Water Availability and Security in Southern EuRope and the Mediterranean
http://www.wassermed.eu

Factsheet No 7

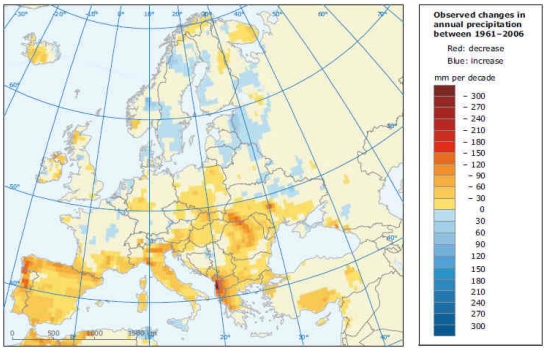
Water balance modelling in the WASSERMed Case Studies

How can climate change impact on water security?

Globally, water resources are being stressed and over-exploited. Numerous studies have shown that surface and groundwater bodies are being over-exploited. This leads to detrimental impacts on humans who have less resource per-capita, on agriculture which must either plant less crop or alter cropping patterns to match the available resources, and on development opportunities as water scarcity can impact on core economic activities and on 'ecosystem services'. It is likely that predicted global change will make the current situation worse for those regions already experiencing water shortages, and may lead to new regions experiencing water security issues. The Mediterranean is a global water security hotspot, with many areas being (close to-) over-exploitation. Climate change impacts are expected to be considerable throughout the region, affecting water security.

As a result, better modelling of the current and potential future water balance in various regions across the Mediterranean is important. In this way, policy makers will be better equipped when deciding how best to target resources in mitigating local water security issues.

Modelling can also account for these policy measures, assessing their overall impact on water security in the future. However, water is not the only sector impacted by change. Changes in water availability also have consequences for food production and local economies. Integrated modelling that can reflect changes in all these sectors together is required for a full understanding of potential future situations and mitigation options.



Observed changes in annual precipitation 1961-2006 (the data come from two projects: ENSEMBLES and ECA&D)

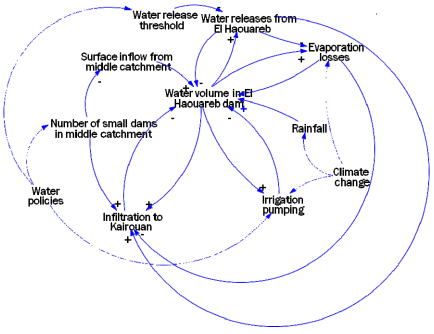
In brief:

- *Climate change may exacerbate water shortage problems in the Mediterranean region.*
- *WASSERMed used water balance modelling in order to analyse and access water-related security threats, by applying either System Dynamics Modelling or the WaterStrategyMan Decision Support System.*
- *Results indicate that there is a wide range of diverse water security problems. Although there are several common options to tackle problems, there is significant risk in investing in one, single policy.*

The WASSERMed approach: Methods and tools

System Dynamics Modelling (SDM) was used in four of the five Case Studies developed in WASSERMed. SDM was used for its ability in modelling complex integrated systems that may be characterised by feedback and delays, such as the water systems analysed in WASSERMed. SDM uses the concepts of stocks (that store material), flows (that move material into and out of stocks) and converters (that alter the rate of flow) to create feedback-driven systems models that can incorporate disparate sectors such as water, food and the economy in the same model.

The relationships between model elements can be summarised in so-called causal-loop diagrams that qualitatively show how the elements influence each other. These are then used to construct the working simulation model(s). Results are output in graphical format to the user.



Causal loop diagram showing the relationships between system components in the El Haouareb sub-model of the Tunisia SDM

The WaterStrategyMan Decision Support System (WSM DSS) was used in two Case Studies. This is a GIS-based package that

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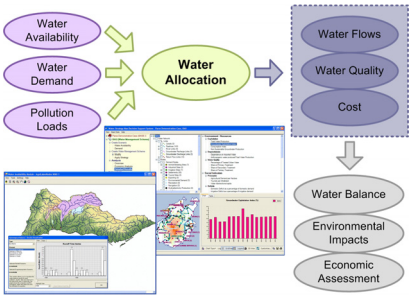
emphasises on the conceptual links between different elements of water systems. The tool can assess water quantity and quality, and can output results as a suite of indicators.

The WSM DSS has five main modules: water availability assessment, water demand assessment, water allocation and water balance estimation, economic analysis and multi-criteria analysis.

As with the SDM approach, baseline, climate-change and climate change with policy intervention scenarios were simulated. The objective was to provide policy makers with detailed information regarding the potential impacts of climate change on local water resources and the cost-effectiveness of potential policy measures.

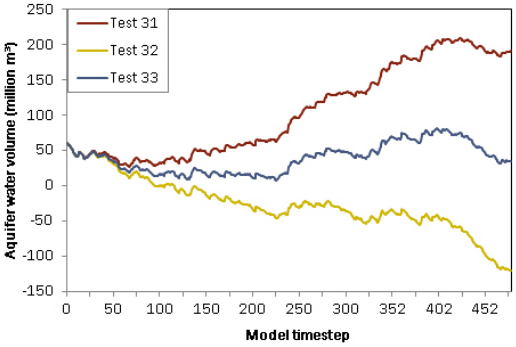


The framework of the WaterStrategyMan Decision Support System

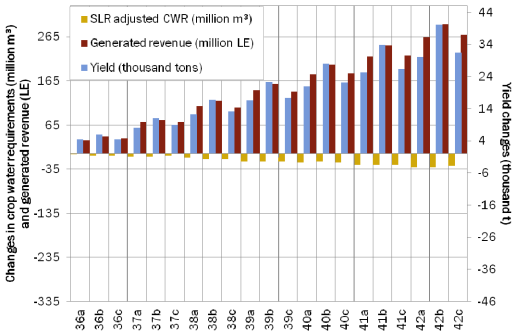
Main results

Results clearly show that throughout the Mediterranean, there are a wide range of diverse water-security problems, each having their own potential solution(s). The severity and complexity of the issues being faced are very diverse in different regions. Water is being over-exploited in most of the case study areas, and even where it is not, it is very close to being so. Therefore, water resources are under threat from future global change. Simulations of climate change impacts show that the current situation is expected to get worse, and that an inaction scenario is not viable for any of the analysed systems.

What-if testing of various policy options, however, showed that considerable improvements can be made, and in some cases, the situation can be turned into one of water surplus. In many of the case studies, this can be done through relatively simple measures, which may not encounter too much local opposition, especially if they are first fully discussed with local actors and users, and if they are gradually implemented. It is shown, however, that most policies may take years to show beneficial effects. Therefore a patient, long-term view is required, and high-impact, short-term changes should not be expected.



Potential policy impacts on the water balance of the Kairouan aquifer, Tunisia



Potential agricultural sector policy impacts in Rosetta, Egypt

Key findings and considerations

- There is no single universal, Mediterranean-wide policy solution for overcoming the various water-related security threats being faced. While the overall threats (i.e. population increases, agricultural demand increases, climate changes) are common among case study areas, their impacts are considerably different. As a result, while some policy measures may be applicable across the entire basin, such as the curbing of domestic and agricultural water demand, and the provisions for 'alternative' water supply, others are location-specific.
- In most regions, a single 'cornerstone' policy should not be implemented in isolation - the risk in the event of failure/underperformance is generally too great in terms of the impact on development opportunities. Multiple policies, which introduce redundancy should any single policy fail and amplify the effects of other policies, will bring about the best chance for a water-secure, sustainable future across the Mediterranean.

Further reading

- Sušnik J., Vamvakeridou-Lyroudia L.S., Savić D.A., Kapelan Z. 2012. Integrated System Dynamics Modelling for water scarcity assessment: case study of the Kairouan region. Science of the Total Environment 440: 290-306.
- Sušnik J., Molina J-L., Vamvakeridou-Lyroudia L.S., Savić D.A., Kapelan Z. 2013. Comparative analysis of System Dynamics and Object-Oriented Bayesian Networks modelling for water systems management. Water Resources Management. 27(3): 819-841. DOI: 10.1007/s11269-012-0217-8.
- Sušnik J., Vamvakeridou-Lyroudia L.S., Savić D.A., Kapelan Z. Accepted. Integrated modelling of a coupled water-agricultural system using system dynamics. Journal of Water and Climate Change.