Groundwater resources sustainability indicators

IHP Contribution to the WWDR

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Groundwater, the hidden part of the hydrological cycle

- Groundwater has to be seen within the broader context of the hydrological cycle and aquifers as a significant hydrological component of watesheds and river basins
- Groundwater should be integrated within the context of broader economy and social dimensions, particular that related to its use and related consequences
- In nature groundwater is a key element in many geological and hydrochemical processes, geotechnical factor conditioning soil and rock behaviour and a component which sustains spring discharge,river basin flow and lakes and wetlands

IHP VI Project: Groundwater resources sustainability indicators

- **International Hydrological Programme – VI**
  Theme 1: Global changes and water resources
  Activity 1: Global estimation of resources:Water supply and quality
- **Objective:** To develop improved techniques, **indicators** and data bases for integrated global water resources assessment
- **Project:** Groundwater resources sustainability indicators
- **Project implementation:** UNESCO / IAEA / IAH Working Group, from 2002 to 2005

Indicators mark the way
WWDR I - Chapter 3

- An Indicator can be a simple data point or variable, or can be a simplified value derived using a complex mathematical algorithm
- Indicators are used to simplify, quatify, communicate and create order within complex data
- Indicators can be either descriptive or normative and indicate qualitative and quantitative information
- Indicators effective use can reduce the total number of measurements and sampling parameters required to assess the state of water resources
- Indicators must be transparent, testable and scientifically sound

Objectives of indicators use

- **Descriptive**:desribing the state of the resource (e.g. water demand and water supply on a country or global level)
- **Showing trends**: regular measurement of indicators provides time series, which can show trends (e.g.long term trends in groundwater quality, nitrate pollution)
- **Communication**: an instrument to communicate policy objectives and decisions to the public (e.g to ilustrate impact of fluoride high content in drinking water on the population health)
  Assessment: an indicator value can be compared to a reference condition that represent the state (e.g. soil quality and thickness and lithology of the unsaturated zone can be a reference to assess aquifer vulnerability)
- **Predicting the future**: a time series can be extended into an estimated future (e.g drinking water demand)

Data availability

- Limitation of data was labeled as one of the most critical problem in groundwater indicators formulation
- Data availability drives the selection of indicators, which, in turn, reinforces monitoring and collection of the same data and leads to more efficient design and operation of monitoring networks and programmes
- The task should rely on the existing data with a philosophy of starting small and building on them
- It may not be feasible to calculate the indicator if the cost of data collection outweight the total indicator benefits (cost-benefit analysis)

Scale - an important aspect in indicators development

- Indicators developed for a certain spatial scale (local, national, global) may not be useful for another scale
- Selection of the optimal scale to aggregate and present the values of the indicator depends on the information need and mode of indicator presentation
- Scale is linked to the issue of boundaries; dicrepancies between natural and administrative boundaries make difficulties in indicator implementation

Problems of indicators mis-iterpretation

- The aggregation of variables and indicators into the index involves various steps of data selection, scaling, valuation and aggregation across different measurement units and the result is dimensionless,
- Inadequate definition of the indicator owing to implementation of the subjective elements because of data scarcity
- Problems in the process of data aggregation
- Use of unreliable data

DPSIR concept

- **Driving force** indicator – driving forces of water use (agricultural development)
- **Pressure** indicator– human activities exert pressure on water (N-load on farms)
- **State** indicator– pressure causes a quality/quantity change in the state of water (nitrate in groundwater)
- **Impact** indicator– describe the effects of the pressure (nitrate in drinking water)
- **Response** indicator – social response to the changes, which are reflected in environmental policy (control of manure/fertiliser production and use)

Groundwater indicators development

- Simple indicators have been chosen to begin the process based on sound scientific understanding
- Proposed groundwater indicators are based on measurable data, provide information about the present status and trends in groundwater quantity, quality and vulnerability to human and natural impacts and are focused on social, economic and environmental aspects of groundwater resources planning, policy and management
- Groundwater indicators are based on a single data (variable) or an output value from a set of data (aggregation of variables). Some indicators are lumped together into an index. Weighting and rating methods are applied to index construction.

Proposed Groundwater Indicators

- are scientifically robust and policy relevant
- provide quantitative and qualitative information about the present status, trends and impacts on groundwater system
- support sustainable management and environmentally sound protection of groundwater resources
- groundwater indicators formulation is affected by uncertainty, which is inherent in all indicators development process

Proposed groundwater indicators

- **Groundwater renewable resources per capita** (m3/y/in)
- **Total GW abstraction / GW recharge** x100%
- **Total GW abstraction / Exploitable GW resources** x 100%
- **Ground water as a percentage of total use of drinking water on country level**
- **Total non-renewable GW resouces (m^3) / Annual abstraction of non-renevable GW resources (m^3/y)**

Proposed groundwater indicators

- **Groundwater depletion indicator-** based on GW level decline, base flow change, change of GW characteristics (age and origin), subsidence
- **Groundwater vulnerability indicator** – based on soil permeability and unsaturated zone lithology and thickness
- **Groundwater quality indicator -** informs about the present status and trends in groundwater quality with respect to drinking water standards, irrigation requirements and other uses
- **Groundwater treatment requirements** (three categories of tratment are applied: without, simple,tchnologically demanding)
- **Dependence of agricultural population on groundwater** – number of farmers dependence on groundwater for agricultural activities / total population of the country

Case studies

- **Proposed groundwater case studies:**

- **Spain (aquifer level),**
- **Nubian Aquifer (transboundary aquifer level),**
- **Republic of South Africa, Finland (national level)**