Economic and Social Commission for Western Asia (ESCWA)
Expert Group Meeting on Assessing Climate Change Impacts on Water Resources and Socio Economic Development in the Arab Region

CLIMATE CHANGE MODELING ACTIVITIES IN JORDAN

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Climate Change Impact on Water Resources

- The Middle East and North Africa region is among the most vulnerable in the world to the effects of climate change. It has the highest levels of scarcity in the world, a significant income and employment dependence on climate-sensitive agriculture, and a large portion of its population and economic activity concentrated in flood-prone coastal zones.
Projected changes in the hydrologic cycle

a) Precipitation

b) Soil moisture

c) Runoff

d) Evaporation

Figure 10.12
Although Jordan does not contribute to more than 0.1% to the causes of global climate change, its effects on the country will be very severe. In fact, Jordan is particularly vulnerable given already scarce water resources and high levels of aridity.

Natural and physical systems in Jordan are already facing heavy pressures, and these will only be intensified as temperatures in Jordan get higher and/or precipitation gets lower.

The Jordan’s Second National Communication suggests that the rising temperatures will lead to a decrease in surface runoff. Climate Change is likely to effect the occurrence and severity of droughts and flash floods.
Rain is the main water resource.
Major Modeling Activities

- Adaptation to Climate Change to Sustain Jordan’s MDG Achievements Project
- GLOWA Jordan River: Vulnerability of Water Resources in East-Mediterranean Environments
- Universities
Adaptation to Climate Change to Sustain Jordan’s MDG Achievements Project

- This Programme was approved under the Spanish MDG-F, Environment and Climate Change thematic window and aligned with the ‘Enhancing Capacity to Adapt to Climate Change’ priority area.

MDG 7: Ensure Environmental Sustainability

UN PARTNERS:
- UNDP, FAO, WHO/CEHA and UNESCO

PROJECT DURATION:
- Three years (2009 – 2011)
Assess direct and indirect climate change risks to water availability and quality in Zarqa River Basin.
Activities under MDG Project

- Assessment of trends in existing Climatic record.
- Statistical Downscaling Model (SDSM 4.2).
- Downscaling GCMs climate change scenarios.
- Generation of Site-Scale Baseline Scenarios.
- Generation of Site-Scale Future climate Scenarios.
- Incremental Future Climate Scenarios.
- Recommendations

Assessment of Direct and Indirect Impacts of Climate Change scenarios on water availability and quality in the Zarqa River Basin Report
Activities under MDG Project

- Precipitation, maximum temperature, minimum temperature and mean temperature time series at selected six climatic stations have been used to investigate the business as usual (BAU) and the future climate scenarios in Zarqa River Basin (ZRB). These stations are Amman A/P, Mafraq, Wadi Dhulail from the Meteorological Department and AL0035 K. H. Nursery Evap. station (BAQ'A), AL0059 Um El–Jmal Evap. station and AL0066 Khirbet Es Samra Evap. station from the Ministry of Water and Irrigation (MWI). Trend analysis revealed obvious decreasing trends in the precipitation time series of most of the stations, the decrease in precipitation started in the decade 1970’s. While temperatures showed increasing trends, the minimum temperature has increased more than the maximum temperature.
TREND ANALYSIS
PRECIPITATION TRENDS

Wadi Dhulail

Amman A/P

Mafraq

AL0035

AL0059

AL0066
MAXIMUM TEMPERATURE TRENDS

Wadi Dhulail

Max. Temperature (°C)

Amman A/P

Max. Temperature (°C)

Mafraq

Max. Temperature (°C)

AL0035

Max. Temperature (°C)

AL0059

Max. Temperature (°C)

AL0066

Max. Temperature (°C)
MINIMUM TEMPERATURE TRENDS

Wadi Dhulail

Min Temperature (C)


Amman A/P

Min Temperature (C)


Mafraq

Min Temperature (C)


AL0035

Min Temperature (C)


AL0059

Min Temperature (C)


AL0066

Min Temperature (C)

Activities under MDG Project

- Climate baseline scenarios of the daily maximum temperature, minimum temperature, mean temperature and precipitation at the 6 locations in the ZRB have been generated for the 50 years baseline period 1961 – 2010 using the NCEP Reanalysis data, Hadley General Circulation Model (HadCM3) and the Statistical Downscaling Model (SDSM).
Baseline scenarios Generation by SDSM;

PDF Plot of observed and downscaled (generated) max. temp. baseline scenario at Wadi Dhulail.
Activities under MDG Project

- Future climate projections derived from the GCMs typically have too coarse resolution to examine the effects of local topography and land use, and to assess climate change impacts on station-scale sites. Therefore, in order to generate future temperature and rainfall scenarios at the 6 stations in the ZRB for the period from 2011 to 2099, we have employed the Statistical Downscaling Model (SDSM4.2) to downscale the HadCM3 General Circulation Model climate projections to the site-scale of each single location. The downscaled future scenarios were investigated within 3 periods: 2011 – 2099, 2011 – 2060 and 2061 – 2099.
The following important results were derived:

- The maximum, minimum and mean temperatures reveal significant warming trends at most of the stations. The warming trends of minimum temperature are greater than that of maximum temperature. As a result the mean temperature shows warming trends in all stations.
- The temperature increase ranges from 1–4 °C.
- The temperature increase is greater in the winter months.
- The temperature increase is greater in the period 2060 – 2099.
- The precipitation climate change scenarios are highly variable.
Impact of climate change on surface water availability

- ArcSWAT was used as described earlier to build up the hydrological model for ZRB. The model was used to simulate surface runoff for the period 1970–2009. The model perform well in simulating the surface runoff as indicated by the high coefficient of determination ($R^2 = 0.95$) and the good agreement between the observed and simulated flow.

- HadCM3 downscaled scenarios A2 and B2 applied to show the impact of climate change on the surface runoff of ZRB. These scenarios were used as inputs of the SWAT to assess the impact of future climate changes on water arability at ZRB. The simulation was run from year 2011 until 2096.
Impact of climate change on surface water availability

In the following is a summary of these findings

- Both experiments (A2, B2) predict that the amounts of surface runoff are going to decrease with the next 90 years.
- This decrease will be highly noticed after the year 2050.
- The two experiments show identical behavior about the future amounts of surface runoff.
- The maximum amount of surface runoff would be received in 2032 based on the two experiments.
- The maximum peak flow will drop from about 50 m³/s recorded in the baseline scenario to less than 35 m³/s in the future scenarios.
Global Change in the Hydrological Cycle’ (GLOWA JR) is an interdisciplinary and international research project providing scientific support for sustainable water management in the Jordan River region.

It is expected that the results will:

- Give guidance as to the potential change and variability in temperatures and precipitation, and to the anticipation of extreme climatic events in the basin over the coming decades, analysing its impacts on the water resources.
- Indicate how new sources of surface („blue“) water can be utilized to the best advantage in the basin.
- Suggest how land use planning and crop patterns can be managed so as to make full use of water retained in the soil („green water“).
- Predict actual and potential changes in ecosystem services and biodiversity in the basin.
GLOWA JR tools, models & approaches

- In order to find out what the future of the region could look like GLOWA JR produces regional climate change scenarios, regional development scenarios and land use scenarios. The effects of these three driving forces on water fluxes, water availability, water demand and productivity for the different human and ecosystem uses is simulated with a set of different models. The results of the models are used in stakeholder dialogues to identify strategies for sustainable water and land resource management for coping with the impacts of global and regional change on water scarcity.

- Tools, models & approaches:
  - Water management tool
  - Approach for scenario development
  - Eco-hydrological modeling
  - Hydrological modeling
  - Land use modeling
  - Ecosystem and agricultural modeling and evaluation
  - Socio economic models and valuation of ecosystem services
  - Regional Climate models
A model–based assessment of the effects of projected climate change on the water resources of Jordan

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This paper is concerned with the quantification of the likely effect of anthropogenic climate change on the water resources of Jordan by the end of the twenty–first century. Specifically, a suite of hydrological models are used in conjunction with modelled outcomes from a regional climate model, HadRM3, and a weather generator to determine how future flows in the upper River Jordan and in the Wadi Faynan may change. The results indicate that groundwater will play an important role in the water security of the country as irrigation demands increase. Given future projections of reduced winter rainfall and increased near–surface air temperatures, the already low groundwater recharge will decrease further. Interestingly, the modelled discharge at the Wadi Faynan indicates that extreme flood flows will increase in magnitude, despite a decrease in the mean annual rainfall. Simulations projected no increase in flood magnitude in the upper River Jordan. Discussion focuses on the utility of the modelling framework, the problems of making quantitative forecasts and the implications of reduced water availability in Jordan.
Thank you