

CLIMATE CHANGE IMPACTS ON GROUNDWATER RECHARGE IN DRAA WATERSHED, MOROCCO

MESSOULI M., MESSANA G., YACOUBI-KHEBIZA M., EL ALAMI EL FILALIA., BOUARAB L., AIT BOUGHROUS A. & BOULANOUAR M.

UCAM, Semlali, Department of Biology, IHEA-ENSI, Mohammed VI, Morocco. messouli@ucam.ac.ma

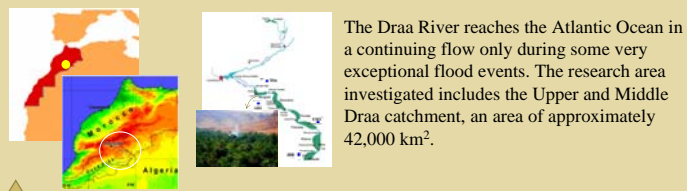
Context and aim of the study

In Morocco the examination of the last three decades shows revealing signs of climate change including: the frequency and intensity of droughts, unusually devastating floods, the decrease in the snow cover period on the peaks of the Rif and the Atlas mountains, the modification of spatial and temporal rainfall distribution

The objective of this study was to assess the impacts of groundwater-surface water interactions on the quantity and quality of water in the oasis and to present an overview of how climate affect directly or indirectly the interaction of ground water and surface water.

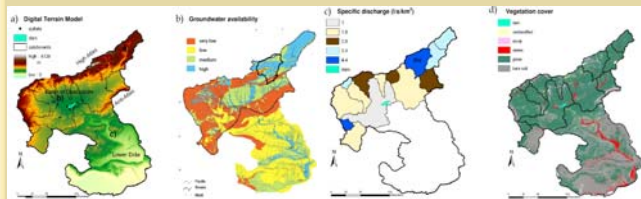
Investigations were carried out following various approaches and at different scales on the mains units of the Upper Draa catchment

Physical setting



The Draa River reaches the Atlantic Ocean in a continuing flow only during some very exceptional flood events. The research area investigated includes the Upper and Middle Draa catchment, an area of approximately 42,000 km².

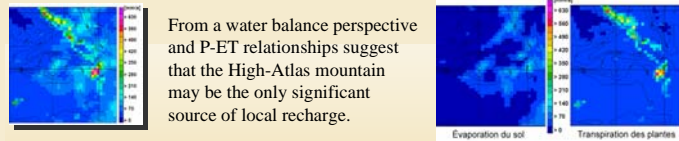
Location of the Upper and Middle Drâa catchment within Morocco



a) Delineation of subbasins on DTM, b) geological map of groundwater availability, c) discharge per unit area (annual average) of subbasins, d) vegetation and irrigated oases (after various sources: DRH, Agadir; IMPETUS, UCAM).

Enhanced climate variability and change

Two major environmental impacts in the Draa river catchment have already been observed: (i) an increase of near surface temperatures and (ii) enhanced weather variability. The observed warming in the last 40 years has already caused a retreat of snow cover in the High Atlas Mountains floor.



From a water balance perspective and P-ET relationships suggest that the High-Atlas mountain may be the only significant source of local recharge.

Thus, recognition of how climate, hydrology, and vegetation interact across the landscape to control the spatial distribution of recharge is critical to long-term water supply issues

conclusions and what more do we need to know ?

- the significant GW recharge in the High Atlas takes place in the folded and trusted liassic limestone units and in a combination with the reduction of surface runoff by river bed infiltration ;
- the contribution of snow to water availability may well be insignificant because of large amounts of snow (averaging 44 %) are removed by sublimation;
- because of water diversion (cemented canals, dams) and evaporative (irrigation) losses, connections between the SW and GW are being altered;
- increase in sediment colmation and in clogging intensity is currently observed in relation to human activities, causing an interruption of aquifer recharge.
- the irrigation system infiltration, canal loss and field infiltration, is the main GW replenishment mechanism in downstream of Ziz River;
- annual potential ET typically exceeds precipitation; there is a reduced connection between surface and subsurface hydrological processes along streams;
- overgrazing and firewood exploitation may increase erosion in a non-linear fashion and produce a positive feedback that further reduces vegetation cover, which further exacerbates soil loss.

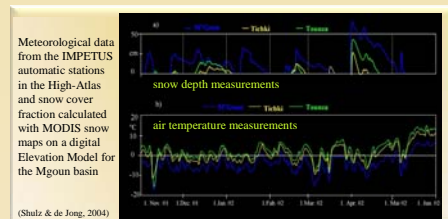
The ability to adequately predict future changes in recharge will depend on developing process-based numerical models that can simulate coupled climate/vegetation/vadose zone processes and incorporate the outputs into GW/SW models that can resolve processes at scales ranging from the hillslope to the basin

References

Schulz O. & de Jong C. (2004) Snow melt and sublimation: field experiments and modelling in the High Atlas mountains of Morocco: Hydrology and Earth System Sciences, 8(6), 1076-1089
Brunke M, Gonsler T (1997) The ecological significance of exchange processes between rivers and ground-water. Freshwater Biol 37:1-33

Recharge processes and Factors affecting GW recharge

Sublimation: Sublimation and snow melt are influenced strongly by differences in snow depth and wind speed. Large amounts of snow (on average 40%) are removed by sublimation during cold and dry climatic. The contribution of snow to water availability may well be insignificant during cold periods.

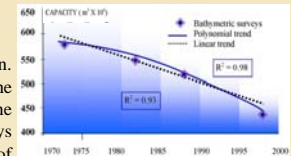


Meteorological data from the IMPETUS automatic stations in the High-Atlas and snow cover fraction calculated with MODIS snow maps on a digital Elevation Model for the M'goun basin (Schulz & de Jong, 2004)

Water diversion: Because of high level of evaporation, large dams and river diversions have proven to be primary destroyers of aquatic habitat, contributing substantially to loss of ecosystem services on which human economy depends

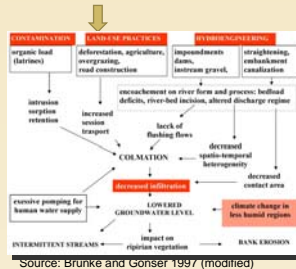
Soil degradation and colmation

Soil erosion by water is a severe problem in the Draa region. This is indicated by the analysis of the sedimentation of the reservoir El Mansour Eddabhi, located in the centre of the catchment. Since its construction in 1972, 4 bathymetric surveys have been carried out, the last one 1998. The data show a loss of capacity of already 25% up to 1998. Assuming a polynomial trend the reservoir will be totally filled by the year 2025.



Development of the capacity of the reservoir El mansour Eddabhi (source: DRH, Agadir)

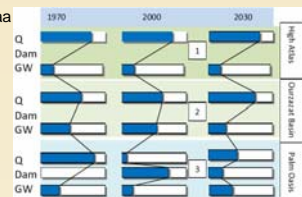
The causes of colmation formation are numerous and are illustrated in the figure below.



Source: Brunke and Gonsler 1997 (modified)

Relative water use in the Draa for

- pre-dam conditions
 - post-dam conditions
 - Future scenario
- Q= discharge
Dam=Mansour Eddabhi dam
GW= groundwater
(Based on MATEE)



Women carrying firewood on their back. A common sight in the mountain Atlas of Morocco. The xerophytes they gather are enough to bake bread and cook for one week

The highly porous channels of Draa rapidly fill with water during heavy and intensive precipitation events. Surface flow peaks within short time spans as soon as interflow storage zones have been saturated and flood recession is equally rapid, producing a characteristic "shark-tooth" flood hydrograph

