REGIONAL WATER BALANCE MODEL

CLIMATE CHANGE IMPACT TO THE WATER RESOURCES IN THE REPUBLIC OF MACEDONIA

SUMMARY

The goal of the study is to provide plausible estimates of the impact of regional future climate change for Macedonia to the water resources, by development of a Regional Water Balance Model. The Water Balance Model for Vardar River catchment in Macedonia is representing 80.4% of the country territory, and around the same share of overall available water resources.

MIKE SHE software from *DHI Water And Environment*, a dynamic modeling tool that can simulate the entire land phase of the hydrologic cycle, has been used. The regional water balance model includes a fully spatially distributed description of overland flow, evapotranspiration and recharge processes.

Spatial GIS data used include Digital Elevation Model (DEM), river network, land cover data (CORINE), and a soil map for the entire territory of the country, as well as derived spatial data and time series.

Basic set of available historical hydrological data (precipitation, temperature, humidity, wind etc) for the whole country and discharge of Vardar river and major tributaries, for the period 1966 - 2000 have been used for model setup. Data on river discharges contained gaps, and information on river cross sections were very limited. Also, extremely scarce information on groundwater (aquifers, GW table & abstraction) caused problems in the setup/modeling process, which was overcome by averaging and by using the linear reservoir module. Two-year median time series was used for calibration of the model. In addition, derived time series of data (eg. evapotranspiration, initial & boundary conditions, etc.) have been produced.

For the development of future scenarios in the model, the predicted changes in temperature, precipitation and other hydrologic parameters have been used as input (base year 2000 and the four future periods: 2025, 2050, 2075 and 2100). The parameters were averaged across the four GCMs,and calculated for all the future CC scenariosfor . The prepared time series of input data were simulated for 3 scenarios:

- LOW: *minimum values across different scenarios averaged across different GCMs,*
- MEAN: *average values across different emission scenarios and different GCMs,*
- HIGH: *maximum values across different scenarios averaged across different GCMs*

The results of the model simulations are predicted discharges and water levels of Vardar and major tributaries in the basin for the three scenarios and for the 5 simulated periods. Based on the data processed with the model, complete annual water balances has been produced.

Various CC scenarios simulated by the calibrated model showed that:

- The model was able to simulate all the hydrological processes (evapotranspiration, baseflow, recharge and surface runoff) adequately. The simulated water balance

showed the permanent trend of decreasing precipitation, baseflow and recharge and increase of evapotranspiration;

- Groundwater recharge for Vardar River catchment will continuously decrease in the future reaching 69.7, **57.6** or 45.6%,of current recharge quantity in 2100 (for low, **mean** and high scenarios respectively);

- Annual discharges for the rivers Vardar, Treska and Bregalnica show decreasing trend. Assuming 100% discharge in 2000, the model predicts that in 2025, 2050, 2075 and 2100, the total annual discharges will reach the following values (in % out of 100)

Vardar	**2000**	**2025**	**2050**	**2075**	**2100**
LOW		93,9	90,4	89,0	87,0
MEAN	100	92,4	88,6	85,6	81,8
HIGH		91,4	87,6	83,2	76,6

Treska	**2000**	**2025**	**2050**	**2075**	**2100**
LOW		98,2	97,4	96,8	95,9
MEAN	100	97,6	96,6	95,2	93,0
HIGH		97,0	96,1	93,5	89,4

Bregalnica	**2000**	**2025**	**2050**	**2075**	**2100**
LOW		91,4	86,3	84,4	82,2
MEAN	100	90,0	83,9	80,7	76,2
HIGH		88,8	83,5	79,0	71,4

- The simulation showed no significant change in seasonal or spatial patterns in the catchment. Notably, no change is expected in the occurrence of extreme floods. Dry spells and flash floods, however, are expected to occur more often and with increased intensity;

- Eastern part of the country shall experience more severe and longer water deficiency than the western part. The predicted average reduction in water availability for year 2100 in Bregalnica river basin is almost 24%, as opposed to 7% in Treska river basin.

- In conclusion, the overall water availability in the country (Vardar river basin) for year 2100 is expected to be reduced by 18% (estimate ranging from 13 to 23 %).

The results of the model should be regarded as indicative only. The reason for this is the limited set of available historical hydrological data and their reliability and the scale limitations of available spatial data. In order to further improve the model, hydro-meteorological data time series should be completed, especially data on river discharges as well as the data on river cross-sections, large reservoirs in the catchments, hydro-geological data (aquifers and groundwater levels), and finally, the soil and land-use data.