Global Groundwater Vulnerability to Floods and Droughts

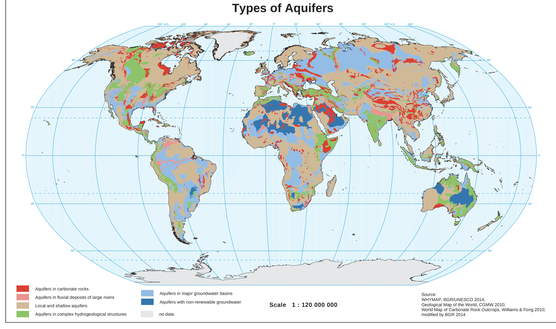
United Nations Educational, Scientific and Cultural Organization · International Hydrological Programme

BGR

IAEA

Scale 1 : 25 000 000

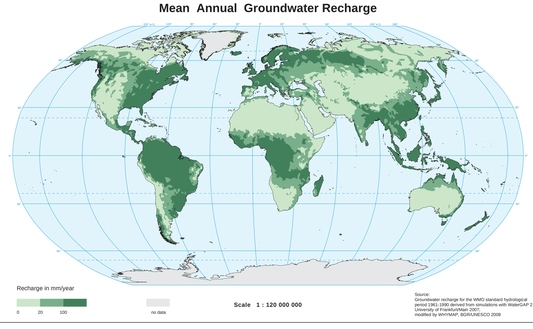
Types of Aquifers



Scale 1 : 120 000 000

Source:
WHYMAP, BGR/UNESCO 2014;
Geological Map of the World, CGMW 2010;
Global Lakes and Wetlands Richa Dalmiya, Williams & Fong 2010;
modified by BGR 2014

Mean Annual Groundwater Recharge



Scale 1 : 120 000 000

Source:
Groundwater recharge for the WHO standard hydrological period 1961-1990 derived from simulations with WaterGAP 2.1, Döll and Fiedler (2008);
modified by WHYMAP, BGR/UNESCO 2008

The concept of global groundwater vulnerability classification

Rising demands from global population growth, rapid urbanisation, intensification of agricultural production, as well as increasing industrialisation will require growing reliable quantity and quality of water. To meet these increased demands, policy makers, natural resource managers and planners have to stop focusing solely on surface water and consider conjunctive uses of both surface water and groundwater resources. Groundwater resources can represent an economical, reliable and sustainable contribution to water challenges. Furthermore, these resources are naturally less vulnerable and more resilient to external influences, such as floods and droughts, than surface waters. These extreme hydrological events can have devastating impacts on human life, generate economic loss and increase poverty and deprivation. Besides that, floods and droughts frequency is increasing due to the effects of climate change. Aquifers often offer opportunities for reducing the effects of the impact of these hydrological extremes and contribute to establish emergency water supplies.

The Global Map of Groundwater Vulnerability to Floods and Droughts indicates the level of vulnerability of groundwater resources of the earth. It presents the intrinsic vulnerability of groundwater systems and the sensitivity or resistance of those systems to natural disasters.

The concept of groundwater vulnerability takes into account that the geological characteristics of the aquifers and the physical environment provide different degrees of protection against natural or human activities related impacts. Aquifers in karst formations or in fluvial unconsolidated deposits of large rivers are highly vulnerable to floods and droughts, and coastal aquifers are particularly prone to tsunamis, while the groundwater resources in deep-seated aquifers are naturally less vulnerable and more resilient to external influences due to their protection from the earth surface by geological layers with low permeability. Some of these aquifers, if accurately managed, could supply drinking water in the post-disaster emergency phase, replacing damaged water supply systems.

The assessment of groundwater vulnerability is usually based on a classification of various natural parameters, such as soil type, properties and thickness of the unsaturated zone, aquifer type, recharge rate and others. However, there is a lack of data in many regions of the world. Thus, the evaluation presented on this world map is mainly based on parameters that were globally available: the type of aquifers and annual groundwater recharge. The groundwater vulnerability classification adopted for this map is intended for use as a global overview. Due to its scale, it cannot be used for site specific and local purposes. More vulnerability parameters based on relevant reliable data sets have to be applied to present groundwater vulnerability on maps at a large scale.

In order to obtain a numerical dimension of groundwater vulnerability, individual weighting and a rating scale have been assigned to the parameters "type of aquifers" and "groundwater recharge". According to their considered importance for the vulnerability assessment, a numerical score for both parameters has been calculated. The final result, called "Total Vulnerability Range" (TVR), is divided into three categories: low, moderate and high groundwater vulnerability. Generally, the lower the numerical score the lower the vulnerability and the higher the level of natural protection of groundwater against hydro-climatic disasters. Finally, the TVR for floods and the TVR for droughts have been combined. The resulting categories of vulnerability are depicted on the map in different colours.

The map is the result of a joint effort of the projects "Groundwater for Emergency Situations" (GWES) and the "World-wide Hydrogeological Mapping and Assessment Programme" (WHYMAP). GWES is a UNESCO International Hydrogeological Programme (IHP) project aiming at providing best practices and guidelines to identify and adequately manage potentially safe groundwater resources with low vulnerability that could be used in emergency situations due to extreme events (natural and man-induced) that adversely impact human health and life. WHYMAP aims at collecting, compiling and visualising hydrogeological information at a global scale, to convey groundwater related data in an appropriate way for the global discussion on water issues and to give recognition to invisible underground water resources. WHYMAP is a programme of a consortium including the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Commission for the Geological Map of the World (CGMW), the International Association of Hydrogeologists (IAH), the International Atomic Energy Agency (IAEA) and the German Bundesanstalt für Geowissenschaften und Rohstoffe (BGR).

Detailed information and the full scheme of vulnerability classification are provided in the corresponding explanatory notes.
See also: www.whymap.org

Categories of groundwater vulnerability specified as Total Vulnerability Range (TVR)

Groundwater of low vulnerability	< 40
Groundwater of moderate vulnerability	40 - 60
Groundwater of high vulnerability	> 60

The TVR is determined by combining individual parameters (weight multiplied by rating index) according to a classification scheme discussed in detail in the explanatory notes.

The Total Vulnerability Range is composed of:

Parameters of groundwater vulnerability

Type of aquifers (weight 5)
Groundwater recharge (weight 3)

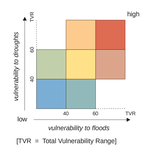
Rating scale of the type of aquifers (1 - 10)

10	Aquifers in carbonate rocks (often karstified)
10	Aquifers in fluvial deposits of large rivers
8	Local and shallow aquifers
5	Aquifers in complex hydrogeological structures
2	Aquifers in major groundwater basins
1	Aquifers with non-renewable groundwater

Rating scale of groundwater recharge

for floods	for droughts
3 < 20 mm/year	9
6 20 - 100 mm/year	6
9 > 100 mm/year	3

Groundwater vulnerability



[TVR = Total Vulnerability Range]

Groundwater recharge

- < 20 mm/year
- 20 - 100 mm/year
- > 100 mm/year

Coastal area mostly with aquifers highly vulnerable to tsunami hazards

- wave hight > 5 m
- wave hight 2 - 5 m

Area of saline groundwater

- > 5 g/l total dissolved solids (TDS)

Geography and surface water

- selected city
- country boundary
- major river
- large freshwater lake
- large saltwater lake
- continuous ice sheet

Disclaimer

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under the auspices of UNESCO IHP and BGR

Topographic base map

UN (2011): Cartographic Data; ESRI (2012): Data & Maps; GRDC (2012): Rivers & Lakes
modified by BGR (2013)

Map projection

Robinson projection, longitude of central meridian 11°E, spheroid WGS84, geographic coordinates

GLOBAL GROUNDWATER VULNERABILITY TO FLOODS AND DROUGHTS

1 : 25 000 000

extracted from:
World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP) www.whymap.org