Food and Agriculture Organization of the United Nations

INFORMING WATER-ENERGY-FOOD NEXUS DECISIONS: *THE INTEGRATED WEF NEXUS MODEL OF JORDAN*

SETTING THE CONTEXT

Due to the water shortage in Jordan, the safe water abstraction yields are often exceeded. Groundwater extractions require large amounts of energy, due to the decreasing water table levels of almost all aquifers in the country (ESCWA, 2015). Therefore, around 14.9 percent of the supplied electricity is consumed by water pumping and other water services. Moreover, additional energy requirements will be needed to deal with an expanding water supply through desalination and wastewater treatment (Copeland and Carter, 2017).

The agriculture sector accounts for the largest share of water demand (around 52 percent), where again, groundwater is the main source. Furthermore, as a consequence of its water-scarce nature, Jordan faces increasing food insecurity being forced to import around 87 percent of its food (Figueroa et al., 2018).

Achieving sustainable water-energy-food (WEF) resources security requires developing safe operational boundaries of water use defining the conditions for water sustainability in Jordan. These boundaries were defined using a Water-Food-Energy-Climate-Ecosystems Nexus analytical framework that was highly stakeholder-driven, combined with quantitative and qualitative methods developed by the Royal Institute of Technology in Stockholm (KTH) and the Stockholm Environment Institute (SEI).

OBJECTIVE

To build an integrated WEF-Nexus model that enables understanding the trade-offs and synergies when considering policies and infrastructure based on a single sector against those across multiple sectors. The model also allows for assessing the impact of some interventions.

METHODOLOGY

All methods, datasets and models in this project were developed through a participatory process with a series of formal and informal meetings, resulting in the co-development of a suite of tools and scenarios:

Timeline for the Nexus approach in Jordan (the original timeline was extended due to the COVID-19 pandemic)

Source: WEPS-NENA project: development of Nexus model

Consultations aimed at 1) identifying the priority challenges:

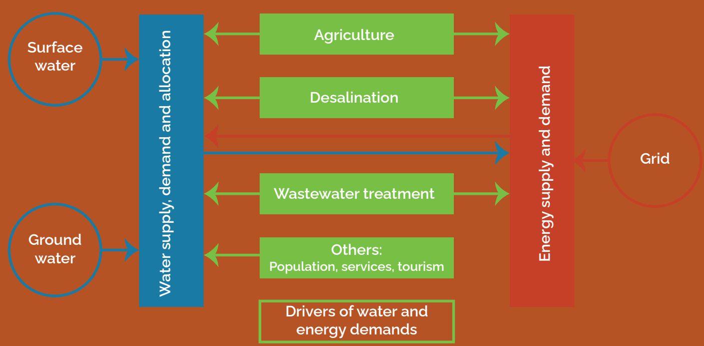
- Water scarcity.
- Agricultural productivity.
- Water quality.
- Shift to energy independence.

While 2) exploring possible solutions/scenarios:

- Implementation of sea water desalination projects.
- Improvement of energy efficiency.
- Reduction of water losses (non-revenue water).
- Improvement of agricultural water productivity.

And combining them in an integrated modelling tool.

Modelling strategy representation



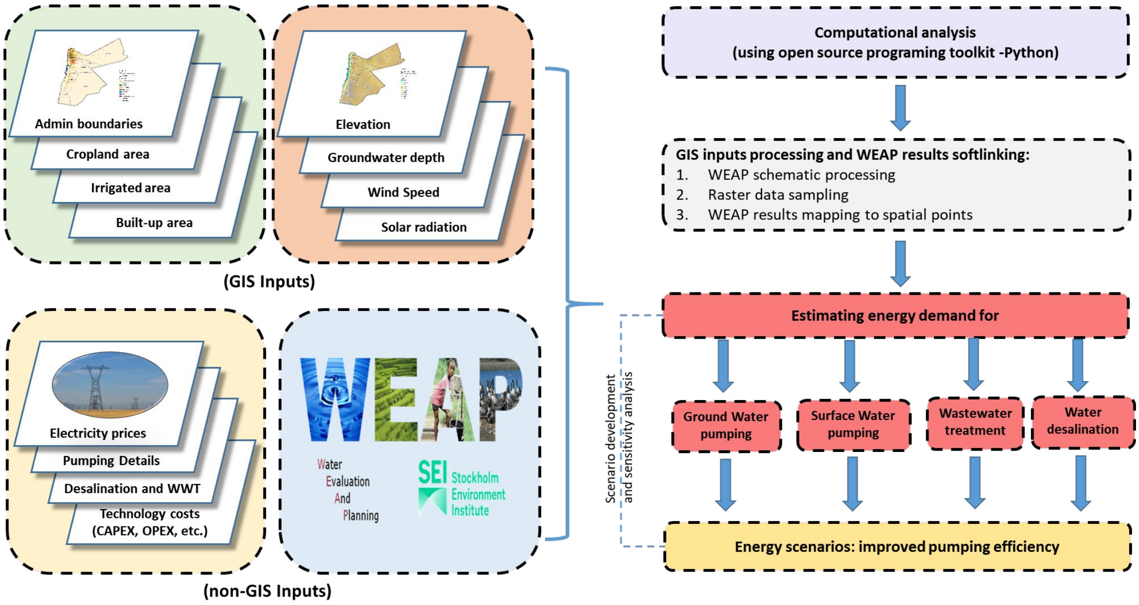
Source: WEPS-NENA project: development of Nexus model

Developing WEF Nexus model

Based on the identified challenges and solutions, three models were considered and integrated to form the (integrated) WEF Nexus model:

- Water Evaluation And Planning (WEAP) model (to estimate non-agricultural water demands, supplies and allocations in order to assess the sustainability of the water system);
- MABIA model (to estimate crop production based on the availability of water); and
- GIS-based energy modelling tool (to estimate the energy requirements for water pumping, water desalination and wastewater treatment).

Overview of the modelling structure showing the key inputs to the energy model and different energy modules

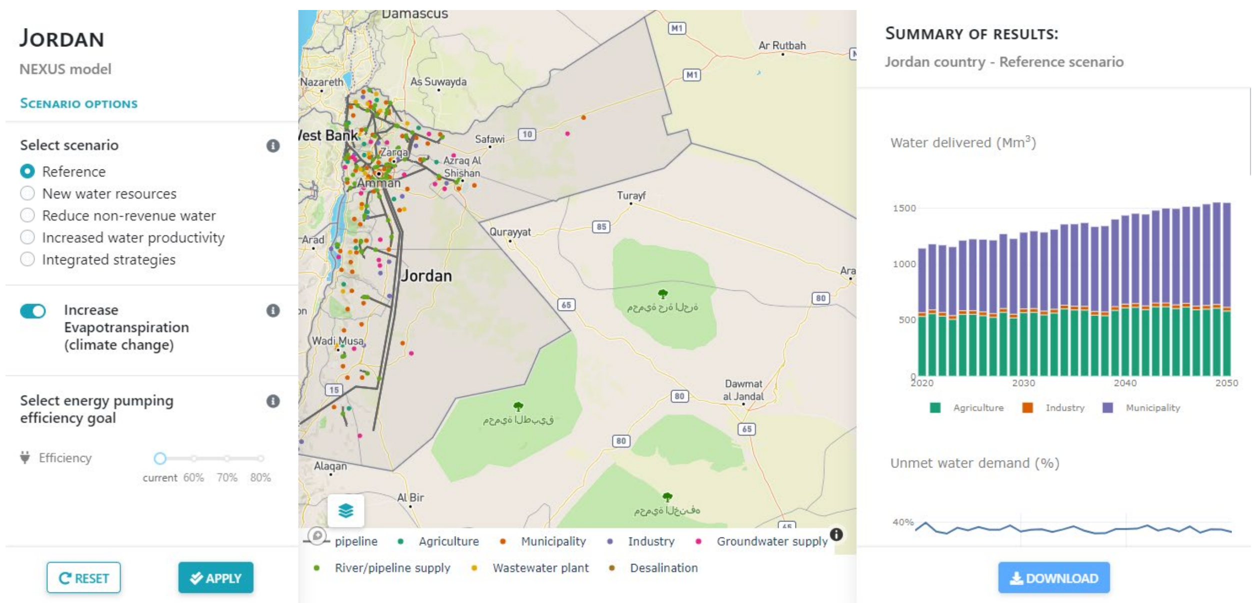


Source: WEPS-NENA project: development of Nexus model

Jordan Nexus visualization platform

- A visualization platform was created to facilitate and ease the exploration of the large modelling results.

The front page of Jordan Nexus model visualisation platform



Source: WEPS-NENA project: development of Nexus Model

The platform can be accessed from this address: https://jordan-nexus-model.herokuapp.com/

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SCENARIOS ANALYSIS

Through the series of dialogues, six scenarios emerged, each of which was tested under two climate futures: (1) based on historical trends of rainfall, temperature and evapotranspiration; and (2) assuming an increment on evapotranspiration due to a warmer climate.

1. No intervention scenario "reference" assumes that the current trends (in terms of demand, supply and growth) are kept unchanged for agriculture and industry. However, the domestic demands was assumed to increase over time.
2. Reduce non-revenue water scenario assumes a reduction of non-revenue water by 20 percent to year 2050.
3. New water resources "desalination" scenario assumes the realization of the Red Sea-Dead Sea project and new desalination plant Red-Dead (110 MCM/yr).
4. Increased agricultural water productivity scenario considers a combination of interventions (e.g. improving irrigation efficiency; grow under greenhouses) targeting to produce more crops with less water.
5. Pumping energy efficiency considers the gradual improvement and modernization of the water network (For example, groundwater pumps and conveyance pipelines) and reaching an average target efficiency by 2050.
6. Integrated strategies scenario brings together all tested interventions in other scenarios.

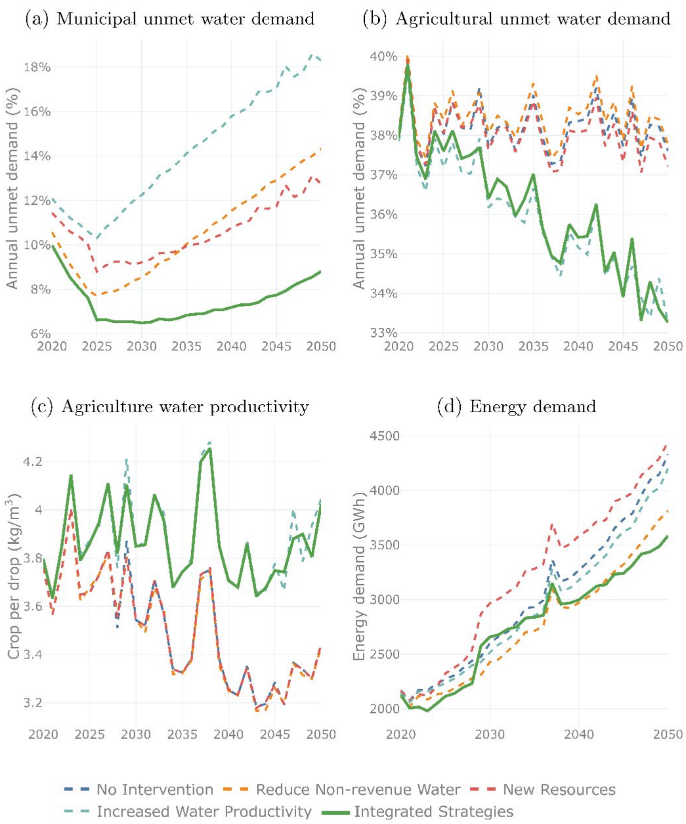
RESULTS

Some results can be summarized thereafter for each sector and then for their nexus integration.

Sectorial solutions

- Reducing non-revenue water uses, helps towards reducing municipal water scarcity while using less energy, but it has negligible effects on agricultural water scarcity and productivity.
- Adding new water resources has substantial improvements on municipal water scarcity, but it has no substantial improvements over agricultural unmet water demand, and the energy demand increases by 500 GWh over year 2029.
- Increasing agricultural water productivity seemed to tackle most challenges as it improved agricultural water scarcity and productivity, reduced energy requirements for groundwater pumping. However, this solution did not have any effect on municipal water scarcity.
- Energy efficiency showed to be a major ally for sustainable development, as it can support execution of high energy-intensive projects reducing stress on the energy system.

Main results for all scenarios in a climate change future



Source: WEPS-NENA project: development of Nexus model

Integrated solutions (Nexus solutions)

By integrating all solutions, benefits were seen over all sectors and improvements to all challenges were achieved, several key results emerged:

- Municipal unmet water demands in the final decade of the analysis 2040-2050 improved by around 9 percent average compared to no intervention.
- Agricultural unmet water demands in the final decade, improved by around 3.6 percent.
- Agricultural production in the final decade increased by 15 percent.
- Drawdowns were consistently reduced through all aquifers.
- Energy demand in 2050 is reduced, despite the high extra energy required for the Red – Dead desalination project.
- Energy efficiency has the potential of flattening out increasing energy requirements for conveyance and groundwater pumping, and support high-energy intensive solutions as the Red-Dead desalination project.

KEY FINDINGS

- Nexus thinking helped to understand how WEF systems are largely intertwined, and how sectorial solutions will not achieve holistic outcomes and can have negative impacts on other sectors.
- A set of interventions assessed with a nexus approach can improve outcomes in all sectors while reducing negative feedback effects.
- The Jordan Nexus visualization platform has proved to be a powerful engagement and planning tool, allowing the exploration of diverse scenarios, supporting decision making and avoiding negative feedback effects.
- The ability to plan across sectors requires coordinate governance and on-going process and dialogues between stakeholders (need to include cross-sectoral planning around nexus issues in the country).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REFERENCE

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Thanks to the multidisciplinary team of experts who contributed to the co-development of the model and its hypothesis.

This activity is under the regional project "Implementing the 2030 Agenda for water efficiency/productivity and water sustainability in NENA countries" under the Water Scarcity Initiative. This project is implemented by the Food and Agriculture Organization of the United Nations and funded by the Swedish International Development Cooperation Agency (SIDA).

Funded by:

Sweden
Sverige

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