International Association of Hydrogeologists

THE UN-SDGs for 2030

ESSENTIAL INDICATORS FOR GROUNDWATER

KEY MESSAGES

- **groundwater is a key resource for the achievement of the UN Sustainable Development Agenda for 2030 — but is still weakly conceptualised in the SDG Indicators**
- **there is a strong case 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**
- **there is urgent need to strengthen current data collection protocols to focus more clearly on the level, types and modes of groundwater use for municipal water-supply and direct drinking water-supply**
- **professional appraisals of 'source design and integrity' will be a critical for assessing the achievement of SDG Target 6.1, given constraints on field monitoring**
- **professional assessment of groundwater status, trends and risks will be required to interpret the condition of the resource base, whose sustainability is essential for achievement of SDG-6 Targets**

How do groundwater resources underpin the UN Sustainable Development Agenda for 2030?

Since earliest times humankind has met much of its needs for good quality water from subterranean sources. During the 20th century there was an enormous boom in waterwell construction for urban water-supply, agricultural irrigation and industrial processing – facilitated by advances in well drilling, pump technology and geological knowledge – and groundwater became a key resource supporting human well-being and economic development.

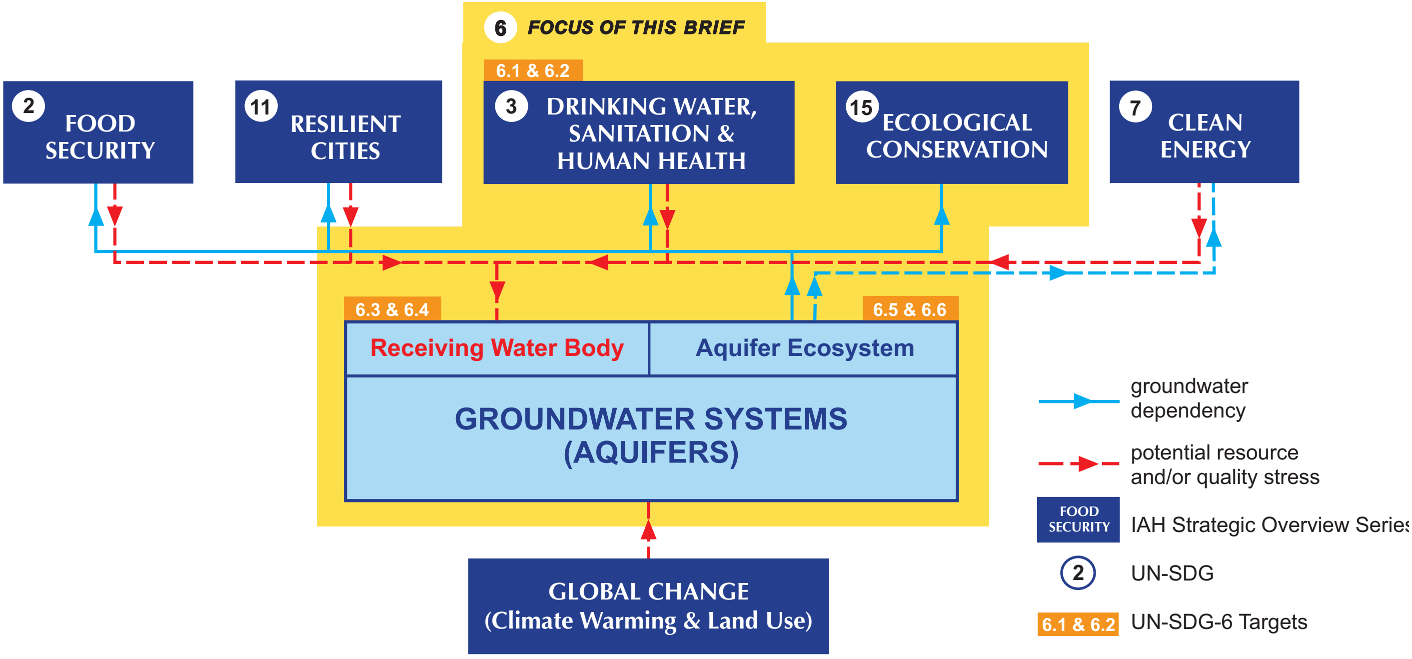
Comprehensive statistics on groundwater abstraction are not available, but global withdrawals are estimated to have passed 900 km^3/a in 2010, providing some 36% of potable water-supply, 42% of water for irrigated agriculture and 24% of direct industrial water-supply[1], with proportions varying widely from country to country and across larger countries. Moreover, groundwater is also often the only option for meeting rural water-supply needs.

The social value of groundwater should not be gauged solely by volumetric use, since it brings major economic benefits per unit volume, because of local availability, scaling to demand, high drought reliability and generally good quality (requiring minimal treatment). The dependence of many cities and innumerable medium-sized towns on

[1] *Döll et al, 2012 : Journal Geodynamics 59-60*

This Series is designed both to inform professionals in other sectors of key interactions with groundwater resources and hydrogeological science, and to guide IAH members in their outreach to related sectors.

A *IAH STRATEGIC OVERVIEW SERIES ON GROUNDWATER IN THE UN-SDGs FOR 2030*



groundwater is increasing, and the contribution of groundwater to irrigated agriculture in terms of crop yield and economic productivity is high.

During 2015-16 the IAH produced a series of 'Strategic Overviews' assessing in detail the ways in which groundwater relates to the achievement of various UN-SDGs for 2030 — 2-Food Security; 3-Human Health; 7-Energy Generation; 11-Resilient Cities & 15-Ecosystem Conservation[2]. In addition the potential impacts of Global Change (namely in land-use and of climate warming) were also evaluated. This overview focuses exclusively on groundwater essentials for the achievement of SDG 6-Water **(A)**.

Why is it essential for groundwater considerations to be included explicitly in the Indicators for UN SDG-6 : Water?

Worldwide the generally excellent natural quality of groundwater makes it the preferred source of drinking-water. Aquifers have widespread geographical occurrence and naturally provide the functions of water-supply filtration, storage, distribution and protection. Moreover, groundwater storage represents a natural buffer against unpredictable water demands arising from accelerated global warming. It is thus essential that groundwater be factored-in fully to the procedures being drawn-up to evaluate the progress in achieving UN SDG-6 Targets.

Groundwater factors will exert a major influence on two distinct facets of SDG-6 – the 'engineering of human water services' (Target 6.1) and the 'status of the water resource base' (Targets 6.3, 6.4 & 6.6) – there being a strong link between provision of the former and sustainability of the latter. In this regard groundwater governance will widely need to be strengthened, so as to prevent further resource depletion and quality degradation[3].

How do groundwater factors affect the provision of human water services?

The provision of universally adequate drinking water-supply (as conceived in SDG Target 6.1) requires a special focus on groundwater sources in view of their major (and growing) importance in this regard. This must always involve appraisal

[2]IAH 2015 & 2016 : www.iah.org
[3]FAO-UN, 2016 : Groundwater Governance–A Framework-for-Action

of their construction integrity, drought security and quality protection, and in certain instances sustainability of the local resource base itself.

Amongst the countries that have most still do to achieve SDG Target 6.1 most have few perennial surface-water sources and unfavourable ground-water conditions, thus successful waterwell siting and construction will require significant hydro-geologic surveys.

SDG Target 6.2 and 6.3 are concerned with the coverage and level of sanitation services, and as such are not strictly groundwater-related. But the potential groundwater impacts of 'sanitation system design' will need to be evaluated to ensure that incidental discharges to the subsur-face do not exceed natural attenuation capacity – otherwise achieving SDG Targets 6.2 & 6.3 could in practice prejudice the chance of achieving SDG Target 6.1.

A further list of comments on these targets is tab-ulated **(B)**. The following issues are highlighted :

- the categorisation of water sources used in the WHO-UNICEF Joint Monitoring Programme (JMP) – the main source of statistical data on national drinking-water services in urban and rural settings – urgently requires refinement **(a)** to distinguish which piped water-supplies are groundwater-derived **(b)** to improve the classification of non-piped groundwater sources (private waterwells, community/ municipal waterwells or springs, water-vendor supplies from waterwells or springs) and **(c)** whether these are 'safe' (ie. adequately sealed and operated, and not affected by natural geogenic contamination).
- the UN-Habitat IBNET Water Utilities Data-base – the primary source of information on utility drinking-water services – urgently needs amplification to capture **(a)** the types and yields of different water sources being utilised (so as to include waterwells and springs), **(b)** the extent to which groundwater sources are operated for 'base-load' supply or conjunctive management is being practiced to improve water-supply security, **(c)** the range and frequency of raw-water quality analyses being undertaken as 'routine monitoring' (in view of the significance for national water monitoring) and **(d)** the scale of private self-supply prevalent in the urban areas concerned and thus proportion of total demand met by the municipal water utility.

Which are the 'main focal points' for ground-water resources in UN SDG-6 : Water?

Groundwater is of central importance to the 'resource-oriented' SDG-6 Targets, but at present is not adequately expressed in respect of resource sustainability and quality protection, and thus new indicators are required.

SDG Target 6.4 (Management & Reduction of Water Stress) — is the best entry-point to address the issue of long-term groundwater resource depletion (or so-called 'aquifer overexploitation'), but is not yet specifically mentioned and merits a separate indicator. The specification of this indicator, for implementation through FAO-AQUASTAT, will require careful definition of the corresponding terms so as to accommodate **(a)** planned overdraft of groundwater storage as a climate-change adaptation measure to cope with extended drought and/or for transition to a lower water-use economy, and **(b)** planned socially-sustainable utilisation of non-renewable ground-water resources.

SDG Target 6.3 (Conserving Water Quality of 'Receiving Water Bodies') & Target 6.6 (Restor-ing & Protecting Water-Related Ecosystems) — groundwater pollution and quality protection enter here but require new indicators for:

- SDG Target 6.3 specifying aquifers as one 'particular class' of 'receiving water body' whose water quality needs to be conserved through appropriate land-use controls in aquifer recharge zones.

B *UN SDG -6 COMMENTS ON GROUNDWATER IMPLICATIONS*

INDICATORS	GROUNDWATER COMMENTS
TARGET 6-1	**universal and equitable access to safe and affordable drinking water**
percentage of population using safely-managed drinking water services	• important to establish extent of dependence on groundwater for municipal piped, private/communal in-situ and packaged/tankered supplies to determine monitoring strategies • indicator does not explicitly address 'affordability' and needs to recognise increasing world-wide dependence on direct-supply from waterwells in this respect and to focus on improving their construction, operation and maintenance • assessing groundwater supply 'safety' will require protocols for assessing construction integrity, quality protection, yield security in drought, and in some settings resource status • clarification of 'target service level' (in lpd/capita) is needed to assess implications for groundwater source improvement and development strategy in areas of 'difficult hydrogeology' • need to clarify potential conflict between groundwater abstraction/use rights in national laws and equitable access as defined by UN Charter of Human Rights • more research is needed on 'rapid screening methods' to facilitate field monitoring of faecal contamination (such as in-situ fluorescence spectroscopy)
TARGET 6-2	**universal and equitable access to adequate sanitation and hygiene, ending open defecation and paying special attention to needs of women/girls and those in vulnerable situation**
percentage of population using safely-managed sanitation services with soap and water hand-washing facility	• indicator concerned only with service-level and thus not groundwater-related – unless sanitation system design involves incldental discharges to the subsurface which could exceed natural pollutant attenuation capacity • in particular in many fast-growing towns and peri-urban slums the only realistic service solution will be in-situ sanitation – but adequate pit-latrine design and operation will be needed to avoid serious groundwater contamination
TARGET 6-3-1	**improve water quality by reducing pollution, eliminating dumping, minimizing release of hazardous materials, halving the proportion of untreated wastewater and substantially increasing safe recycling and reuse**
percentage of wastewater safely treated	• indicator concerned only with service-level and thus not groundwater-related – unless system design and operation (and notably wastewater reuse and sludge management) result in coincldental discharge to the subsurface which could exceed natural pollutant attenuation capacity

- SDG Target 6.6 explicitly naming aquifers as one class of 'aquatic ecosystem' irrespective of whether they are associated with a specific groundwater-dependent ecosystem.

In both cases the questions of 'which aquifers are to be included' and 'how to allow for natural pollutant attenuation' will need to be addressed. Additionally a clear distinction is required between 'point pollution sources' (addressed by the current wording of the SDG Indicator 6.3.2) and 'diffuse source pollution' (which is of equal or greater concern for groundwater but apparently not covered by the indicator).

At present the field data on global groundwater resource status and quality collected in the UN-FAO-Aquastat System, the UN-GEMI-GEMS Water Quality Database and the IGRAC-Global Groundwater Monitoring Network are not considered adequate for the purpose of assessing progress with SDG-6 Targets – and these initiatives will need to make a major coordinated effort on improving national groundwater monitoring systems, protocols, assessment and databasing.

Groundwater monitoring is fundamentally different from surface-water monitoring, and necessitates a different strategy. The extensive experience with EU Water Framework Directive-Groundwater Quality Status Characterisation and USGS National Groundwater Quality Surveys clearly illustrate that reliable interpretation of groundwater status and trends requires periodic intensive surveys on a systematic aquifer-by-aquifer basis, with supporting data on anthropogenic pressures and aquifer dynamics, in addition to regular monitoring of a few selected long-term monitoring stations to improve interpretation.

SDG Indicator 6.4.2 (Improving Water-Use Efficiency) – while not specifically related to groundwater – requires acknowledgement that 'so-called inefficient' surface-water irrigation is a major incidental source of groundwaterrecharge, and thus of aquifer storage which enhances water resource availability for use in dry-seasons and surface-water droughts. The existence of operative MAR (managed aquifer recharge) schemes could also be a criterion of 'efficient water-use', since this practice leads to water resource conservation.

SDG Target 6.5 (Implementing Integrated Water Resources Management) — where appropriate through Trans-Boundary Cooperation - will require better conceptualisation of groundwater within the overall scheme and strengthening governance provisions[3] through improved cross-sector policy making, and this will be aided by the establishment of an appropriate 'policy check list'.

How can groundwater quality monitoring be streamlined in the context of UN SDG-6 implementation ?

The challenge of groundwater quality monitoring (both for water-supply vigilance and water resource status assessment) is different from that for rivers, whose monitoring provides a composite response from an extensive catchment buffering-out the effect of factors local to the sampling station. The reverse is true for groundwater, for which wellhead contamination, well-screen depths, waterwell pumping rates, immediate catchment factors and sampling protocols, are predominant. It is essential that groundwater quality monitoring protocols are graduated and varied according to different hydrogeologic types and land-use settings – and a 'short-list' of analytical parameters is tabulated **(C)**.

Groundwater quality monitoring and assessment is not straightforward **(D)** because :

- very large natural aquifer storage of aquifers complicates sampling and can obscure negative trends in contemporary recharge quality

[3]FAO-UN, 2016 : Groundwater Governance–A Framework-for-Action

DETERMINAND		COMMENTS
Basic Care Parameters (for periodic measurement in all situations – frequency to depend on groundwater system characteristics and pollution risks)		
EC pH T	electrical conductivity acidity temperature	require field measurement at waterwell, spring or observation borehole
NO_3	nitrate	ubiquitous contaminant - stable in oxic conditions
Cl	chloride	more sensitive indicator of change than EC
Supplementary Parameters at Lower Frequency (following marked change in those above)		
Ca, Mg, Na, K (Cl), HCO_3, SO_4	major cations major anions	will help to evaluate hydrogeologic processes and to detect and diagnose significant temporal changes
TDS	total dissolved solids	but EC usually acceptable as surrogate
Microbiological Monitoring of Drinking Water Sources (sources designated at risk from sanitary inspection)		
FC FS E Coli	fecal coliforms fecal streptococci Escherichia coli	some monitoring needed for sources routinely used without disinfection, but temporal variability and sampling difficulties mean that this must be combined with other approaches to assessing sanitary completion
Supplementary Parameters (required in specific hydrogeologic settings)		
F As U	fluoride soluble arsenic soluble uranium	essential in some hydrogeologic conditions
NH_4 Fe Mn	ammonium soluble iron soluble manganese	only in strongly anoxic/reducing conditions
P	orthophosphate	only in karst (and other highly-permeable) aquifers with intensive agriculture
Supplementary Parameters (will need to be introduced if specific agricultural or industrial pressures identified)		
	specific pesticides selected volatile organics selected hydrocarbons heavy metals certain emerging contaminants	each parameter will require sound protocols, skilled personnel and specialist laboratories

- data aggregation (when reporting status and trends) has to deal with wide three-dimensional variability of groundwater quality and aquifer residence time, and with the strong influence of local factors which are artefacts of the design and completion of monitoring wells

In some aquifers slow groundwater movement, marked vertical and lateral variations in groundwater quality, constraints related to sampling access and unstable determinands mean that a large number of groundwater monitoring points can be required to achieve a representative survey at any one time.

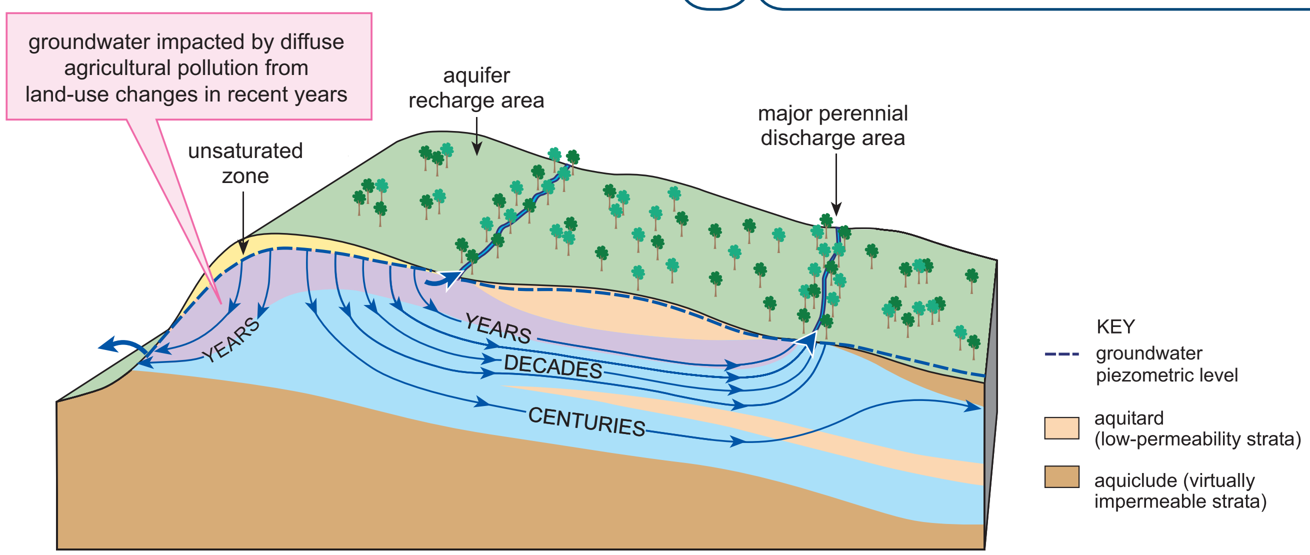
It will be necessary to make use of indirect methods (such as sanitary survey risk scores for rural waterwells, aquifer vulnerability and pollution pressure surveys, isotopic evidence on groundwater dynamics) as critical inputs when trying to identify groundwater systems at 'quality risk', and complement (often limited) field monitoring data.

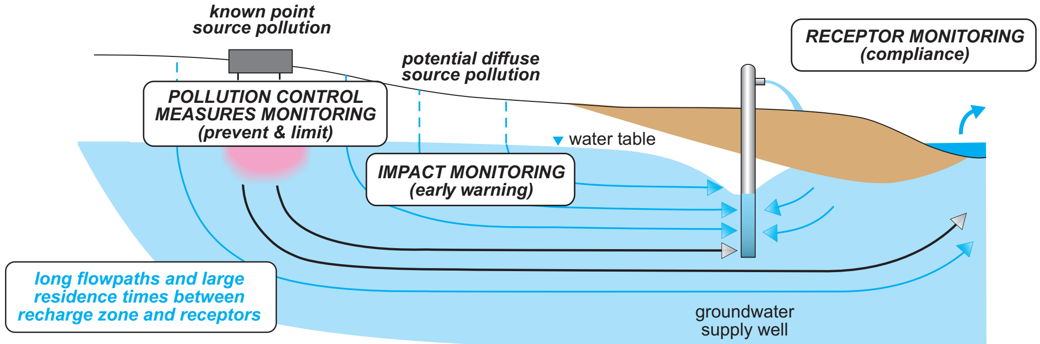
A pragmatic approach to microbiological quality screening of groundwater sources is required, given the numerous factors that exert an influence on the incidence of contamination, with intense rainfall events often being a factor.

What are the institutional needs for improving incorporation of groundwater factors in the implementation of UN SDG-6 : Water ?

Experience from more developed economies makes it clear that improving groundwater monitoring, management and protection requires

D GROUNDWATER FLOW DYNAMICS - INFLUENCE ON QUALITY MONITORING AND ASSESSMENT





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strong stable institutions and concerted efforts at local level. Water-service utilities usually have large records of groundwater quality and it will be essential to capture this when making national biennial groundwater status and trend reports.

The IAH has become aware of a chronic shortage of qualified groundwater specialists and experienced waterwell drilling technicians in low- and middle-income countries, and considers that continued and intensified efforts on education and training in these regards will be critical to achieving many SDG-6 Targets.

The mobilization of waterwell users on the monitoring of their groundwater sources appears to hold promise in terms of reducing the burden of public sector agencies – and more protocols and training in this regard would appear to be a useful development during SDG-6 implementation.

There is a need for the incorporation of groundwater in national IWRM plans and promotion of groundwater resource management in the programmes of river basin agencies. Planned conjunctive management of groundwater and surface-water resources in many cases represents the best prospect for improving water-supply security for urban and irrigation use, and for sustainable resources. At the same time the institution responsible nationally for groundwater monitoring and data-basing needs to be clearly identified and supported.

PRIORITY ACTIONS

- **it is strongly recommended SDG Indicators should be included for :**
  – SDG 6.3 stating that 'groundwater systems (aquifers) are receiving water bodies that require protection against polluting discharges and inappropriate land-uses'
  – SDG 6.4 stating that 'halting the long-term continuous depletion of ground water systems is a central activity for dealing with global water stress'
- **clarifiy whether SDG Target 6.6 includes a requirement for 'protecting aquifers generally as aquatic ecosystems or only where they are directly associated with dependent ecosystems'**
- **include the use of information on aquifer vulnerability, groundwater dynamics and pollution pressures when interpreting groundwater quality status and trends**
- **for SDG Target 6.1 modify current data collection protocols of the WHO/ UNICEF-JMP and the UNHabitat-IBNET to establish the level, types and modes of groundwater use for drinking water-supply and municipal water-supply respectively, as an aid to determining water-source security and safety**

COORDINATION : Stephen Foster, Richard Carter & Gillian Tyson
CONTRIBUTIONS : William Alley, Sean Furey, Ralf Klingbeil, Binaya-Raj Shivakoti, Seifu Kabede & Ricardo Hirata
MANAGEMENT : Bruce Misstear, Antonio Chambel & John Chilton