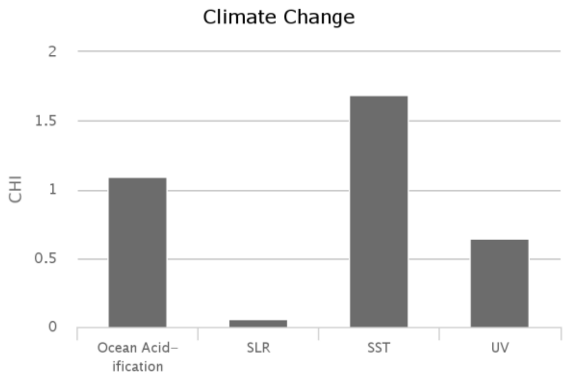


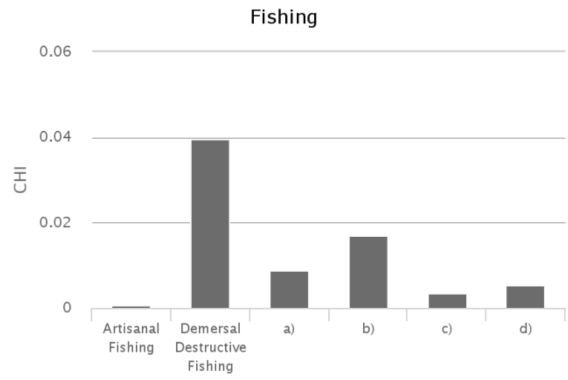
Marine Protected Area change

The Agulhas Current LME experienced an increase in MPA coverage from 1,547 km^2 prior to 1983 to 23,967 km^2 by 2014. This represents an increase of 1,449%, within the low category of MPA change.

Cumulative Human Impact

The Agulhas Current LME experiences an above average overall cumulative human impact (score 3.84; 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 (1.09; maximum in other LMEs was 1.20), UV radiation (0.64; maximum in other LMEs was 0.76), and sea surface temperature (1.68; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, sea level rise, and ocean based pollution.





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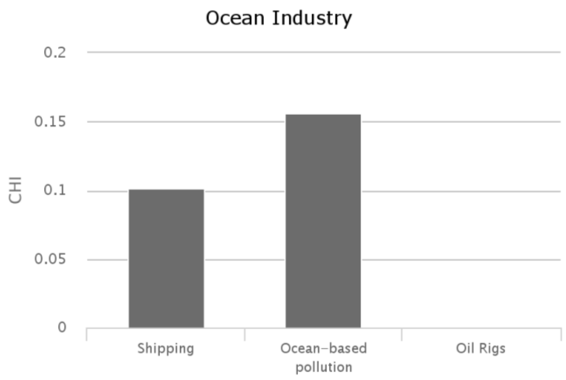
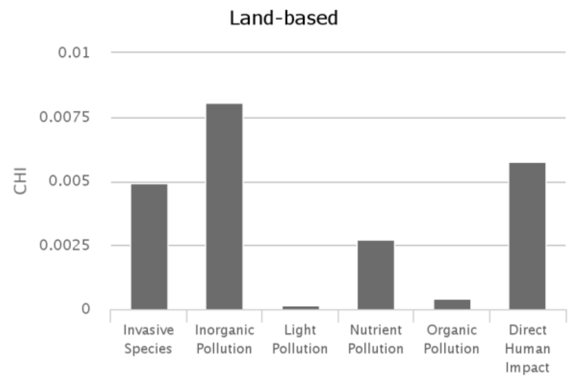
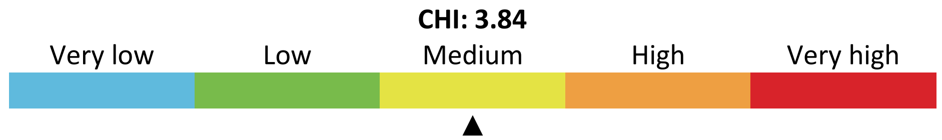
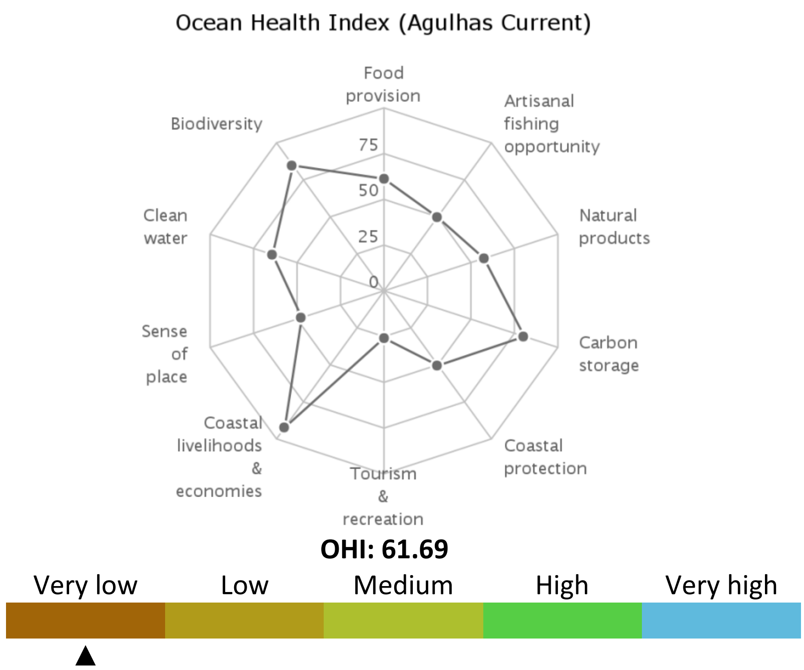






Ocean Health Index

The Agulhas Current LME scores below average on the Ocean Health Index compared to other LMEs (score 68 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is well below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 decreased 1 point compared to the previous year, due in large part to changes in the scores for coastal livelihoods and clean waters. This LME scores lowest on mariculture, coastal protection, tourism & recreation, and sense of place goals and highest on artisanal fishing opportunities, coastal economies, and habitat biodiversity goals. It falls in risk category 4 of the five risk categories, which is a relatively high 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 754 317 km^2. A current population of 40 698 thousand in 2010 is projected to increase to 75 018 thousand in 2100, with a density of 54 persons per km^2 in 2010 increasing to 99 per km^2 by 2100. About 66% of coastal population lives in rural areas, and is projected to decrease in share to 62% in 2100.

Total population		Rural population	
2010	2100	2010	2100
40,698,269	75,017,836	26,774,317	46,812,396

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

Coastal poor

The indigent population makes up 51% 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
20,823,995

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. This LME ranks in the medium-revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $576 million for the period 2001-2010. Fish protein accounts for 20% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013

$12 598 million places it in the low-revenue category. On average, LME-based tourism income contributes 9% 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
576,439,193	19.9	12,598,037,285	8.7	0.9228

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 0.551, this LME has an HDI Gap of 0.449, 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
0.5511	0.7703	0.2780

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

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (e.g. overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m^2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index of this LME is within the very high-risk (very high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is very 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**
0.7703	0.4686	0.5336	0.7837

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

Governance

Governance architecture

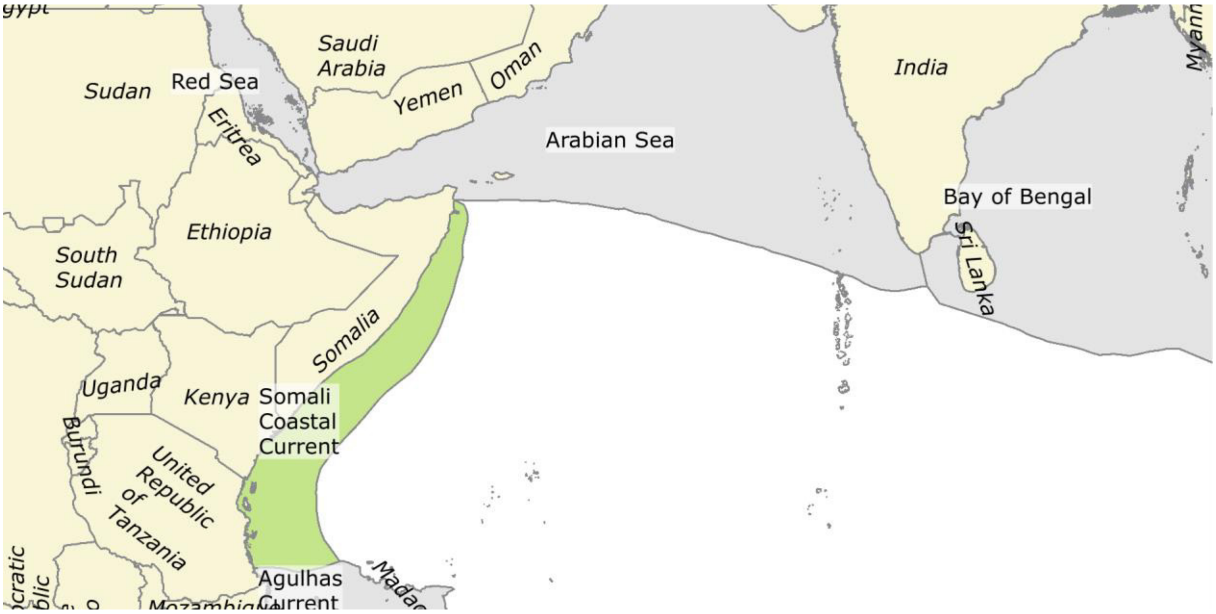
In this LME, the two transboundary arrangements for fisheries in the areas within national jurisdiction (SWIOFC) and demersal resources in ABNJ (SIOFA) are supposed to be closely connected but given the fact that the latter is not fully operational, it is difficult to tell if this is happening. The arrangements for pollution and biodiversity that fall under the Nairobi Convention are also linked. However neither of these sets appears to be integrated with each other or with the tuna arrangement (IOTC). Further, no integrating mechanisms, such as an overall policy coordinating organisation for the LME, could be found. However, the ASCLME Project appears to be performing that role. There may be interaction amongst the arrangements through participation in each other's meetings, but this appears to be informal.

The overall scores for the ranking of risk were:

Engagement	Completeness	Integration
69	**47**	**0.1**

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

LME 31 – Somali Coastal Current



Bordering countries: Kenya, Somali, United Republic of Tanzania.
LME Total area: 844,524 km^2

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LME overall risk

This LME falls in the cluster of LMEs that exhibit high percentages of rural coastal population, high numbers of collapsed and overexploited fish stocks, as well as high proportions of catch from bottom impacting gear.

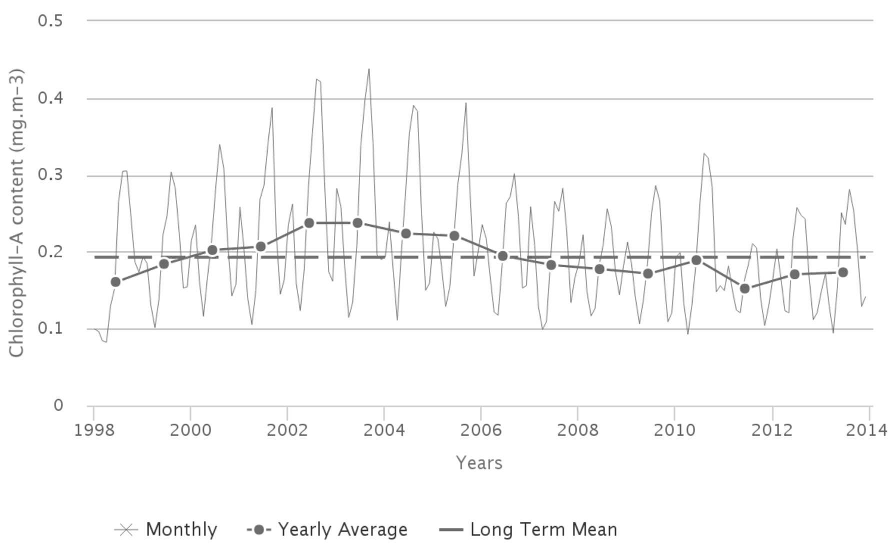
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is very high..

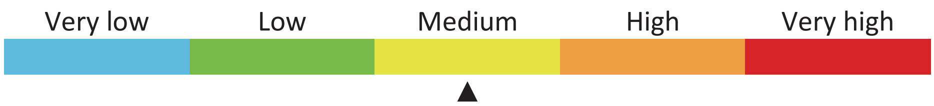
Productivity

Chlorophyll-A

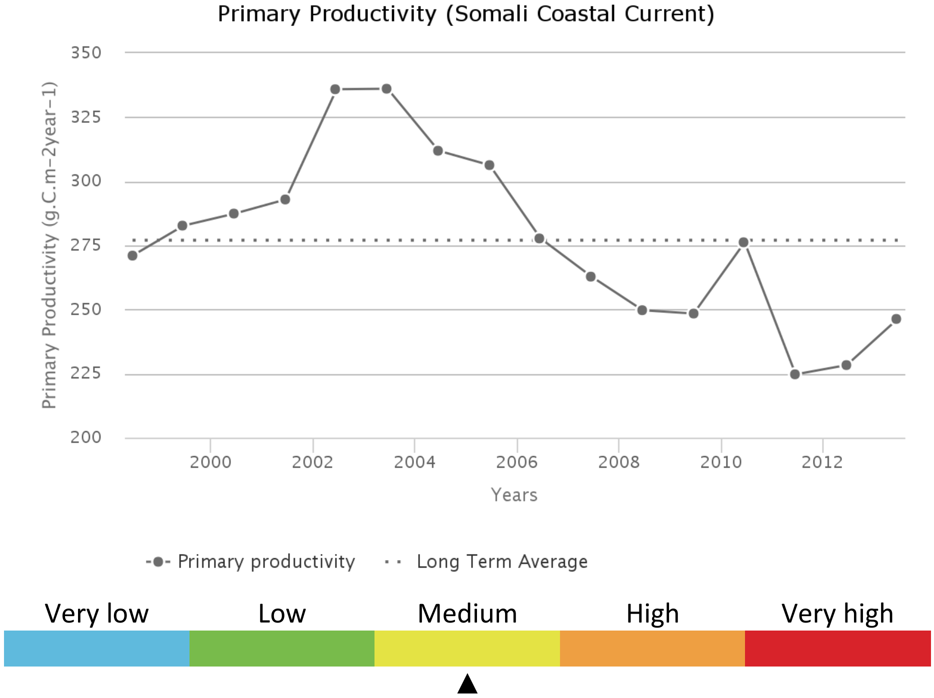
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.306 mg.m^{-3}) in August and a minimum (0.107 mg.m^{-3}) during April. The average CHL is 0.193 mg.m^{-3}. Maximum primary productivity (336 g.C.m^{-2}.y^{-1}) occurred during 2003 and minimum primary productivity (225 g.C.m^{-2}.y^{-1}) during 2011. There is a statistically insignificant decreasing trend in Chlorophyll of -31.7 % from 2003 through 2013. The average primary productivity is 277 g.C.m^{-2}.y^{-1}, which places this LME in Group 3 of 5 categories (with 1 = lowest and 5= highest).

Chlorophyll-A (Somali Coastal Current)



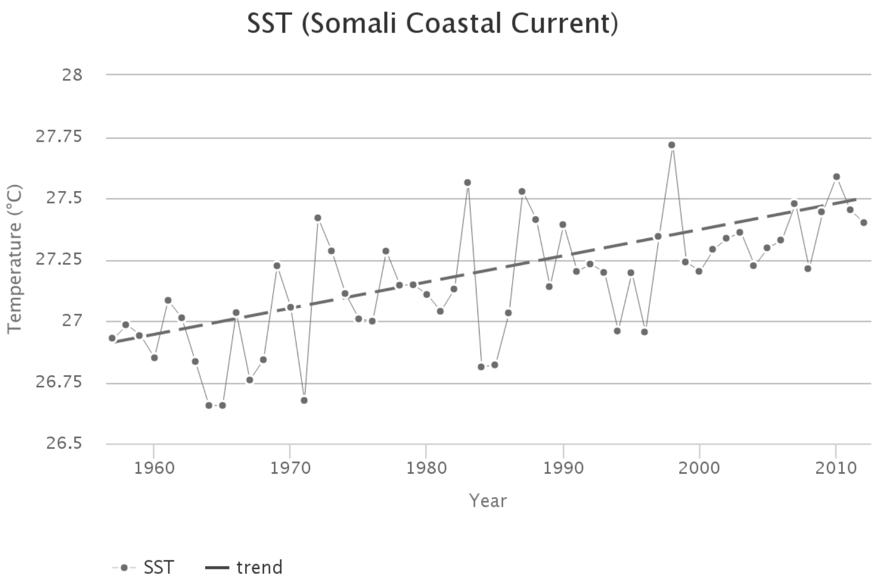


Primary productivity



Sea Surface Temperature

From 1957 to 2012, the Somali Coastal Current LME #31 has warmed by 0.55°C, thus belonging to Category 3 (moderate warming LME). The Somali Current warmed rather steadily since 1957 until present. During the warm event of 1998, SST peaked at the all-time maximum of 27.7°C. Cold/warm events at the southern periphery of the Somali Current likely affected the Agulhas Current LME #30 through sporadic southbound leakages. On the northern end, the Somali LME has no LME neighbor and its connection to the Arabian Sea LME #32 is tenuous at best. Yet the all-time maximum of 1998 (El Niño year) occurred simultaneously in both LMEs and was observed more or less synchronously around the entire Indian Ocean. This synchronism could only have resulted from large-scale forcing such as the El Niño 1997-1998.

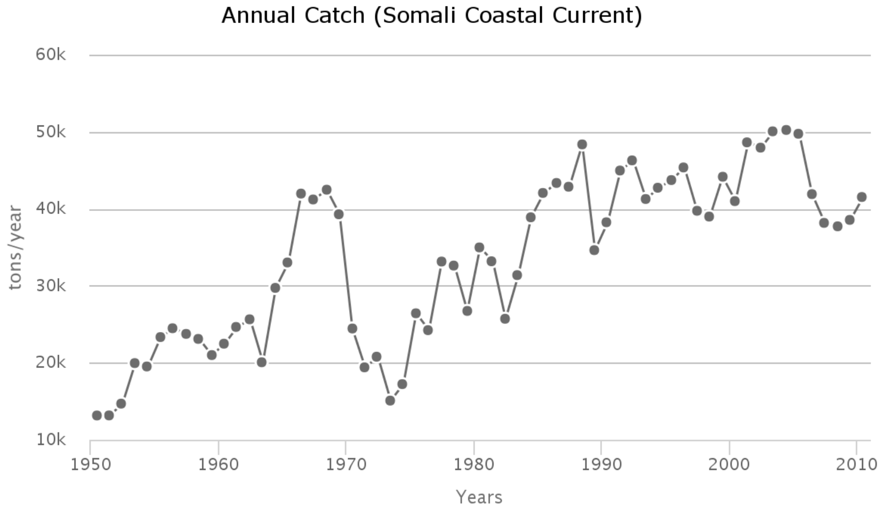


Fish and Fisheries

Over half of the reported landings in the Somali Coastal Current LME consist of "mixed groups". This LME notably contains a high level of subsistence and artisanal fisheries, which are confined to its inshore areas. Consequently, oceanic fisheries in the LME are dominated by distant-water fishing fleets from Europe and East Asia. Due to the poor quality of the available landings statistics in the region, the majority of the landings in the LME can only be classified as 'unidentified marine fish', making interpretation of the status of marine fisheries in the LME extremely difficult.

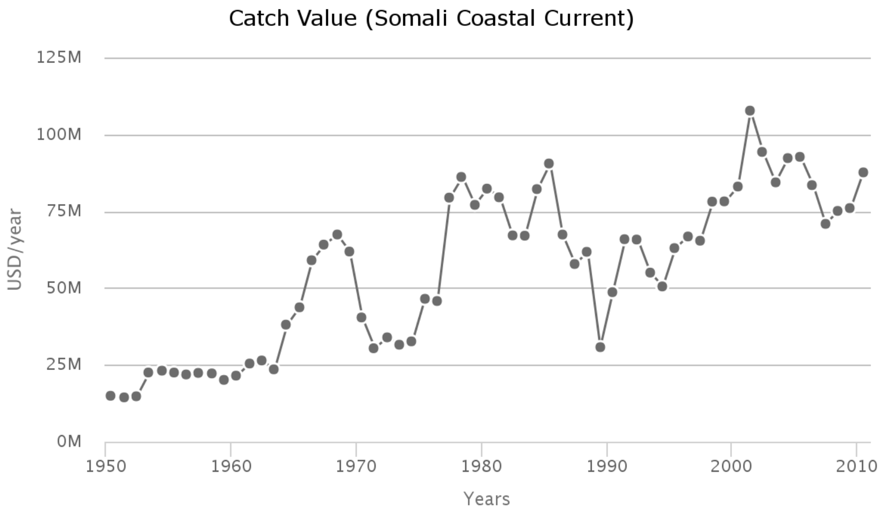
Annual Catch

Total reported landings in the LME showed a general increase over the reported period, but with marked fluctuations, recording 50,000 t in 2004.



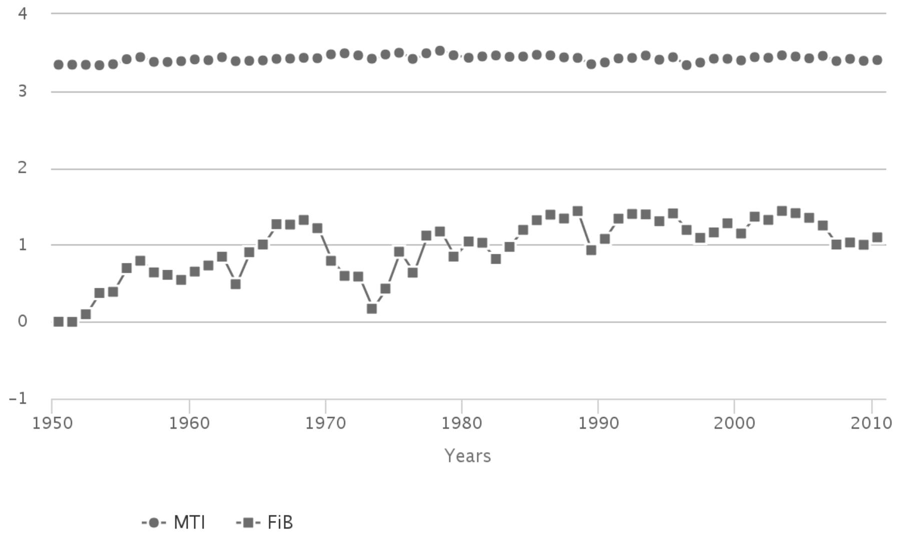
Catch value

The value of the reported landings peaked in 2001 at around 100 million US$ (in 2005 real US$), and in the last 10 years between 38-50 million US$.



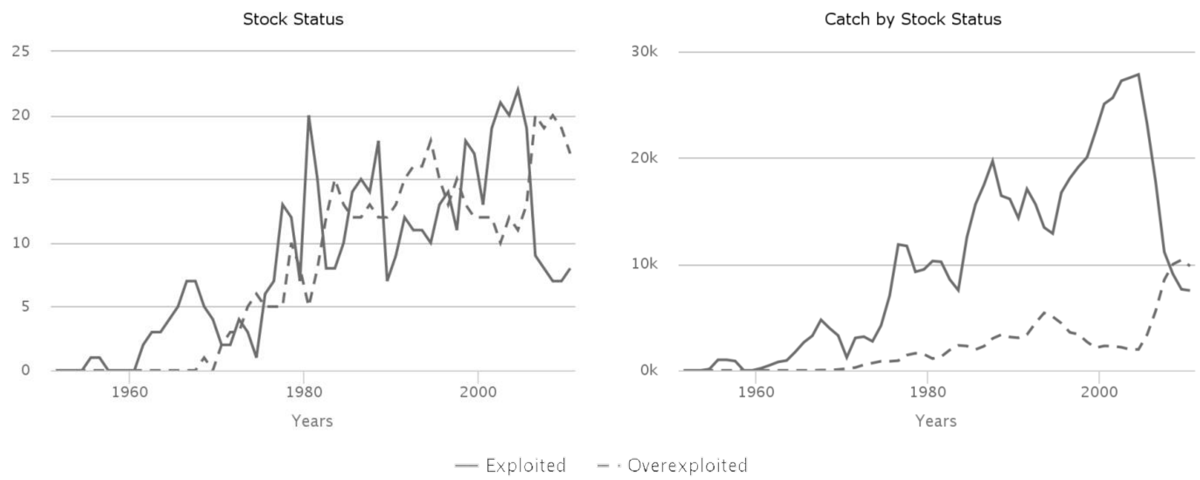
Marine Trophic Index and Fishing-in-Balance index

Due the high proportion of unidentified catches in the underlying statistics, the MTI and the FiB index of the reported landings estimated for this LME should not be viewed as good indicators of the state of its fisheries, i.e., the increase in the MTI from 1950 to the mid-1970 is likely a result of the improvement in the taxonomic details of the reported landings; the increase in the FiB index during this period seems to be informative, as it suggest the spatial expansion of fisheries in the region. The decrease in FiB index from mid-1990 indicates that the ecosystem is impaired by the removal of excessive levels of biomass.



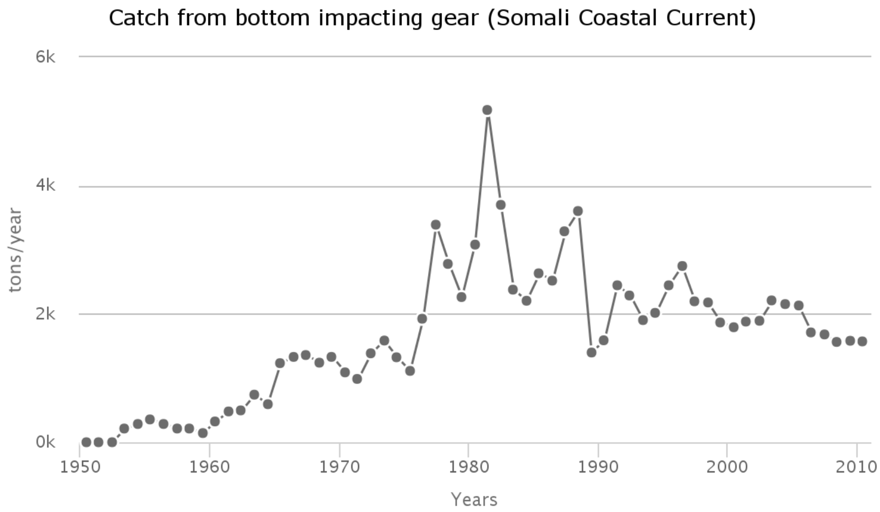
Stock status

The Stock-Catch Status Plots show that the number of overexploited stocks is higher than that of collapsed or fully exploited stocks, and the overexploited stocks contribute almost half of the total catch biomass.



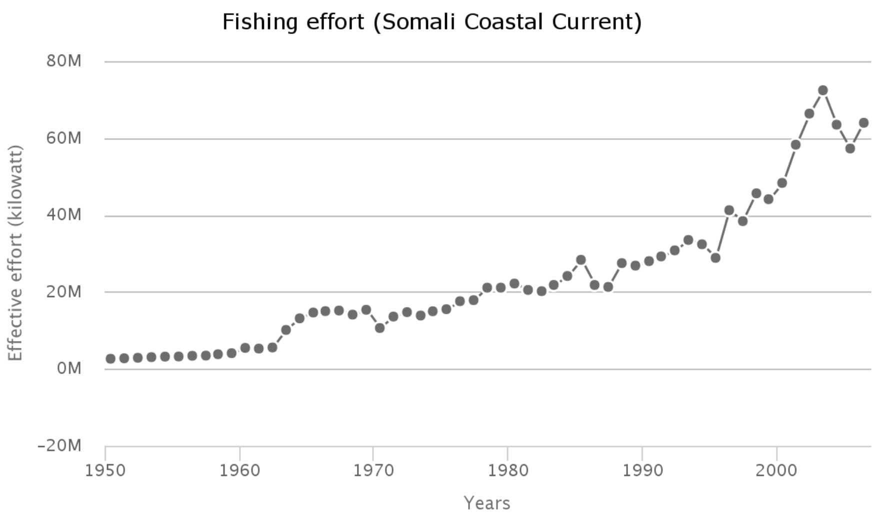
Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch reached its first peak at 15% in 1980 and then declined. In the recent decade, this percentage fluctuated around 4%.



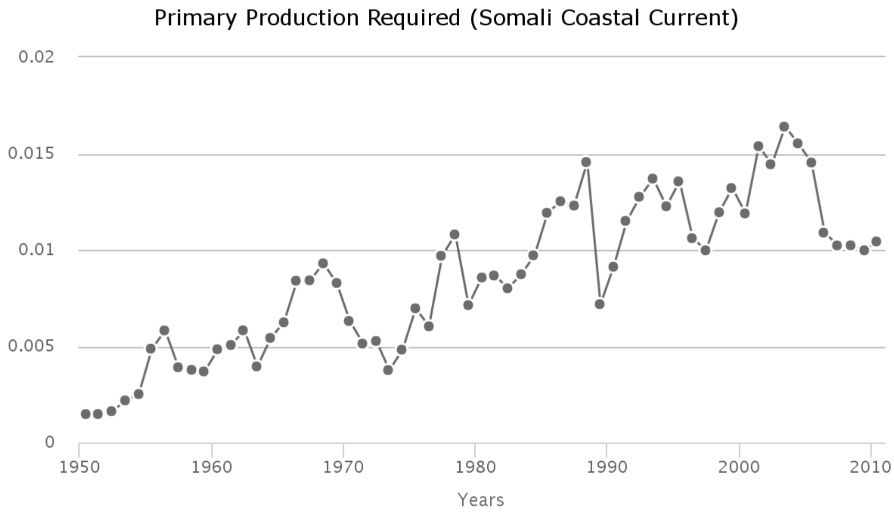
Fishing effort

The total effective effort increased from around 3 million kW in the 1950s to its peak at 72 million kW in the early 2000s. In the recent few years, the fishing effort kept declining.



Primary Production Required

The primary production required (PPR) to sustain the reported landings in the LME is low, reaching 2.5% only in recent years.



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 increased to low in 2030 and remained low in 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was low (2). According to the Global Orchestration scenario, this remained the same in 2030 and increased to moderate in 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 increased to low in 2030 and remained 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	2	1	2	2	2	2	3	2

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

POPs

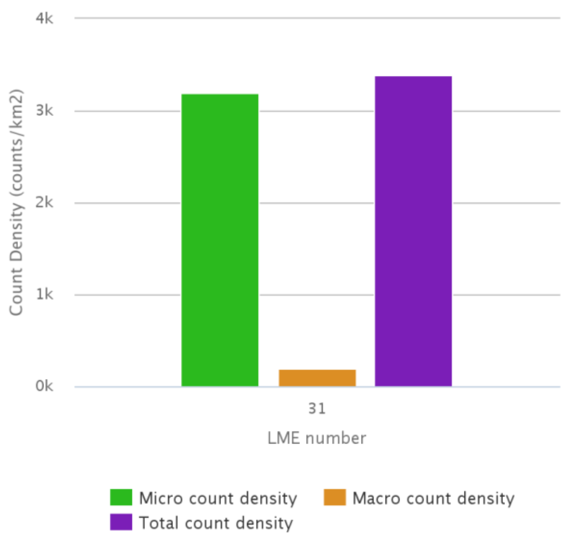
Four samples at four locations, mainly from Kenya, are available. This LME shows low average concentrations (ng.g^{-1} of pellets) of 25 (range 1-42 ng.g^{-1}) for PCBs and 10.5 (range 2-16 ng.g^{-1}) for DDTs, both corresponding to risk category 2, while trace average concentration of 0.6 (range 0.1-0.9 ng.g^{-1}) for HCHs corresponding to risk category 1, of the five risk categories (1 = lowest risk; 5 = highest risk). All locations in Kenya had higher concentrations of PCBs (15 – 42 ng.g^{-1}) and DDTs (11 – 16 ng.g^{-1}) than background levels (10 and 4, respectively). Current emission of PCBs from e-waste or old equipment may occur and the application of DDT pesticide for Malaria control may contribute. More locations should be monitored in this LME.

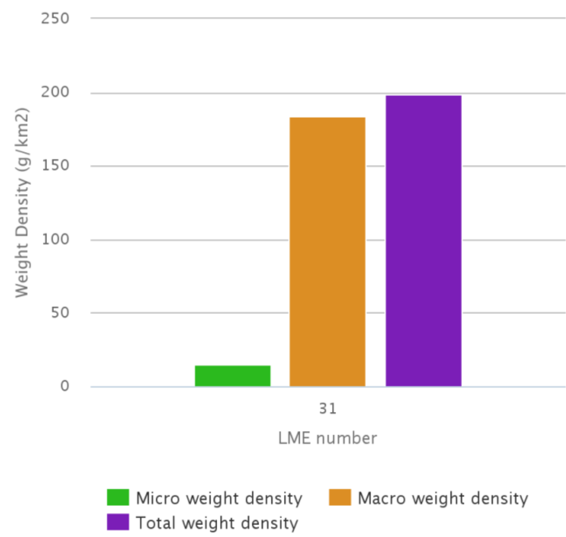
	PCBs		DDTs		HCHs	
Locations	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk	Avg. (ng/g)	Risk
4	25	2	10	2	0.6	1

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.





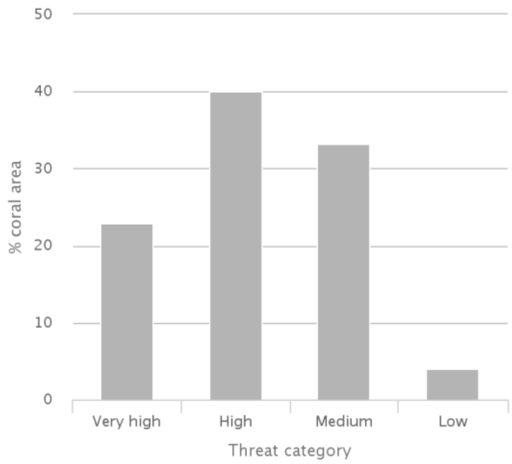
Ecosystem Health

Mangrove and coral cover

0.15% of this LME is covered by mangroves (US Geological Survey, 2011) and 0.46% by coral reefs (Global Distribution of Coral Reefs, 2010).

Reefs at risk

This LME has a present (2011) integrated threat index (combining threat from overfishing and destructive fishing, watershed-based and marine-based pollution and damage) of 282. 23% of coral reefs cover is under very high threat, and 40% under high threat (of the 5 possible threat categories, from low to critical). When combined with past thermal stress (between 1998 and 2007), these values increase to 51% and 37% for very high and high threat categories respectively. By year 2030, 29% of coral cover in this LME is predicted to be under very high to critical level of threat from warming and acidification; this proportion increases to 63% by 2050.

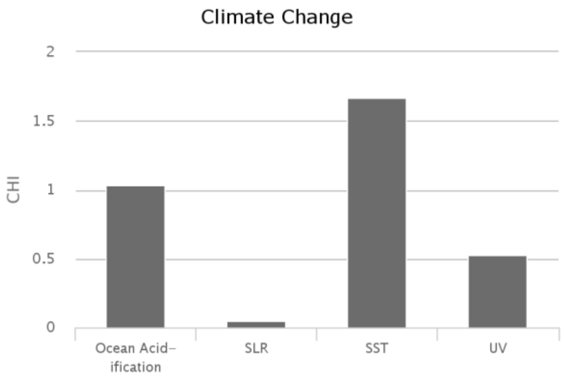


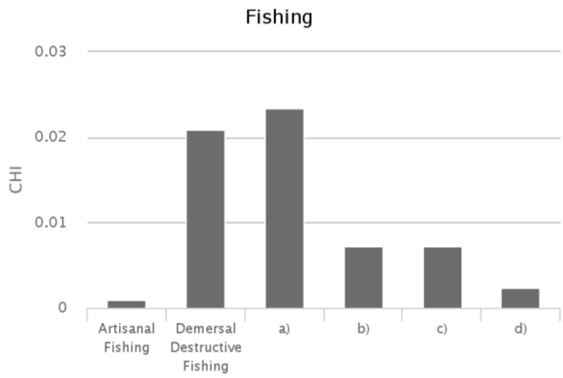
Marine Protected Area change

The Somali Coastal Current LME experienced an increase in MPA coverage from 544 km^2 prior to 1983 to 5,489 km^2 by 2014. This represents an increase of 910%, within the low category of MPA change.

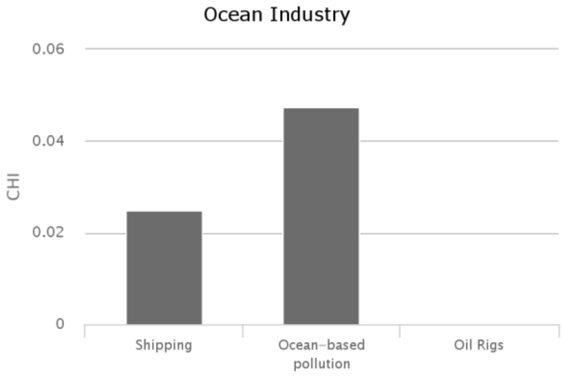
Cumulative Human Impact

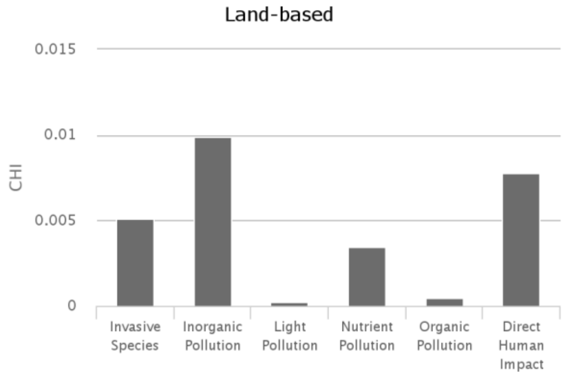
The Somali Coastal Current LME experiences an average overall cumulative human impact (score 3.44; maximum LME score 5.22), but which is still well above the LME with the least cumulative impact. It falls in risk category 2 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is 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 (0.52; maximum in other LMEs was 0.76), and sea surface temperature (1.67; maximum in other LMEs was 2.16). Other key stressors include sea level rise and ocean based pollution.

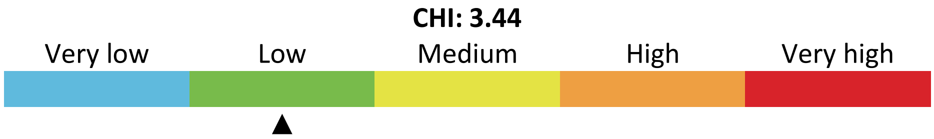




a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing

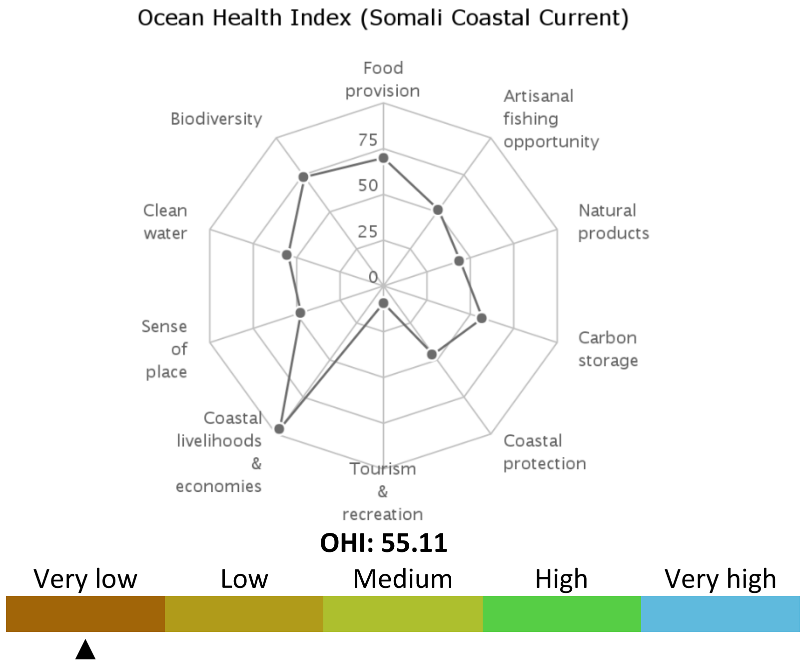






Ocean Health Index

The Somali Coastal Current LME scores below average on the Ocean Health Index (score 61 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is well below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 decreased 5 points compared to the previous year, due in large part to changes in the scores for natural products and clean waters. This LME scores lowest on mariculture, natural products, coastal protection, carbon storage, tourism & recreation, sense of place, and clean waters goals and highest on artisanal fishing opportunities and coastal livelihoods & economies goals. It falls in risk category 5 of the five risk categories, which is the highest level of risk (1 = lowest risk; 5 = highest risk).



Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for this LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The coastal area stretches over 298 926 km^2. A current population of 15 672 thousand in 2010 is projected to increase to 92 037 thousand in 2100, with a density of 52 persons per km^2 in 2010 increasing to 308 per km^2 by 2100. About 64% of coastal population lives in rural areas, and is projected to decrease in share to 63% in 2100.

Total population		Rural population	
2010	2100	2010	2100
15,671,779	92,037,170	9,996,331	57,816,834

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

Coastal poor

The indigent population makes up 49% 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
7,675,312

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. This LME ranks in the very low-revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $103 million for the period 2001-2010. Fish protein accounts for 13% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013

$944 million places it in the very low-revenue category. On average, LME-based tourism income contributes 12% 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
102,869,730	13.2	943,984,859	12.2	0.9097

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 0.337, this LME has an HDI Gap of 0.663, 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 medium 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
0.3370	0.7468	0.2570

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

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (*e.g.* overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m^2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index of this LME is within the very high-risk (very high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is very 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
0.7870	0.5143	0.5404	0.7791

Legend:

Very low | Low | Medium | High | Very high

LME 33 – Red Sea

Bordering countries: Djibouti, Egypt, Eritrea, Israel, Jordan, Saudi Arabia, Sudan, Yemen.
LME Total area: 480,385 km^2

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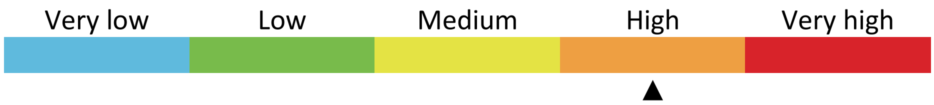
LME overall risk

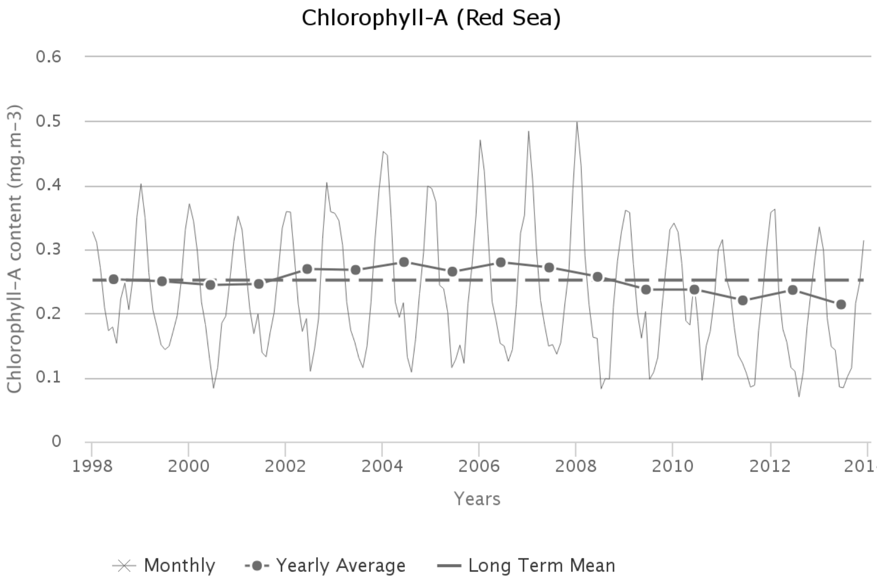
This LME falls in the cluster of LMEs that exhibit high rates of increase in MPA coverage.
Based on a combined measure of the Human Development Index and the averaged indicators for fish & fisheries and pollution & ecosystem health modules, the overall risk factor is high.

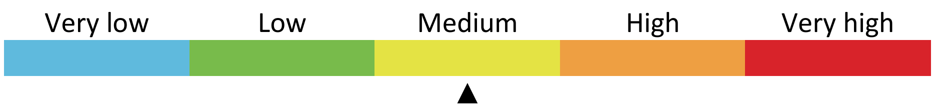


Productivity

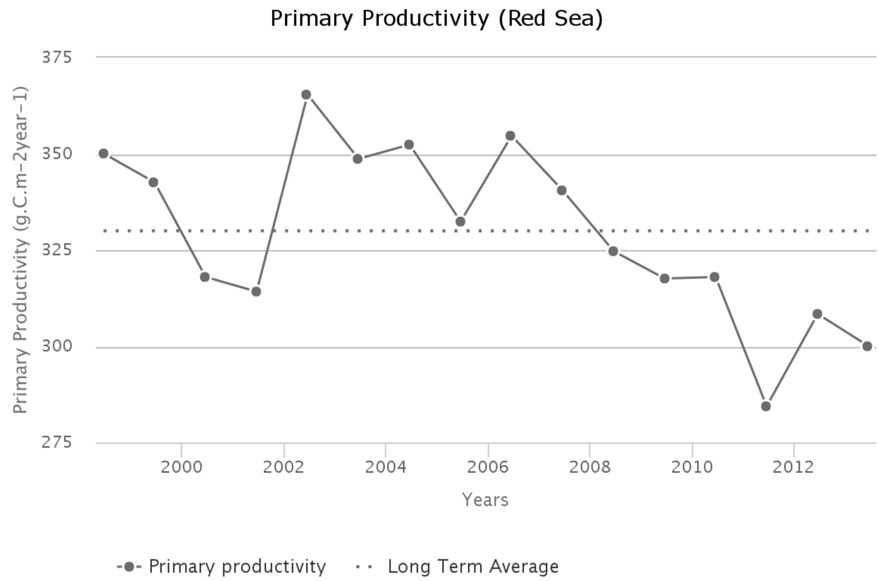
Chlorophyll-A

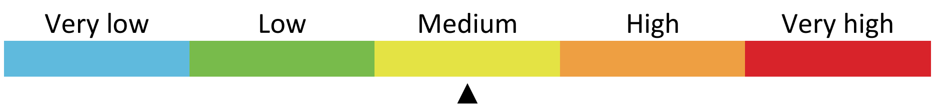
The annual Chlorophyll a concentration (CHL) cycle has a maximum peak (0.390 $mg.m^{-3}$) in January and a minimum (0.183 $mg.m^{-3}$) during September. The average CHL is 0.252 $mg.m^{-3}$. Maximum primary productivity (365 $g.C.m^{-2}.y^{-1}$) occurred during 2002 and minimum primary productivity (284 $g.C.m^{-2}.y^{-1}$) during 2011. There is a statistically insignificant decreasing trend in Chlorophyll of -22.1 % from 2003 through 2013. The average primary productivity is 330 $g.C.m^{-2}.y^{-1}$, which places this LME in Group 3 of 5 categories (with 1 = lowest and 5= highest).





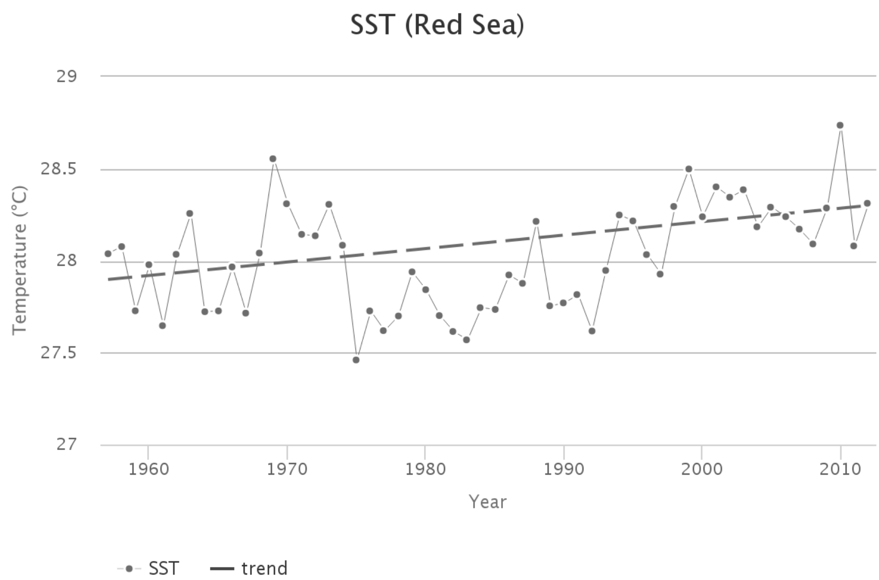
Primary productivity





Sea Surface Temperature

From 1957 to 2012, the Red Sea LME #33 has warmed by 0.40°C, thus being on a threshold between Categories 3 and 4 (moderate-to-slow warming LME). The Red Sea saw its SST rising rather gradually except for a sharp drop in the mid-1970s. The most recent peak SST of 28.7°C in 2010 marked the all-time maximum. Using the all-time minimum of 27.4°C in 1975 as a reference point, SST rose by 1.4°C to 28.8°C in 2012. As a relatively small land-locked water body, the Red Sea and its thermal regime, especially of the surface layer, are heavily influenced by the terrestrial climates of adjacent landmasses of Africa and the Arabian Peninsula.

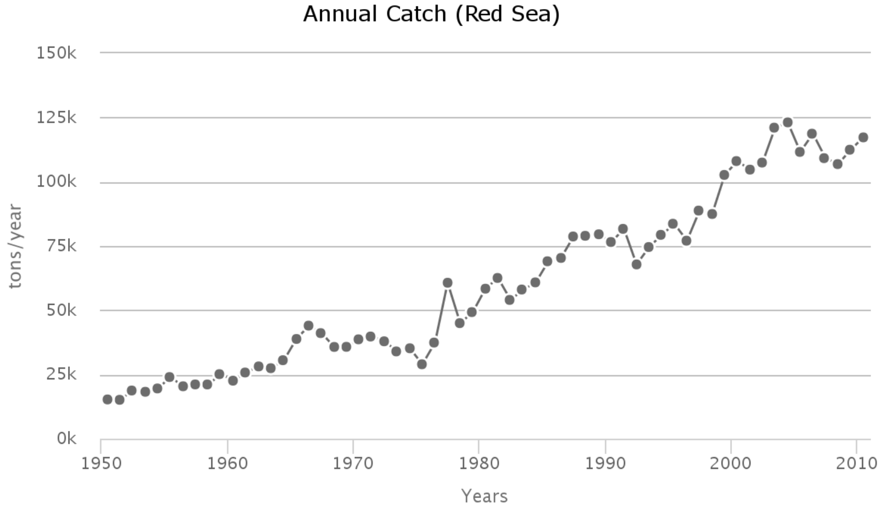


Fish and Fisheries

About 1,200 species of fish are known to occur in the Red Sea LME, and marked differences occur in fish species richness, assemblage compositions and species abundance in different parts of the Red Sea, reflecting the heterogeneous nature of its environment. Fishing occurs mainly at the subsistence or artisanal levels, although commercial trawling and purse seining are also carried out in Egypt, Saudi Arabia and Yemen

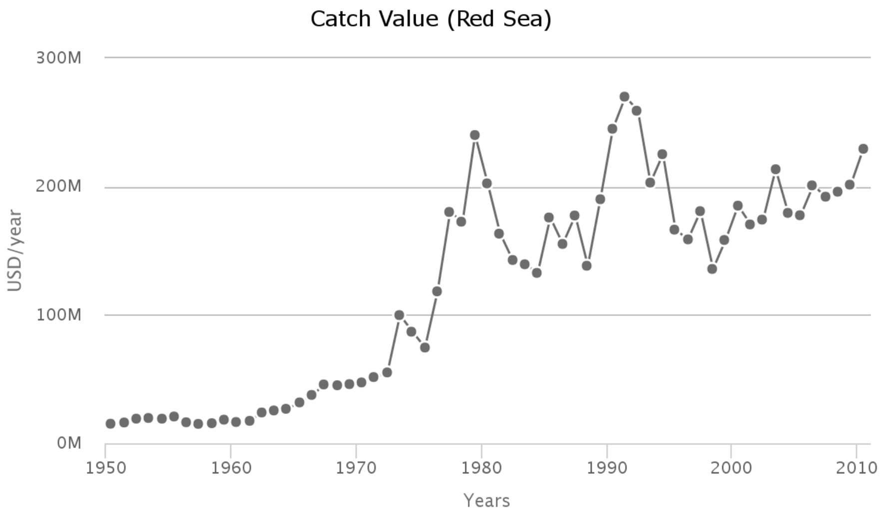
Annual Catch

Total reported landings from this LME have increased steadily, recording over 130,000 t in 2004, most of it in the "mixed group".



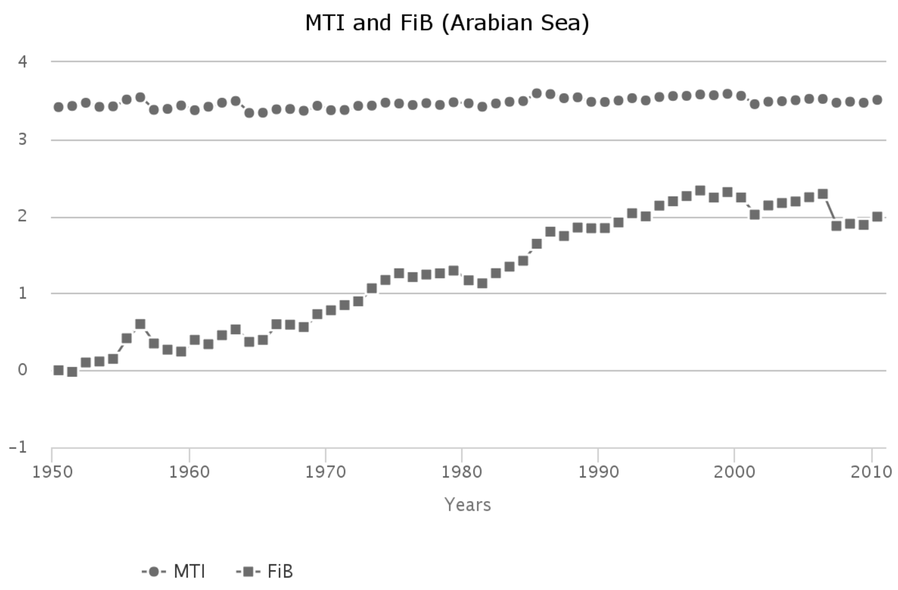
Catch value

The value of the reported landings also increased to about 270 million US$ in 1991 (in 2005 real US$).



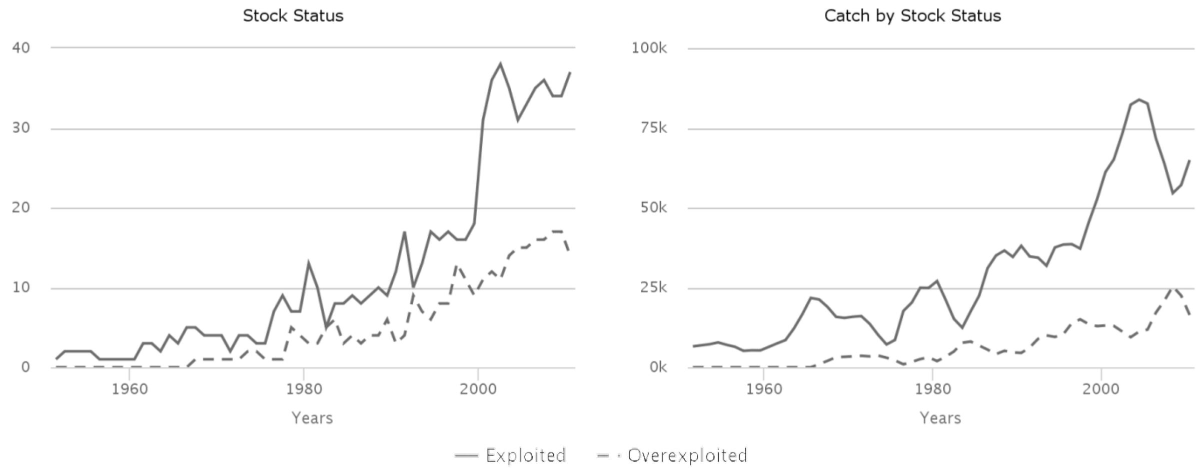
Marine Trophic Index and Fishing-in-Balance index

The fisheries of the Red Sea LME are still expanding, and therefore, they show high and stable MTI values, with an increase in the FiB index.



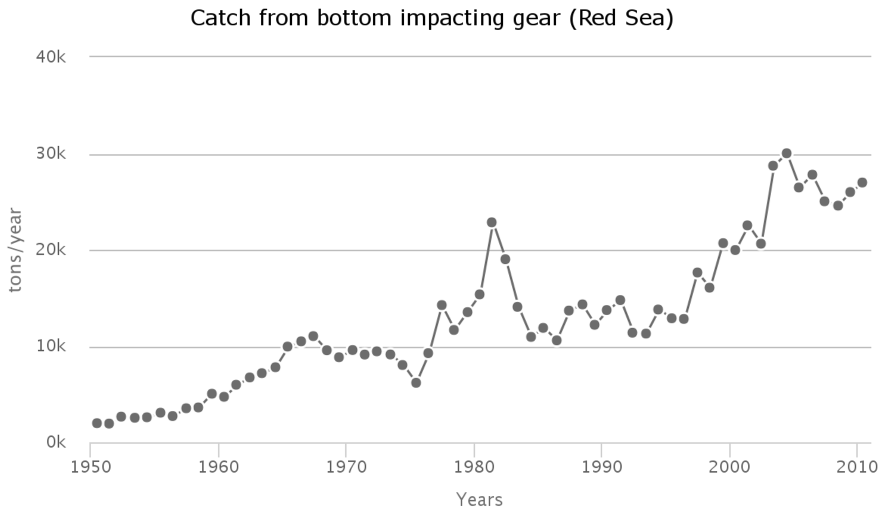
Stock status

The Stock-Catch Status Plots indicate that the number of collapsed stocks is similar to that of overexploited stocks (16 – 17%), but the collapsed stocks only contribute a very small amount of the total catch. About 85% of the catch originates from overexploited and fully exploited stocks.



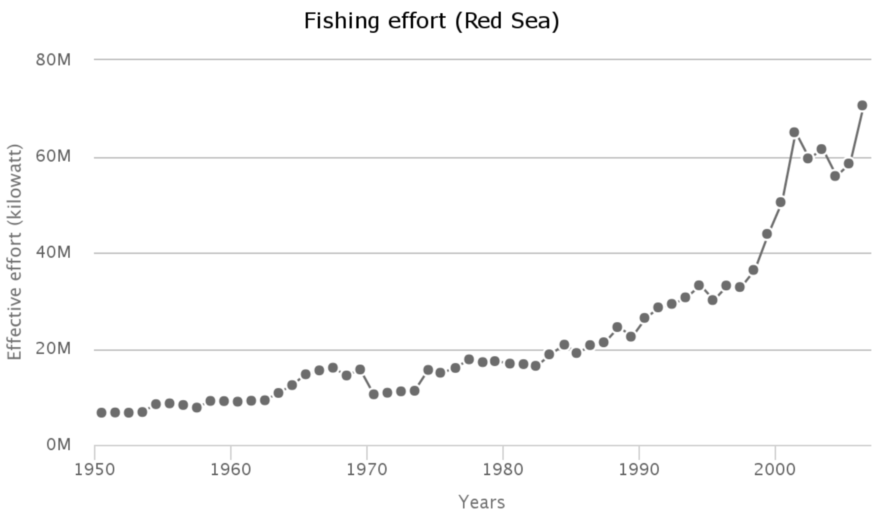
Catch from bottom impacting gear

The percentage of catch from the bottom gear type to the total catch increased from 13% in the 1950s to its first peak at around 35% in 1981. Then, this percentage kept decreasing and fluctuated around 23% in recent decade.



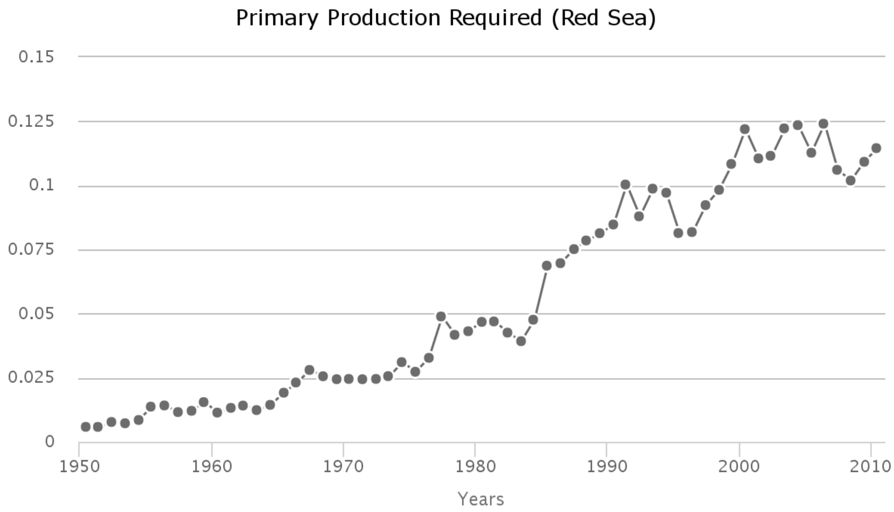
Fishing effort

The total effective effort continuously increased from around 7 million kW in the 1950s to its peak around 70 million kW in the mid-2000s.



Primary Production Required

The primary production required (PPR) to sustain the reported landing in this LME is increasing in recent years, but has yet to reach 10% of the observed primary production.



Pollution and Ecosystem Health

Pollution

Nutrient ratio, Nitrogen load and Merged Indicator

Human activities in watersheds are affecting nutrients transported by rivers into LMEs. Large amounts of nutrients (in particular *nitrogen load*) entering coastal waters of LMEs can result in high biomass algal blooms, leading to hypoxic or anoxic conditions, increased turbidity and changes in community composition, among other effects. In addition, changes in the *ratio of nutrients* entering LMEs can result in dominance by algal species that have deleterious effects (toxic, clog gills of shellfish, etc.) on ecosystems and humans. An overall nutrient indicator (*Merged Nutrient Indicator*) based on 2 sub-indicators: *Nitrogen Load* and *Nutrient Ratio* (ratio of dissolved Silica to Nitrogen or Phosphorus - the Index of Coastal Eutrophication Potential or ICEP) was calculated.

Nitrogen load

The Nitrogen Load risk level for contemporary (2000) conditions was very low (level 1 of the five risk categories, where 1 = lowest risk; 5 = highest risk). Based on a "current trends" scenario (Global Orchestration), this remained the same in 2030 and 2050.

Nutrient ratio

The Nutrient Ratio (ICEP) risk level for contemporary (2000) conditions was high (4). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

Merged nutrient indicator

The risk level for the Merged Nutrient Indicator for contemporary (2000) conditions was very low (1). According to the Global Orchestration scenario, this remained the same in 2030 and 2050.

2000			**2030**			**2050**		
Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator	Nitrogen load	Nutrient ratio	Merged nutrient indicator
1	4	1	1	4	1	1	4	1

Legend:

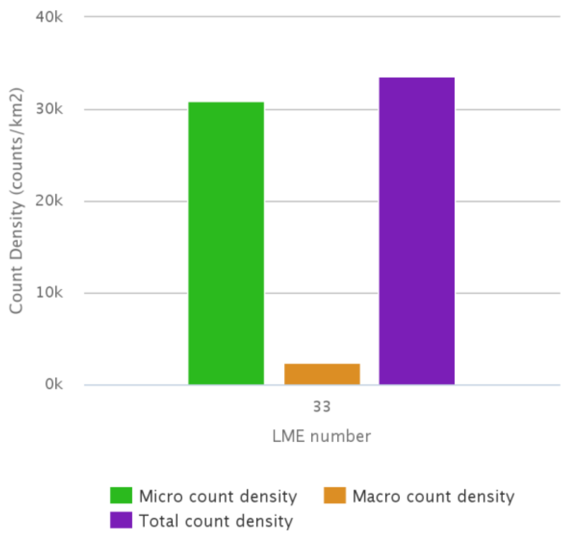
Very low · Low · Medium · High · Very high

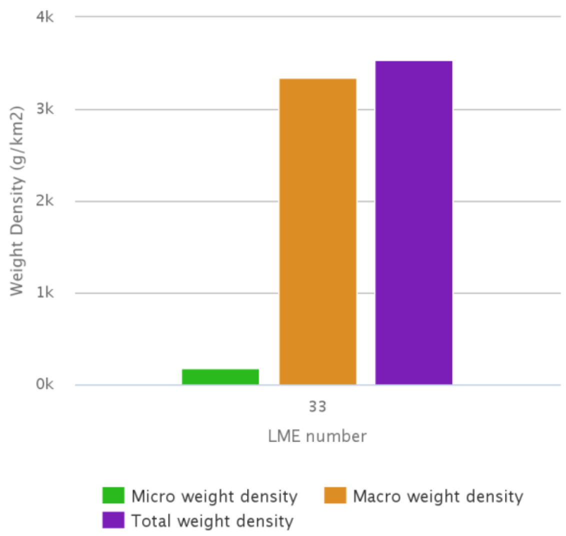
POPs

No pellet samples were obtained from this LME.

Plastic debris

Modelled estimates of floating plastic abundance (items km^{-2}), for both micro-plastic (<4.75 mm) and macro-plastic (>4.75 mm), indicate that this LME is in the group with the highest plastic concentration. Estimates are based on three proxy sources of litter: shipping density, coastal population density and the level of urbanisation within major watersheds, with enhanced run-off. The high values are due to relative importance of these sources in this LME. The abundance of floating plastic in this category is estimated to be on average over 400 times higher that those LMEs with lowest values. There is limited evidence from sea-based direct observations and towed nets to support this conclusion.





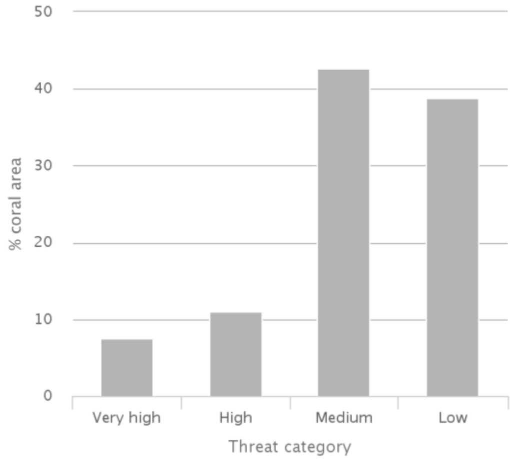
Ecosystem Health

Mangrove and coral cover

0.02% of this LME is covered by mangroves (US Geological Survey, 2011) and 2.7% by coral reefs (Global Distribution of Coral Reefs, 2010).

Reefs at risk

This LME has a present (2011) integrated threat index (combining threat from overfishing and destructive fishing, watershed-based and marine-based pollution and damage) of 187. This is the highest integrated threat score of any LME. 11% of coral reefs cover is under very high threat, and 7% under high threat (of the 5 possible threat categories, from low to critical). When combined with past thermal stress (between 1998 and 2007), these values increase to 11% and 23% for very high and high threat categories respectively. By year 2030, 12% of coral cover in this LME is predicted to be under very high to critical level of threat from warming and acidification; this proportion increases to 18% by 2050.

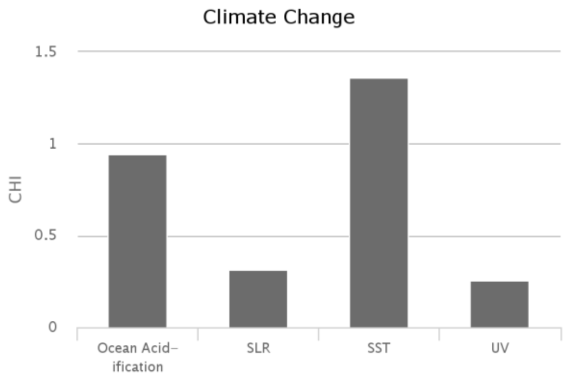


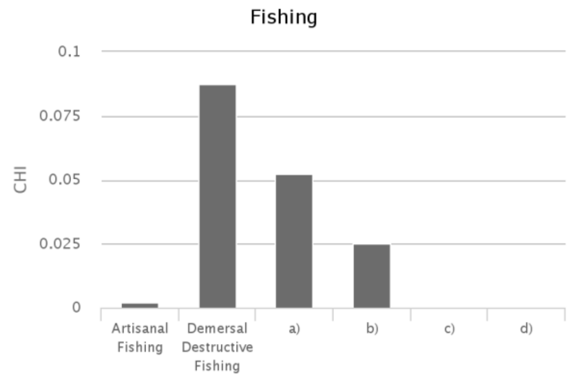
Marine Protected Area change

The Red Sea LME experienced an increase in MPA coverage from 1.7 km^2 prior to 1983 to 16,630 km^2 by 2014. This represents an increase of 50,000%, within the highest category of MPA change.

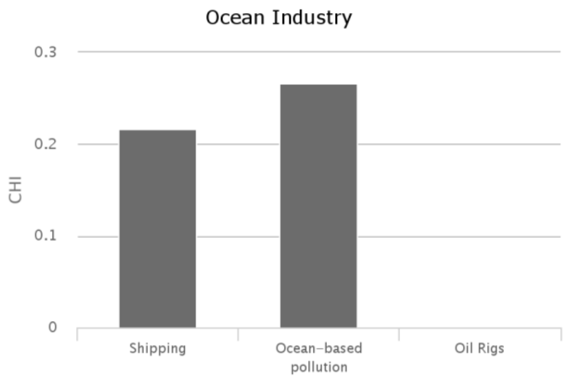
Cumulative Human Impact

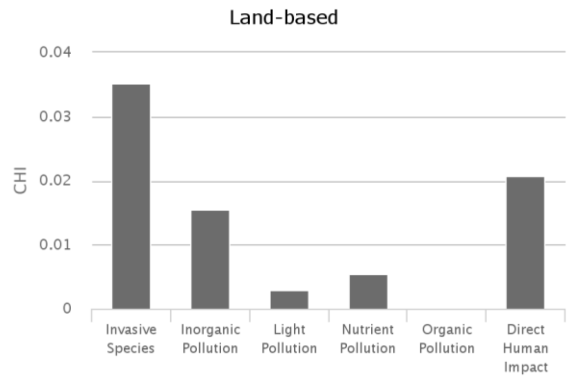
The Red Sea LME experiences an above average overall cumulative human impact (score 3.61; maximum LME score 5.22), which is also well above the LME with the least cumulative impact. It falls in risk category 3 of the five risk categories (1 = lowest risk; 5 = highest risk). This LME is most vulnerable to climate change. Of the 19 individual stressors, all four connected to climate change have the highest average impact on the LME: ocean acidification (0.94; maximum in other LMEs was 1.20), UV radiation (0.26; maximum in other LMEs was 0.76), sea level rise (0.31; maximum in other LMEs was 0.71), and sea surface temperature (1.36; maximum in other LMEs was 2.16). Other key stressors include commercial shipping, ocean based pollution, invasive species, demersal destructive commercial fishing, and demersal non-destructive low-bycatch commercial fishing.

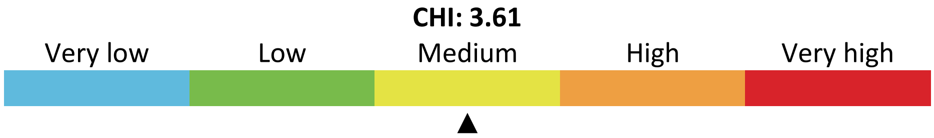




a) Demersal Non-destructive High Bycatch Fishing
c) Pelagic High Bycatch Fishing
b) Demersal Non-destructive Low Bycatch Fishing
d) Pelagic Low Bycatch Fishing



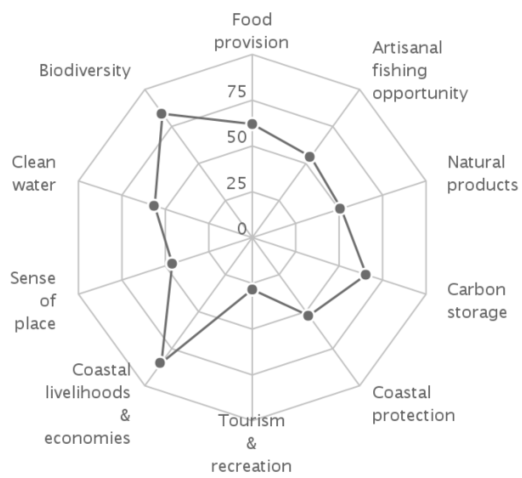




Ocean Health Index

The Red Sea LME has one of the lowest scores on the Ocean Health Index (score 60 out of 100; range for other LMEs was 57 to 82). This score indicates that the LME is well below its optimal level of ocean health, although there are some aspects that are doing well. Its score in 2013 decreased 2 points compared to the previous year, due in large part to changes in the scores for natural products and clean waters. This LME scores lowest on mariculture, natural products, coastal protection, tourism & recreation, and sense of place goals and highest on artisanal fishing opportunities and habitat biodiversity goals. It falls in risk category 5 of the five risk categories, which is the highest level of risk (1 = lowest risk; 5 = highest risk).

Ocean Health Index (Arabian Sea)



OHI: 55.42

Socio-economics

Indicators of demographic trends, economic dependence on ecosystem services, human wellbeing and vulnerability to present-day extreme climate events and projected sea level rise, are assessed for the this LME. To compare and rank LMEs, they were classified into five categories of risk (from 1 to 5, corresponding to lowest, low, medium, high and highest risk, respectively) based on the values of the individual indicators. In the case of economic revenues, the LMEs were grouped to 5 classes of revenues from lowest, low, medium, high and highest, as revenues did not translate to risk.

Population

The coastal area stretches over 513 873 km^2. A current population of 27 950 thousand in 2010 is projected to increase to 108 998 thousand in 2100, with a density of 54 persons per km^2 in 2010 reaching 202 per km^2 by 2100. About 58% of coastal population lives in rural areas, and is projected to increase in share to 68% in 2100.

Total population		Rural population	
2010	2100	2010	2100
27,949,857	103,998,449	16,155,251	70,332,905

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

Coastal poor

The indigent population makes up 24% of the LME's coastal dwellers. This LME places in the very high-risk category based on percentage and in the high-risk category using absolute number of coastal poor (present day estimate).

Coastal poor
6,778,119

Revenues and Spatial Wealth Distribution

Fishing and tourism depend on ecosystem services provided by LMEs. This LME ranks in the medium-revenue category in fishing revenues based on yearly average total ex-vessel price of US 2013 $230 million for the period 2001-2010. Fish protein accounts for 9% of the total animal protein consumption of the coastal population. Its yearly average tourism revenue for 2004-2013 of US 2013

$12 134 million places it in the medium-revenue category. On average, LME-based tourism income contributes 7% to the national GDPs of the LME coastal states. Spatial distribution of economic activity (e.g. spatial wealth distribution) measured by night-light and population distribution as coarse proxies can range from 0.0000 (totally equal distribution and lowest risk) to 1.0000 (concentrated in 1 place and most inequitable and highest risk). The Night Light Development Index (NLDI) thus indicates the level of spatial economic development, and that for this LME falls in the category with high risk.

Fisheries Annual Landed Value	% Fish Protein Contribution	Tourism Annual Revenues	% Tourism Contribution to GDP	NLDI
230,291,568	9.2	12,133,838,451	6.9	0.8135

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

Human Development Index

Using the Human Development Index (HDI) that integrates measures of health, education and income, the present-day LME HDI belongs to the low HDI and high risk category. Based on an HDI of 0.648, this LME has an HDI Gap of 0.352, the difference between present and highest possible HDI (1.000). The HDI Gap measures an overall vulnerability to external events such as disease or extreme climate related events, due to less than perfect health, education, and income levels, and is independent of the harshness of and exposure to specific external shocks.

HDI values are projected to the year 2100 in the contexts of shared socioeconomic development pathways (SSPs). This LME is projected to assume a place in the very low risk category (very high HDI) in 2100 under a sustainable development pathway. Under a fragmented world scenario, the LME is estimated to place in a very high-risk category (low HDI) because of reduced income levels and increased population values from those in a sustainable development pathway.

	HDI 2100	
HDI	SSP1	SSP3
0.6480	0.8163	0.4606

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

Climate-Related Threat Indices

The Climate-Related Threat Indices utilize the HDI Gaps for present-day and projected 2100 scenarios. The contemporary climate index accounts for deaths and property losses due to storms, flooding and extreme temperatures incurred by coastal states during a 20-year period from 1994 to 2013 as hazard measures, the 2010 coastal population as proxy for exposure, and the present day HDI Gap as vulnerability measure.

The Contemporary Threat Index incorporates a Dependence Factor based on the fish protein contribution to dietary animal protein, and on the mean contribution of LME tourism to the national GDPs of LME coastal states. The HDI Gap and the degree of dependence on LME ecosystem services define the vulnerability of a coastal population. It also includes the average of risk related to extreme climate events, and the risk based on the degrading system states of an LME (e.g. overexploited fisheries, pollution levels, decrease in coastal ecosystem areas).

The 2100 sea level rise threat indices, each computed for the sustainable world and fragmented world development pathways, use the maximum projected sea level rise at the highest level of warming of 8.5 W/m2 in 2100 as hazard measure, development pathway-specific 2100 populations in the 10 m × 10 km coast as exposure metrics, and development pathway-specific 2100 HDI Gaps as vulnerability estimates.

Present day climate threat index of this LME is within the very high-risk (very high threat) category. The combined contemporaneous risk due to extreme climate events, degrading LME states and the level of vulnerability of the coastal population, is high. In a sustainable development scenario, the risk index from sea level rise in 2100 is very low, and increases to very high risk under a fragmented world development pathway.

2010		2100	
Climate Threat	**Contemporary Threat**	**SSP1**	**SSP3**
0.6870	0.3934	0.4606	0.6622

Legend:

Very low · Low · Medium · High · Very high

Governance

Governance architecture

The two arrangements for pollution and for biodiversity fall under the Jeddah Convention. However, there does not appear to be any specific regional arrangements for fishing in general nor habitat degradation and its effect on biodiversity within the Red Sea and Gulf of Aden. The transboundary arrangement for turtles and their habitat in the Indian Ocean does not appear to be integrated formally with the other arrangements. No integrating mechanisms, such as an overall policy coordinating organisation for the LME, could be found. There may be interaction amongst the arrangements through participation in each other's meetings, but this appears to be informal.
The overall scores for ranking of risk were:

Engagement	Completeness	Integration
65	**52**	**0.2**

Legend:

Very low · Low · Medium · High · Very high

Rich Beilfuss

Robert Simmon, NASA Earth Observatory, Landsat 8 data from USGS

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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: Eastern & Southern Africa, Volume 6-Annex G -- is one of 12 annexes to the Crosscutting Analysis discussed in Volume 6. The global compendium organized into 14 TWAP regions, compiles information sheets on 765 international water systems including the baseline values of quantitative indicators that were used to establish contemporary and relative risk levels at system and regional scales. Over the long term, it is envisioned that these baseline information sheets will continue to be updated by future assessments at multiple spatial and temporal scales to better track the changing states of transboundary waters that are essential in sustaining human wellbeing and ecosystem health.

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