



Using SWAT Model to Determine Runoff, Sediment Yield in Maroon-Dam Catchment

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Abstract: The Soil and water assessment tool (SWAT) model is a flexible, physically distributed model was developed as a river basin scale to quantify and predict runoff and transportation from watersheds and river basins. The semi-automated Sequential Uncertainty Fitting (SUF2) calibration process built in SWAT calibration and uncertainty program (SWAT-CUP) were used to calibrate the model parameters using time series of flow and sediment load data of 1994 to 2002 and validated with the observed data from years 2002 to 2007. The performance of the model was evaluated using statistical and graphical methods to assess the capability of the model in simulating the runoff and sediment yield for the study area. The result showed relatively good fitness between measured and simulated discharge and sediment. The Nash Sutcliffe efficiency and R² were nearly 70% for discharge and 76% for sediment load. Overall, simulation of runoff and sediment is satisfactory by using the SWAT model.

Keywords: Runoff; Sediment Yield; Calibration; Validation; SWAT-CUP; SUF2

1. INTRODUCTION

Soil erosion is a worldwide environmental problem that degrades soil productivity and water quality, causes sedimentation in reservoirs, and increases the probability of floods [1-9].

Sediment transport rate is affected by hydrological as well as hydraulic characteristics. Since the former cannot be adequately taken into account quantitatively, a high degree of accuracy in sediment load computations cannot be expected [2-3]. Watershed management programs frequently fail to reduce sediment yield because either the physical nature of the problem is not properly diagnosed or the economic and cultural conditions leading to accelerated erosion are not addressed and erosion control practices are abandoned as soon as government subsidies are removed (Gregory and Fan, 1998). Besides, the development of a comprehensive sediment yield model requires substantial funding, extensive time and expertise, which are often unavailable in developing countries [4-6].

The soil and water assessment tool (SWAT) is a physically based, continuous time model, developed by Dr. Jeff Arnold for the USDA-ARS (Agricultural Research Service) (Arnold et al., 2001), mostly used to predict the impact of land management practices on water, sediment, and nutrient yields over

long periods of time [7-9]. SWAT model has been used extensively to assess water quality and quantity changes in the catchment responding to agricultural management across the US, Canada and other European countries [10-15]

In previous studies, it was difficult to account for sediment yield deposition the catchment and to model the individual erosion processes. Therefore, this study aimed at assessing the suitability of SWAT2005 model [16-18] as one of the watershed erosion models in simulating inflow and sediment yield in Maroon Dam mountainous catchment. The model was used to assess its suitability in modeling sediment yield in the data scarce catchments, located in south western of IRAN.

2. METHODS AND MATERIAL

2.1. Study Area

The studied watershed, named Maroon Dam (Idanak station), is in south west of IRAN (Figure 1). The area of the watershed is about 2700 ha and located in a Semi- arid climatic region. Annual average precipitation is approximately 639.0 mm concentrated between November and May. Mean annual temperature is 23°C.

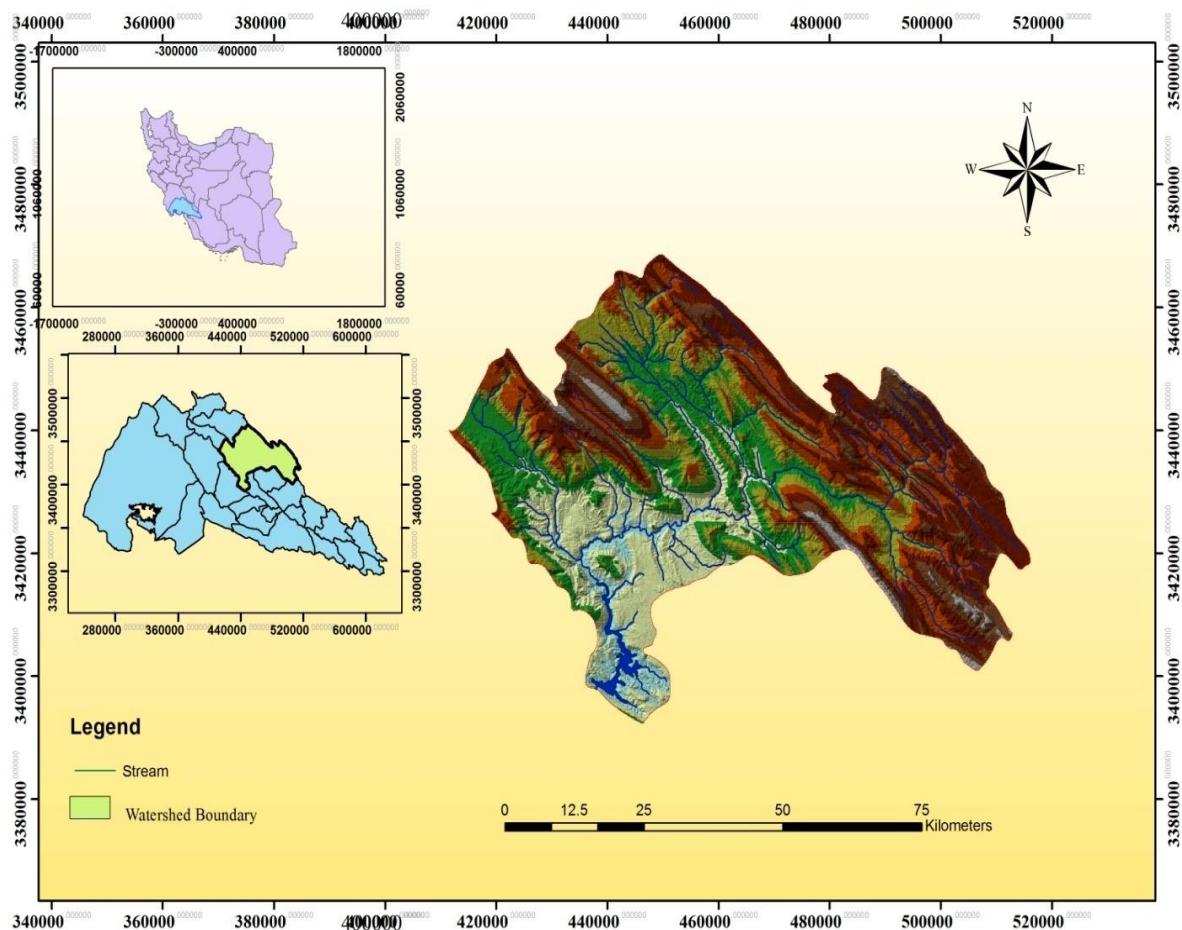


Figure1. Research site: Dam Maroon watershed

2.2. SWAT Input Data

The basic input data included the digital elevation model (DEM), land use, soil maps and climate data. Data has been collected and processed for daily rainfall, runoff and sediment discharge, and maximum and minimum temperature for the watershed during 1987 to 2006.

The SWAT2005 was used to delineate the boundaries of the entire study area and its sub-basins. The model was calibrated using data in the catchment of Maroon Dam. During the simulation process the inflow and sediment yield was calibrated and then validated.

3. RESULTS AND DISCUSSION

Model calibration and validation are indispensable for simulation process, which are used to assess model prediction results. Calibration was performed by comparing the simulated and observed surface runoff. After achieving a reasonable runoff data, the same parameters were used for calibration of the sediment and further for validation.

River sediment yields were estimated primarily by quantifying soil losses from HRU^s with the Modified Universal Soil Loss Equation (MUSLE) [19-24]. K_{USLE} is the USLE soil erodibility factor, C_{USLE} is the USLE cover and management factor, P_{USLE} is the USLE support practice factor and $CFRG$ is the coarse fragment factor [25-32].

The available measurements of flows and sediments were used for comparison with the predicted results in order to test the SWAT simulation efficiency. Calibration took place in monthly basis at Idanak Station, where inflow data is existed from 1994 to 2006 and sediment measurement data from 1995 to 2006. Figures 2 and 3 represents the graphical comparison between predicted and observed flows and sediment yields in Idanak during calibration and validation periods [33-59].

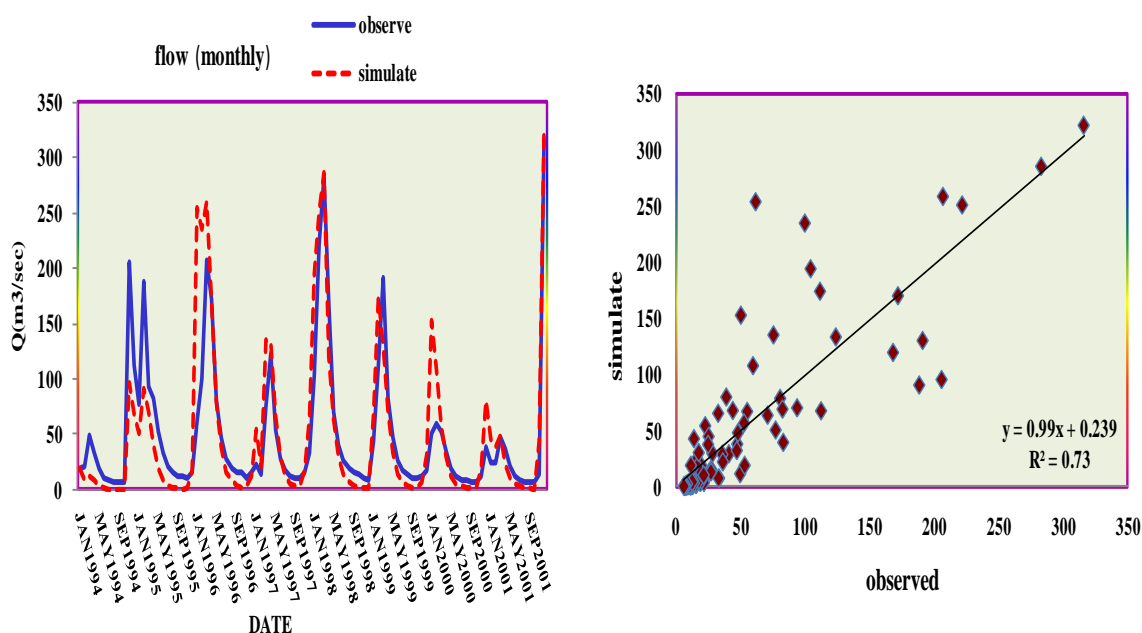


Figure2. Observed and predicted flows in Idanak Station during calibration period

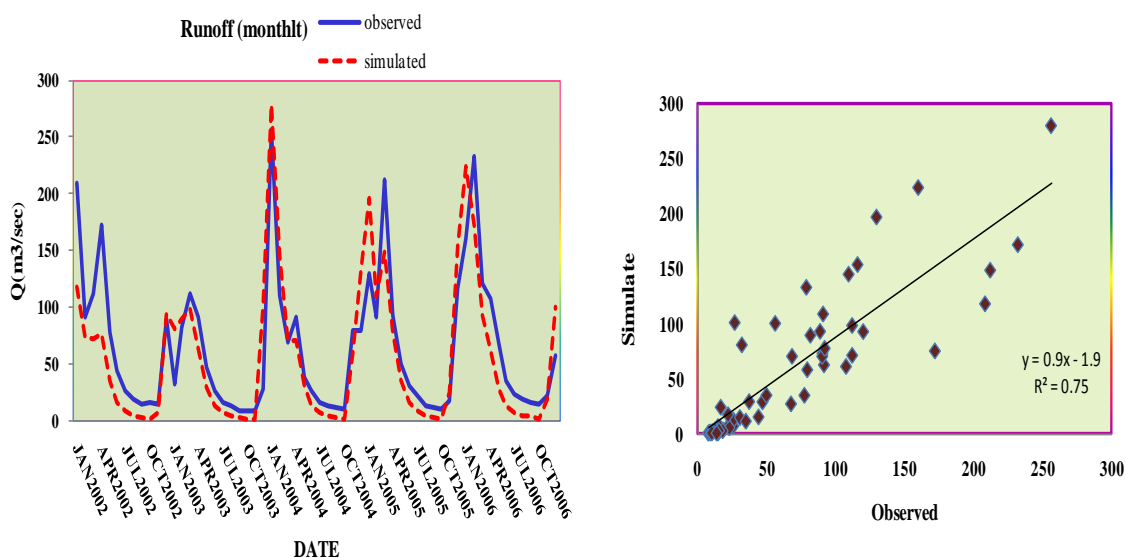


Figure3. Observed and predicted flows in Idanak Station during validation period

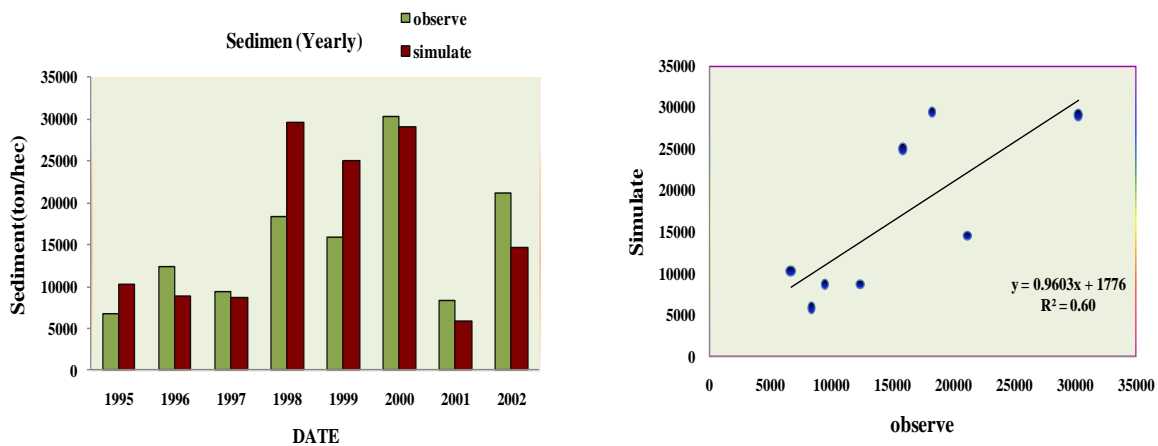


Figure4. Observed and predicted sediment yields in Idanak Station during calibration period

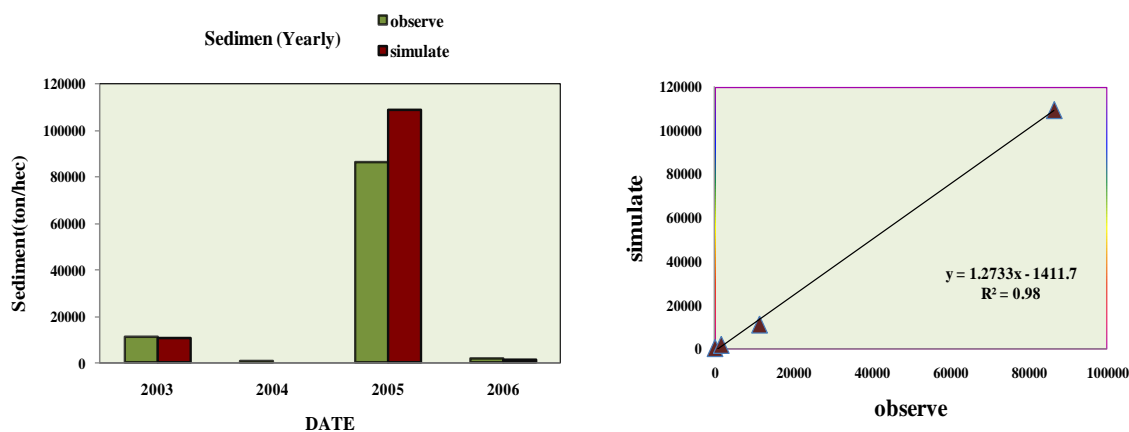


Figure5. Observed and predicted sediment yields in Idanak Station during validation period

Different values appeared between the simulated and observed monthly-runoff during the simulation for 1994–2001. The difference might be explained by the measured errors in runoff data, and system errors of SWAT [60-79]. After reasonable parameter calibration, in validation process, simulated monthly-runoff was in the range of the observed values (Figure.3) [80-98].

The correlation coefficient and Nash-Sutcliffe coefficient reached 0.75 and 0.70 respectively, which showed the validity of the simulation (Figure.4). Also the correlation coefficient in calibration and validation process during sediment load simulation reached to 0.60 and 0.98 respectively (Figure.5) [99-124].

4. CONCLUSION

In this study SWAT was used to simulate inflow and sediment yield in the Maroon Dam watershed in south west of Iran. Simulated flow and sediment yields were generally in agreement with measured data.

The Auto-calibration Tool in Arc SWAT provides a user-friendly method for specifying various inputs including calibration parameters and desired widths of uncertainty confidence intervals. It also facilitates specification of measured data sets and the desired output parameters and objective functions. The text-based summaries from the three components of the Tool can be used to determine the optimal parameter set for calibration purposes, parameter sensitivity ranges and corresponding objective function ranges. Time series graphs, with or without parameter and model uncertainty bounds, can be created from additional output files to facilitate comparison between the amount of variation in the model results and the measured data.

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