The contribution of groundwater monitoring to SDG monitoring

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International conference "Groundwater, key to the sustainable development goals"
18-20 May 2022, Paris (France)

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Intergovernmental Hydrological Programme

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International Groundwater Resources Assessment Centre

World Meteorological Organization

Government of The Netherlands

Integration of groundwater in SDG targets and indicators

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2015

GROUNDWATER IN THE SUSTAINABLE DEVELOPMENT GOALS

Position Paper No. 1
Including Groundwater in the Draft Goals

Author: Kirstin I. Conti, IGRAC and University of Amsterdam

GROUNDWATER IN THE SUSTAINABLE DEVELOPMENT GOALS

Position Paper No. 2
Emphasizing Groundwater in the Negotiation of the Final Goals

March 2015

Author: Kirstin I. Conti, IGRAC and University of Amsterdam

Brief for GSDR – 2016 Update

Groundwater in the Context of the Sustainable Development Goals: Fundamental Policy Considerations

Kirstin I. Conti [12]; Maya Velis[2]; Andreas Antoniou[2]; Geert-Jan Nijsten[2]*

2017

International Association of Hydrogeologists

THE UN-SDGs for 2030
ESSENTIAL INDICATORS FOR GROUNDWATER

IAH called for “defining new ‘groundwater resource status indicators’ for SDG Targets 6.3, 6.4 and 6.6, because groundwater resources are integral to these but not dealt with adequately at present”

UNU-INWEH Report Series
Issue 04

2018

Groundwater and Sustainable Development Goals: Analysis of Interlinkages

Lisa Guppy, Paula Uyttendaele, Karen G. Villholth and Vladimir Smakhtin

Although 42% of SDG core targets interlink with groundwater, only one target mentions groundwater explicitly.

Current state of reporting on groundwater resources

Reporting on the quantitative and qualitative status of groundwater resources is embedded in indicators 6.3.2, 6.4.2 and 6.6.1.

Indicator 6.3.2: Proportion of bodies of water with good ambient water quality

It requires countries to identify groundwater bodies, then to calculate a water quality index for each of them, based on salinity/conductivity, pH and nitrate concentration. This approach is similar to the reporting under the WFD in Europe.

There are important data gaps. Among 89 countries reporting on this indicator, only 52 report on groundwater bodies. Over ¾ of all water bodies reported were in 24 high GDP-countries. The latest progress report concludes that capacity development is needed to improve groundwater monitoring networks and the knowledge of groundwater flow systems in general (UNEP 2021).

→ *Podgorski J. & Ruz Vargas C., Assessing global groundwater quality to complement SDG indicator 6.3.2 [poster]*

In 2020, groundwaters were again the water body type least reported on. While many countries know the location of aquifers and their importance as water sources, where the groundwater comes from and goes to may not be well understood. Capacity development is needed to make sure that groundwater monitoring programmes are appropriately designed to ensure good network coverage, suitable sampling points, frequent sampling and appropriate choice of parameters. In countries where monitoring is aspirational, there is a need to identify aquifers, understand groundwater flow systems and develop simple conceptual hydrogeological models. This is important because the source of recharge, which could be infiltration from rainfall or surface water bodies, is also likely to be a source of pollution inputs to the aquifer, thereby contributing to quality deterioration. Similarly, the locations of discharge to springs, rivers, lakes, wetlands or water wells are the points at which poor groundwater quality impacts on these receptors.

UNEP (2021). Progress on ambient water quality. Tracking SDG 6 series: global indicator 6.3.2 updates and acceleration needs. Nairobi.

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Indicator 6.4.2: Level of water stress: freshwater withdrawal as a proportion of available freshwater resources

Water stress is defined as the ratio between water abstraction and renewable water resources that are not mobilized as environmental flow:

$$\text{Water stress (\%)} = \frac{TFWW}{TRWR - EFR} * 100$$

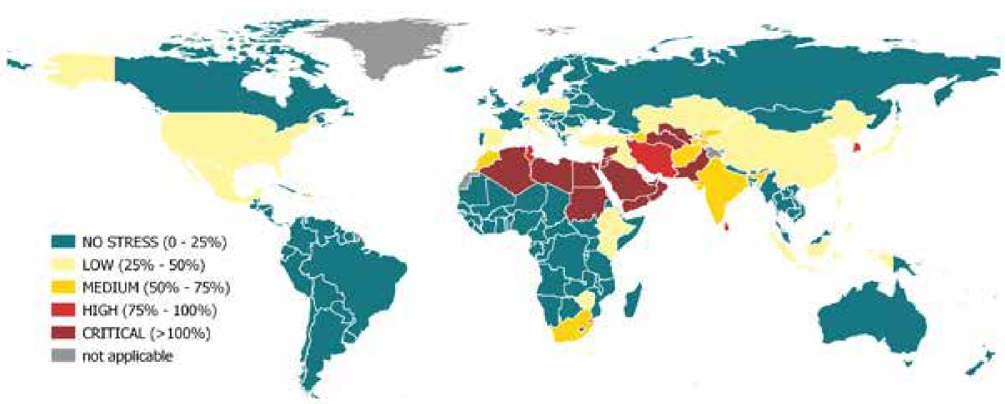
where TFWW is the total fresh water withdrawn, TRWR is the total renewable freshwater resource (the sum of precipitation and net inflow of water from neighboring countries), and EFR are the environmental flow requirements.

The latest progress report mentions a response rate of 46% in the last reporting phase (FAO 2021). Historical data from AQUASTAT are used to overcome these gaps. EFR are computed by a global model (GEFIS).

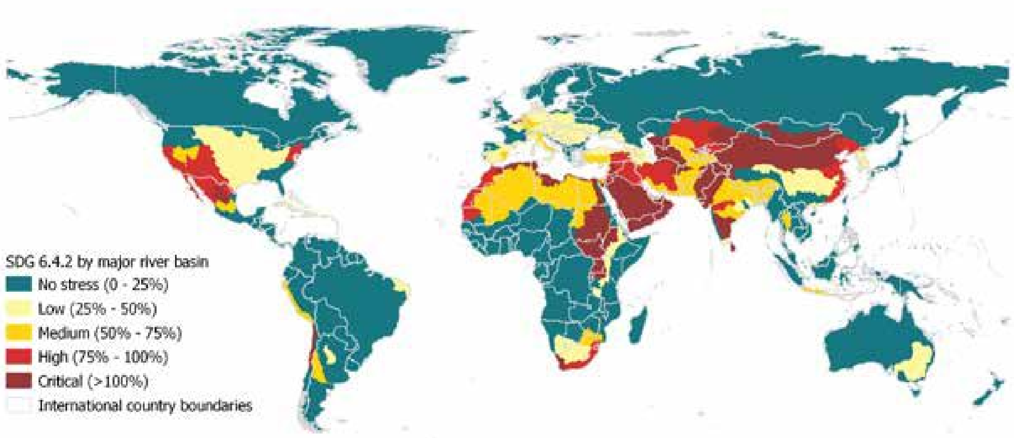
If the water stress is > 1, water abstraction is not sustainable.
If the water stress is ≤ 1, it provides an indication on the risk of water scarcity and competition among users.

The indicator is also calculated per major river basin using a global model (GlobWat).

Water stress per country



Water stress per major river basin



The indicator seems to capture some regional cases of groundwater depletion related to large-scale irrigation, in particular in the major river basins' map. E.g. northwest India, North China Plain, California in USA, MENA – not the Great Plains in USA.

The indicator doesn't capture local (yet significant) cases of groundwater depletion or scarcity, for instance in Dakar (Senegal), Bobo Dioulasso (Burkina Faso), Sikasso (Mali), Jakarta (Indonesia), Perth (Australia), southern Madagascar, etc.

- There is no distinction of groundwater from surface water;
- The scale doesn't allow capturing significant variations in water demand / water availability.

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Indicator 6.6.1: Change in the extent of water-related ecosystems over time

Countries are expected to report on the extent of various water-related ecosystems: lakes, rivers and estuaries, vegetated wetlands, artificial water bodies, and aquifers. The "extent" is a combination of spatial extent, quality and quantity.

		Water-related ecosystems categories				
		Lakes	Rivers and estuaries	Vegetated wetlands	Aquifers	Artificial waterbodies
Extent components	Spatial extent				N/A	
	Quality					
	Quantity	N/A		N/A		N/A

UNEP (2021). Progress on freshwater ecosystems: tracking SDG 6 series – global indicator 6.6.1 updates and acceleration needs.

The methodology report mentions that "only significant ground water aquifers [*sic*], that can be seen as individual freshwater ecosystems will be included in the reporting" (UNEP 2020).

The progress report of 2018 (UNEP 2018) mentioned that groundwater quality data would be imported from Indicator 6.3.2, while data on groundwater quantity would be collected from the countries. In practice, the indicator relies on global datasets based on satellite imagery. There has been no collection and reporting on aquifers to date under indicator 6.6.1.

The progress report of 2021 (UNEP 2021) highlights the issue of groundwater data gaps and calls for countries to "establish groundwater monitoring regimes [*sic*]".

Beyond the issue of groundwater data gaps, in particular in low-income countries, there is currently:

- little consistency between these three indicators;
- no reporting on the quantitative status of groundwater resources.

Indicator		Information on the quantitative status of groundwater resources	Information on the qualitative status of groundwater resources	Spatial disaggregation	Disaggregation per water type	Current state of reporting on groundwater
6.3.2	Proportion of bodies of water with good ambient water quality		✓	Water bodies	Yes: lakes, rivers, **groundwater bodies**	Ongoing
6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	✓ (indirectly)		Major river basins	No	N/A
6.6.1	Change in the extent of water-related ecosystems over time	✓	✓	Freshwater-related ecosystems	Yes: lakes, rivers, **aquifers**, reservoirs, vegetated wetlands	None

The quantitative status of groundwater is captured by indicator 6.4.2, but without distinction from surface water, at a scale that is generally not meaningful for their management, and indirectly.

How can we address this gap?

Calculate water stress over aquifers?

The next steps in the monitoring of 6.4.2 include (FAO 2021):

> **Spatially disaggregate the indicator by aquifer:** This would provide useful information for those areas that mainly rely on groundwater. However, significant methodological limits and knowledge gaps impede any global assessment of this aspect since there are varying degrees of uncertainty in water storage and aquifer groundwater withdrawals in most of the known aquifers.

At the scale of what aquifers ?

Assessing groundwater budget components is indeed challenging: groundwater abstraction, groundwater recharge by precipitations, interactions with surface water, interactions with other aquifers, return flow, artificial recharge, groundwater EF…

Previous attempts to calculate groundwater stress or similar indicators like the groundwater footprint eventually resorted on global hydrological models (Wada et al. 2010, Gleeson et al. 2012).

Under the TWAP project, groundwater stress was estimated for 199 transboundary aquifers. Estimates from expert knowledge and global hydrological modeling disagreed.

Groundwater budgets are important tools for groundwater management, but they are not enough to determine whether abstraction is sustainable or not, cf. water budget myth (Bredehoeft et al. 1982). They are useful in combination with observations of the state of groundwater flow systems.

→ Groundwater monitoring networks remain a cornerstone of sustainable groundwater management.

Some suggestions

Develop a sub-indicator assessing the quantitative state of groundwater bodies based on direct evidences, such as observations of:

- Decline of groundwater levels (based on groundwater monitoring networks),
- Subsidence,
- Seawater intrusion,
- Degradation of groundwater-dependent ecosystems (GDE) and surface water bodies.

In addition, the indicator could also rely on estimations of:

- Decline of groundwater storage (derived from water budgets, models, or GRACE),

although it requires important research, it might not be available at the desired scale, and it might not be accurate.

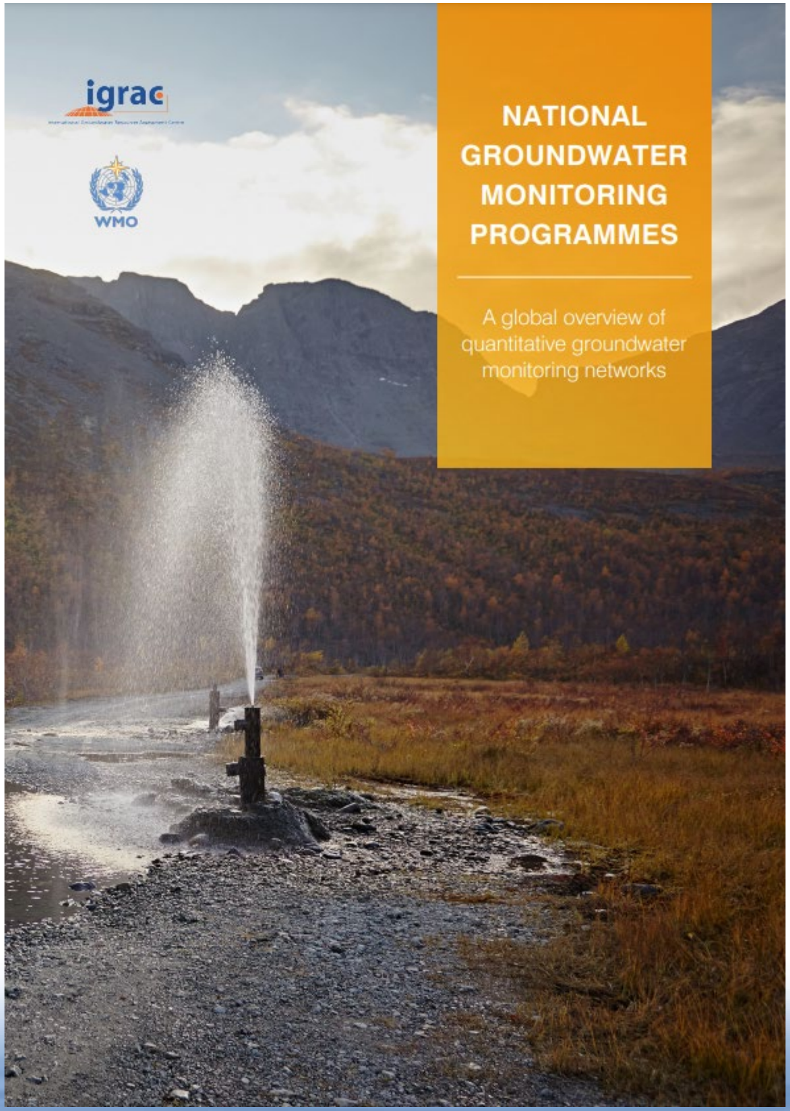
This indicator would be at a scale where groundwater is in principle managed.

In combination with indicator 6.3.2, the actual state of groundwater resources would be determined both in quantitative and qualitative terms, like under the WFD.

Similar indicators are already in use, for instance in California under the Sustainable Groundwater Management Act (SGMA), cf. groundwater sustainability indicators.

There are important gaps in groundwater monitoring worldwide. Still, several countries do have groundwater monitoring networks, also developing countries. Interesting developments are being made in terms of reporting at the country level. SDG reporting could build upon these efforts.

The SDG are also an opportunity to bring the issue of gaps in groundwater monitoring at the highest political level, where solutions can eventually be developed. This will not happen if groundwater and groundwater monitoring are not properly taken into account in the indicators.



IGRAC, 2020. Groundwater monitoring programmes: A global overview of quantitative groundwater monitoring networks.

Thank you for your attention!

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UNESCO

United Nations Educational, Scientific and Cultural Organization

International Hydrological Programme

World Meteorological Organization

Government of The Netherlands

GRACE-derived estimations of groundwater storage

Only at a large scale (≥200 000 km^2) and high uncertainty.

WHYMAP aquifer no.	WHYMAP aquifer name	SD in GRACE GWS (cm)	Range of uncertainty (%)	WHYMAP aquifer no.	WHYMAP aquifer name	SD in GRACE GWS (cm)	Range of uncertainty (%)
1	Nubian Sandstone Aquifer System	1.05	83	20	Maranhão Basin	5.68	136
2	Northwestern Sahara Aquifer System	1.29	121	21	Guarani Aquifer System (Paraná Basin)	3.37	77
3	Murzuk–Djado Basin	1.17	189	22	Arabian Aquifer System	2.01	163
4	Taoudeni–Tanezrouft Basin	0.99	193	23	Indus River Basin	3	78
5	Senegal–Mauritanian Basin	3.23	96	24	Ganges–Brahmaputra Basin	9.84	58
6	Iullemmeden–Irhazer Aquifer System	1.52	116	25	West Siberian Artesian Basin	7.53	79
7	Lake Chad Basin	2.23	91	26	Tunguss Basin	7.4	103
8	Umm Ruwaba Aquifer (Sudd Basin)	4.95	113	27	Angara–Lena Basin	3.73	48
9	Ogaden–Juba Basin	1.52	57	28	Yakut Basin	4.15	83
10	Congo Basin	5.09	98	29	North China Plains Aquifer System	3.93	77
11	Upper Kalahari–Cuvelai–Zambezi Basin	10.03	36	30	Songliao Plain	2.63	62
12	Lower Kalahari–Stampriet Basin	1.76	106	31	Tarim Basin	1.37	219
13	Karoo Basin	3.06	74	32	Paris Basin	4.06	84
14	Northern Great Plains Aquifer	4.18	111	33	East European Aquifer System	5.91	75
15	Cambro-Ordovician Aquifer System	4.56	44	34	North Caucasus Basin	4.67	66
16	California Central Valley Aquifer System	9.73	55	35	Pechora Basin	8.55	94
17	Ogallala Aquifer (High Plains)	4.05	104	36	Great Artesian Basin	2.77	69
18	Atlantic and Gulf Coastal Plains Aquifer	2.56	193	37	Canning Basin	5.34	57
19	Amazon Basin	10.93	58				

Variability (expressed as standard deviation) in GRACE-derived estimates of GWS from 20 realisations (three GRACE TWS values and an ensemble mean of TWS, four LSMs and an ensemble mean of surface water and soil moisture storage, and snow water storage) and their reported range of uncertainty (% deviation from the ensemble mean) in the world's 37 large aquifer systems.

Shamsudduha & Taylor (2020) https://doi.org/10.5194/esd-11-755-2020

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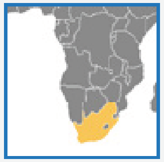

South Africa (RSA)

Capital city: Cape Town (legislative) / Pretoria (administrative) / Bloemfontein (judicial)
Inhabitants: 57.8 Million

INSTITUTIONAL SETTING AND PURPOSE

The institution in charge of groundwater management in Republic of South Africa (RSA) is the Department of Water Affairs and Forestry (DWA). The DWA has delegated most of the monitoring tasks to its regional offices. Regional offices are set up in all the provinces of RSA, but some of them lack capacity to complete all the delegated tasks.

The objectives of the groundwater monitoring plan are to identify spatial and temporal trends, and to understand the causes and effects of groundwater changes in affected areas. The plan includes the monitoring of groundwater levels and its quality.

CHARACTERISTICS OF THE NETWORK

Groundwater levels are monitored monthly at approximately 1,800 monitoring points. Piezometric levels are measured manually with water level dippers. The Department of Water and Sanitation (DWS) makes use of (detailed) field forms developed by an in-house Groundwater Field Monitoring Committee.

Standard operation procedures (SOP) are applied as a data quality control to ensure proper data collection. Two main procedures are: standard for Geosite description, and standards for capturing groundwater data.

PROCESSING AND DISSEMINATION

DWS produces annual Groundwater Level Maps, Figure 1. Currently three maps are available on the website of the DWS indicating the difference of groundwater levels between Septembers of 2017 to 2018, of 2018 to 2019 and of 2017 to 2019.

Data are stored in the National Groundwater Archive (NGA), which is a centralized database with a web interface. Everyone with an interest in groundwater can register to search, capture and store data. Only one value of water level per month is stored in the NGA; larger time-series are stored separately in a Hydstra database.

The databases can be accessed from inside and outside the department and are accessible for registered users. However, not all data are online and detailed water level time series must be requested.

Figure 1 - Difference in groundwater levels September 2018 to September 2019. Source: DWA

Sources

- Department of Water and Sanitation (DWS). Groundwater level maps 2017-2019 - http://www.dwa.gov.za/Groundwater/maps/gwlevelmaps.aspx;
- DWS. The National Groundwater Archive (NGA) - http://www.dwa.gov.za/groundwater/nga.aspx;
- Feedback from the Department of Water Affairs and Forestry - received on 05-10-2020;
- IGRAC, 2013. Groundwater Monitoring in the SADC Region, 2013. Overview prepared for the Stockholm World Water Week - https://www.un-igrac.org/sites/default/files/resources/files/Report_Groundwater%20Monitoring%20in%20SADC%20region.pdf; and
- SADC Country visits - 2017.

Institution in charge of national groundwater monitoring programme (if any).

Number of monitoring stations, frequency of observations, automatic vs manual, etc.

Processing: data processing methods to interpret data.

Dissemination: website, database or web portal where data and information (raw data, reports, graphs, indicators, etc.) are stored/shared.