

A world map with a grid of latitude and longitude lines. The map is color-coded with various shades of blue, green, and orange, representing different hydrogeological data. Major cities are labeled, including New York, London, Moscow, Istanbul, Beijing, Tokyo, and Sydney. The title 'World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP)' is overlaid in large, bold, dark blue text.

# World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP)

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Mashreq Waters Knowledge Series – 15-17 June 2021



Bundesanstalt für  
Geowissenschaften  
und Rohstoffe

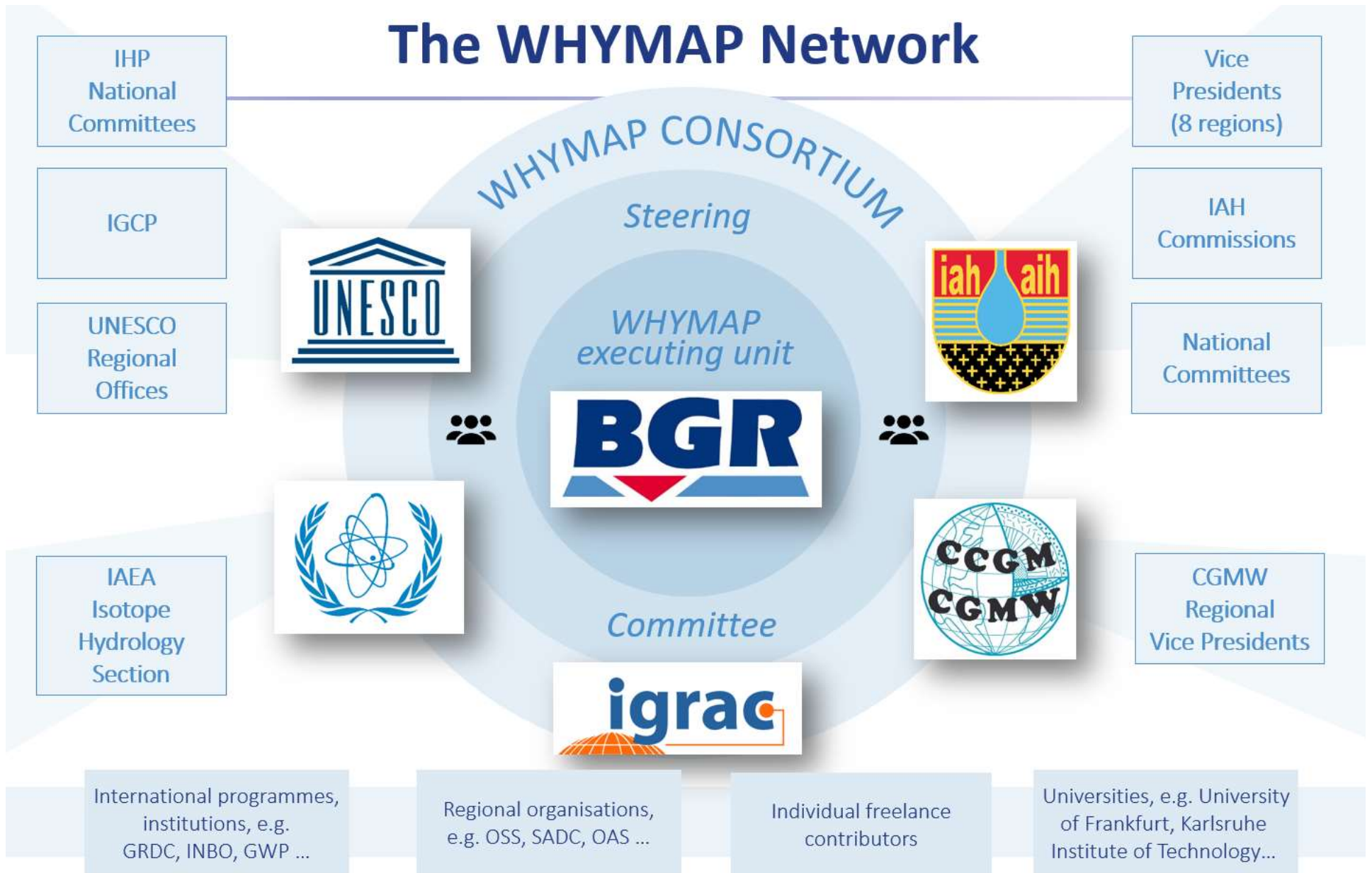
GEOZENTRUM HANNOVER

# Motivation

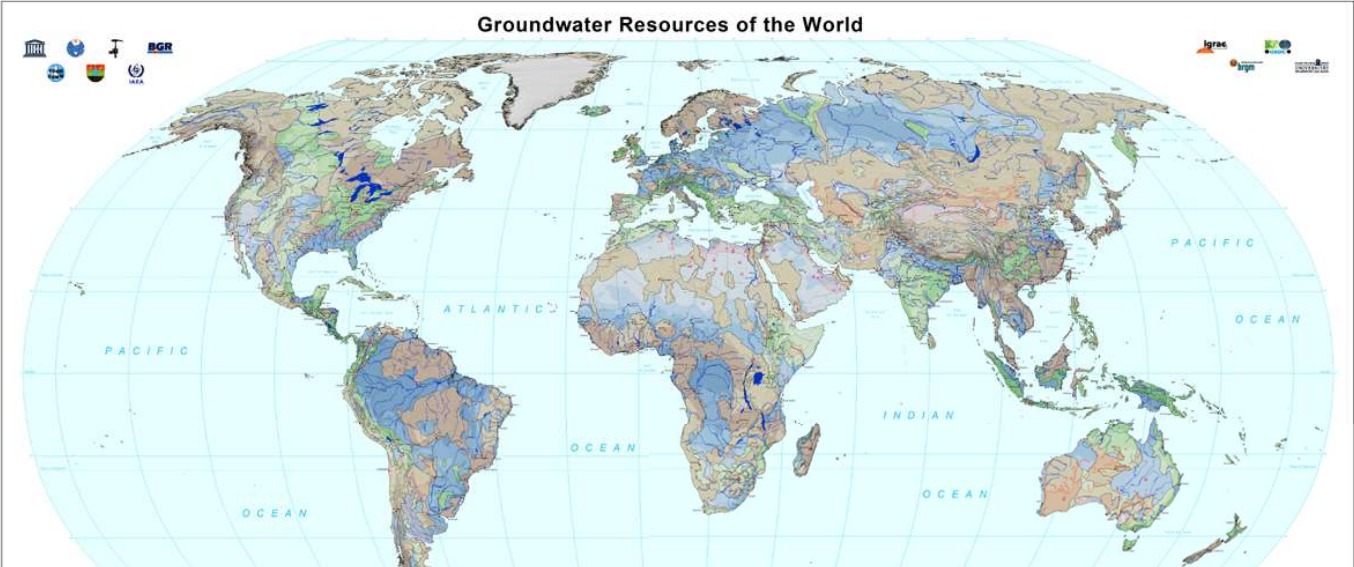
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- 💧 Awareness rising for groundwater
- 💧 General overview on potentials/risks, simple legend
- 💧 Full coverage world-wide
- 💧 Globally harmonised view on groundwater resources
- 💧 Contribute to the world-wide efforts to better study and manage aquifer resources
- 💧 Groundwater as a possible solution of increasing water shortage problems (“water crisis”)

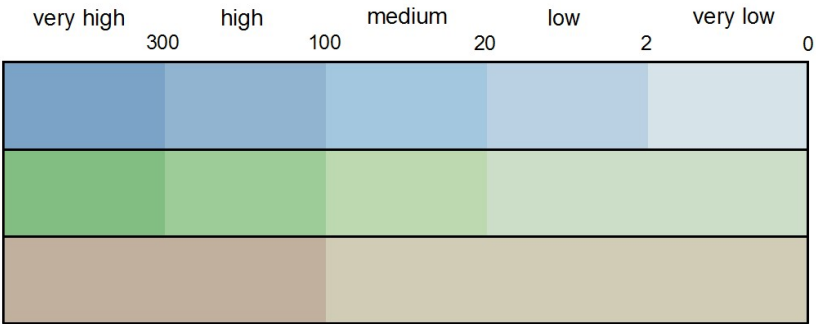
# The WHYMAP Network



# Example 1: Global Groundwater Resources Map



**Groundwater resources and recharge (mm/year)**

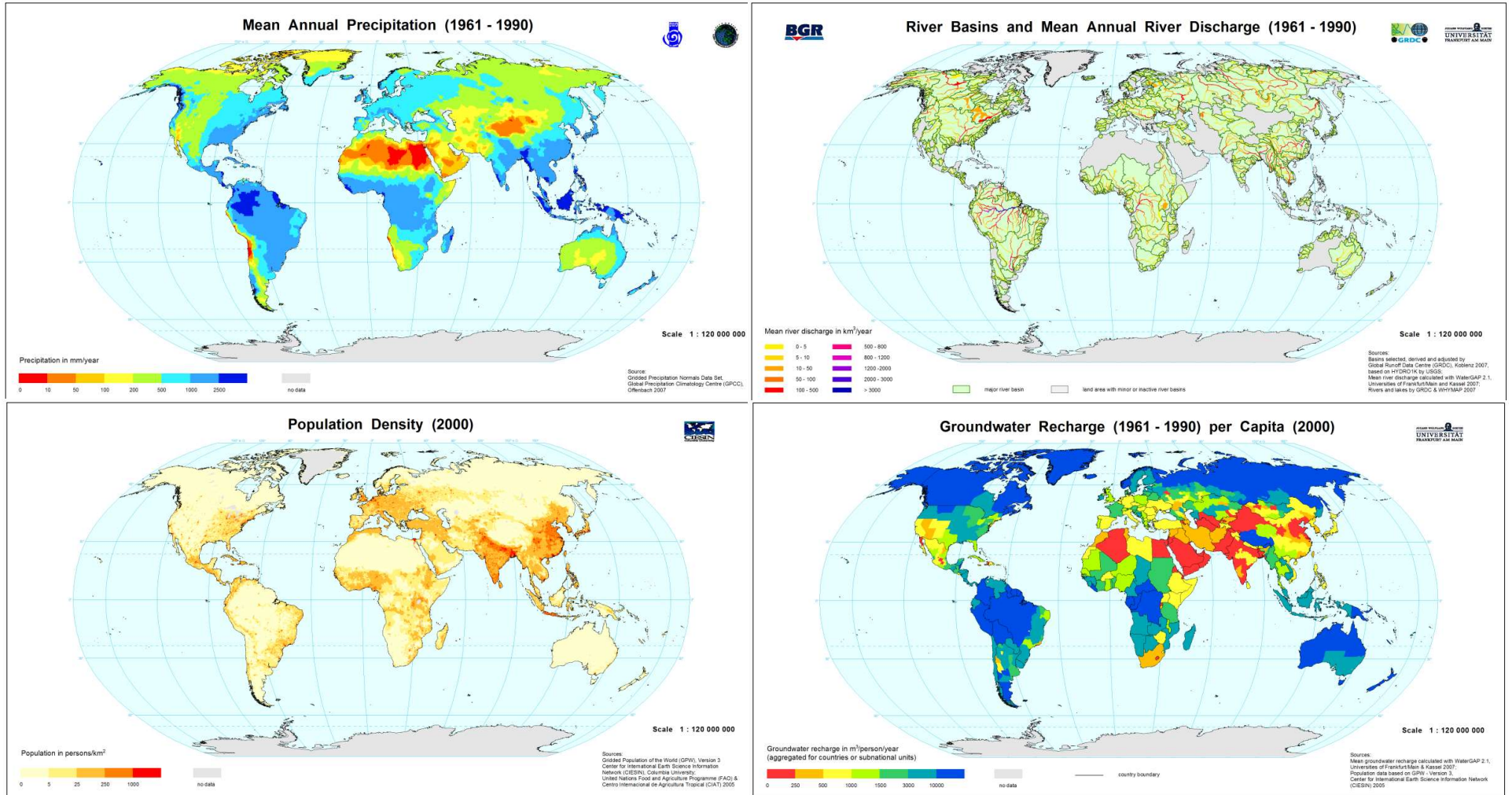


- in major groundwater basins
- in areas with complex hydrogeological structure
- in areas with local and shallow aquifers





# Example 1: Global Groundwater Resources Map cont'd

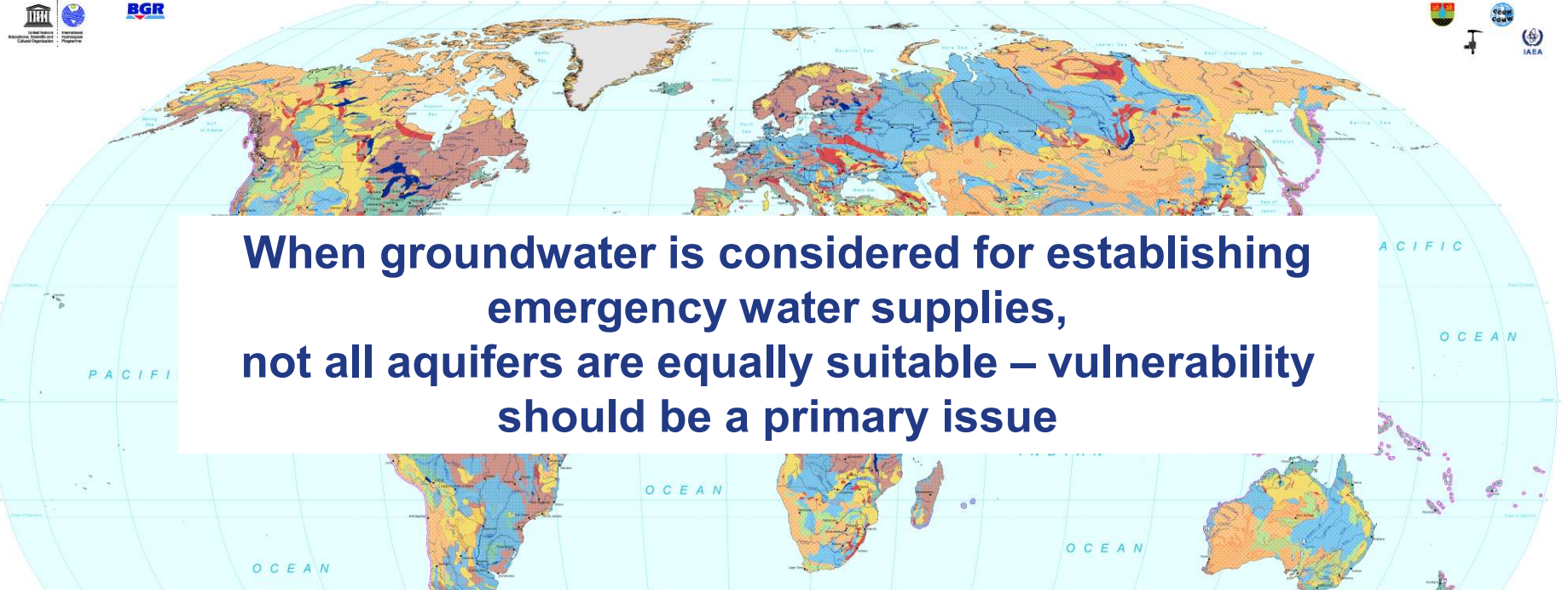


# Example 2: Global GW Vulnerability to Floods & Droughts

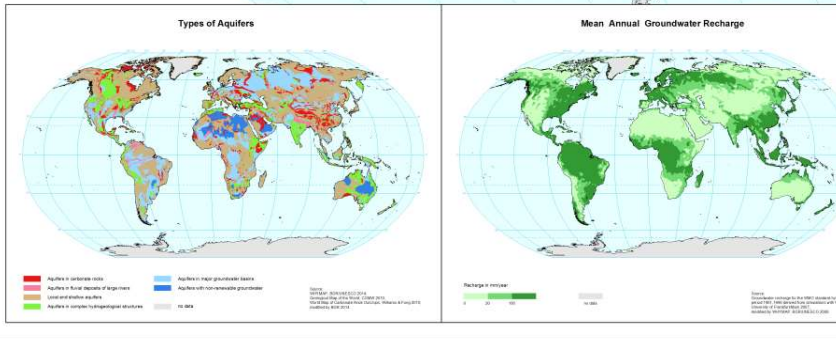
Global Groundwater Vulnerability to Floods and Droughts



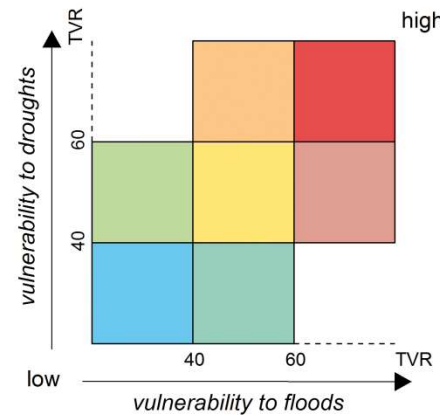
When groundwater is considered for establishing emergency water supplies, not all aquifers are equally suitable – vulnerability should be a primary issue



Scale 1 : 40 000 000



Groundwater vulnerability

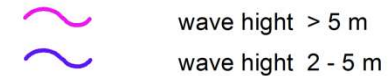


[TVR = Total Vulnerability Range]

Groundwater recharge



Coastal area mostly with aquifers highly vulnerable to tsunami hazards



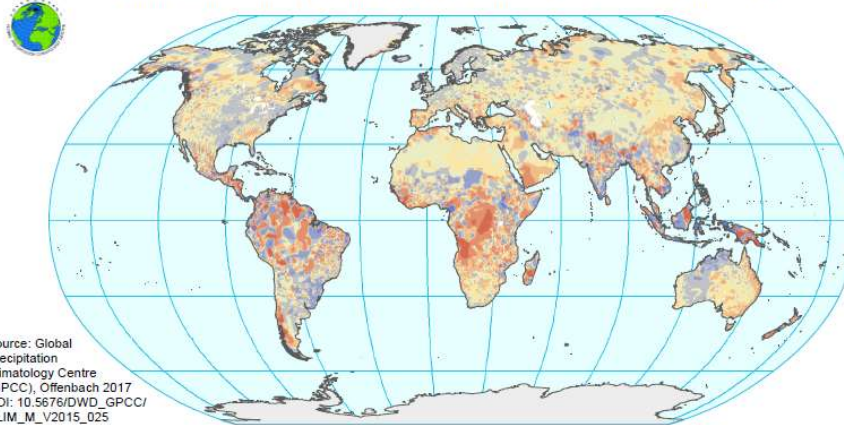
Area of saline groundwater





# Example 3: World Karst Aquifer Map (WOKAM)

Change of mean annual precipitation between the periods 1961-1990 and 1981-2010



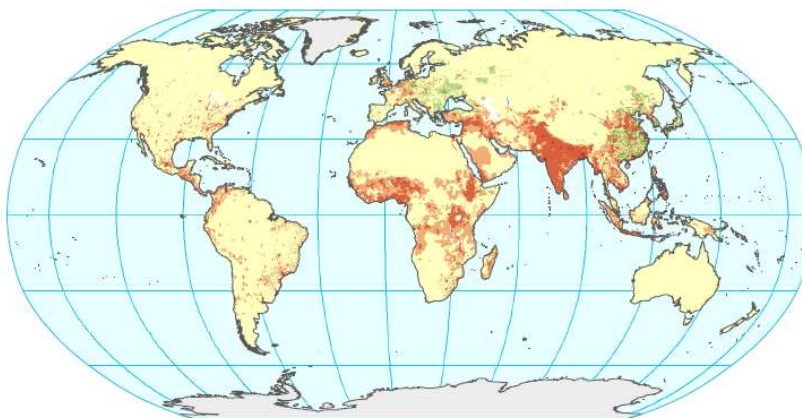
Source: Global Precipitation Climatology Centre (GPCC), Offenbach 2017  
DOI: 10.5676/DWD\_GPCC/CLIM\_M\_V2015\_025

Change of annual precipitation totals [mm]



The change of the mean annual precipitation is calculated based on the land surface precipitation climatology from rain gauges of the reference periods 1961 to 1990 and 1981 to 2010. Note that the number of rain gauge stations is highest for the 1980s and 1990s, with up to 50 000 stations, while this number decreases below 30 000 until the year of 2010.

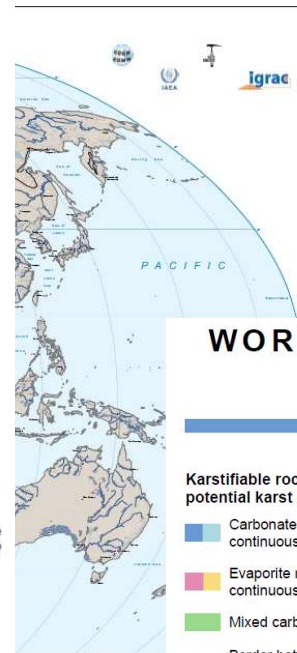
Change of population density between 1990 and 2010



Change of population density [persons/km²]



Source: Center for International Earth Science Information Network - CIESIN - Columbia University, and Centro Internacional de Agricultura Tropical - CIAT, 2005. Gridded Population of the World, Version 3 (GPWv3): Population Density Grid & Population Density Grid, Future Estimates. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). <http://dx.doi.org/10.7927/H4ST7MRB>. Accessed 20-07-2017.



## WORLD KARST AQUIFER MAP 1 : 40 000 000

### Karstifiable rocks / potential karst aquifer

- Carbonate rocks continuous / discontinuous
- Evaporite rocks continuous / discontinuous
- Mixed carbonate and evaporite rocks
- Border between exposed and non-exposed karstifiable rocks

### Selected karst water sources and caves

- Spring with low flow discharge  $\geq 2 \text{ m}^3/\text{s}$
- Spring with low flow discharge  $< 2 \text{ m}^3/\text{s}$
- Submarine spring
- Thermal spring
- Water abstraction structure in karst aquifer
- Cave system

### Geography and climate

- Selected city, partly groundwater dependent
- Selected city
- National boundary
- Permafrost boundary (areal percentage  $> 50\%$ )

### Surface water

- ~ Major river
- Large freshwater lake
- Large saltwater lake
- Continuous ice sheet

This map was prepared and published as part of the World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP) – [www.whymap.org](http://www.whymap.org)

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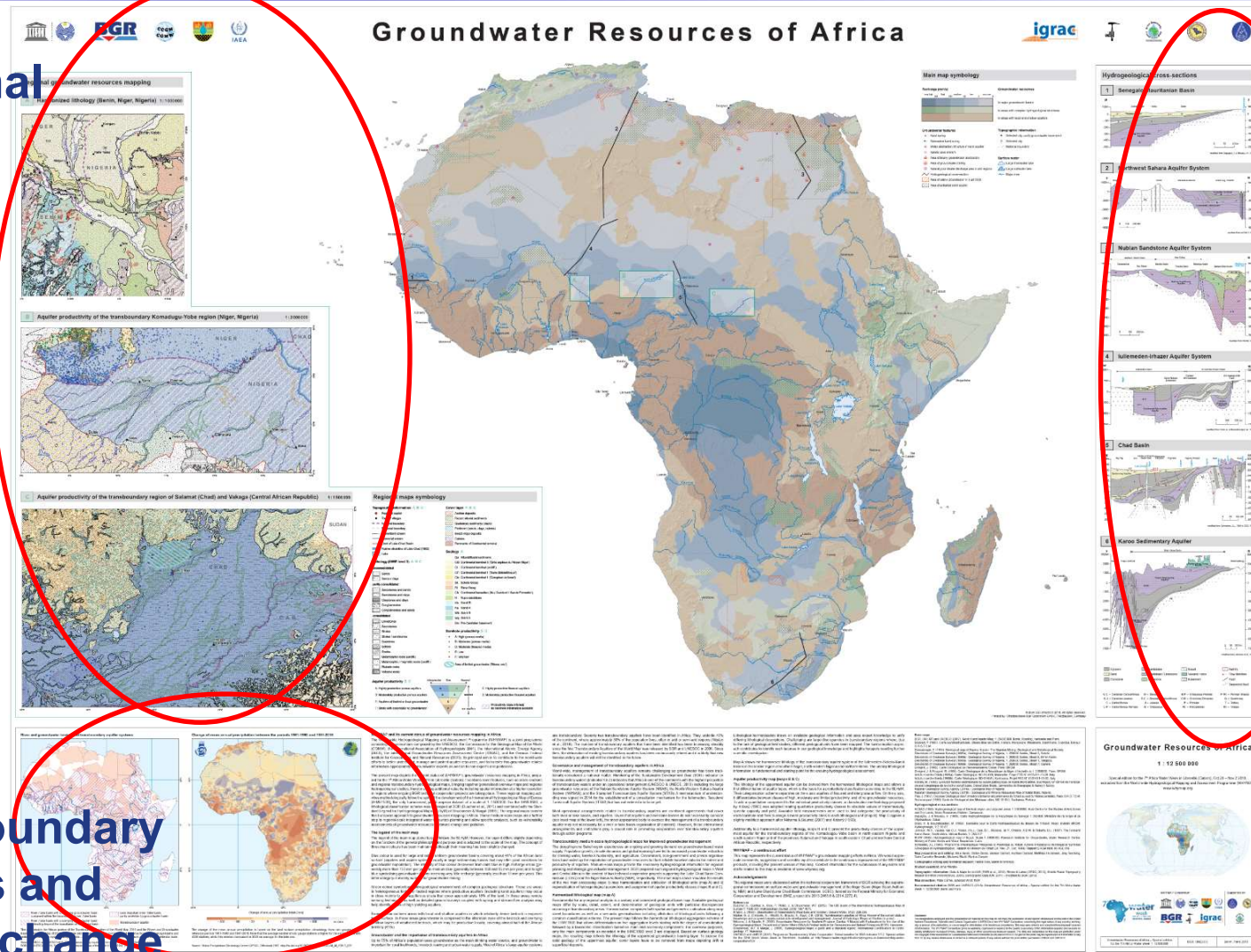


# Example 4: Groundwater Resources of Africa

Regional maps

2.5D

Transboundary aquifers and climate change

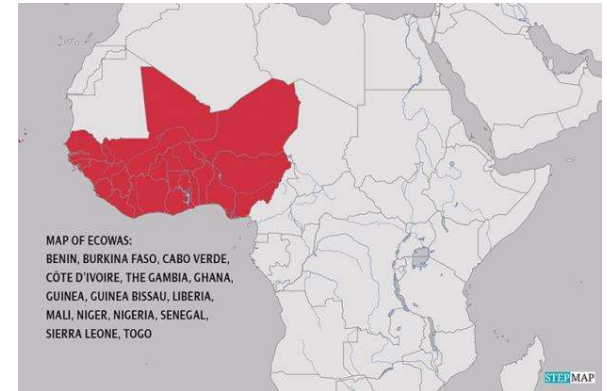




## Example 5: ECOWAS Hydrogeological Map (ongoing)

- 💧 Consolidate and harmonise existing continental-scale mapping activities to increase water security through sustainable use, management and protection of groundwater

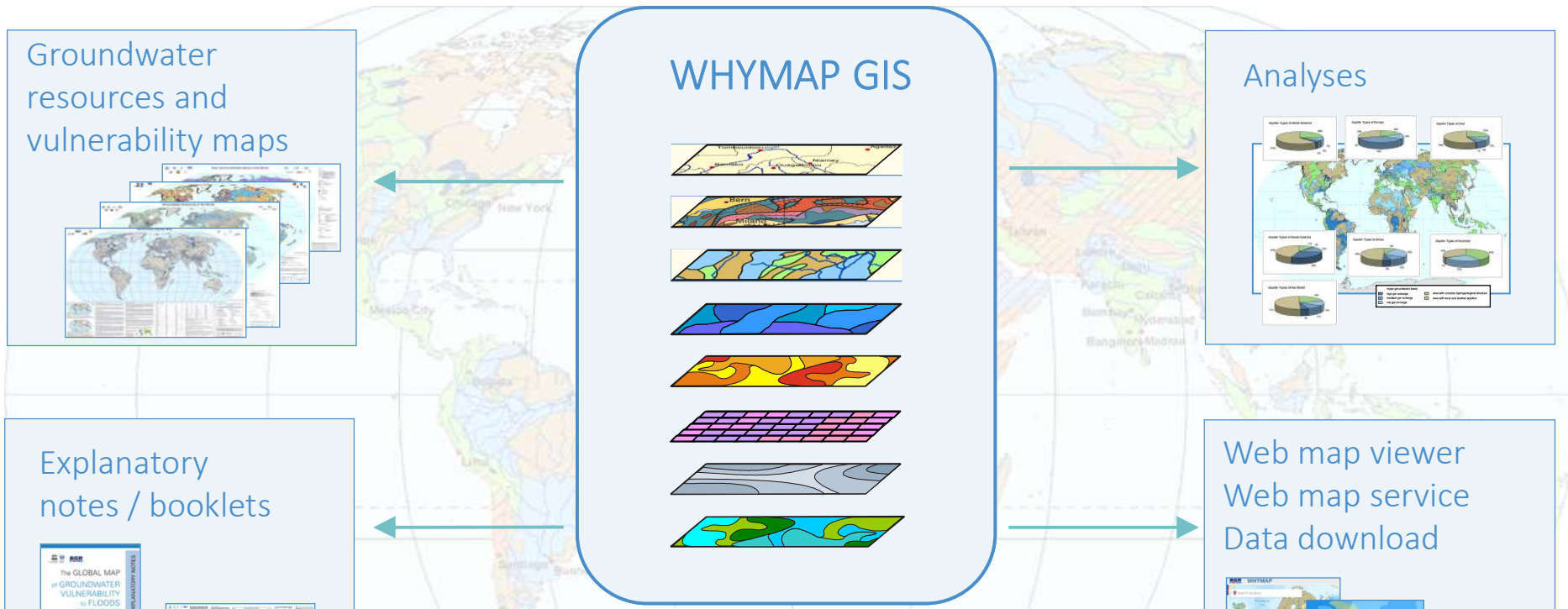
- Hydrogeological/thematic map
- Advocacy map
- Summary report/reference list mapping activities on Africa



→ Publication at WWF/AWW 2022



# Products summary



More information at: [www.whymap.org](http://www.whymap.org)

WHYMAP online viewer: [www.whymap.org/whymap-viewer](http://www.whymap.org/whymap-viewer)

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Contributions to external publications, atlases, text books etc., e.g. small sketch-maps



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GEOZENTRUM HANNOVER



# Applications

## LETTER

doi:10.1038/nature11295

### Water balance of global aquifers revealed by groundwater footprint

Tom Gleeson<sup>1</sup>, Yochibide Wada<sup>2</sup>, Marc F. P. Bierkens<sup>2,3</sup>, E. I. Subbotina<sup>2,3</sup>, D. H. van Beek<sup>2</sup>



#### RESEARCH ARTICLE

10.1002/2015WR017349

**Special Section:**  
The 50th Anniversary of Water Resources Research

#### Key Points:

- Renewable groundwater stress is quantified in the world's largest aquifers
- Characteristic stress regimes are defined to determine the severity of

#### Journal of Geophysical Research: Solid Earth

#### RESEARCH ARTICLE

10.1002/2017JB014845

#### Key Points:

- Terrestrial water storages exhibit positive trend for the Niger River basin over the last decade
- Significant part of storage rise originates from groundwater
- Observations confirm large-scale impact of previously found water table rises in response to land cover changes

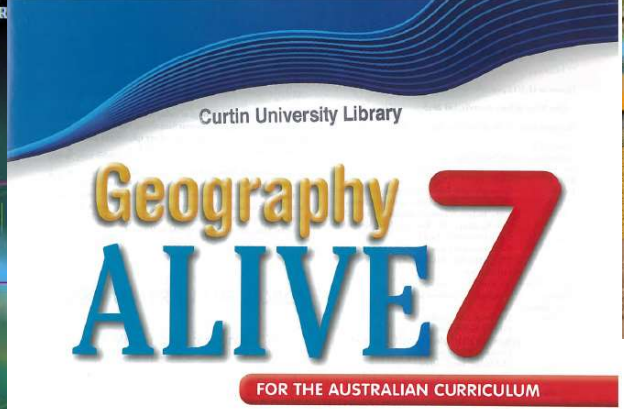
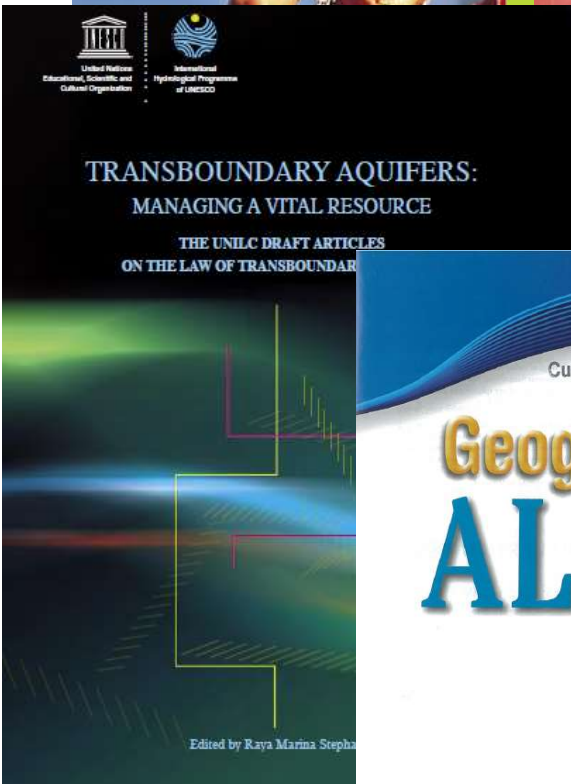
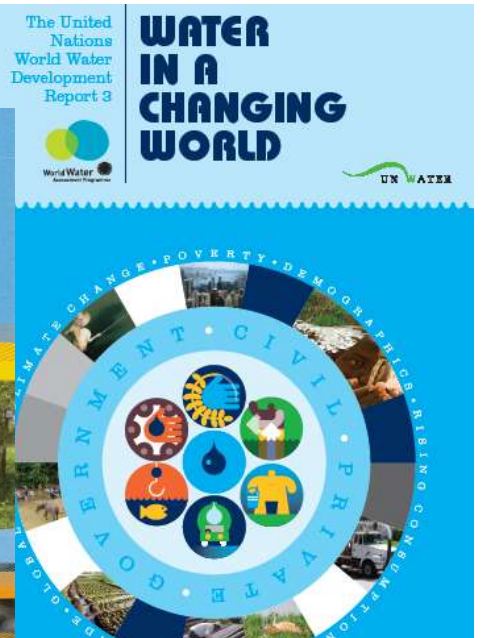
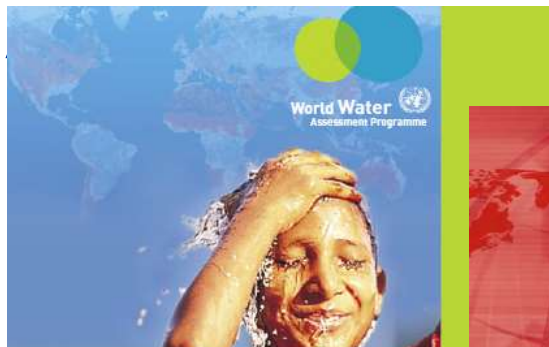
#### GRACE Detected Rise of Groundwater in the Sahelian Niger River Basin

S. Werth<sup>1,2</sup>, D. White<sup>3</sup>, and D. W. Bliss<sup>4</sup>

<sup>1</sup>School of Geographical Sciences and Urban Planning, Arizona State University, Tempe, AZ, USA, <sup>2</sup>School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA, <sup>3</sup>School of Community Resources and Development, Arizona State University, Tempe, AZ, USA, <sup>4</sup>School of Electrical and Computer Engineering, Arizona State University, Tempe, AZ, USA

**Abstract** West African regions along the Niger River experience climate and land cover changes that affect hydrological processes and therewith the distribution of fresh water resources (WR). This study provides an investigation of long-term changes in terrestrial water storages (TWS) of the Niger River basin

id

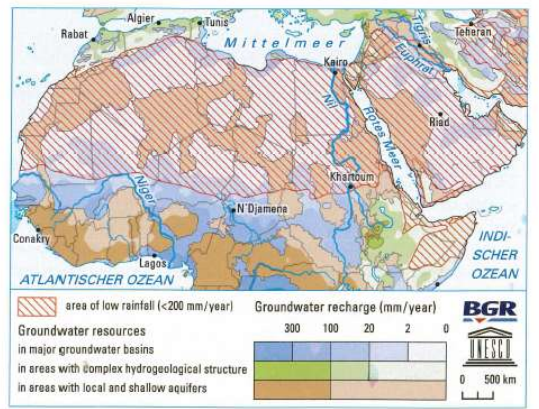


**Nicht-erneuerbares (fossiles) Grundwasser**  
 „Der Begriff nicht-erneuerbares Grundwasser bezeichnet Grundwasservorkommen, die gegenwärtig nicht Teil des hydrologischen Kreislaufs sind. Dies bedeutet, dass keine Erneuerung über Niederschläge oder Infiltration erfolgt bzw. dass diese Erneuerung sehr gering ist und nur in sehr langen Zeiträumen zu einer nennenswerten Grundwasserneubildung führt. Da diese Zeiträume – häufig handelt es sich um mehrere hundert bis tausend Jahre – den menschlichen Planungshorizont deutlich übersteigen, werden diese Ressourcen als nicht-erneuerbar betrachtet. Der Grund für die Abkoppelung vom hydrologischen Kreislauf sind Veränderungen der klimatischen Bedingungen im Einzugsgebiet. Nicht-erneuerbares Grundwasser findet sich insbesondere in ariden und semiariden Gebieten wie dem Nahen Osten, Nordafrika, Zentralasien und im südlichen Afrika. Die Vorkommen haben sich zu einer Zeit gebildet, als in den betreffenden Regionen noch feuchteres Klima vorherrschte. Aufgrund ihres hohen Alters spricht man auch von fossilem oder Paläo-Grundwasser. Die Abkoppelung vom aktuellen hydrologischen Kreislauf und die daraus resultierende Nicht-Erneuerbarkeit unterscheidet diese Vorkommen wesentlich von ‚normalem‘ Grund-

„grünen“ Ressourcen wie Wald und Boden zu vergleichen. Treffenderweise wird die Nutzung dieses Wassers im Englischen auch als „groundwater mining“ bezeichnet. Diese natürlichen Rahmenbedingungen haben weitreichende Konsequenzen für die Bewirtschaftung der Vorkommen.“ [1]

Oberflächenwasser  
 Grundwasser  
 Kapillarwasser  
 Aquifer (G), Quelle  
 Grundwasserneubildung  
 fossiles Grundwasser

**M 6** Verteilung gering- bzw. nicht-erneuerbarer Grundwasservorkommen in Nordafrika und Nahost



Mashreq Waters Knowledge

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jacaranda  
 A Wiley Brand



# Thank you!

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« *We never know the worth of water  
till the well is dry.* »

Thomas Fuller,  
Gnomologia, 1732

