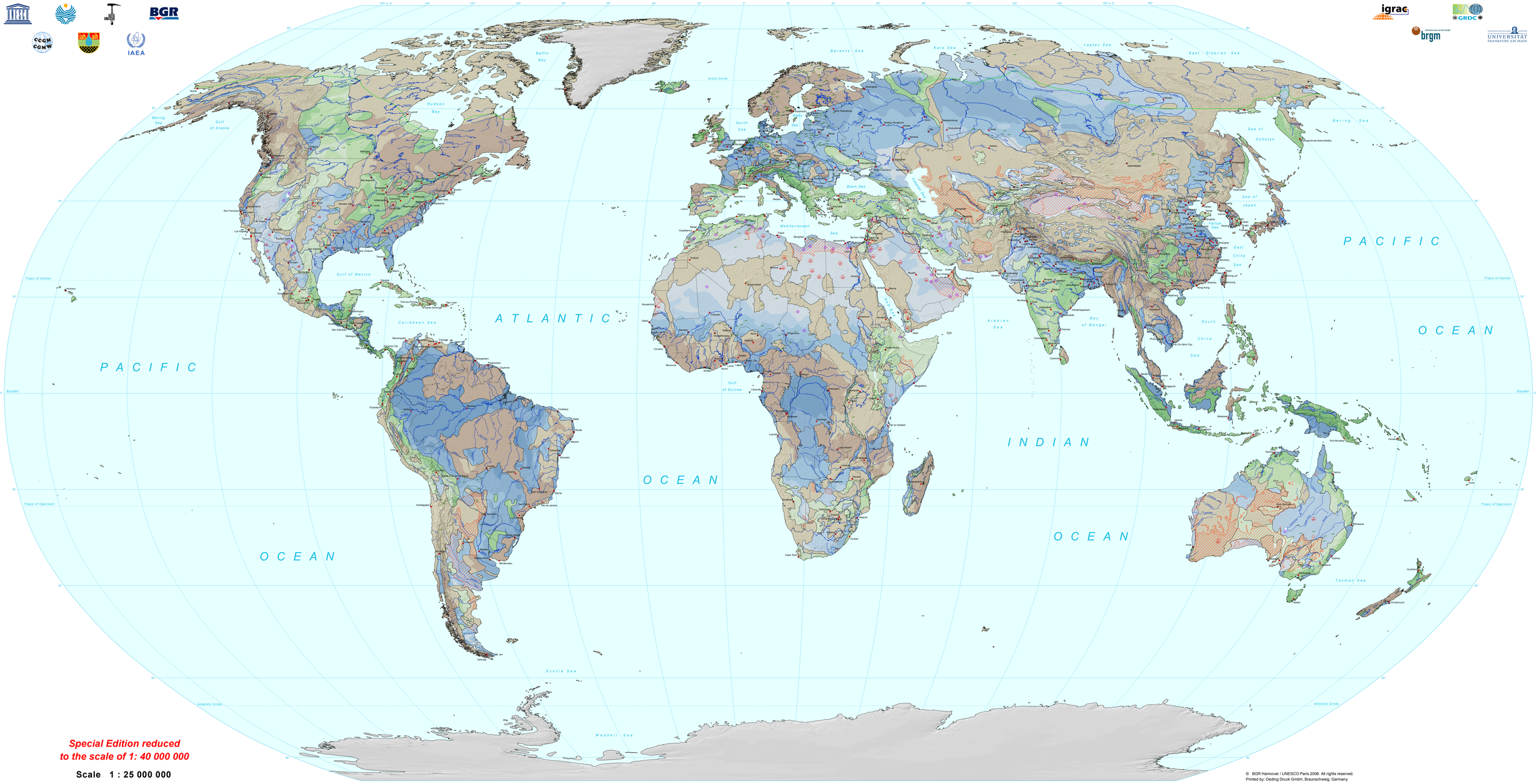
Groundwater Resources of the World

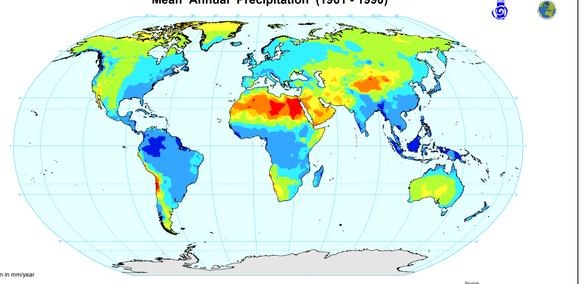


Special Edition reduced to the scale of 1: 40 000 000

Scale 1 : 25 000 000

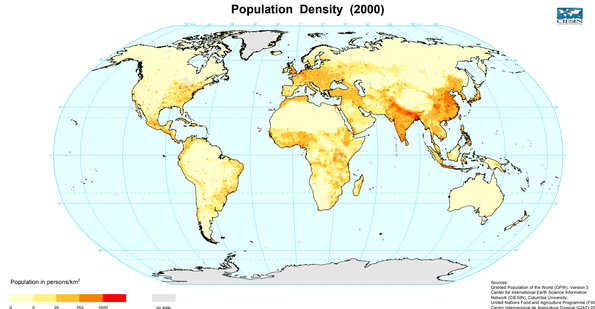
Printed by: Oeding Druck GmbH, Braunschweig, Germany

Mean Annual Precipitation (1961 - 1990)



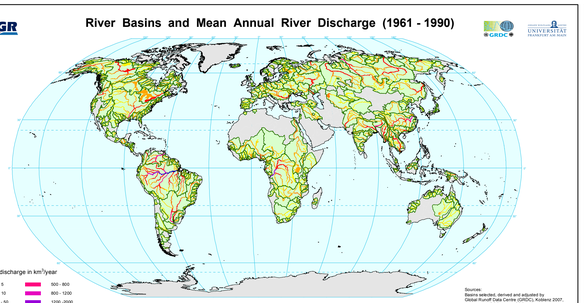
Source:
Gridded Precipitation Normals Data Set,
Global Precipitation Climatology Centre (GPCC),
Offenbach 2007

Population Density (2000)



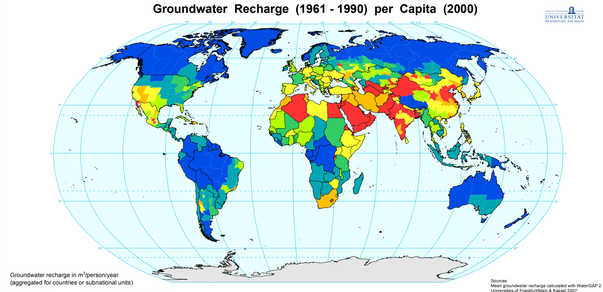
Sources:
Gridded Population of the World (GPW), Version 3
Center for International Earth Science Information Network (CIESIN), Columbia University
United Nations Food and Agriculture Programme (FAO) & Centre International de Agricultura Tropical (CIAT) 2005

River Basins and Mean Annual River Discharge (1961 - 1990)



Sources:
Data collected, derived and adjusted by
Global Runoff Data Centre (GRDC), Koblenz 2007,
based on HYDRO1K by USGS;
Mean river discharge calculated with WaterGAP 2.1,
Universities of Frankfurt/Main and Kassel 2007;
Rivers and lakes by GRDC & WHYMAP 2007

Groundwater Recharge (1961 - 1990) per Capita (2000)



Sources:
Mean groundwater recharge calculated with WaterGAP 2.1,
Universities of Frankfurt/Main & Kassel 2007;
Population data based on GPW - Version 3,
Center for International Earth Science Information Network (CIESIN) 2005

WHYMAP and the Groundwater Resources Map of the World 1 : 25 000 000

Within the past decades the interest in groundwater has increased considerably due to water shortage problems on local, regional and even global levels. In order to support the sustainable management of groundwater resources, it is necessary to map, model and quantify the stored volume and the average annual replenishment, and to determine the chemical quality of groundwater. Therefore, the World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP) was created in 1999 as a contribution to the world-wide efforts to improve the management of the earth's water resources including groundwater.
WHYMAP is a joint programme of 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 Federal Institute for Geosciences and Natural Resources (BGR).
It aims at collecting, compiling and visualising hydrogeological information at a global scale, to convey groundwater related information in an appropriate way for the global discussion on water issues and to give recognition to invisible underground water resources. WHYMAP brings together the huge efforts in hydrogeological mapping, at regional, national and continental levels. BGR, together with the partners above, is gradually building up a geographic information system (WHYMAP GIS) in which the groundwater data are managed and visualised.

This Groundwater Resources Map of the World at the scale of 1 : 25 000 000 is a result of WHYMAP and combines the related data known or published so far. It shows various characteristic groundwater environments in their areal extent: blue colour is used for large and rather uniform groundwater basins (aquifers and aquifer systems usually in large sedimentary basins that may offer good conditions for groundwater exploitation), green colour areas have complex hydrogeological structure (with highly productive aquifers in heterogeneous folded or faulted regions in close vicinity to non-aquifers), and brown colour symbolises regions with limited groundwater resources in local and shallow aquifers.
Within the three main hydrogeological units up to five different categories are defined according to their modelled recharge rates from over 300 mm to less than 2 mm per year. Dark colours (dark blue, green and brown) represent areas with very high recharge rates while light blue, green and brown colours outline regions with very low recharge potential. The latter category is vulnerable to groundwater mining. Groundwater recharge rates refer to the period 1961 - 1990 and are derived from simulations with the global hydrological model WaterGAP, version 2.1f, provided by the University of Frankfurt/Main, Germany (Doell et al., 2006).
Aspects of hydrodynamic conditions are addressed by outlining areas of groundwater discharge in arid zones (e.g. endorheic basins or "chotts" and "sebkhas").

Groundwater resources frequently sustain important wetland ecosystems. Therefore, wetlands with a surface larger than 500 hectares which are supposed to be groundwater related have been abstracted from the existing data base listing wetlands according to the RAMSAR convention (www.wetlands.org/rsis).
Rising demands from population growth and food production are calling for a closer look at the use of groundwater. Therefore, known areas of heavy groundwater abstraction prone to over-exploitation and areas of groundwater mining are mapped. Cities shown on the map (mostly those with a population estimated at more than 1 million inhabitants in 2005 according to the United Nations Department of Economics and Social Affairs) known to have at least 25 % of the total water consumption supplied by groundwater have been identified by a special symbol.
Groundwater quality is an important issue for the use of groundwater such as drinking water supply and irrigated food production. Areas where salinity of groundwater regionally exceeds 5 g/l are highlighted by orange hatching.

The global Groundwater Resources Map contains only selected information related to groundwater. For reasons of clarity and readability important complementary information has been deferred to a set of four insert maps at the scale of 1 : 120 000 000 (see left). These thematic maps highlight the issues of "Mean Annual Precipitation", "River Basins and Mean Annual River Discharge", "Population Density" and "Groundwater Recharge per Capita".
Comparison between the main Groundwater Resources Map and the four thematic small-scale maps should help to understand the global picture of groundwater and surface water resources and provide insight into their pressures, in particular the priority use for drinking purposes. Essential geographic differences are revealed over the globe in the distribution and amount of rainfall, the most important input factor for both, surface water flow and groundwater replenishment. The latter is mirrored in the main map by various colour shades. The rainfall map is based on data from the Global Precipitation and Climate Centre (GPCC) in Offenbach, Germany. To highlight the surface water situation, a map of major active water basins (surface water catchment areas) has been provided by the Global Runoff Data Centre (GRDC) in Koblenz, Germany. In addition, the surface water courses and lakes have been classified according to their mean annual discharge. This picture complements with the main map, particularly in the dry regions of the world, where no surface water is available but luckily some of the biggest aquifer systems are located. Population density also varies largely on earth and is a key factor for the broad variation of water demand on the continents. This information combined with the amount of groundwater recharge modelled by Doell et al. (2006) provides categories of mean annual groundwater recharge per capita. On this map, large countries have been subdivided into individual sub-regions or states, if this was appropriate or known, to highlight the regional variation.
Further information will be provided in a corresponding explanatory booklet to be published soon.
See also: www.whymap.org

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Cartographical editing / GIS

BGR — Uta Philipp, Andrea Richts

Topographic base map

CGMW / UNESCO (2000):	Geological Map of the World 1 : 25 000 000, 2nd edition
UN (2006):	Cartographic Data
ESRI (2006):	Data & Maps
USGS (2003):	Global GIS
GRDC (2007):	Rivers & Lakes

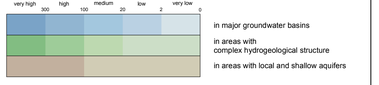
modified by BGR (2007/2008)

Map projection

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

Legend

Groundwater resources and recharge (mm/year)



Special groundwater features

- area of saline groundwater (> 5 g/l total dissolved solids (TDS))
- natural groundwater discharge area in arid regions
- area of heavy groundwater abstraction with over-exploitation
- area of groundwater mining
- selected wetland, mostly groundwater related

Surface water

- major river
- large freshwater lake
- large saltwater lake
- continuous ice sheet

Geography and Climate

- selected city
- selected city, partly dependent on groundwater
- country boundary
- boundary of continuous permafrost

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extracted from:
World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP)

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