BRIEFING / 2.6

June 2013

Jordan River

GLOWA

Projecting water availability within the Western Aquifer Basin: WEAP-MODFLOW Coupling

Key findings

- The aquifer's inflow is dominated by rainfall over the replenishment areas with an annual average of 373 MCM/yr during the period 1951-2007.
- The annual recharge is directly correlated with monthly rainfall, where the largest recharge occurred whenever the most annual rainfall is received between November and February.
- Under current climate conditions, two pumping scenarios could be considered:
  - 85% of the aquifer yield (Constant pumping: 310 MCM/yr).
  - 85% of the (7-year) moving average of the estimated recharge (Avg. 328 MCM/yr)
- Under climate change and reduced recharge conditions, two actions could be taken:
  - Immediate Action: reducing the average pumping rate to 221 MCM/yr.
  - Stepwise Action: limiting the pumping rate to the 7-year moving average (average pumping rate: 254 MCM/yr).

Overview and Objectives

Groundwater is one of the main sources of fresh water in the Middle East, with millions of cubic meters of water pumped from aquifers each year. The annual abstraction rates are increasing constantly in order to meet the rising demand, driven by an increasing population (Briefing 2.2) and climate change (Briefing 1.3). As a result of these variables, over-pumping may occur, leading to unsustainable resource use. In order to inform management approaches, we quantified such effects for trans-boundary groundwater, namely the Western Aquifer Basin (WAB), using the Water Evaluation and Planning tool (WEAP, Briefing 2.1) coupled to the groundwater model MODFLOW.

Research Methods

The WAB stretches across the West Bank and Israel, covering an area of 9000 km^2 (Figure 1). It is a highly karstic aquifer with a general thickness ranging from

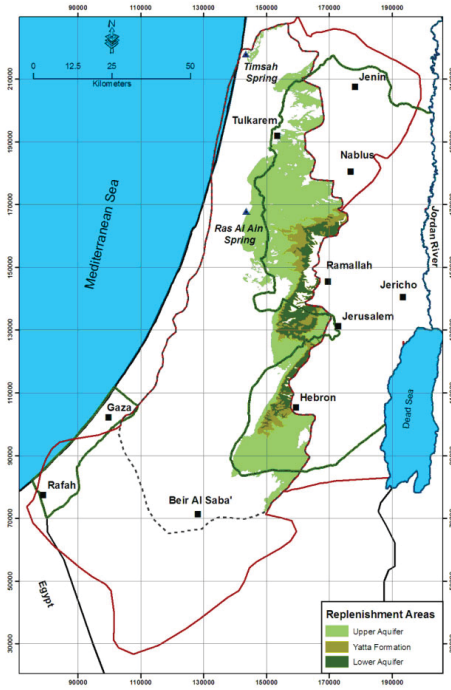

Figure 1: Location and extension of the Western Aquifer Basin (WAB, in green).

Teams of researchers from Germany, Israel, Jordan and the Palestinian Authority work on how best the hazards posed by global change to the future of the Jordan River basin can be faced and overcome.

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The GLOWA Jordan River project is part of a larger research initiative launched by the German Federal Ministry of Education and Research under the title "Global Change and the Hydrological Cycle".

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600m to 1000m (Abusaada 2011). All three lithological layers of the aquifer were considered in the model: the upper and lower permeable layer and the separation layer of lower permeability. The WAB was simulated using MODFLOW-2000 with a grid size of 150-750m. The period 1951-2000 was used for calibrating the model and 2000-2007 for model validation. The modelled period (56 years) was used to study the flow dynamics of the WAB and its response to different hydrological and management scenarios.

I. WEAP-MODFLOW coupling

Due to the complexity of both the natural and man-made systems of the WAB, the MODFLOW model was extended to represent the management period 2010–2035 and then linked with WEAP. This coupled WEAP-MODFLOW approach was used to assess different climate, pumping and management scenarios in eight management zones of the WAB (Figure 2). For each zone, demand, groundwater and catchment nodes were defined. The recharge quantities for each climate scenario were estimated based on an empirical equation (Abusaada 2011) and then entered to WEAP as "Natural Recharge" values. The actual demands were replaced by defining the "Maximum Withdrawal" according to the aquifer safe yields under different climate scenarios.

II. Management Options

In total, 24 management options were developed as a combination of the three types of scenarios:

1) Pumping Scenarios:

- 85% of a seven-year moving average of the estimated annual recharge
- 85% of the aquifer yield
- Pumping according to annual rainfall amount

2) Rainfall Scenarios:

- No climate change: historical rainfall data was replicated. Accordingly, the average annual rainfall was estimated at 570 mm/yr with an average estimated annual recharge of 386 MCM/yr.
- Climate Change: data was obtained from the climate model (Krichak & Alpert 2012). The average annual rainfall was estimated at 450 mm/yr with an average estimated annual recharge of 277 MCM/yr.

3) Management Scenario:
Use storm water generated in the main Western watersheds for artificial recharge (Abusaada 2011).

Conclusions

The coupled WEAP-MODFLOW model recommended two pumping scenarios to maintain the water level and the aquifers ability to continue discharging. These scenarios are (a) pumping 85% of the historical aquifer yield under the no change in rainfall scenario (i.e. 310 MCM/yr) and (b) 85% of the 7 year moving average of the aquifer recharge (254 MCM/yr) under the possible reduction in rainfall as expected by regional climate model.

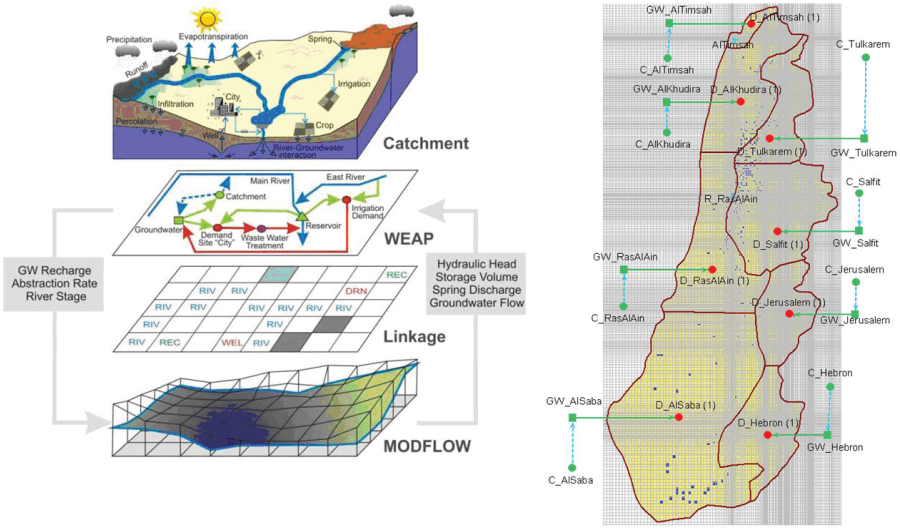

Figure 2: Schematic diagram of WEAP-MODFLOW coupling and the WAB management zones used in this study

References

Abusaada, M. (2011). PhD Thesis: Flow Dynamics and Management Options in a Stressed Carbonate Aquifer System, The Western Aquifer Basin, Applied Geosciences Department, Gottingen University.

Krichak S. O. and Alpert P. (2010): Projection of climate change during the first half of twenty-first century over the Eastern Mediterranean region according to results of a transient RCM experiment with 25 km resolution. Geophysical Research Abstracts, EGU2010.

GLOWA JR Briefings present relevant scientific results of the GLOWA Jordan River project concerning the effects of climate and global change in the Jordan River basin.

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