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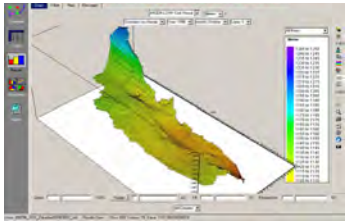
Arab-German Cooperation: Management, Protection and Sustainable Use of Groundwater and Soil Resources in the Arab Region

A Decision Support System for Integrated Water Resources Management

WEAP · MODFLOW by SEI

Background

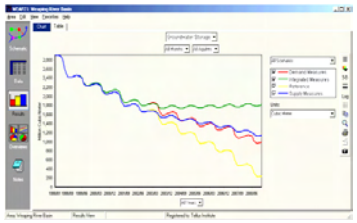
Water Resources are very scarce in the Arab region. Recent climate change models predict for the future years even more severe conditions, due to increasing temperatures and decreasing precipitation.



Therefore it is important that water resources are managed carefully in a sustainable way following the Integrated Water Resources Management (IWRM) concept. This is a very difficult task and reliable tools are needed to support the management and planning.

In most countries of the region the key problem is the limited knowledge of the hydrological system and thus the water resources are not well evaluated. The impact of the limited knowledge and management of the resources is often overexploitation and water quality deterioration.

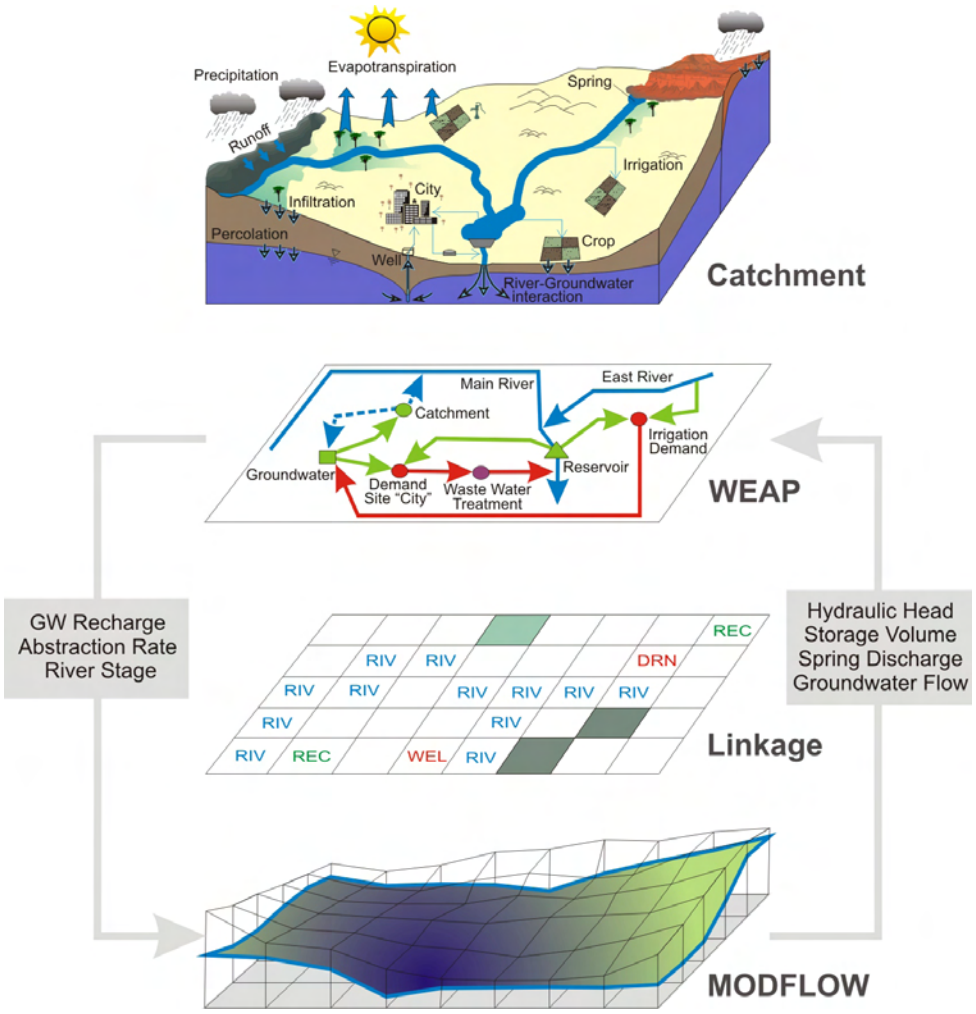
ACSAD, BGR and SEI have jointly improved and applied such an IWRM-tool by combining WEAP www.weap21.org and MODFLOW2000 **water.usgs.gov/nrp/gwsoftware/modflow.html**. Various additional institutions, researchers and projects have also been improving WEAP further on since its initial creation by SEI in 1988. A growing number of water professionals are finding WEAP to be a useful addition to their toolbox of models, databases, spreadsheets and other software.



The philosophy of SEI is to always keep the software license free of charge to any non-profit, governmental or academic organization in a developing country.

THE DSS-Concept

The basic principle of WEAP is water balance accounting. That means that the user can simulate by WEAP all the processes in the hydrological cycle. WEAP is comprehensive, straightforward and easy-to-use, and attempts to assist rather than substitute for the skilled planner. As a database, WEAP provides a system for maintaining and updating water demand and supply information. As a forecasting tool, WEAP simulates water demand, supply, runoff, stream flows, storage, pollution generation, treatment and discharge, and instream water quality. As a policy analysis tool, WEAP evaluates a full range of water development and management options, and takes account of multiple and competing uses of water resources.



Applications

The technical cooperation project „Management Protection and Sustainable Use of Soil and Water Resources in the Arab Region“ is committed to disseminate and further improve WEAP as a Water Management Planning Tool in the region (www.bgr.bund.de/IWRM-DSS).

By the project activities several applications have been initiated in the Arab Region:

Country	Region/ Aquifer	Institution
JORDAN	Corridor Well Field Azraq Basin	Ministry for Water and Irrigation, Amman Ministry for Water and Irrigation, Amman
MOROCCO	Berrechid Haouz	ABH Bouregreg - Ben Slimane ABH Tensift, Marrakech
PALESTINE	Eocene Aquifer Western Aquifer Basin	Al Najah University, Nablus Palestinian Hydrology Group, Ramallah
SYRIA	Zabadani Aleppo	ACSAD/ DAWSSA Damascus Ministry for Irrigation, Syria
TUNISIA	Zeuss Koutine Kairouan	INAT, Tunis INAT, Tunis
LEBANON	Jeita Spring	Water Establishment Beirut and Mount Lebanon (WEBML)

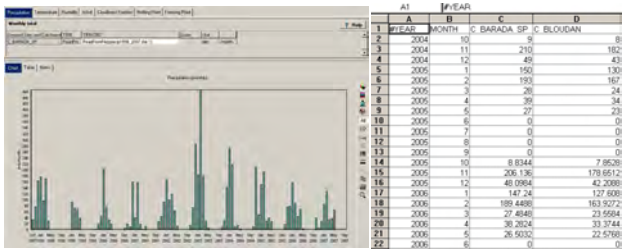
The Jordanian Ministry of Water and Irrigation has decided to use WEAP for its national water planning. As a pilot basin the Amman-Zarqa basin is currently under work.

On overview of past and current SEI projects as well as several publications can be found under www.weap21.org:

Data Managment

An intuitive GIS-based graphical interface provides a simple yet powerful means for constructing, viewing and modifying the configuration—the user designs a schematic of the water system using the mouse to “drag and drop” system elements, overlaid on standard GIS vector or raster layers. Data for any component can be edited directly by clicking it on the schematic. Wizards, prompts and error messages provide advice throughout the program. Spreadsheet data can be read in via the csv-format directly and as output graphic data, all input and result data can be exported back to csv- or Excel files. Own variables can be defined and through the expression builder either built in functions or own formulas can be created and related to WEAP variables.

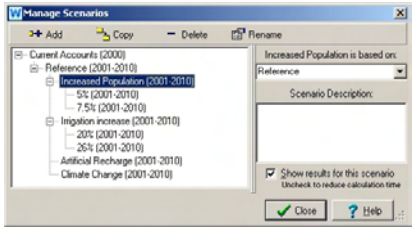
Data update is an important issue, in WEAP models can be easily updated by simply updating respective input data tables, e.g. adding respective data lines in the spread sheet table (data format: year, timestep, value).



Through WEAP’s Applied Programming Interface (API), WEAP can be run and data imported or exported remotely controlled by code only or out of another application.

Scenarios

Scenario analysis is central to WEAP. Scenarios are used to explore the impacts with a wide range of questions, e.g. :



- What if demographic or economic patterns change?
- What if water conservation is introduced?
- What if ecosystem requirements are tightened?
- What if the mix of agricultural crops changes?
- What if irrigation efficiency is improved?
- What if groundwater is more fully exploited?
- What if reservoir operating rules are altered?
- What if climate change alters demand and supplies?
- How does pollution affect water quality?
- How will land use changes affect runoff?

	MODFLOW2000 Groundwater flow	**WEAP** Water management and planning
Calculation and tools	Level Storage River interaction Discharge at springs	Groundwater recharge Irrigation demand Surface runoff Detailed water balances for defined spatial planning units Remote control to MODFLOW
Resolution	As model grid	Catchment, land use class, grid
Input	3D geometry of the aquifer Permeabilities, Storativity Boundary conditions, initial head, GW abstraction	Climate data Water demand data Soil and crop data Planning scenario setup
License	Open source	Free to all Arab and developing country government and research institutions

As most countries in the Arab region rely mainly on groundwater it is necessary to simulate respective groundwater balances and their spatial impacts.

Standalone WEAP simulates an aquifer as a simple tank or a simple wedge along a river valley. The MODFLOW2000 code is internationally the most widely used one in groundwater modeling. Additionally it is open source and can be linked to WEAP to simulate more accurate the prevailing groundwater system.

Supported MODFLOW packages: BAS6, BCF6, CHD, DIS, DRN, HUF2, LPF, NAM, OC, RCH, RIV, WEL

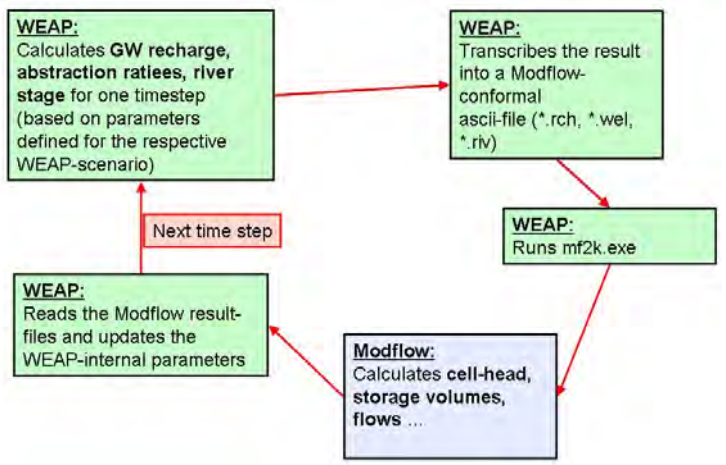
If a MODFLOW2000-model is linked:

- River-groundwater interactions can be simulated (RIV-package)
- Spring discharges can be simulated (DRN-package)
- Detailed information on storage, flow and head are available for each model cell and layer.
- Well field and artificial recharge impacts can be simulated and management constraints regarding the maximum groundwater drawdown/ raise can be defined.

Link

The link is done through a GIS-shapefile containing one polygon for each MODFLOW grid cell. A helper tool (Modflow2Weap) to establish the link and assigning respective data is freely available for download at:

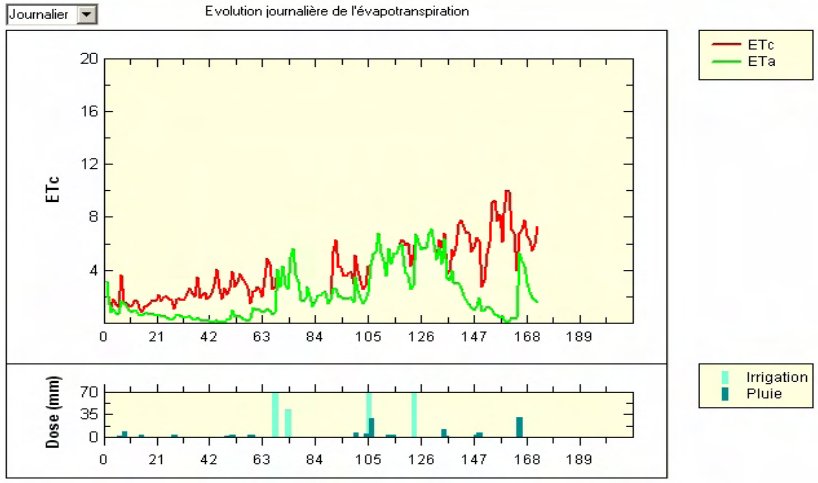
(www.acsad-bgr.org, www.weap21.org).



WEAP internal models

WEAP is a tool to simulate the whole hydrological cycle, evapotranspiration, surface runoff, groundwater recharge and irrigation demand. In many countries monitoring of these data is limited and therefore a reasonable estimate or model is needed. Optional either own models can be used or built in ones:

- **Hard Data entry:** in WEAP it is possible to enter all data directly or use the output of external models as input variables. Via the expression builder in WEAP also local empirical formulas (e.g. infiltration coefficient, runoff coefficient,…) can be entered and utilized for respective calculations.
- **FAO-irrigation demand only:** only the irrigation demand is modeled by WEAP based mainly on precipitation, reference evapotranspiration and crop coefficient.
- **FAO-Rainfall-Runoff:** same like above, however additionally surface runoff and groundwater recharge are modeled.
- **Soil Moisture Method:** lumped parameter model considering also the soil compartment. Detailed climate input data area required, soil and crop data need to be calibrated by the user. Regarding irrigation scheduling the user can define the threshold values of soil moisture content.
- **MABIA-Method:** Soil water balance model running on daily time steps, based on the FAO-56 dual crop coefficient approach. Real world field or FAO-reference parameters can be used for the water balance calculation. User defined irrigation scheduling is possible.



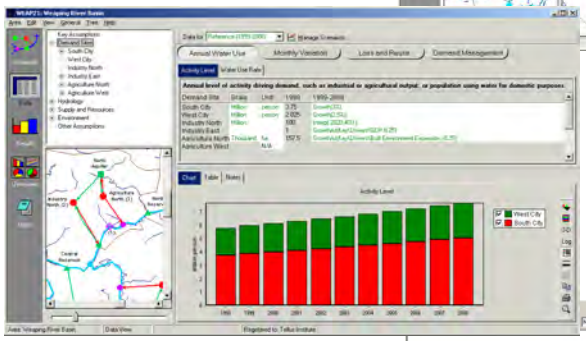
In addition a built in linear programming optimization algorithm maximizes the satisfaction of all entered constraints (demand, supply, reservoir filling priorities, flow requirements, quality constraints etc.).

Programm structure

WEAP consists of five main views: Schematic, Data, Results, Overviews and Notes.

SCHEMATIC

GIS tools for configuring your system. Drag and drop to create and position. Add ArcView or other standard GIS vector or raster files as background layers. Instant access to data and results for any node.

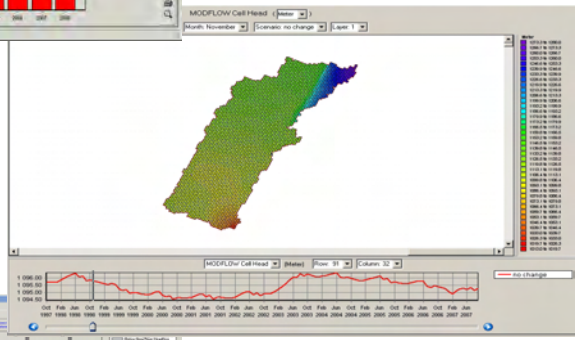


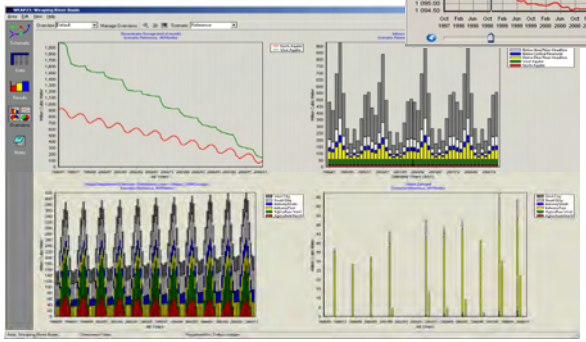
DATA

Model building: create variables and relationships, enter assumptions and projections using mathematical expressions, dynamically link to Excel.

RESULTS

Detailed and flexible display of all model outputs, both in graphical, 3D view and tabular form.





OVERVIEW

Highlight key indicators in your system.

NOTES

Document your data and assumptions.