

Groundwater component

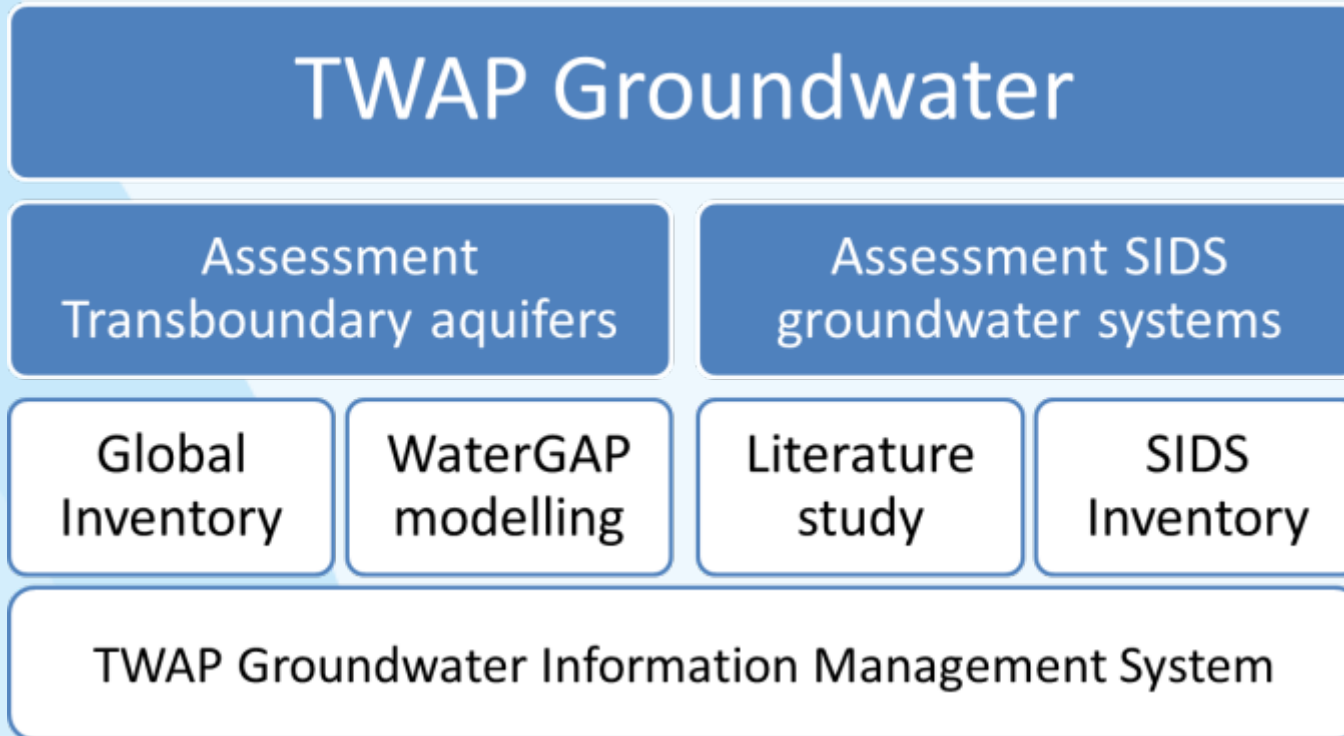
Transboundary aquifers & Groundwater systems in Small Island Developing States

Geert-Jan Nijsten – IGRAC (UNESCO Centre)
Matthew Lagod – UNESCO-IHP

Washington DC - 12 July 2016



Approach



Core group:

- UNESCO - International Hydrological Program (IHP)
- UNESCO - International Groundwater Resources Assessment Centre (IGRAC, Netherlands)

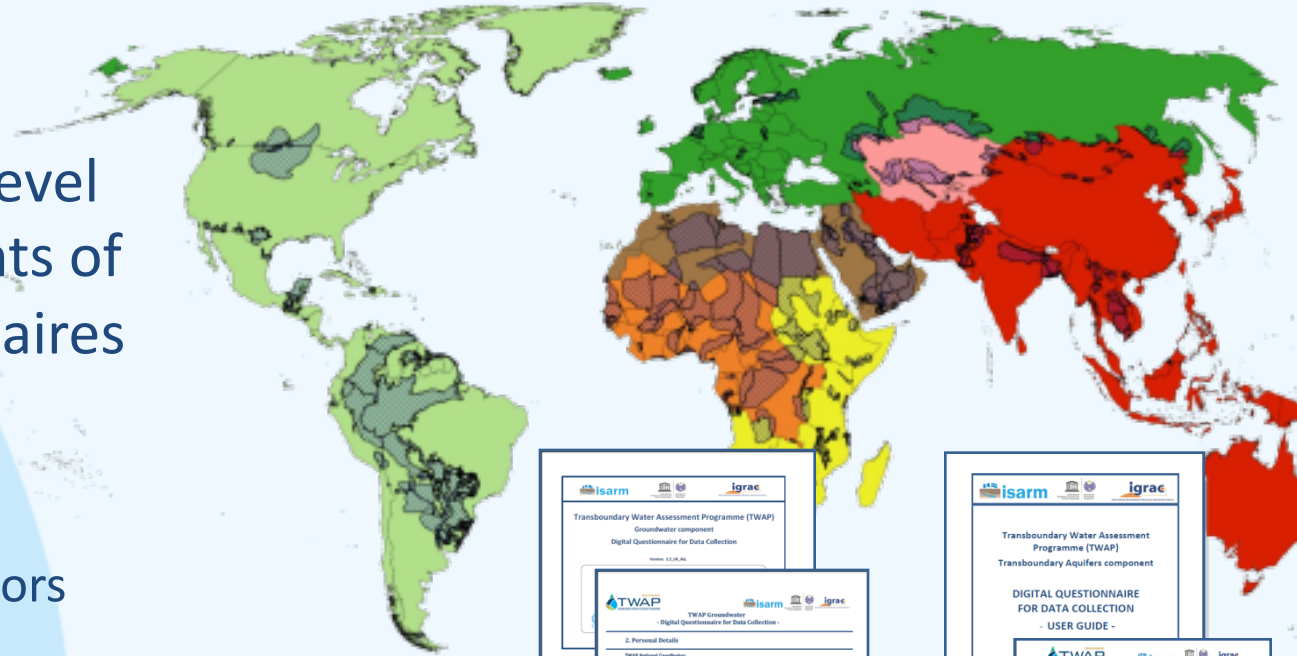
Expertise provided by:

- Goethe University Frankfurt (Germany)
- Simon Fraser University (Canada)
- National specialists , regional coordinators and regional organisations



Global Inventory: The ISARM* approach

- Data collection at level of national segments of TBAs via questionnaires
- Network of:
 - National experts
 - Regional coordinators
- Regional workshops



A collage of digital questionnaire forms and user guides for the TWAP Groundwater component. The forms include sections for 'Personal Details', 'Aquifer Information', and 'Aquifer Characteristics'. One form features a diagram of a transboundary aquifer system with a well and a recharge area. The user guide provides instructions on how to use the questionnaire and how to submit the data.

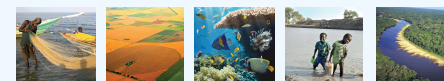
*ISARM: Internationally Shared Aquifer Resources Management Initiative is a UNESCO and IAH led multi-agency effort aimed at improving the understanding of issues related to the management of transboundary aquifers.



10 Core indicators for groundwater

Thematic cluster	Core Indicators
QUANTITY	<ul style="list-style-type: none"> • Groundwater Recharge • Groundwater Depletion
QUALITY	<ul style="list-style-type: none"> • Groundwater natural background quality • Groundwater pollution
SOCIO-ECONOMIC	<ul style="list-style-type: none"> • Population density • Renewable groundwater per capita • Human dependence on groundwater • Groundwater development stress (=abstraction / recharge)
GROUNDWATER GOVERNANCE	<ul style="list-style-type: none"> • Transboundary legal framework • Transboundary institutional framework

Also:
 Projections for 2030 and 2050 and determination of hotspots



TWAP TBAs in numbers

Global Inventory :

199 Aquifers

502 Country segments

126 Countries

> 200 Experts from 76 countries
contributed

WaterGAP model study:

91 Aquifers (TBAs > 20,000 km²)

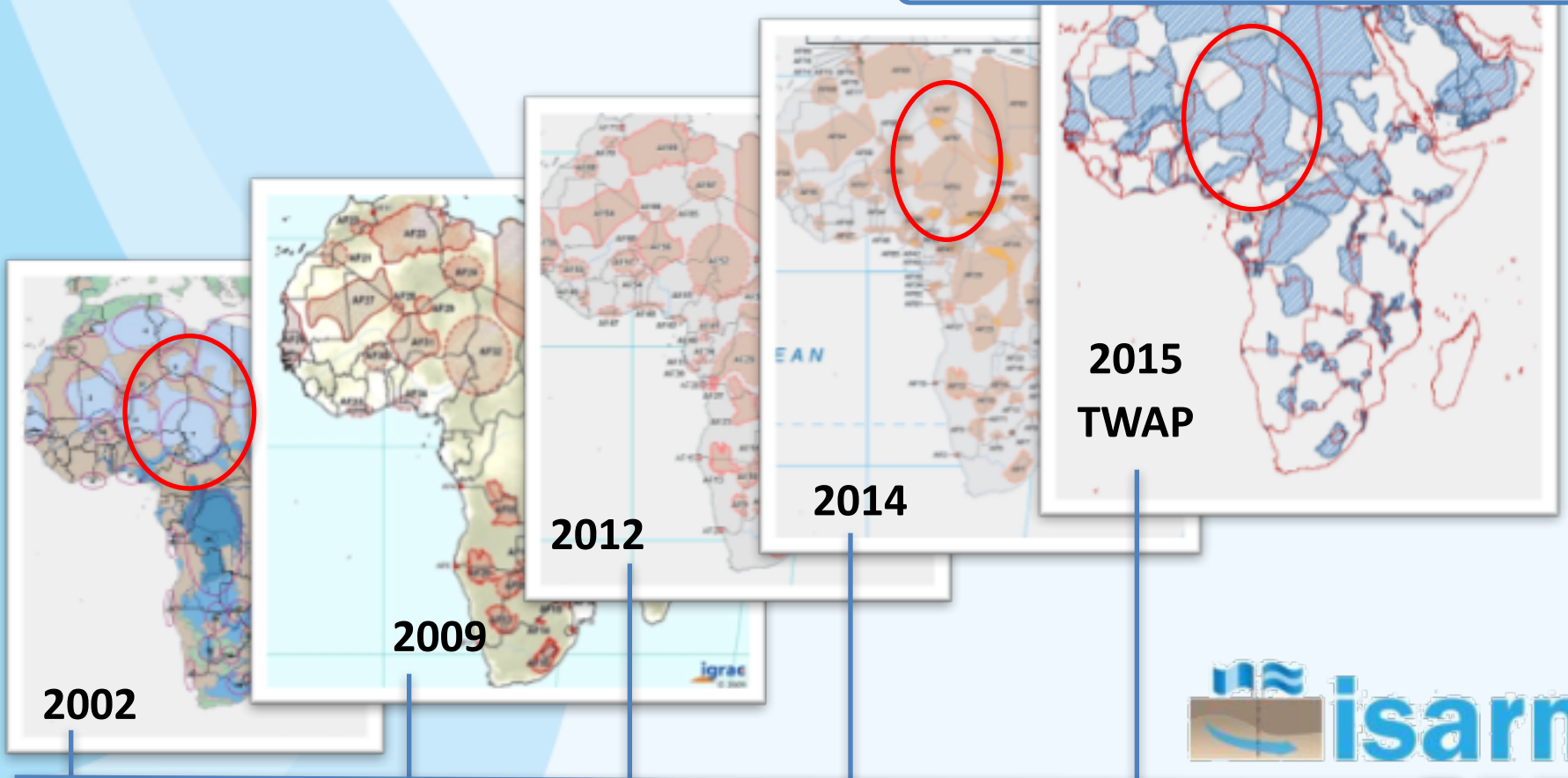


Results

Improved delineations of aquifer boundaries

History of a on-going process

TWAP workshops worldwide:
199 TBAs selected with
74 delineations improved



Transboundary aquifers

Key messages

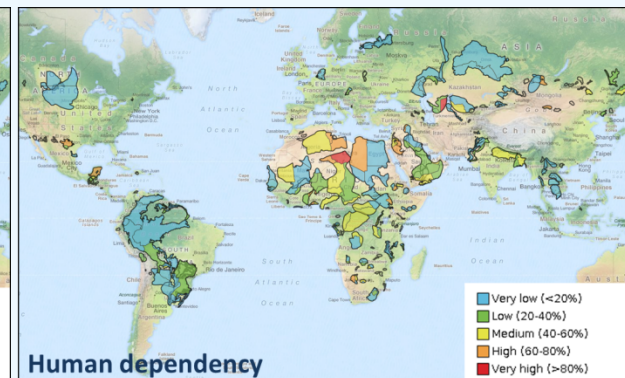
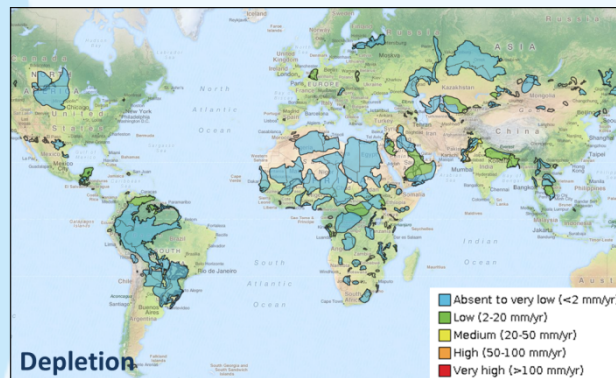
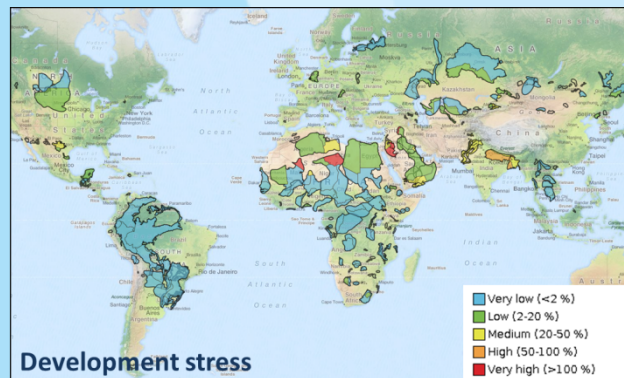
1. Transboundary aquifers represent a **largely untapped resource**
2. Areas of elevated groundwater development stress are presently limited, but are expected to **more than double by 2050**
3. There is an alarming **lack of modern data**
4. There is **near absence of governance frameworks for TBAs**



1. Transboundary aquifers represent a largely untapped resource

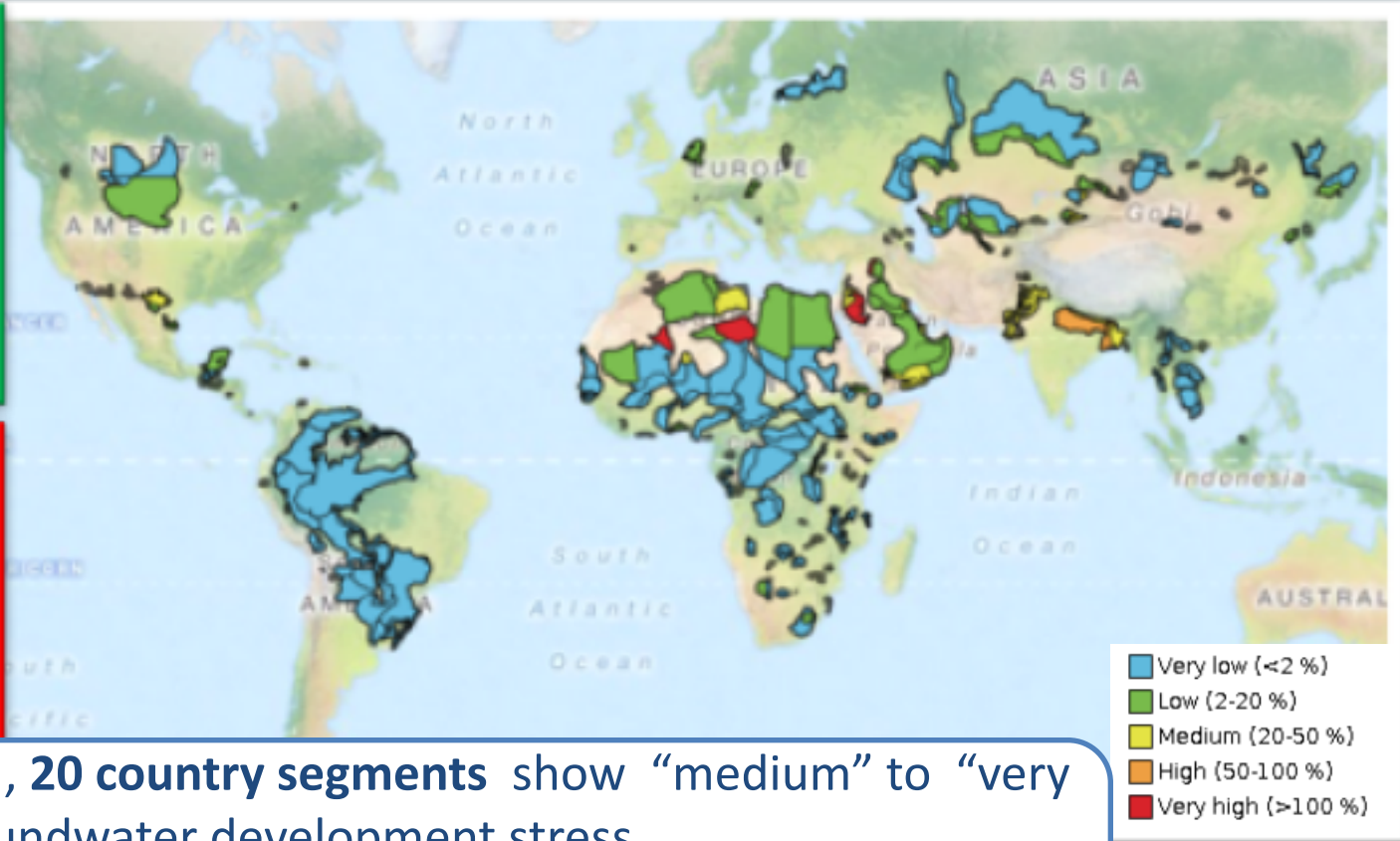
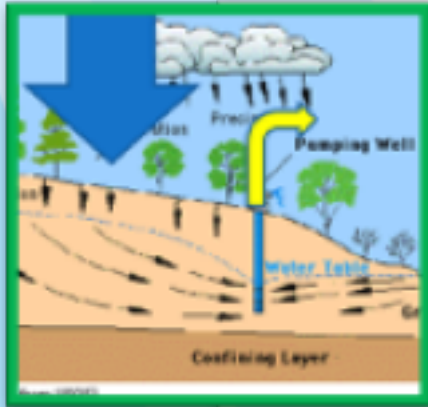
The majority of TWAP transboundary aquifers:

- Are located outside regions highly affected by groundwater development stress
- Show low depletion rates in most regions of the world
- Show generally low to very low human dependency on transboundary groundwater



Key messages TBAs

2. Aquifers with elevated development stress presently limited but expected to more than double by 2050



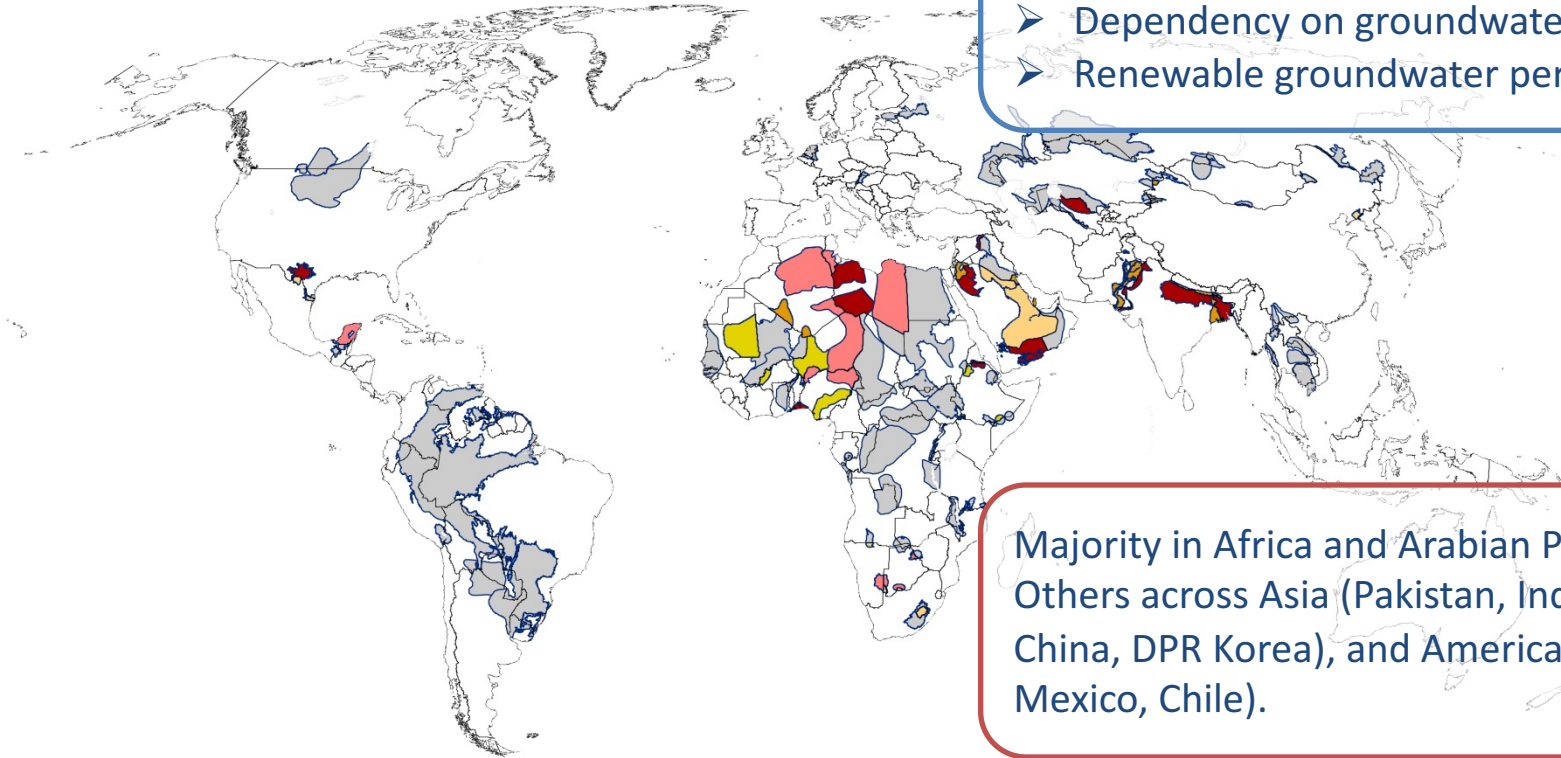
- Currently , **20 country segments** show “medium” to “very high” groundwater development stress.
- By **2050**, this number may increase to **58 country segments**.

Hotspots

Today and 2030, 2050

Combining indicators to define hotspots:

- Groundwater development stress
- Dependency on groundwater
- Renewable groundwater per capita



Majority in Africa and Arabian Peninsula. Others across Asia (Pakistan, India, Nepal, China, DPR Korea), and Americas (USA, Mexico, Chile).

Hotspots under current and future conditions

- Very high risk (16 country segments)
- High risk (11 country segments)

Hotspots under future conditions only

- Very high risk (15 country segments)
- High risk (16 country segments)
- Groundwater crowding (8 country segments)



Key messages TBAs

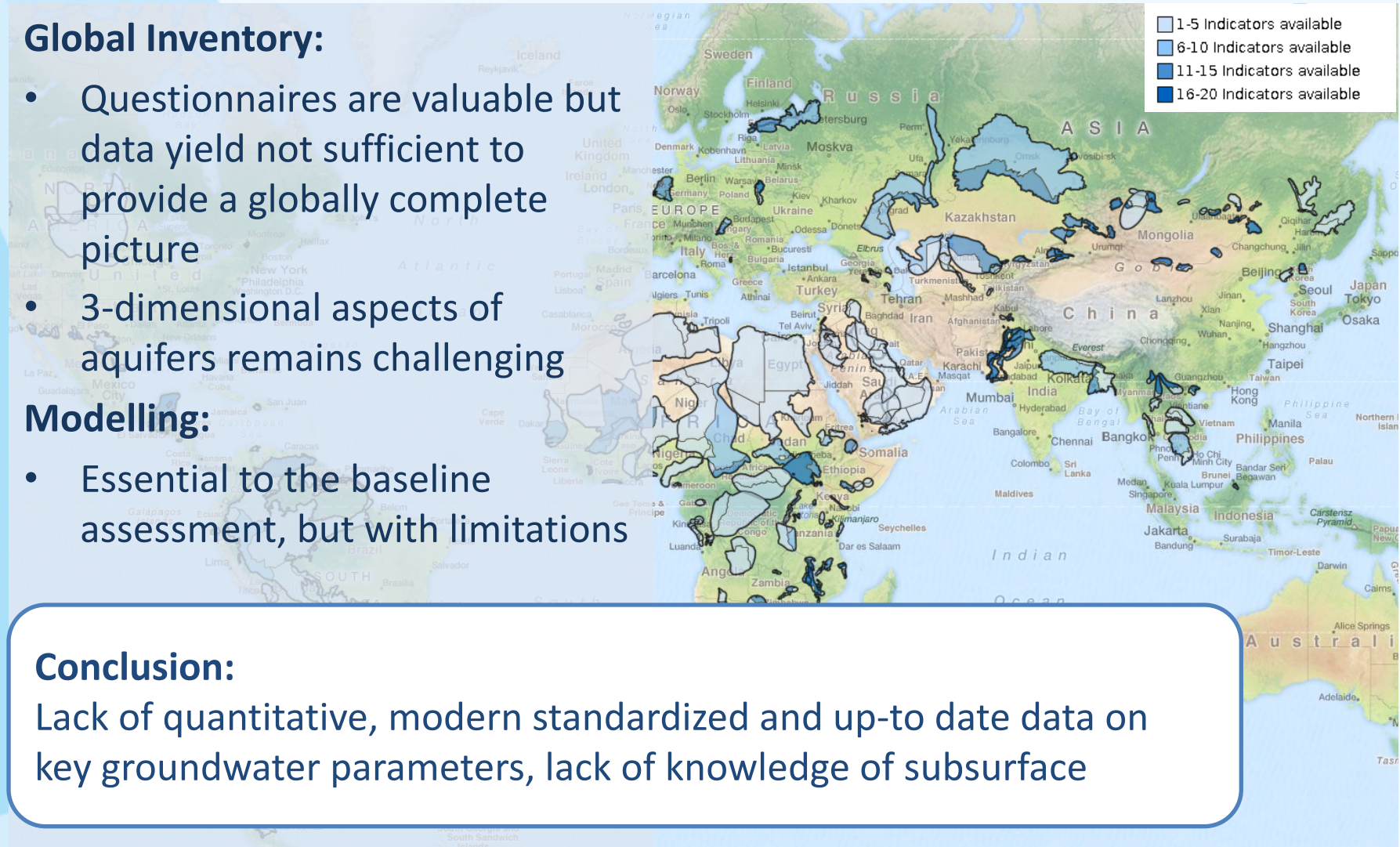
3. Alarming lack of modern data

Global Inventory:

- Questionnaires are valuable but data yield not sufficient to provide a globally complete picture
- 3-dimensional aspects of aquifers remains challenging

Modelling:

- Essential to the baseline assessment, but with limitations



Conclusion:

Lack of quantitative, modern standardized and up-to date data on key groundwater parameters, lack of knowledge of subsurface



Key messages TBAs

4. Near absence of governance frameworks

- The vast majority of TBAs have no transboundary governance framework:

Only eight (8!) TBAs have transboundary legal agreements

- The lack of adequate groundwater governance at the global, regional and local levels hinders the achievement of water security.

Formal agreements:

- Guarani aquifer (21S),
- Genevese aquifer (EU24),
- Illumedden Aquifer System (AF56),
- Nubian Sandstone Aquifer System (AF63),
- North-western Sahara Aquifer system (AF69),
- Al-Disi Aquifer (part of AS126 Saq-Ram)

Informal agreements:

- Hueco-Bolson Aquifer (15N)
- Abbotsford-sumas aquifer (1N)

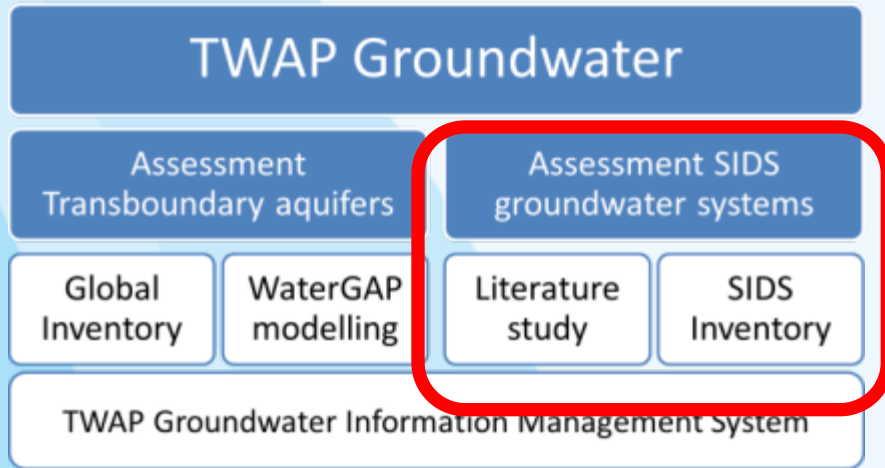
- GEF Groundwater Governance Project

But also:

- *As groundwater development of TBAs is still quite low there still is a chance to do it right!*



Groundwater Systems of Small Islands Developing States



Thematic cluster	Core Indicators
QUANTITY	<ul style="list-style-type: none"> Groundwater Recharge Groundwater Depletion
QUALITY	<ul style="list-style-type: none"> Groundwater natural background quality Groundwater pollution Sea water intrusion
SOCIO-ECONOMIC	<ul style="list-style-type: none"> Population density Renewable groundwater per capita Human dependence on groundwater Groundwater development stress (=abstraction / recharge)
GROUNDWATER GOVERNANCE	<ul style="list-style-type: none"> Transboundary Legal framework Transboundary Institutional framework

42 SIDS assessed

- For each, a representative island was selected
- A geological map and conceptual hydrogeological profile was developed
- Assessment of risk factors for mountainous vs. low-lying SIDS
- Additional indicator to address seawater intrusion

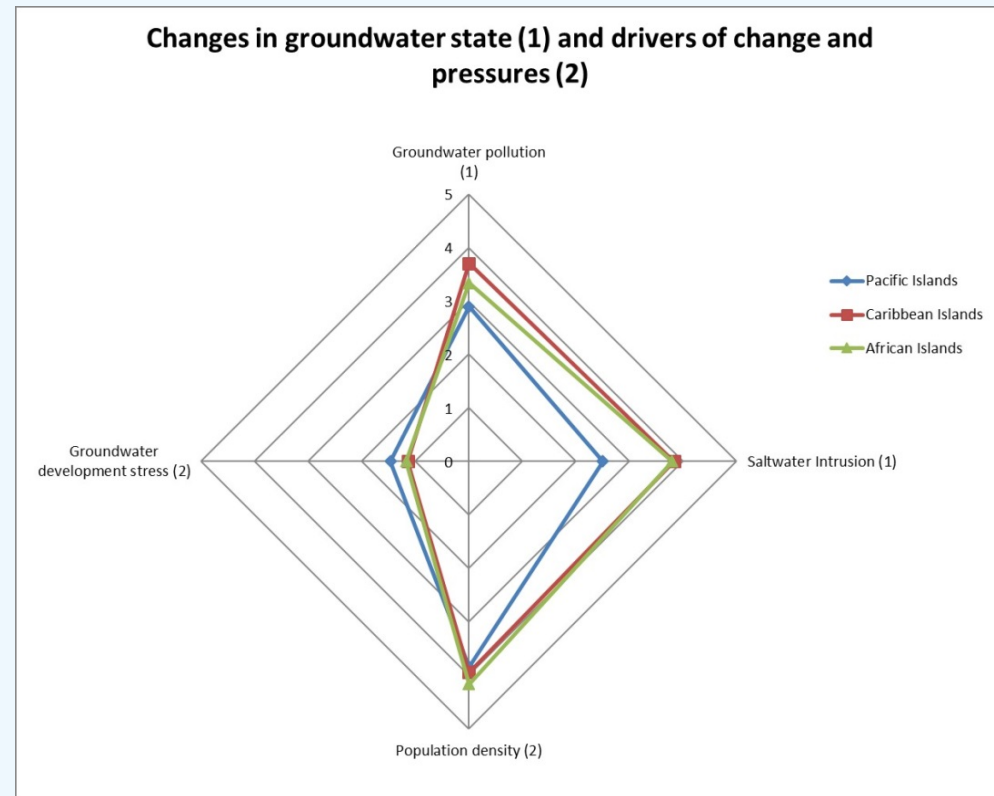


SIDS Groundwater systems

Key messages

Many Island States are facing serious issues in ensuring:

1. Safe water supply
2. Groundwater sustainability (Water scarcity, pollution and high human dependency)



On many islands, degradation of groundwater quality and growing demands are posing short-medium term threats to human health and impairing ecosystem services of great economic value.



SIDS Groundwater systems

Key messages

High dependence on groundwater

- 10% of Caribbean and Atlantic/Indian Ocean SIDS experience high human groundwater dependence
- 72% of Pacific SIDS experience high human groundwater dependence

Extremely vulnerable groundwater resources

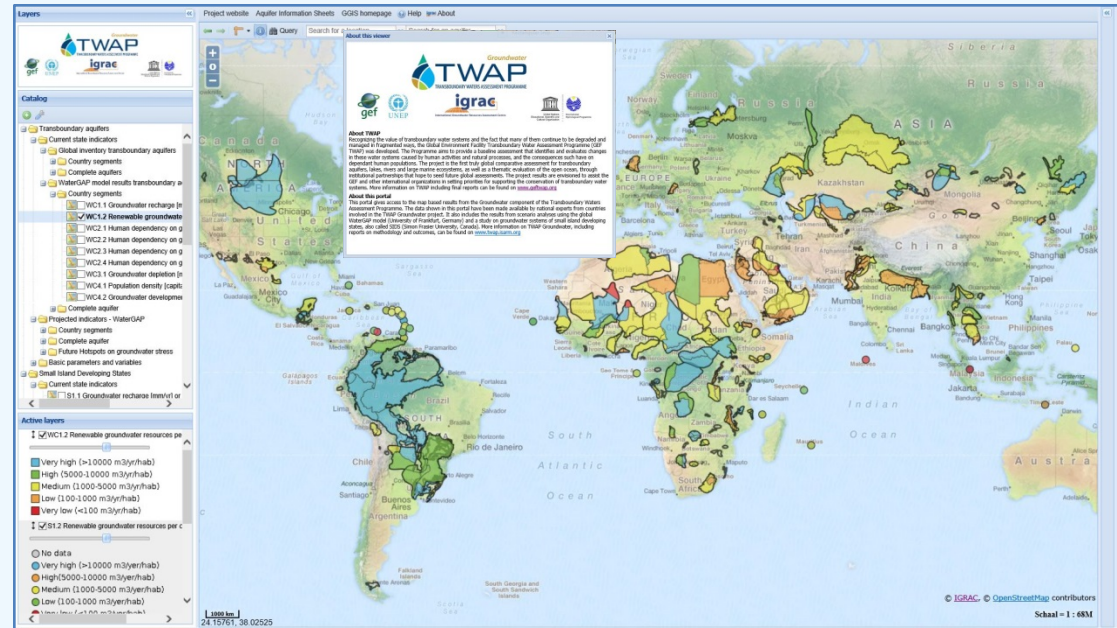
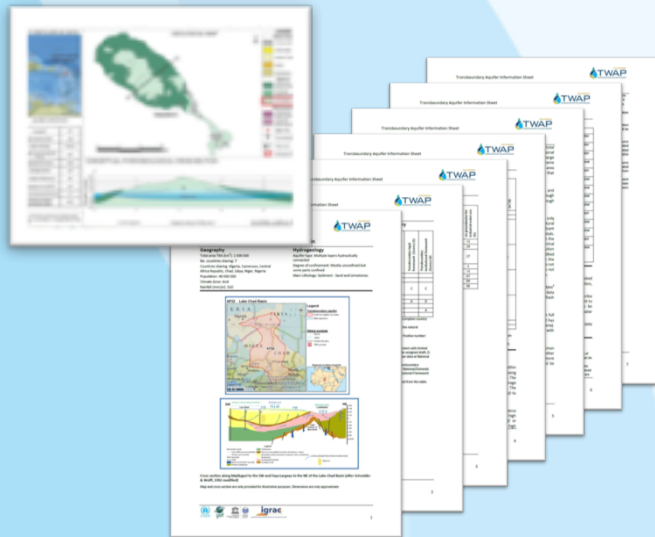
- 71% of all SIDS are at risk of water scarcity / 91% of low-lying islands are at risk of water scarcity
- 73% of SIDS are at risk of groundwater pollution, often worsened by seawater intrusion

Population density is the main driver of water stress in the SIDS assessed



TWAP Groundwater Knowledge products

- Structured database
- Information Management System - web-based



- Multi-disciplinary assessment methodology & questionnaire
- Assessment report of transboundary aquifers
- Summary for Policy makers
- TBA and SIDS information sheets,
- Reinforced international networks (ISARM)

Information Management System

<http://twapviewer.un-igrac.org>

TWAP Groundwater Website

www.twap.isarm.org



TWAP Groundwater Information Management System

Transboundary Waters Assessment Programme

Project website Aquifer Information Sheets GGIS Homepage Help About

Query Search for a location Search for an aquifer

WC1.2 Renewable groundwater resources per capita [m3/yr/capita]

Name	Value
Annual amount	2130.0
Region code	WAF69_DZA
Aquifer name	Northwest Sahara Aquifer System...
Aquifer area based on sinusoid...	732863.280365

View Aquifer information sheet (pdf)

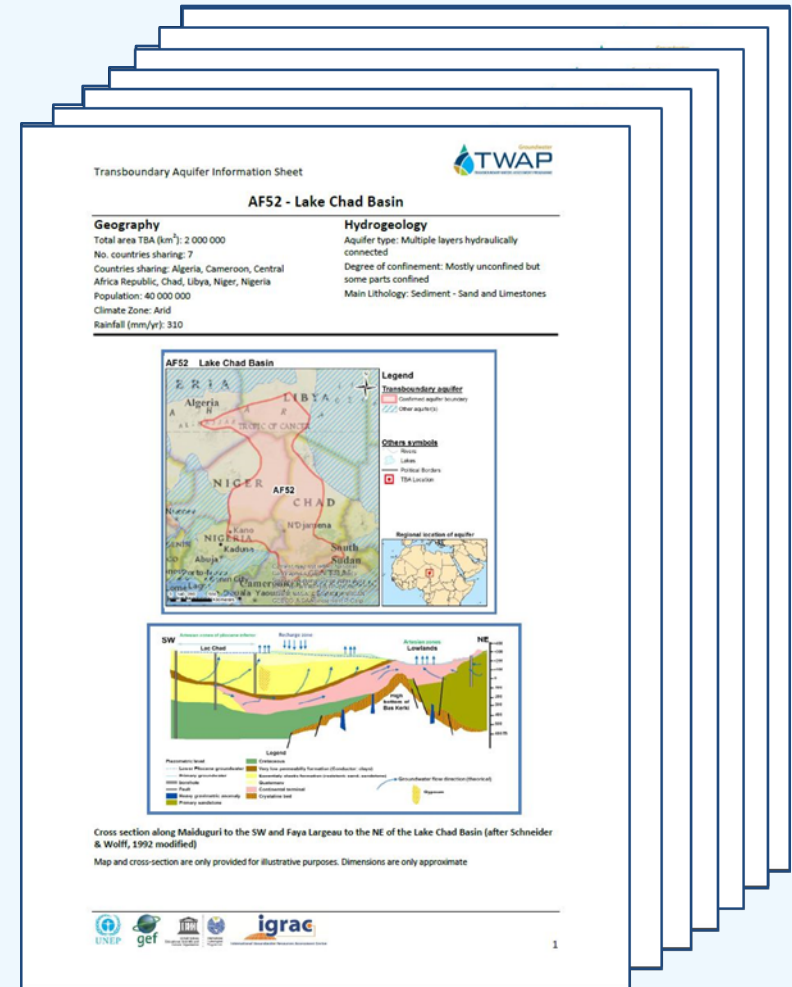
Indicator 1.2 – WaterGAP model - Current state.
Groundwater recharge (including recharge from surface water bodies and return flows from irrigation) [m3/yr] divided by the number of inhabitants [capita] on top of the country segment of the aquifer. Reference year for population: 2010.
WC: WaterGAP indicator at Country segment level.

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Scale = 1 : 70M



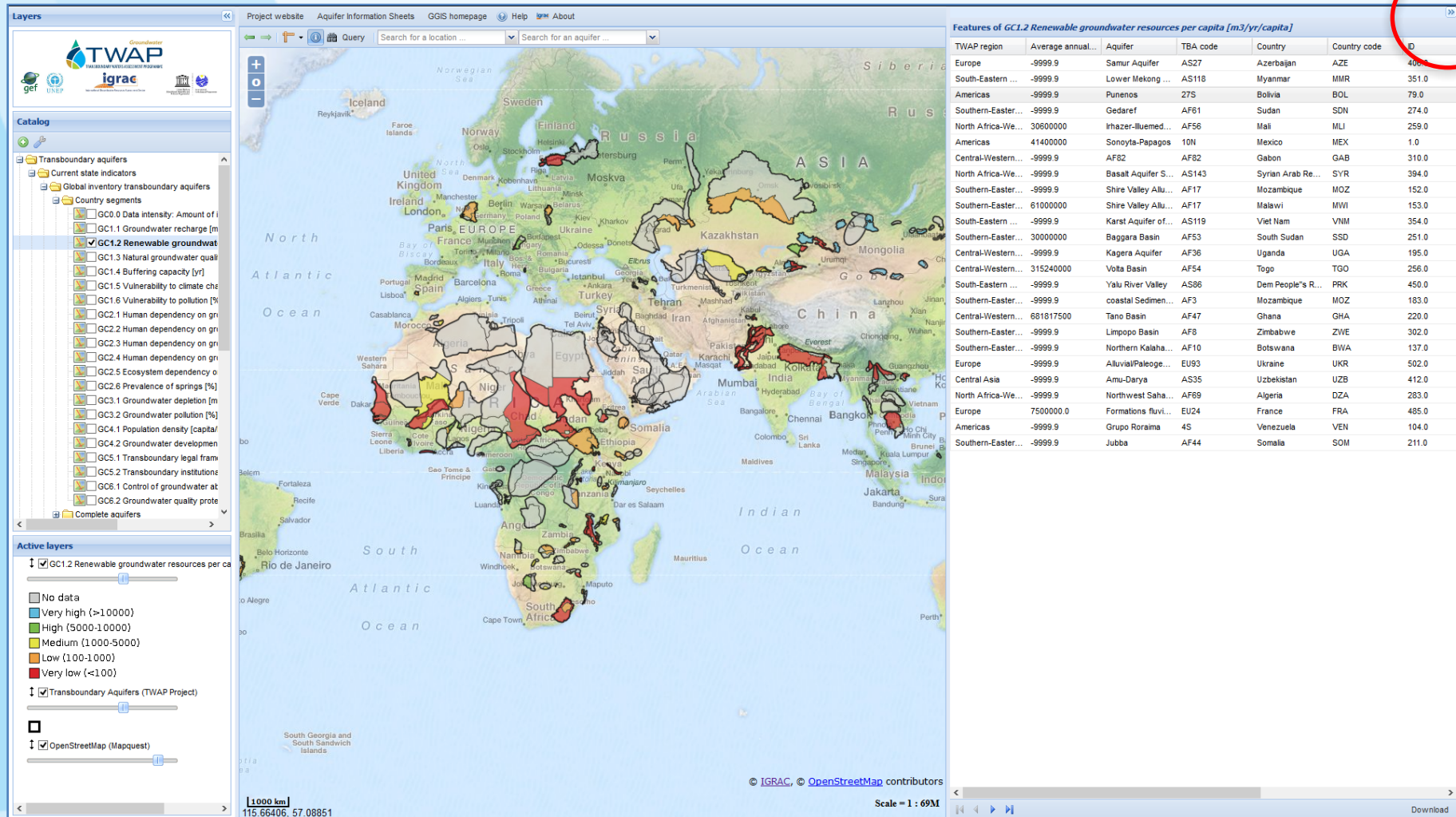
TBA information sheets

- Basic geographical and hydrogeological info
- Location map with delineation
- Cross-section (if available)
- Table with core indicators
 - Global Inventory
 - WaterGap Model
- Table with key variables
- Narratives of:
 - ✓ Aquifer geometry
 - ✓ Hydrogeological aspects
 - ✓ Linkages with other water systems
 - ✓ Environmental aspects
 - ✓ Socio-economic aspects
 - ✓ Legal and Institutional aspects
 - ✓ Priority issues and Hotspots
- Contributors (national experts)
- Colophon, incl. reference & call for additional information



TWAP Groundwater IMS

Download feature information / data



Layers Project website Aquifer Information Sheets GGIS homepage Help About

Catalog

- Transboundary aquifers
- Current state indicators
 - Global inventory transboundary aquifers
 - Country segments
 - GC0 Data intensity: Amount of I
 - GC1.1 Groundwater recharge (m
 - GC1.2 Renewable groundwat
 - GC1.3 Natural groundwater quali
 - GC1.4 Buffering capacity [yr]
 - GC1.5 Vulnerability to climate cha
 - GC1.6 Vulnerability to pollution [%]
 - GC2.1 Human dependency on gr
 - GC2.2 Human dependency on gr
 - GC2.3 Human dependency on gr
 - GC2.4 Human dependency on gr
 - GC2.5 Ecosystem dependency o
 - GC2.6 Prevalence of springs [%]
 - GC3.1 Groundwater depletion (m
 - GC3.2 Groundwater pollution [%]
 - GC4.1 Population density (capita/
 - GC4.2 Groundwater developmen
 - GC5.1 Transboundary legal fram
 - GC5.2 Transboundary instituti
 - GC6.1 Control of groundwater at
 - GC6.2 Groundwater quality prote
 - Complete aquifers

Active layers

- GC1.2 Renewable groundwater resources per ca
- No data
- Very high (>10000)
- High (5000-10000)
- Medium (1000-5000)
- Low (100-1000)
- Very low (<1.00)
- Transboundary Aquifers (TWAP Project)
- OpenStreetMap (Mapquest)

Features of GCI.2 Renewable groundwater resources per capita [m3/yr/capita]

TWAP region	Average annual...	Aquifer	TBA code	Country	Country code	ID
Europe	-9999.9	Samur Aquifer	AS27	Azerbaijan	AZE	406...
South-Eastern ...	-9999.9	Lower Mekong ...	AS118	Myanmar	MMR	351.0
Americas	-9999.9	Punenos	275	Bolivia	BOL	79.0
Southern-Easter...	-9999.9	Gedaref	AF61	Sudan	SDN	274.0
North Africa-We...	30600000	Irhazer-Ilumed...	AF56	Mali	MLI	259.0
Americas	41400000	Sonoyta-Papagos	10N	Mexico	MEX	1.0
Central-Western...	-9999.9	AF82	AF82	Gabon	GAB	310.0
North Africa-We...	-9999.9	Basalt Aquifer S...	AS143	Syrian Arab Re...	SYR	394.0
Southern-Easter...	-9999.9	Shire Valley Allu...	AF17	Mozambique	MOZ	152.0
Southern-Easter...	61000000	Shire Valley Allu...	AF17	Malawi	MWI	153.0
South-Eastern ...	-9999.9	Karet Aquifer of...	AS119	Viet Nam	VNM	354.0
Southern-Easter...	30000000	Baggara Basin	AF53	South Sudan	SSD	251.0
Central-Western...	-9999.9	Kagera Aquifer	AF36	Uganda	UGA	195.0
Central-Western...	315240000	Volta Basin	AF54	Togo	TGO	256.0
South-Eastern ...	-9999.9	Yalu River Valley	AS86	Dem People's R...	PRK	450.0
Southern-Easter...	-9999.9	coastal Sedimen...	AF3	Mozambique	MOZ	183.0
Central-Western...	681817500	Tano Basin	AF47	Ghana	GHA	220.0
Southern-Easter...	-9999.9	Limpopo Basin	AF8	Zimbabwe	ZWE	302.0
Southern-Easter...	-9999.9	Northern Kalaha...	AF10	Botswana	BWA	137.0
Europe	-9999.9	Alluvial/Paleoge...	EU93	Ukraine	UKR	502.0
Central Asia	-9999.9	Amu-Darya	AS35	Uzbekistan	UZB	412.0
North Africa-We...	-9999.9	Northwest Saha...	AF69	Algeria	DZA	283.0
Europe	7500000.0	Formations fluvl...	EU24	France	FRA	485.0
Americas	-9999.9	Grupo Roraima	4S	Venezuela	VEN	104.0
Southern-Easter...	-9999.9	Jubba	AF44	Somalia	SOM	211.0

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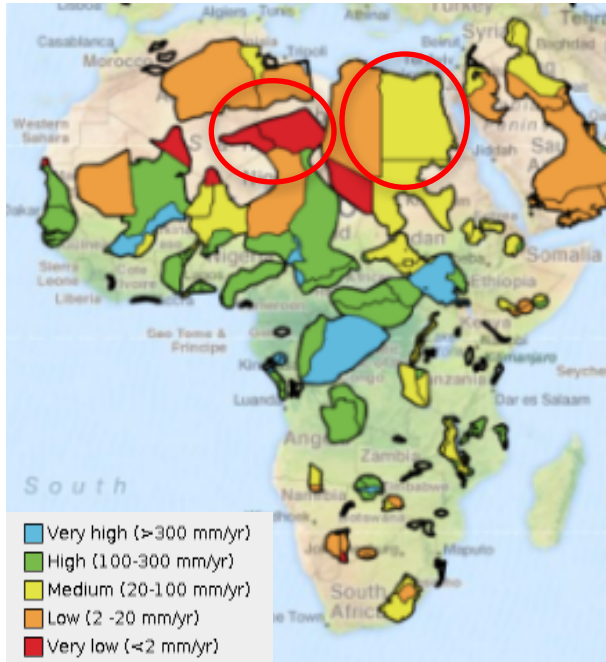
Scale = 1 : 69M

Download

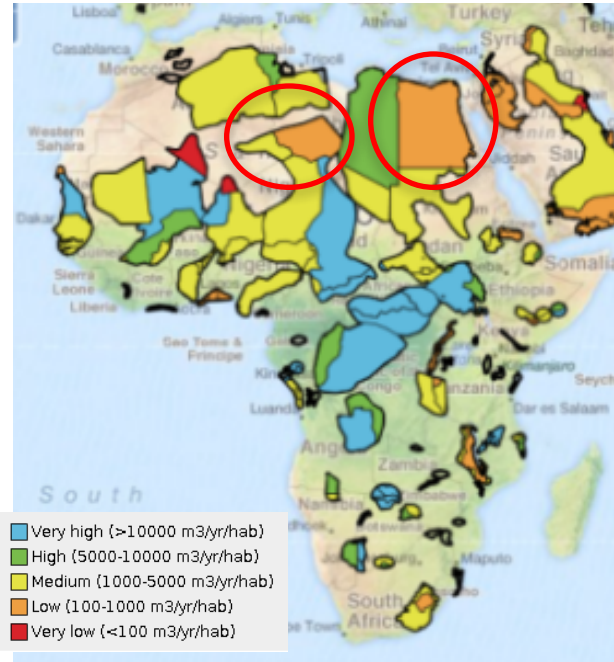


Additional insights through indicators and maps

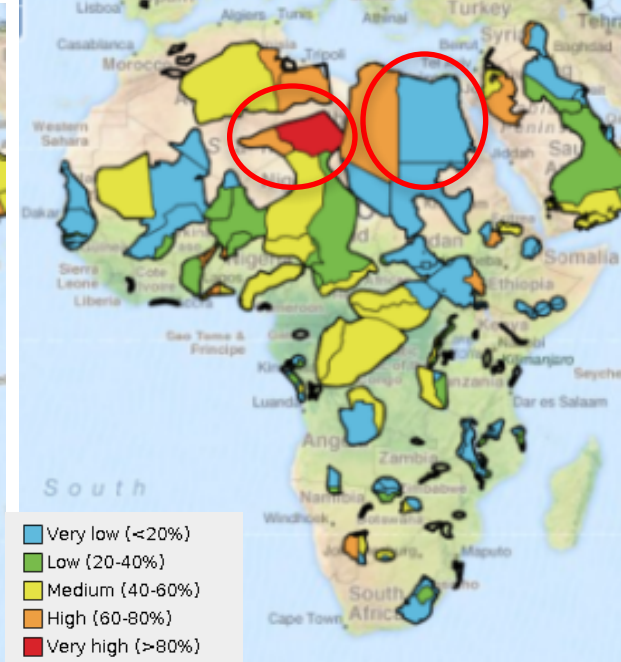
WaterGAP model data - Goethe University Frankfurt



Recharge



Renewable groundwater per capita

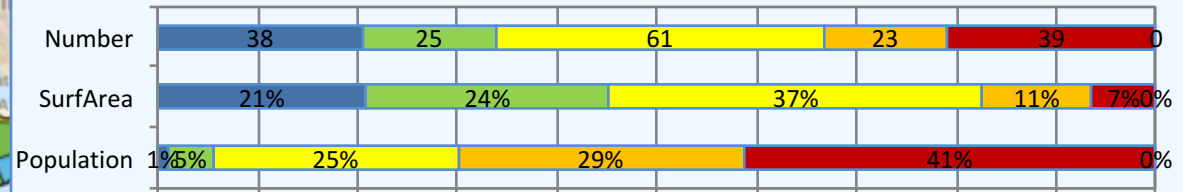
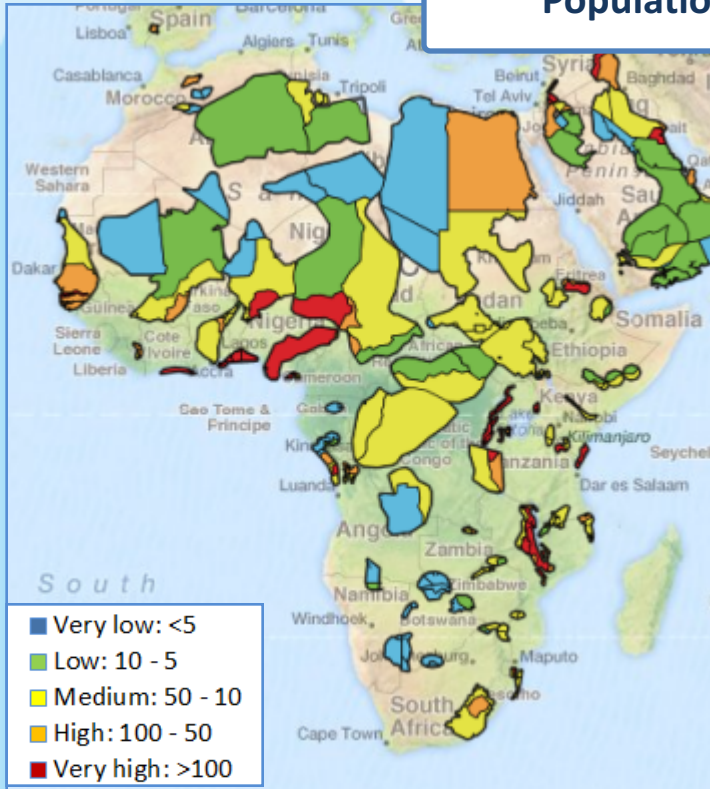


Human dependency on groundwater

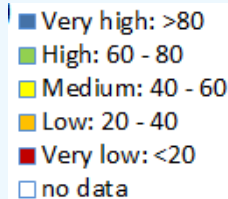
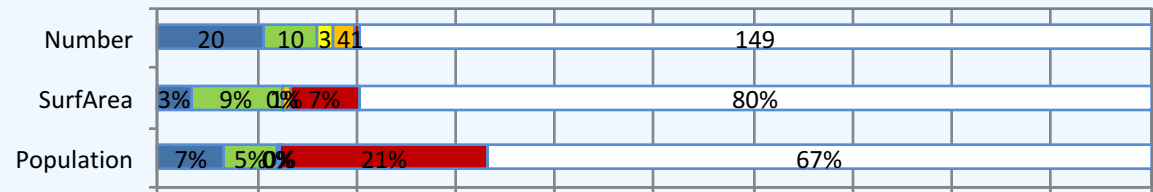


Different visualisation of indicators creates additional insights

Population density [cap/km²]



Natural background quality [% of surface area with good quality]



TWAP Groundwater SIDS data base & IMS

Example:

Observed zones of saltwater intrusion as a percentage of total island area (salinity exceeding drinking water quality standards).
(Specific indicator for SIDS)



Full functionality similar to
TBA Information Management System



SIDS information sheets

SAINT KITTS ISLAND - FEDERATION OF SAINT KITTS AND NEVIS

LAT: 17.3000°N LONG: 62.7333°W

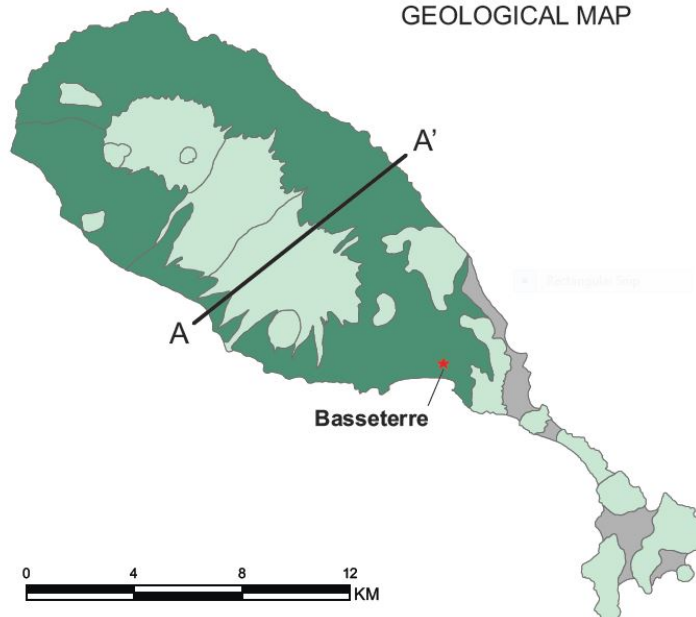


ISLAND STATISTICS

Area (km ²)	176
Max. Elevation (masl)	1156
Aquifer Lithology	Volcanic
Average Annual Precipitation (mm/a)	2165
Calculated AET (mm/a)	1346
Recharge (mm/a)	766
Max. Aquifer Thickness (m)	300
Groundwater Vol. (x10 ⁹ m ³)	5.28
GW Vol. Abstracted (x10 ⁶ m ³ /a)	20
Predominant Natural Groundwater Quality	Fresh

REF: DEM: USGS (2004), Shuttle Radar Topography Mission
GEO: Roobol, J. M. and Smith, A. L. Geological Map of St. Kitts, West Indies.

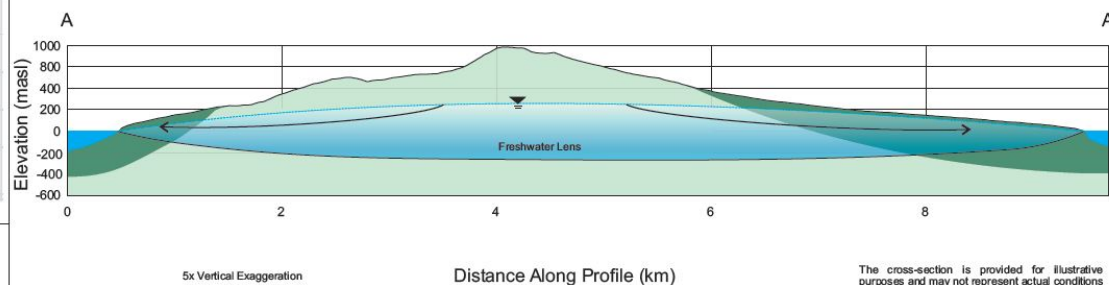
GEOLOGICAL MAP



LEGEND

Sedimentary	
	Coarse Alluvium
	Carbonate
	Karstic Carbonate
	Shale
	Sandstone
Igneous	
	Unfractured Igneous (Undif.)
	Fractured Igneous (Undif.)
	Permeable Volcanic
Metamorphic	
	Unfractured Metamorphic (Undif.)
	Fractured Metamorphic (Undif.)
	Major City
	Groundwater Table
	Flow Line
	Dominant Aquifer

CONCEPTUAL HYDROGEOLOGICAL CROSS-SECTION



**Thank you for your attention
&
Thank you to
all TWAP Groundwater partners across the world**

<http://twapviewer.un-igrac.org>
www.twap.isarm.org / www.geftwap.org



10 Additional indicators

Thematic cluster	Additional Indicators
QUANTITY	<ul style="list-style-type: none">• Aquifer buffering capacity• Aquifer vulnerability to climate change• Ecosystem dependency on groundwater• Prevalence of springs
QUALITY	<ul style="list-style-type: none">• Aquifer vulnerability to pollution
SOCIO-ECONOMIC	<ul style="list-style-type: none">• Human dependency on groundwater – Domestic use• Human dependency on groundwater – Agricultural use• Human dependency on groundwater – Industrial use
GROUNDWATER GOVERNANCE	<ul style="list-style-type: none">• Control of groundwater abstraction• Protection of groundwater quality

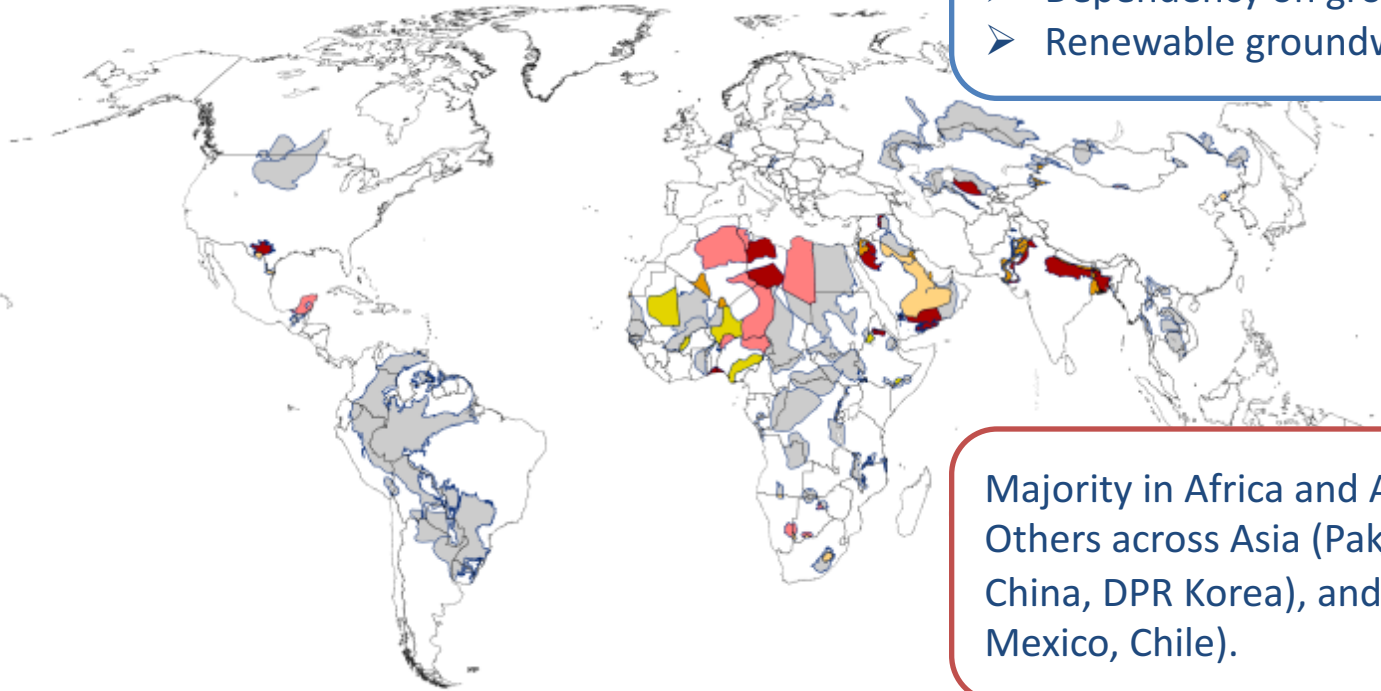


Hotspots

Today and 2030, 2050

Combining indicators to define hotspots:

- Groundwater development stress
- Dependency on groundwater
- Renewable groundwater per capita



Majority in Africa and Arabian Peninsula. Others across Asia (Pakistan, India, Nepal, China, DPR Korea), and Americas (USA, Mexico, Chile).

Hotspots under current and future conditions

- GW dev. stress > 20%, dependency on GW > 40% (16)
- GW dev. stress > 20%, dependency on GW < 40% (11)

(All eight TBA-CUs with economic GW stress under current conditions suffer from GW development stress > 20% under future conditions)

Hotspots under future conditions only

- GW dev. stress > 20%, dependency on GW > 40% (15)
- GW dev. stress > 20%, dependency on GW < 40% (16)
- Potential economic GW stress: GW dev. stress < 20%, while per-cap. GW recharge < 1000 m³/(yr cap) and dependency on GW > 40% (8)

