P20

IMPETUS Morocco

Agricultural production and income security under increasing water uncertainty in the Drâa valley

C. Heidecke [1], A. Kuhn [1], T. Heckelei [1], W. Britz [1], A. Enders [2], H.E. Goldbach [3], Th. Gaiser [3], M. Abdel-Razek [3], F. Gresens [3], A. Roth [3], Kirscht, H. [4]

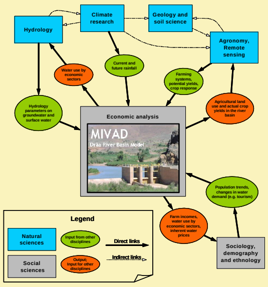
[1]Institute for Food and Resource Economics, University of Bonn, Nussallee 21,
[2]Institute of Geography, University of Bonn, Meckenheimer Allee 166, Bonn
[3]Institute of Crop Science and Resource Conservation – Plant Nutrition, University of Bonn, Karlrobert-Kreiten-Strasse 13, Bonn
[4]Institute of Cultural and Social Anthropology, Albertus-Magnus-Platz 1, Cologne.

Problem Setting

- High share of rural population
- Major part of family income consists of remittances from family members working in bigger cities or abroad
- Importance of agricultural production for income generation and food security
- Agricultural production depends heavily on irrigation, either of water that is coming from the reservoir Mansour Eddahbi, or from groundwater pumping
- Declining water availability in the Mansour Eddahbi reservoir reduces water availability for irrigation, inducing farmers to increase pumping of groundwater
- This has lead to a problems of salinisation and decreasing groundwater tables

A multi-disciplinary approach for water management

Income from agriculture is analysed using an non-linear optimisation model for the Drâa region. The model allocates surface and groundwater use such that agricultural revenues of the six Drâa oases are maximised with respect to various hydrological and agronomic constraints. Data from different sources and other problem clusters of IMPETUS are used to simulate the integrated water management situation in the Drâa valley. A Decision Support System is designed on the basis of the MIVAD model to simulate long-term scenarios dealing with climate change and management interventions.



MIVAD: Modèle intégré de la vallée du Drâa

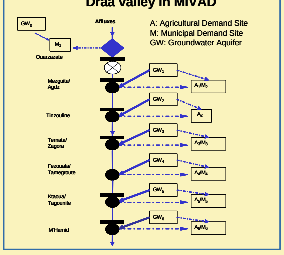
The MIVAD Model

- Integrated hydrologic-agro-economic simulation model at the river basin scale based on non-linear optimisation
- Water supply and demand are balanced while agricultural net revenues for the six oases in the Drâa valley are maximized
- Nodes represent river reaches, reservoirs and demand sites (oases and villages)
- 8 crops are simulated

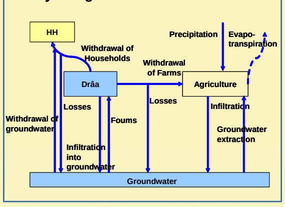
Components of MIVAD

- Hydrologic components: flow balance for each node, water balance of the Mansour Eddahbi reservoir, and water balance in irrigated fields
- Agronomic component: crop yield functions on the basis of the FAO methodology $1-\frac{Y_{actual}}{Y_{max}} = k_y\left(1-\frac{ET_{actual}}{ET_{max}}\right)$ and salinity tolerance of the crops
- Economic components: water use benefits from irrigation, hydropower generation, and municipal/industrial use

Node-Link network of the Drâa valley in MIVAD



Hydrological Structure in the Model



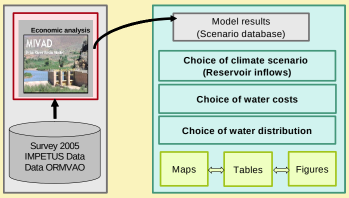
Specific features of MIVAD

- Salinity is a major problem in the Drâa valley as it has negative effects on crop yield
- The salt content of soil water is determined by the relation of evapotranspiration and infiltration
- Specific crop tolerances to salt content in soil water are considered

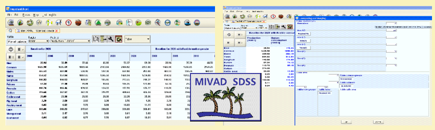
Salinisation of soils in the Drâa valley, 2005

- The model is calibrated using the method of positive mathematical programming. The model is calibrated to observed cropping patterns in the region
- Recursive-dynamic multiannual structure: reservoir fill rates and groundwater tables are carried over to the next year

SDSS MIVAD: Analysis and Visualisation



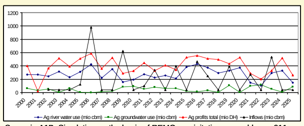
- The MIVAD SDSS is constructed as a scenario database of the MIVAD simulation results
- The aim is to structure and visualise scenarios with the help of tables, diagrams, and geographic maps
- MIVAD SDSS allows to structure tables in an individual manner, to customise table formats, and to visualise figures in using charts and maps
- Three different themes are depicted for analysis: climate change, water allocation and water costs
- The user can also upload new scenario files in GDX-format



The SDSS MIVAD: Exemplary results

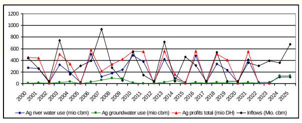
Climate scenarios in MIVAD

- Climate change scenarios IPCC A1B and B1 as well as a constant reduction of 4% per year is simulated from 2000 until 2025.



Scenario A1B: Simulation on the basis of REMO precipitation ensemble run 911 assuming population growth in the villages until 2025

The examples show that scenario B1 is a slightly better scenario for water availability in the region than scenario A1B which leads to higher and more stable incomes on average in B1.



Scenario B1: Simulation on the basis of REMO precipitation ensemble run 921 assuming population growth in the villages until 2025

Water distribution in the Drâa valley

- Surface water releases from the reservoir Mansour Eddahbi are distributed among the oases by decision of the relevant authorities
- Surface water may be allocated according to distribution rules between oases, whereas groundwater use is not subject to common rules

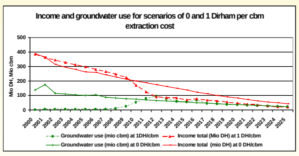
Income for six oases, standard deviation and variation coefficient under constant reduction of reservoir inflows for 25 years for two distribution scenarios D1 and D2

	D1 Income (M Dirham)	D2 Income (M Dirham)
Mezguita	28.95	24.91
Tinzouline	26.75	21.94
Ternata	37.68	48.74
Fezouata	16.32	18.22
Ktaoua	23.51	24.50
Mhamid	8.81	6.57
Average	23.67	24.15
Stand deviation	10.08	13.82
Variation coefficient	0.43	0.57

- The first allocation rule (D1) distributes water according to the area cultivated and the water requirements of the crops
- If distribution does not follow explicit rules (D2), allocation of water follows the aim of revenue maximization. The different effects on water allocation can be simulated with the MIVAD SDSS. Under D2 overall revenues are higher, but variation between the oases is higher as well.

Groundwater extraction costs in the Drâa valley

- In times of scarcity farmers tend to use more groundwater for irrigation which lowers water tables
- The following two examples show a ten year drought period with groundwater extraction costs of zero and 1 MAD/m³, respectively.

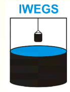


- Groundwater tables are declining more rapidly at zero extraction costs. With a water charge of 1 MAD/m³ groundwater is preserved until surface water becomes extremely scarce.
- Southern oases are more vulnerable to water scarcity than the northern oases.
- Agricultural revenues decline in both scenarios due to the intensifying drought
- Revenues decline stronger under the water charge but charges can be redirected to farmers or invested into water saving technologies

Conclusions

1. *Analysing income and resources use at the same time is important in the Drâa valley as people are depended on agricultural production for income and food security, and agriculture is dependent on available water resources.*
2. *The MIVAD model integrates hydrological and hydrogeological balances with agricultural production and income generation, and is hence a tool to better understand the economic significance of water in the Middle Drâa valley*
3. *The SDSS MIVAD helps to visualises results of the integrated model and enables to design tables, diagrams and maps in an individual manner for further use and input.*

See also SDSS IWEGS:



Impacts of Water Exploitation on Groundwater and Soil

More information:

- www.impetus.uni-koeln.de

Universität zu Köln
GLOWA
Ministry of Innovation, Science, Research and Technology of the German State of North Rhine-Westphalia
Federal Ministry of Education and Research
universitätbonn