Impact of Climate Change on Water Resources in Seyhan River Basin

Modeling of the Seyhan River Basin: Preliminary Results

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1. Introduction

The water resources of Seyhan River Basin were investigated within the framework of the ICCAP Project, dividing the basin into two parts: the alluvial plain and the upstream mountainous section. This division was based upon the fact that the plain comprise the major groundwater resources while the upstream section requires methods of surface hydrology though significant karstic aquifers exist in this part of the basin. Upstream of the Seyhan Dam was considered as the study area where the impact of climate change on surface hydrology was investigated. This part of the basin covers about 21750 km^2. Three main tributaries make the Seyhan River; namely, Cakit, Zamanti and Goksu (Figure 1).

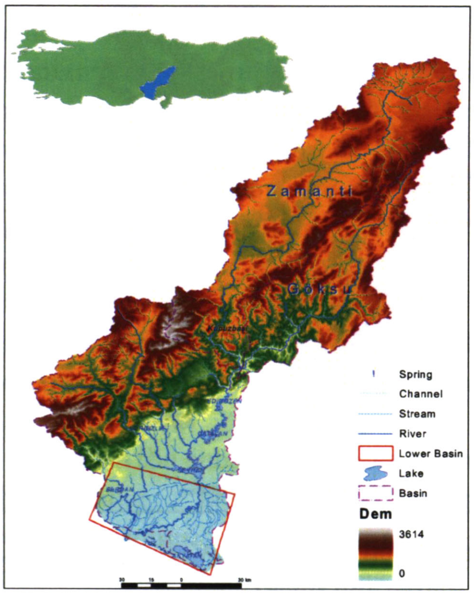

Figure 1 Location map of the study area

The physiography and oro-hydrography of the basin varies from south to north; the lowlands characterizing the south while the north is represented by harsh topography. The Zamanti subbasin, being the largest, requires a special attention due to its relatively complex hydrological structure. The average elevation of this subbasin is about 1250 m. asl., and karstic discharges supply the main contribution to the river flow. The pervious lithological units are generally made of carbonate rocks most of which are extensively karstified. The distribution of the hydrogeological units is depicted in Fig. 2.

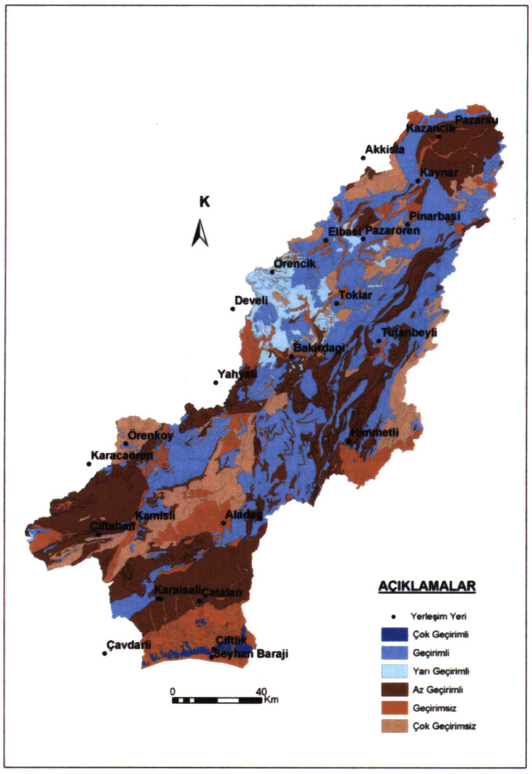

Figure 2 Hydrogeological units in the basin

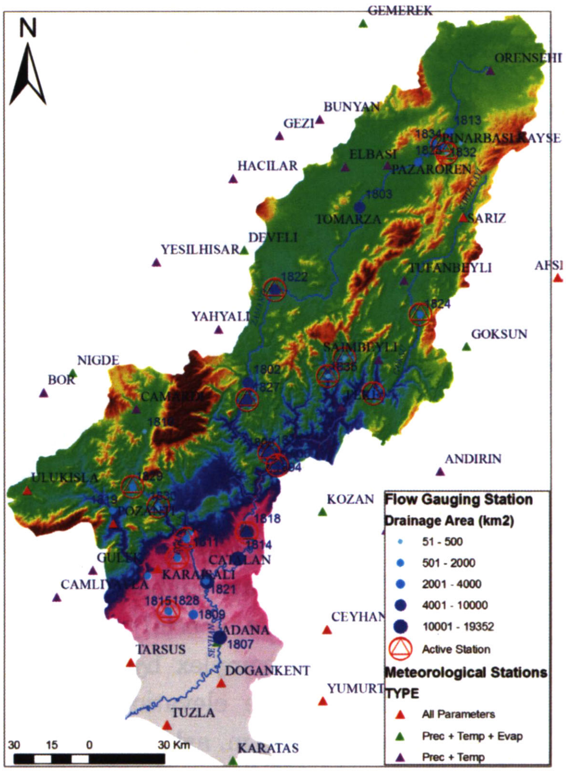

Figure 3 Hydrometeorological station whose data were used in the model

The response of the basin hydrology to any change in the climatic and inherent vegetative and land-use conditions was studied by modeling approach, which required, first, the hydrological characterization of the basin under the prevailing conditions. Description of the basin behavior using tools like mathematical models, then will enable prediction the response of the basin to a future change in any component of the basin. MIKE-SHE/11 (Systeme Hydrologique Europeen) a deterministic and distributed parameter model, integrating surface and subsurface flow and transport processes was utilized toward this purpose (Abbot et al., 1986).

2. Preparation and Processing Relevant Data

The available data were designated, digitized and transferred to a geographical information system software as required by the MIKE-SHE model. Hydro-meteorological data such as flow rates, rainfall (Fig. 3) and snow cover were input to the database, topographical, geological maps, soil map (Fig. 4) were digitized and given as separate layers. The basin boundaries were defined according to the topographical divide. The model parameters such as precipitation, evapo-transpiration and surface run-off were defined and transferred to the model.

Vegetation and leaf area index (LAI) were also defined and transferred to the model (Fig. 5). Calibration of the model was based on the observed flow rates at certain sections of the river system. Prediction of the response of the basin to decrease in precipitation and increase in temperature and evapo-transpiration was then made by running the model for changes forecasted by the GCM.

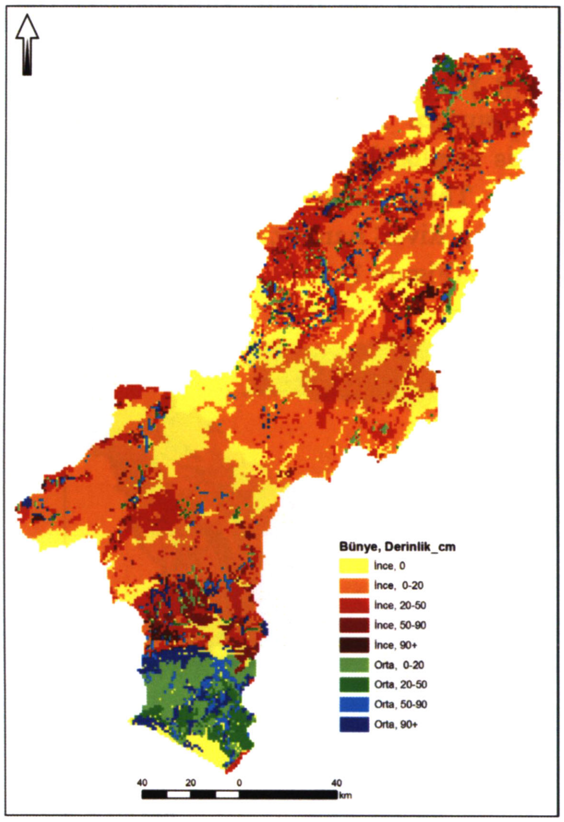

Figure 4 Soil map (yellow: fine and thin, blue: coarse and thick)

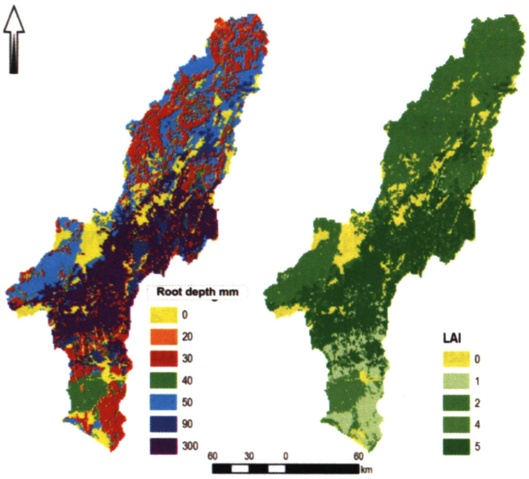

Figure 5 Root depth and LAI in the basin

3. Mathematical Model of the Seyhan Basin

The basin was discretized into 216x299 finite difference grids of 1 km2 each. The boundary of the basin was defined in the model by assigning the a value indicating impervious unit in cells that fall on the divide. MIKE-SHE computes the areal precipitation either by interpolation or by Thiessen polygons. Daily precipitation data of 13 stations were input to the model as time series (Fig. 6).

The evapo-tarnsipration is similarly computed by the model in two ways: 1) the water budget in vadose zone 2) Penman-Monteith method for potential and Leaf Area Index approach for actual evapo-transpiration. Due to the lack of available data to allow the water budget approach, the Penman-Monteith method was used and the leaf area index was utilized with the combination of the root depth (see Fig. 5). The time series of daily potential evapotranspiration is given in Fig 7.

Because the subsurface water is among the major factors that control evapo-transpiration rate and the infiltration, the vadose zone was taken into account in the model. The soil map was re-arranged so as to define the soil type and some model parameters like effective porosity, specific retention, saturated hydraulic conductivity,and Van Genuchten (1980) parameters that are used in solving the Richards equation were defined for two major types of soil in the basin. The vertical dimension of the vadose zone was taken as 50 m. and divided into 80 finite-difference layers of thickness varying between 0.125 and 5 m.

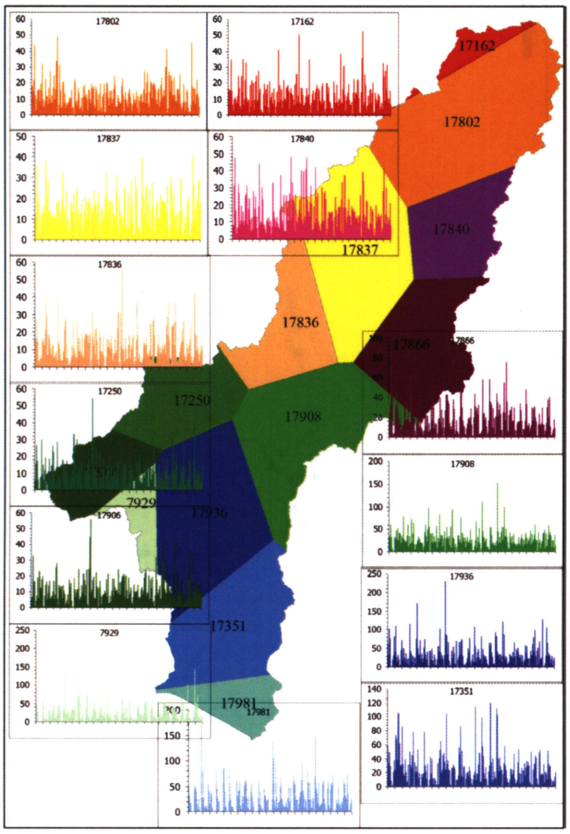

Figure 6 Precipitation distribution in the Seyhan River Basin

The surface runoff was simulated by finite difference solution of the Saint Venant equation. Runoff occurs whenever the overland storage exceeds a certain threshold. Overland storage starts to develop when precipitation rate exceeds the infiltration capacity. The model parameters required in this calculation are the Manning coefficient and overland storage threshold which was assigned a value of 6 mm for the basin.

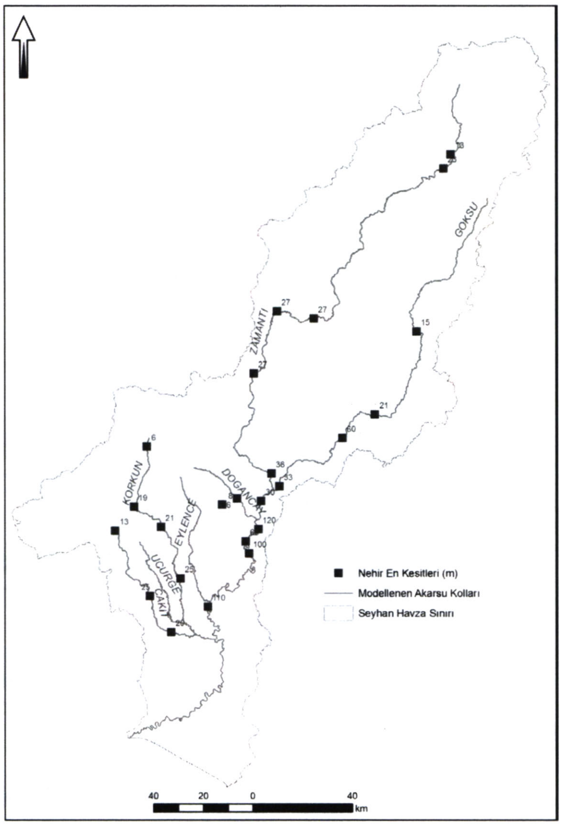

Figure 7 Sections where measurements were made for channel flow simulation

Channel flow component was simulated using the geometry of the river bed defined by finite difference nodes. This required measurement of width and depth of the river at sections where flow rate was observed (Fig. 7).

The distance between river nodes ranges between 200 and 1500 m depending on the river morphology. More frequent nodes were defined where the river bends in shorter distances.

4. Calibration of the Model

The model was calibrated using the data available/derived for the period between 1980 and 1992. The model was calibrated on the basis of measured flow rates at different sections of the Seyhan River. As seen in Fig. 8. the correlation between the observed and calculated flow rates is poor. The extent of the model area, lack of adequate meteorlogical stations to represent the precipitation and evapo-transpiration distribution over the basin accounting for also the great differences in elevation and the significant contribution of karstic discharges into the river flow are regarded as the major factors responsible for this poorness. However, adjustment in the water budget components was realized to better understand the role karstic effluents in the basin.

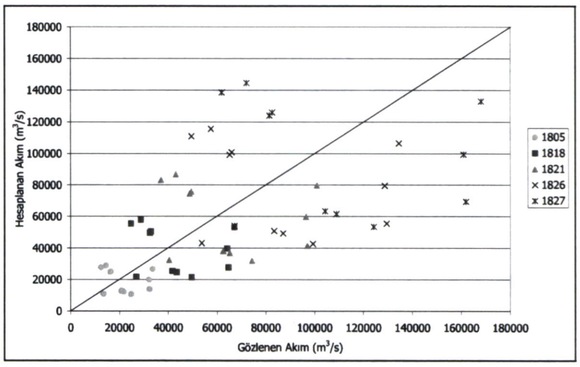

Figure 8 Correlation between observed and calculated flow rates

5. Water Budget

The water budget components calculated by the model for the period between 1980 and 2000 are tabulated in Figure 9. According to this calculation, about 40 % of the precipitation is lost by evapo-transpiration. This rate corresponds to a volume of 15.89 billion m3/year. About 12 % of the total precipitation which

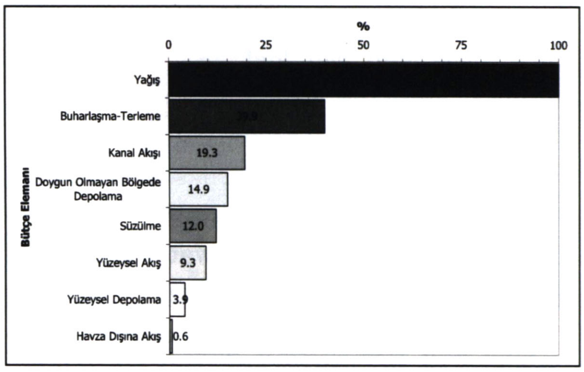

Figure 9 Percentages of water budget components for the period 1980-2000

corresponds to 4.76 billion m3/year is infiltrated to form the groundwater. About 5.94 billion m3/year is stored in the vadose zone and 3.71 billion m3/year is the surface runoff. As seen from Fig. 9, about 0.6 % of the total precipitation which corresponds to 0.24 billion m3/year lost through outflow from the basin. This outflow is the inflow to the Adana Plain groundwater system.

6. References

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