

Climate change impacts and adaptation in the Merguellil catchment, Tunisia



An overview of the Merguellil catchment

The Merguellil catchment, situated in the central semi-arid region of Tunisia, suffers from increasing water scarcity as a result of climatic and human influences, including agricultural withdrawals and changes in land use. The upper catchment (1180 km²), which recharges the El Haouareb dam and the downstream aquifer, has seen the development of numerous water and soil conservation works. Groundwater resources in the Kairouan alluvial plain (area of about 3000 km²) are heavily exploited for irrigated agriculture. Mean annual rainfall varies between 300 mm in the plain and 510 mm in the highest parts of the catchment, but is subject to large inter-annual variability. The mean temperature is 26.8 °C in summer and 8.2 °C in winter, and the mean annual potential evapotranspiration is around 1600 mm. Representative of many water resources issues in the Mediterranean basin, and designated as of major importance within the Tunisian national policy for maximal and optimal use of water resources, the Merguellil catchment has been the focus of several research projects at the national and international level.



The Merguellil catchment and its main water supply sources

The available water resources comprise:

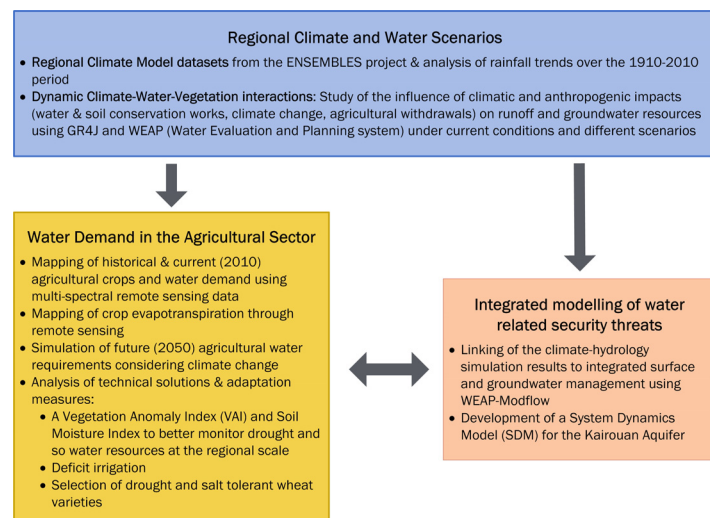
- Surface water supply from the El Haouareb dam with storage capacity of 95 Mm³ and mean annual inflow around 17 Mm³, but subject to high inter-annual variability.
- Groundwater from phreatic and deep aquifers with renewable resources equal to 31 and 61 Mm³ respectively. The thick phreatic aquifer of the Kairouan plain is over-exploited (150% of annual renewal; annual decline of the water table between 0.25 and 1 m).

The water demand sectors include agriculture (80% of the total water usage), drinking water supply (for local cities and transfers to coastal towns), industry and tourism (local and transfer to tourist destinations at the east coast).

In brief:

- The Merguellil catchment is considered representative of many water management issues in the Mediterranean basin, and has been the focus of several national and international research initiatives
- WASSERMed focused particularly on the analysis of climate change impacts on agriculture and water security
- The main climate change impacts on the agricultural sector concern the reduction in cycle length of wheat, tomato and potato
- Suggested adaptation measures for the agricultural sector include the use of suitable late-maturing varieties, together with early sowing and deficit irrigation

Employed methods

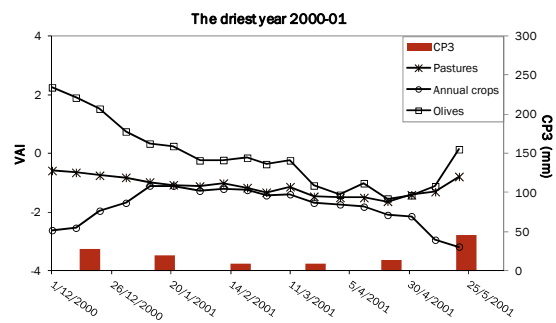


Further Information
Dr. Zohra Lili Chabaane
INAT, University of Carthage
Tunisia, e-mail:
zohra.lili.chabaane@gmail.com

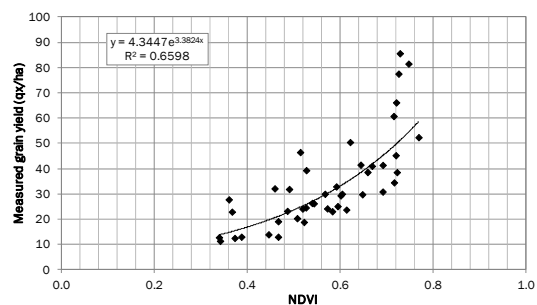
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Main results

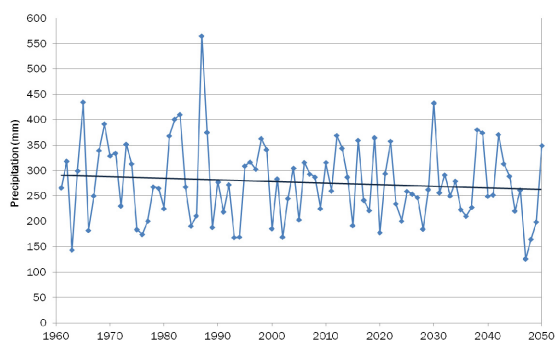
- Historical agricultural maps produced using remote sensing data from 1986 reveal an annual 2% increase in irrigated areas.
- A multi-temporal series of satellite SPOT-VEGETATION Normalized Difference of Vegetation Index (NDVI) data from 1998 to 2010 were used to analyze vegetation dynamics over the catchment and to propose a Vegetation Anomaly Index (VAI) for drought monitoring.
- Based on grain yield measures on test plots, a relationship was established between NDVI and grain yield. The results showed that earlier forecasts are possible from mid-March to mid-April with approximately a root mean square error (RMSE) equal to 8.5 quintals/ha and an average yield equal to 36 quintals/ha.
- A combination of chemical and isotopic approaches provided greater precision on evaporation losses from the El Haguareb dam and from small reservoirs in the catchment.
- The analysis of rainfall-runoff trends at the event scale reveals a 40% decrease in the runoff generated by rainfall events under 40mm. The decrease is a result of the construction of water and soil conservation works that drain 28% of the upper catchment.
- However, the large variations observed in catchment runoff were driven by changes in the number of rainfall events over 15 mm, and the conditions of these events (rainfall intensity & location, soil moisture and land cover).
- Statistical tests on rainfall time series over the past 50 years reveal no significant shift of the long term average and of the number of extreme events. Projections with the regional climate model RCA (driven by ECHAM5) point to a 10% decrease in annual precipitation by 2050 and an increase in annual average maximum, minimum and average air temperatures, up to +1.7 °C. This will induce an increase (+118.6 mm) of annual reference evapotranspiration.
- The WEAP model was used to simulate the influence of a 10% precipitation decrease and +2% increase in irrigated areas on groundwater resources, and to test adaptation measures, such as deficit irrigation, which can save up to 13 Mm³.
- The main projected climate change impacts on the agricultural sector concern the reduction in cycle length of wheat, tomato and potato. Suggested adaptation measures include the use of suitable late-maturing varieties (LMV), together with early sowing.



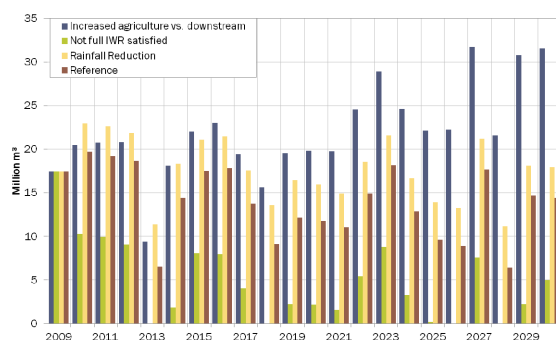
During the driest year 2000-2001 a consistently negative Vegetation Anomaly Index is observed for all months



Relationship between measured grain yield and SPOT-NDVI index on 17/03/2011 and 31/03/ 2012



Regional climate model RCA (driven by ECHAM5) projections show a 10% decrease in precipitation from 1960 to 2050



Unmet water demand in private irrigated areas under different scenarios generated and simulated by the WEAP model

Recommendations

- Further research is required to reduce uncertainties in crop water requirements and in the hydrological modelling of the catchment, notably the water balance and influence of small reservoirs and the El Haguareb dam on downstream groundwater resources under existing and future conditions.
- Deficit irrigation seems to be a good adaptation measure for water saving but its acceptability by farmers must be tested.