GRAPHIC Symposium – Kyoto April 4-6, 2006

The Groundwater Resources Assessment under the Pressures of Humanity and Climate Changes (GRAPHIC) Project, an initiative of UNESCO International Hydrological Programme (IHP), seeks to improve the understanding and management of groundwater as a vital contributor to the global water cycle, ecosystems and communities, under changing climatic and anthropomorphic regimes. GRAPIC focuses on variations of the flows, stocks, and quality of groundwater recharge, discharge and storage and on groundwater-related management and policy.

The Kyoto Graphic Symposium was convened to report on studies of groundwater from throughout the world under a range of climate and human pressures and to develop potential projects to be pursued under the GRAPHIC Project. Researchers from Japan, China, the US, England, the Netherlands, Nigeria, India, Israel, Spain, South Africa, Sudan and Australia attended the Symposium. The final day of the Symposium was spent summarizing the lesson emerging from the Symposium and in proposing projects to be carried out under GRAPHIC.

Day 3 Summary of Discussion and Conclusions

1. Lessons from the Symposium

1.1 recharge change due to **climate** variability/change

- We may be able to use borehole temperature for reconstruction of recharge (vertical groundwater flow rate) (Makoto)
- Spatial scaling is the key for evaluating recharge change due to climate variability (Tim)
- Uncertainty of recharge (using hydrograph separation)
- Different methods appropriate in different settings and for different time scales
- Some shallow groundwater systems are tightly coupled to oceanic-drivers of climate variability.

1.2 recharge change due to **human** impact

- Seasonal difference of recharge change due to land cover change (Henk)
- Annual differences due to crop cover change (Ian White)

1.3 discharge change due to **climate** variability

- SGD spring drying (Kevin Hiscock)

- shallow groundwater systems coupled to oceanic-drivers of variability (Ian White0

1.4 discharge change due to **human** impacts

- low flows; declining water tables = lower production from wells (Bret Bruce); regional differences High Plains Aquifer (Jason Gurdak) Lake Biwa deforestation effect (Jens Hartmann)

1.5 storage change due to **climate** variability

- climate variability signals (such as ENSO) can be extracted from storage change time series on decadal scale , monitoring (Jason)
- GRACE is useful tool for evaluation of global groundwater storage change, however, we need specific models (for vapor, soil moisture,,,,) and higher special resolution of signals and filters for basin scale and ground truthing (Fukuda)
- Change in fresh-water lens storage in island settings (Kudo, Ian White)

1.6 storage change due to **human** impacts

- regulation of pumping due to subsidence caused buoyancy effect for subsurface structure (subway station) in Big cities (such as Tokyo/London) (Makoto, Tokunaga)
- overpumping Limpopo basin (Ola Busari) Mongolia/Ulanbator (Maki Tsujimura), land subsidence Jakarta (Loebis), and the north China plain.

1.6 quality change due to **climate** variability

- Subsurface temp. change (during 4 years) reached 40 m deep in Tokyo due to surface warming (global warming and heat island) (Sakura)
- The effect on biogeochemistry and redox conditions are unknown (Naganuma)
- Flushing of natural vadoze zone stores to the water table in arid environments (Bruce)
- Salinity increases due to climate variability / rising sea level (White)
- Weathering processes change?

1.7 quality change due to **human** impacts

- Land use change impacts / anthropogenic inputs/ agriculture/ mining / water use change associated with urbanization

1.8 management for **climate** variability

- Long-term monitoring and analysis; long-term perspective; adaptation measures; capacity building; modeling incorporating uncertainty

1.9 management for **human** impacts

- community involvement; capacity building; regulation and policy;

- every groundwater resource is a transboundary issue because of individual perspectives; legal frameworks and international aid adjusted to culture/local customs;
- groundwater governance needs to based on groundwater basins rather than surface water catchments

2 Proposed Pilot Studies under the GRAPHIC Project

2.1 Selection of GRAPHIC Pilot Studies

The Criteria for selection of projects will be defined by the GRAPHIC group of experts who will be responsible for the case studies to be selected. However the Symposium believed that it was useful to propose some working criteria. It was proposed that projects should have:

1. The potential to disaggregate climate and human effects.
2. Be Geographical representative
3. Represent a range of climate conditions
4. Have stressed aquifers (urban / agricultural)
5. Have dependent human populations
6. Permit lessons to be transferable

Potential cases studies were discusses in terms of their geographical representativity:

2. 2 Asia and the Pacific:

- Tokyo basin (urbanization; good dataset; SGD; quality + quantity issues; policy issues, part of existing project(RIHN)) (Taniguchi; RIHN)
- Atolls/small islands: got it all: large geographic distribution; coastal aquifers; highly variable climate conditions; highly stressed, agriculture and urban; social factors and governance important, highly groundwater dependent populations (Ian White; ANU)
- China: north shortage problem; south water quality problems (Chen; Sun-Yat Sen Univ.)
- Mongolia: alluvial deposits; semi-arid; stressed by urbanization; overgrazing affects recharge; climate change apparent (Maki; Tsukuba Univ.)

2.3 Americas:

- High Plains Aquifer (agriculturally stressed; climatic impact uncertain; data available; already lessons learned; semi-arid; quantity + quality; existing people network/expertise; part of existing project (NAWQA) aimed at water quality on a national (US) basis; future: coupled groundwater, unsaturated zone, climate, economic models; technology transfer; establishment of data bases; test case for appropriate methods of data use/aggregation) (Jason Gurdak; USGS)

2.4 Africa:

- South Africa; different climates; non-perennial river flows; agriculturally stressed; expanding domestic requirements; mining impacts; bedrock aquifers lessons learned (Mutsa; Int. Wat. Man. Inst.)
- Uganda (urbanization; water quality….) (Richard Taylor; UCL, UK)
- Sudan (arid zone, highly variable climate conditions; highly stressed, agriculture and urban) (Hiyama, Nagoya Univ.)

2.5 Europe:

- UK (SE England; chalk aquifer sensitive/vulnerable) (Kevin Hiscock; UEA)
- Iberia (Guardiana river; major human development over last decades; climate change major issue; long-distance water transfers discussed; desertification; political issues; wetlands supported by groundwater) (Fornes; IGME; Kooi, VU)
- Middle East: Israel (Arie Issar)

3. Special issue on GRAPHIC of Vadose Zone Journal

To date 14 potential papers have been nominated to the special issue. Tim Green and Makoto will guest-edit these papers which will go through the full editing procedure. The papers will have a groundwater focus but will beed to mention the vadose zone. Tim is going to ask other specialists related to GRAPHIC to submit the papers.

4. Database and monitoring

Necessary monitoring requirements (variables, parameters and aggregated data)

- Time series Climate (Temperature, Precipitation, Pan Evaporation or solar rasiatio, wind speed and humidity)
- Time series piezometric heads, water levels prefereably at different locations and depths.
- Time series abstractions and discharges.
- Time series water quality

Global Hydrogeological basemap → IGRAC
Pilot studies → scientific database
Global map of aquifer depression

Global map of index of **stressed aquifers**

Recharge: baseflow?
Discharge: baseflow?
Storage: water level
Quality: ?? (salinity, EC, ,,)
Management: ???

Stress (sustainability) indexes:
Abstraction/recharge, **water demand/ water resources**

- Up scaling of local knowledge
- Development of people networks