Estimation of Hydrologic Budget for Gharasou Watershed, Iran

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ABSTRACT The performance of the SWAT2012 model for estimation of hydrological budget in Gharasou watershed, west of Iran, during 1995 to 2005 was assessed. Digital Elevation Model, hydro-climatological data, soil and land use maps with their properties relevant to the watershed were considered to fulfill the model. A branch program in SWAT-CUP software (SUFI2) program implemented to simulate and validate the model. Both coefficients of determination (R2) and Nash- Sutcliffe coefficient exploited reliable analysis for simulation of the model from 0.37 to 0.87 and 0.39 to 0.73, respectively. Results showed that evapotranspiration was the main source of waste water (49.3%) in the study area. Surface runoff, subsurface flow, groundwater flow, and variation of soil moisture are 14.8, 0.8, 29.9 and 5.2 percent during the study period, respectively. The monthly proportions of different water pathways of input to the river flow take place from intense storms and snow melt during April to the end of May. This study has produced a technique with reliable data base for water budget in Gharasou catchment, which could be successfully developed to manage water resources by many government agencies.

Key words: *Iran, Gharasou Watershed, SUFI2 program, SWAT model, Water budget*

1 INTRODUCTION

Planning water balance for the future is an important problem for developing countries. It is necessary to understand the water quantity and quality in space and time through studies to use water for the future (McCornick *et al.,* 2003). The hydrological models and their relevant equations can quantify hydrologic budget that includes surface runoff, subsurface flow, groundwater flow, evapotranspiration and soil water content. They are affected by both climate and geophysical characteristics, such as soil, land use and topography. Understanding of the relationship between the physical boundaries and hydrological components is a major task for any water supply project (Sathian and Symala, 2009). Because of complexity of this relation, the integrated model can be

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important for proper hydrological budget separation. Major water sources available in many countries originate from highland watersheds (Sanjay *et al.,* 2010), including the Gharasou watershed in Iran that supplies the Kharkheh Reservoir. Therefore, estimation of annual and monthly water budget can be helpful in sustainable land use and water management in downstream. The Soil and Water Assessment Tools (SWAT) is a semi distributed model that performs continuously on a daily time step (Arnold *et al.,* 1998). This model was selected among fifteen hydrological models to separate water components, which successfully fulfilled the annual and monthly water budget estimation as well as suspended sediment yield in the Taleghan catchment during 1987-2007, with a high accuracy (Hosseini *et al.,* 2010).

Different calibration methods have been developed to increase efficiently of test models. These methods applied to improve the prediction reliability of the SWAT simulations, including manual and automated calibration (Eckhardt and Arnold, 2001; Lu *et al.,* 2012; Niraula *et al.,* 2012; Z. Lu *et al.,* 2015). A

comparison of the water budget components performed by this model in Taleghan catchment from 1995 to 2004 and estimated using three land uses maps of 1987, 2001 and 2007 (Hosseini and Ashraf, 2015). Therefore, SWAT2012 with ArcGIS selected to test efficiency of the model and separating water components in the Gharasou catchment. Hydro-climatological data at meteorological stations with daily period used to calibrate and validate the SWAT model in this area. The objective of this study was to simulate SWAT model and estimate hydrologic budget in Gharasou watershed, Kermanshah province, which would also establish a database for planners and engineers to achieve as effective plan for water management.

2 MATERIALS AND METHODS
2.1 Study area
The study area is located at the upper part of Karkheh Reservoir in Kermanshah province, west of Iran (46˚ 20´ to 47˚ 20´ E and 34° 05' to 34° 50´ N) (Figure 1).
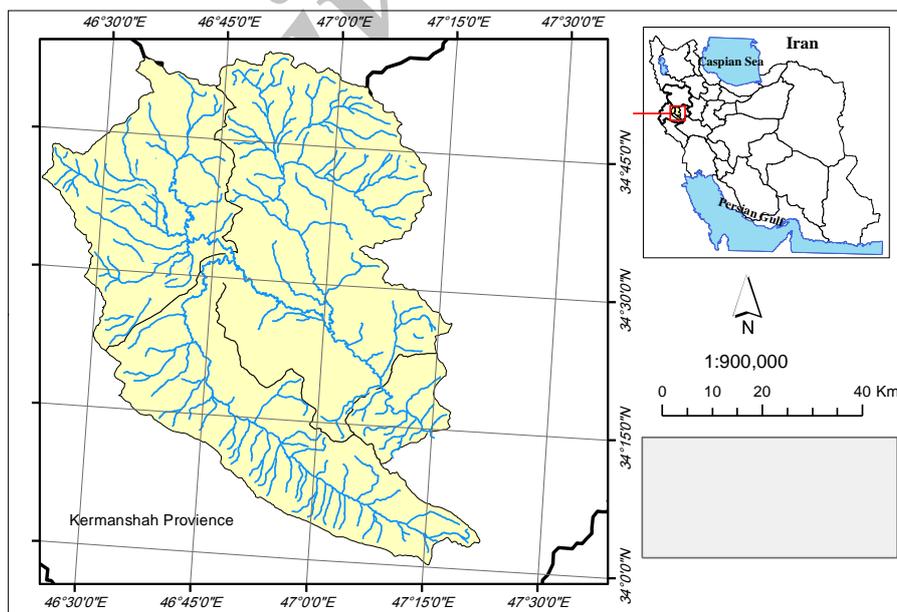
Figure1 Location of study area

This catchment with an area of 5793 km^2 is the main source of water supply for the Karkheh Reservoir. The climate is dry and cold in the south to cold and humid in the northern Zagros Mountain Ranges (altitudes from 1244 to 3351, average 1559 above sea level). Topography of the study area consists of highlands (48%) and plains (52%), the latter of which includes three plains of Mahidasht-Sanjabi (1463 km^2), Kamyaran-Bilevar (356 km^2), and Kermanshah (984 km^2).The average annual precipitation of this basin is 400 mm and the highest one takes place in February and the lowest in July; the average annual temperature is 14°C and the mean annual potential evaporation is 2132 mm (Hosseini *et al.,* 2012).

2.2 SWAT model

SWAT model is a comprehensive tool to assess the impact of land management practices on water, sediment and chemical yields in different land use and management practices for large and complex watersheds (Neitsch *et al.,* 2005). It was developed to simulate the major hydrological processes for watersheds in routine planning and decision making (Ogden *et al.,* 2001). One of the main advantages of the model is its computational efficiency for large catchments, which makes it of practical use to land and water managers dealing with vast areas (Arnold *et al.,* 1998).

The hydrological simulation of a watershed can be separated into two major divisions, the first of which is the land phase cycle that controls the water, sediment, nutrient and pesticide loadings to the main channel; the second division is the routing cycle which can be defined as moving water, sediments, etc., through the channel network (Neitsch *et al.,* 2011).

The hydrological model based on the water budget equation in the soil profile consists of precipitation, infiltration, surface runoff, evapotranspiration, lateral flow and percolation.

SWAT partitions groundwater into two aquifer systems: a shallow unconfined aquifer and a deep and confined aquifer. Surface runoff volume is predicted from daily rainfall by using the SCS curve number equation (USDA, 1972).

Partitioning the catchment into sub basins in simulation is particularly useful when the catchment is dominated by various land uses or soils properties differ well enough to impact the hydrology of the catchment. Besides, it enables the user to spatially compare different areas of the catchment. Above all, partitioning the catchment into a suitable number of subdivisions increases the accuracy of the model in reflecting differences in the hydrological variables of concern, e.g., evapotranspiration for various crops and soils, and between the various catchment subdivisions. On the other hand, runoff is predicted separately for each HRU and routed to obtain the total runoff for the catchment. This further increases the accuracy of the model and gives a much better physical description of the water budget.

Hydrological response unit (HRU), is the smallest land unit in this model which is obtained from the combination of slop, land use and soil maps. Implementation of this model in a collaborative environment using Arc GIS software eases the use of this model and increases its functionalities.

The needed basic maps, including of digital elevation model (DEM), land use and soil must be given to the model in raster format. Other information related to meteorological data, water quality, factors affecting surface flow and channel, ground water, water harvesting, land management, information related to the water quality, tanks and some other areas must be included in the model according to the study purpose (Nitch *et al.,* 2005). In addition, at least one monthly data from reference synoptic station is required. Other requested data, including mean daily rainfall and temperature,

1457

were collected from meteorological stations within the study area or nearby.

2.2.1 Model input and calibration

The main data requirements for SWAT model consists of climate data, topography, soil, land use map, and topographic information. SWAT hydrological model requires input on soils (bulk density, available water capacity, sand, silt, clay, organic matter, and saturated conductivity), land use (crop and rotation), management (tillage, irrigation, nutrient, and pesticide applications), weather (daily precipitation, temperature, and solar radiation), channels (slope, length, bank full width and depth), and the shallow aquifer (specific yield, recession shallow aquifer by deep roots or water that travels from the shallow aquifer to the soil profile and is then lost to soil evaporation or plant root uptake (Arnold *et al.,* 1993). The climate data, including of rainfall, temperature and discharge, relative humidity, wind and solar radiation collected in daily steps. This data collected from both synoptic meteorology stations from Iranian Meteorological Organization and also climatology stations from Ministry of Energy in the study area during 1995-2005. Collected data from 52 rain gauge and 10 synoptic stations were prepared and stored in a database for the simulation. The hydro-climatological stations within and near the Gharasou watershed are shown in Figure2. The digital elevation model (DEM), showing the topography of the land by a cellular network in Raster format, was used in the model with specified geographic coordinate system (Figure 3). The model determines the location of rivers, divides basin into sub basins, and extracts physical characteristics of the catchment. Soil units were classified into 20 classes with attributes based on the FAO map with scale 1:1000000 (FAO/UNESCO-ISWC, 1998). This map was revised by Kermanshah Watershed Management Department (Figure 4). Field work increased the accuracy of soil units by collecting 45soil samples and testing in laboratory (Table 1). Land uses in Raster format were obtained from the Soil Conservation and Watershed Management Institute (SCWMRI). Land use maps, also available in SCWMRI, were prepared using data from Landsat satellite images in 2005 by supervised classification and visual interpretation (Figure 5). A Large number of parameters used for calibration, validation and sensitivity analysis by "one parameter at a time (OAT)" method in order to identify factors with important and sensitive impacts on river flow simulation from 1995 to 2005. Calibration, validation and uncertainty analysis were performed by using SUFI2 algorithm among the others due to its accuracy.
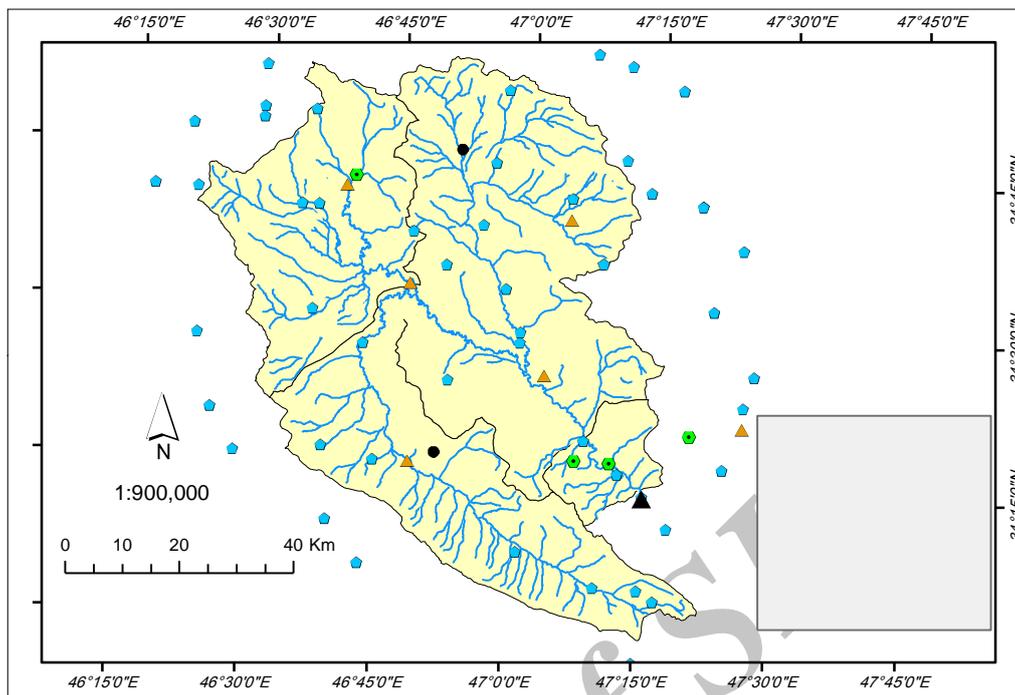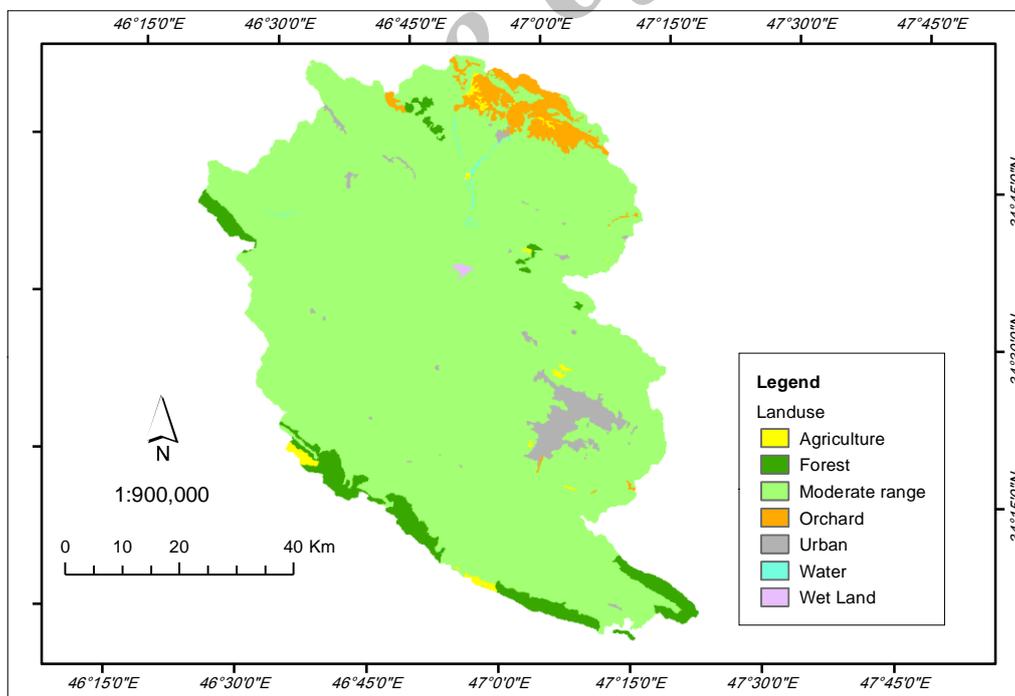
Figure 2 Hydro-climatological stations within and near the Gharasou watershed
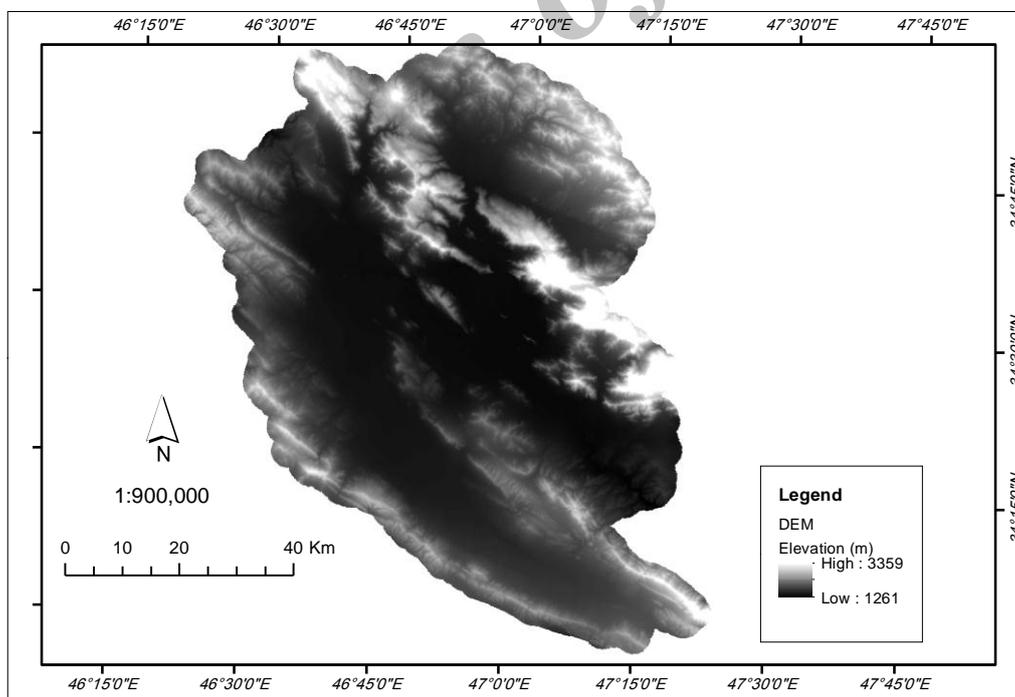
Figure 3 Digital Elevation Model in Gharasou watershed

1459
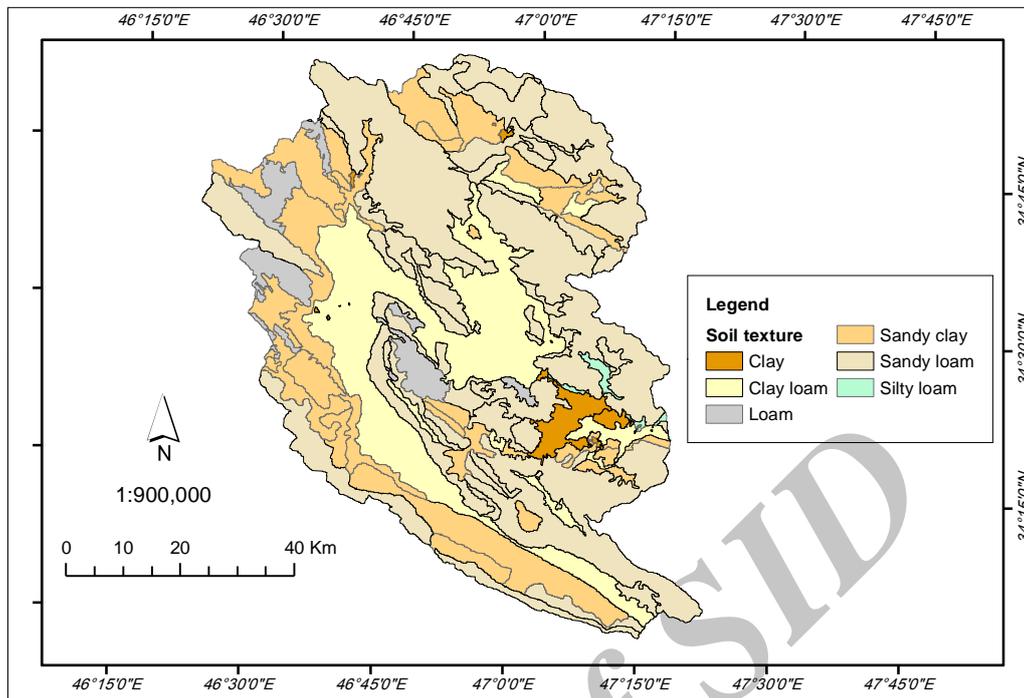
Figure 4 Classified soil textures in Gharasou watershed (Source: Kermanshah Watershed Management Department, 2005)

Figure 5 Land use map in Gharasou watershed (Source: SCWMRI, 2006)

1460

For automatic calibration, Abbaspour *et al.* (2007 and 2015) developed a set of five different calibration programs as Sequential Uncertainty Fitting (SUFI2), Parameter Solution (ParaSol), Generalized Likelihood Uncertainty Estimation (GLUE), Markov Chain Monte Carlo (MCMC) and Particle Swarm Optimization (PSO), which could be linked to SWAT. This model is able to separate water budget components such as evapotranspiration, surface runoff, sub surface runoff, groundwater flow, and soil water content.

Table 1 Soil properties in Gharasou watershed

ID	Hydrologic group	Soil depth (cm)	Soil cracks	Texture	Available water capacity	Carbon content (%)	Clay	Silt	Sand	EC (μm)
1	A	70	0.1	CL-L	0.3	0.5	30.0	38.0	32.0	0.7
2	B	150	0.2	L-SL-L-S	0.2	0.4	18.0	34.0	48.0	0.6
3	B	35	0.1	C	0.3	1.9	50.0	28.0	22.0	0.6
4	A	90	0.2	C	0.4	1.5	46.0	32.0	22.0	0.7
5	B	110	0.2	CL-SL-SL	0.4	1.7	36.0	26.0	38.0	0.4
6	B	70	0.2	SCL	0.4	0.1	20.0	20.0	60.0	0.5
7	A	100	0.1	C-C	0.3	1.6	50.0	30.0	20.0	0.6
8	D	100	0.3	C-C	0.1	1.4	52.0	36.0	12.0	1.0
9	B	120	0.1	CL-CL	0.3	0.3	32.0	24.0	44.0	0.5
10	A	100	0.2	C	0.2	2.0	66.0	20.0	14.0	0.7
11	B	50	0.2	CL-SCL	0.4	0.9	40.0	32.0	28.0	0.5
12	B	120	0.2	C-CL	0.4	0.8	42.0	30.0	28.0	0.4
13	D	40	0.0	CL-CL	0.0	0.4	36.0	30.0	34.0	0.4
14	C	150	0.2	C-CL-SCL	0.3	0.9	42.0	38.0	20.0	0.4
15	D	30	0.0	C	0.0	0.3	46.0	40.0	14.0	0.3
16	A	180	0.3	SCL-C-C	0.4	1.0	38.0	44.0	18.0	1.2
17	D	35	0.0	C	0.0	0.5	54.0	32.0	14.0	0.4
18	B	30	0.2	C	0.4	0.8	51.0	31.0	18.0	0.6
19	D	150	0.3	SC-C-C	0.1	1.5	44.0	40.0	16.0	0.5
20	D	30	0.0	CL	0.0	1.2	30.0	32.0	38.0	0.7

3   RESULTS AND DISCUSSION
3.1 Model calibration and validation
Sensitivity analysis deals with how the variation in the output of a model (numerical or otherwise) can be apportioned, qualitatively or quantitatively (Santhi *et al.,* 2001). Out of twenty six flow parameters assessed by the model in this study, eight of them were found to be more sensitive, the most sensitive of which were curve number (CN2), available water capacity of the soil layer (SOL_AWC), and Groundwater "revap" coefficient

1461

(GW_REVAP). A brief description of each hydrological parameter is listed in the SWAT model user's manual (Neitschc *et al.,* 2005). The model was calibrated for the water budget and stream flow for the average annual and monthly steps in two main gauge stations, viz. Golchehr and Gharabaghestan. Statistical criteria were provided from the final report of a project (Hosseini et al., 2012). The visualized output elucidates that the observed and simulated average monthly discharge for both calibration (1995 to 2001) and validation (2002 to 2005) periods for main stream gauges in study area are in good agreement with one another (Figures 6, 7, 8, and 9). Evaluation of the hydrologic budget in this study entailed employment of the pertinent parameters optimized by SUFI2 to test the performance of SWAT in both the model calibration and validation for the period January 1995to December2005. The statistical results showed the successful performance of the model in both calibration and validation periods at three main stream gauge stations (Table 2). Since the values for the mean absolute relative error (MARE) and standard error are generally too low and close to zero, R^2 and NS coefficient are two important statistical analyses for evaluation of the results. Low MARE and high values of R^2 indicated that SWAT model can be used safely to simulate the water balance components in study area.

In this research R^2 values, corresponding to the relationships between the observed and predicted average monthly discharges in three main stream gauges (viz. Golchehr, Gharabaghestan and Gharasou), were 0.40, 0.71, and 0.61 for calibration and 0.37, 0.87 and 0.65 for validation periods, respectively. Coefficients of efficiency (NS) at outlet were 0.43 to 0.73 in the three outlets for both periods. These ranges were adopted in this study for interpretation of the model performance. Nash Sutcliffe coefficients for both calibration and validation periods for stream gauges of study area shows reliable value with good agreement.

According to Norusis (1999), when R^2 equals to 1, the regression equation model is considered as a perfectly fit model, but if the R^2 is lower than 0.5 (near to zero), the model is considered as not suitable. Otherwise, the values for the coefficient of efficiency (NS) can range from extreme negative values to 1, with 1 indicating a perfect fit between the observed and predicted runoff. According to common practice, the simulation of a model is considered good for values greater than 0.75 and acceptable for values between 0.36 and 0.75 (Motovilov *et al.*, 1999). Values less than 0.36 indicate a poor model performance.

In SUFI2, parameters uncertainty accounts for all sources of uncertainties. These sources include variables (e.g. rainfall), the conceptual model, model parameters, and measured data. To evaluate such uncertainties, SUFI2 offers two criterion factors: the P-factor and the R-factor. The P-factor indicates the percentage of measured data bracketed by the 95% prediction uncertainty (95PPU) whereas the R-factor calculates the average thickness of the 95PPUband divided by the standard deviation of the measured data. Theoretically, the value of the P-factor ranges from 0 to 100%, while that of the R-factor ranges from 0 to infinity. A P-factor of 1 and R-factor of zero indicate a simulation that exactly complies with measured data. The degree to which we are away from these numbers can be used to judge the strength of our calibration. Further goodness of fit can be quantified by the R^2 and Nash-Sutcliff (E_{NS}) coefficient between the observation and the final "best" simulation (Hosseini et al., 2012).
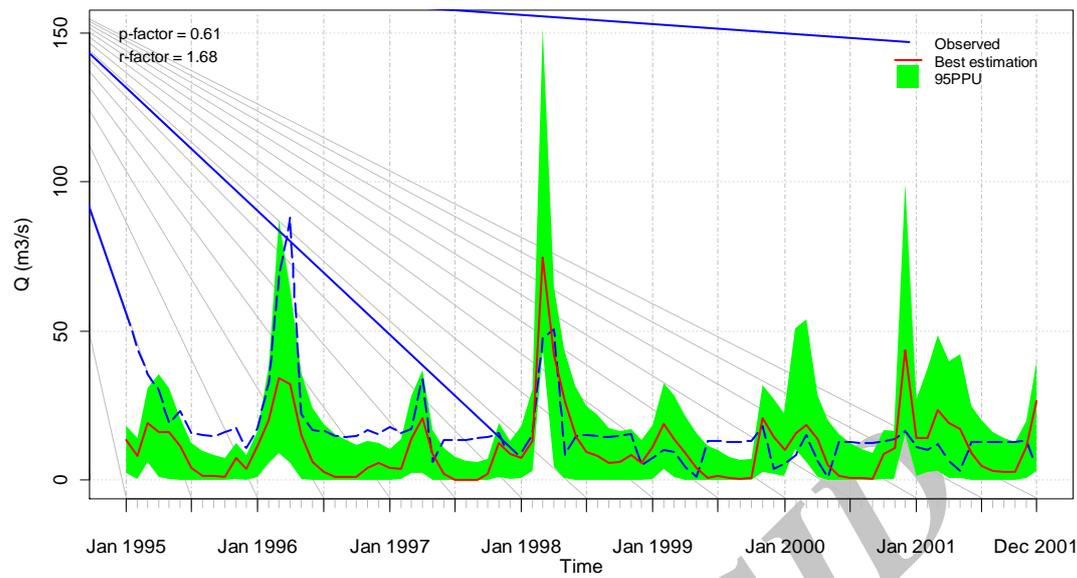
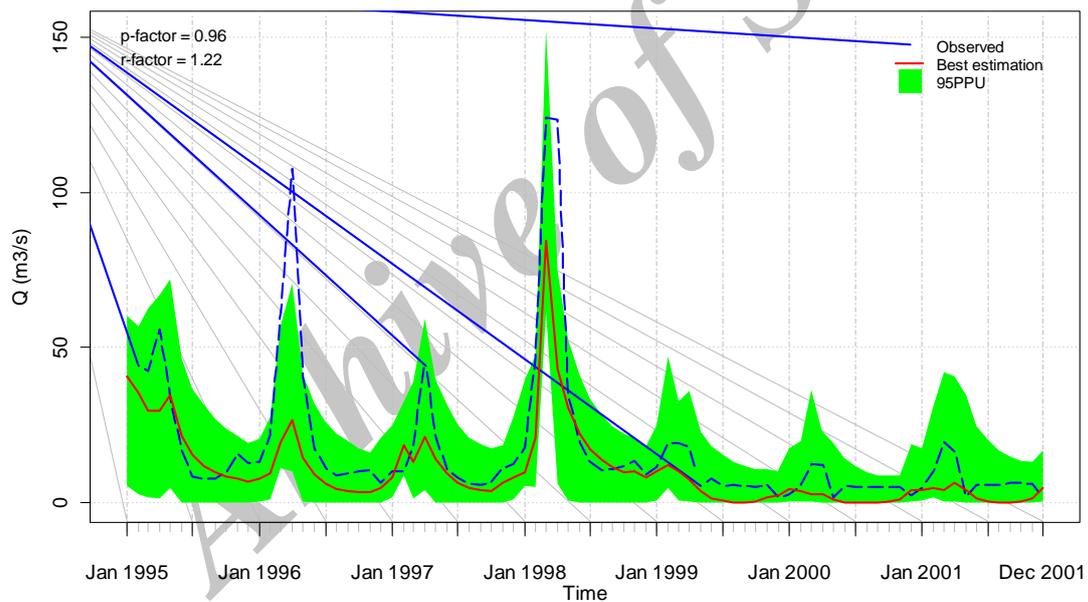**Figure 6** Observed and estimated mean monthly discharge at Polchehr station in calibration period

Figure 7 Observed and estimated mean monthly discharge at Gharabaghestan in calibration period
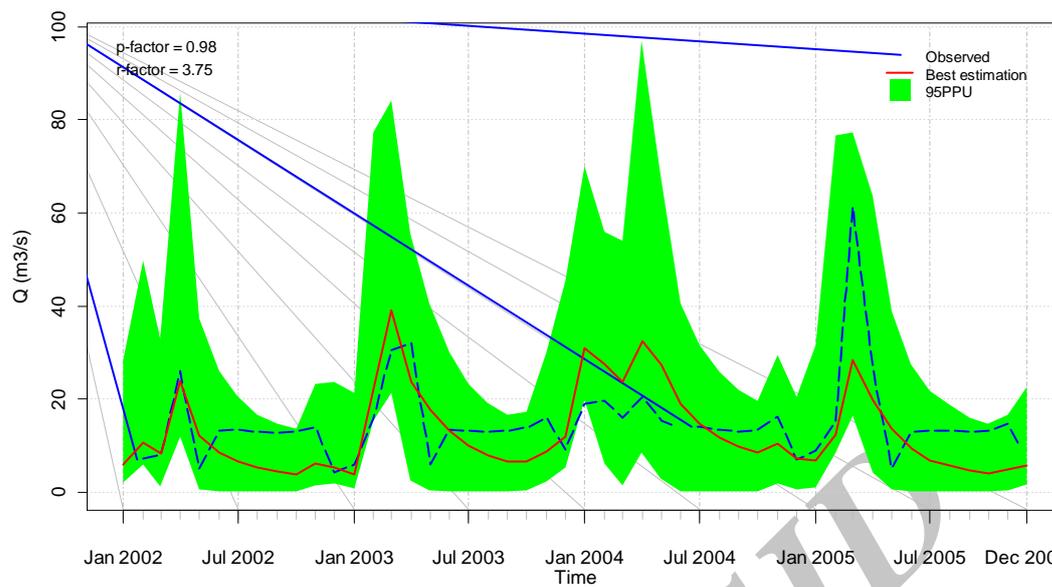
Figure 8 Observed and estimated mean monthly discharge at Polchehr station in validation period
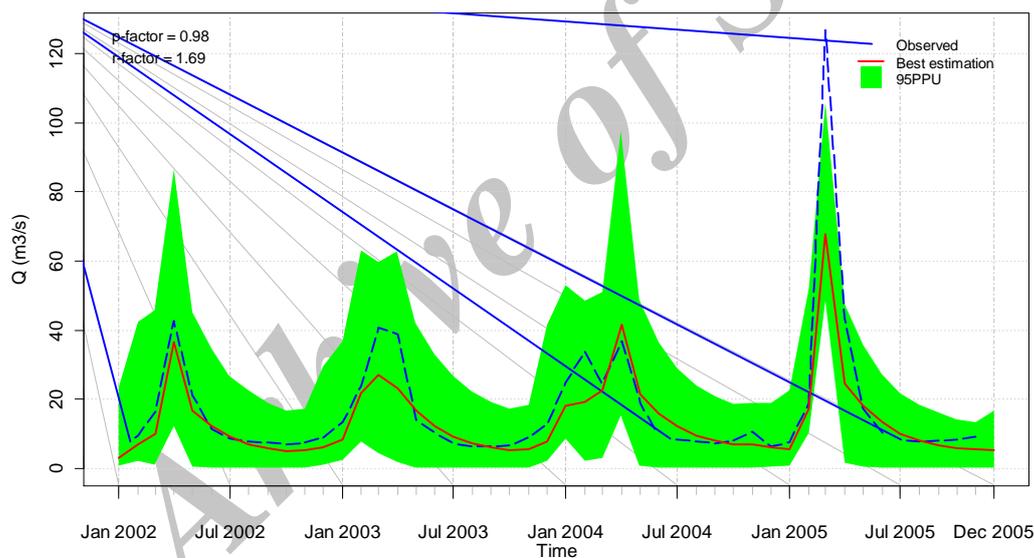

Figure 9 Observed and estimated mean monthly discharge at Gharabaghestan in validation period

1464

Table 2 Statistical evaluation of the model performance on the monthly discharge in the calibration and validation periods at main outlets of Gharasou stream gauge stations

| Main stream gauges		R^2	NS	RMSE	VE
Polchehr	Calibration	0.40	0.43	14.16	0.37
	Validation	0.37	0.39	8.13	0.57
Gharabaghestan	Calibration	0.71	0.52	15.99	0.52
	Validation	0.87	0.73	10.08	0.71
Gharasou	Calibration	0.61	0.56	18.26	0.33
	Validation	0.65	0.60	12	0.45

The hydrologic budget for selected years at the outlets of subbasins included such components as surface flow, lateral flow, groundwater flow, evapotranspiration and soil water content (Table 2).

Results of annual interpretation indicated that the highest water loss (49.3%) occurred through evapotranspiration (Figure 10), which was lower than the country's average (72%). Groundwater flow constituted 30% of the hydrologic budget, followed by the surface runoff (15%). Variation of soil moisture during simulation period was equal to 26.2 mm (5.2 % of mean average precipitation). The study has developed a database system for the Gharasou in Iran that organizes the otherwise dispersed datasets of the water budget and link them to the GIS environment that can be easily used by the interested government agencies and other stakeholders.

Table 3 Water budget at Gharasou Station during the Period 1995 to 2005

Variables	Total	
	(mm)	(%)
Precipitation	502.5	100
Evapotranspiration	247.5	49.3
Surface Runoff	74.6	14.8
Sub surface flow	4.21	0.8
Groundwater flow	150.13	29.9
Soil Water content	26.2	5.2
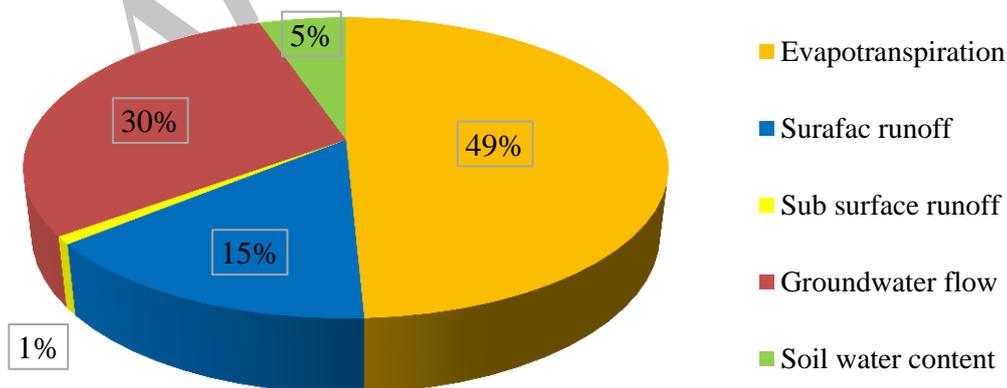
Figure 10 Mean annually hydrologic budget in Gharasou watershed

1465

The monthly proportions of different water pathways of input to the river flow, as has been pointed out in an earlier study (Hosseini *et al.,* 2012), are shown in Figure 11 for outlets of sub basins. It can be seen that from April to the end of May, most of the river flow originates from surface runoff due to the intense storms and snow melt occurring during that period. Most of the surface runoff in June depends on snow melt that takes place at high elevation areas. Climate of study area is influenced by both Caspian Sea. In general, the precipitation regime in the study area is the result of the Mediterranean regime with one main maximum precipitation episode at the end of winter and early spring followed by one long dry season in the summer. In fall there is another rainy period wherein precipitation is influenced by moist air in contact with northern Siberian air masses. The influence of the monsoon from the Indian Ocean is very rare during the year.
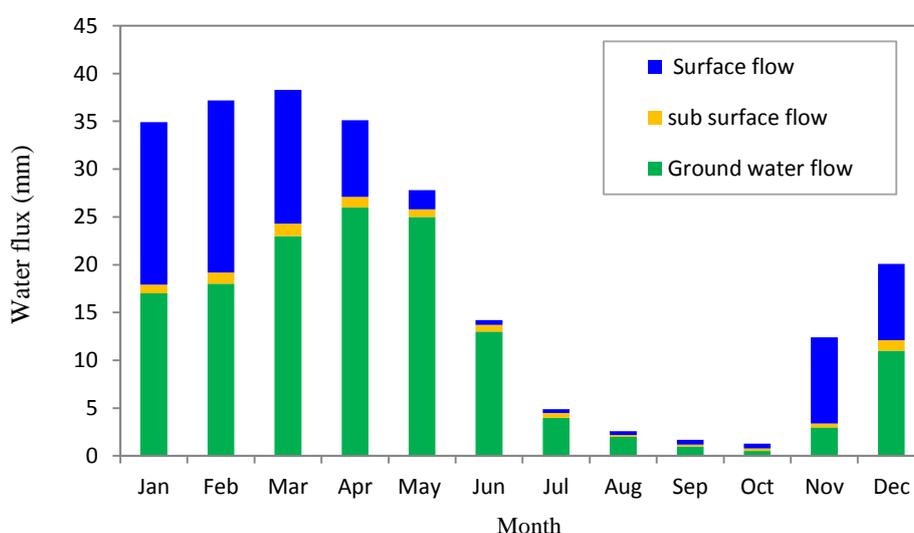

Figure 11 Mean monthly proportions of different water flux inGharasou watershed

4   CONCLUSION

In this research, SWAT optimized the hydrologic budget in three main stream gauge stations reasonably well. By implementation of SWAT physical model in Gharasou catchment (Kermanshah), the monthly flow simulation became possible. Each components of the model gives reasonable output. This should allow more realistic appraisal of various land use management practices on a large watershed. The highest water loss (49.3%) occurred through evapotranspiration, which was lower than the country's average (72%). Groundwater flow constituted 30% of the hydrologic budget, followed by the surface runoff (15%).The portion of ground water flow (30%) shows a reliable potential to support water supply in agriculture. The 15% surface runoff (about 436 MCM in volume) can have an important role in the agricultural planning of the area.

4   ACKNOWLEDGEMENTS

5 REFERENCES

Abbaspour, K. C. SWAT-CUP2: SWAT Calibration and Uncertainty Programs – A User Manual. Department of Systems Analysis, Integrated Assessment and Modeling (SIAM), Eawag, Swiss Federal Institute of Aquatic Science and Technology, Duebendorf, Switzerland.2005; 100pp.

Abbaspour, K. C., Yang, J., Maximov, I., Siber, R., Bogner, K., Mieleitner, J., Zobrist, J., Srinivasan, R. & Reichert, P. Modeling of hydrology and water quality in the pre-alpine/alpine Thur watershed using SWAT. Journal of Hydrology.2007; 333: 413–430.

Arnold, J.G., Srinivasan, R., Muttiah, R.S. and Williams, J.R. Large area hydrologic modeling and assessment part I: model development. Journal of the American Water Resource Association. 2008; 34 (1): 73–89.

Arnold, J.G., Allen, P.M. and Bernhardt, G.A comprehensive surface-groundwater flow model.J. ofHydrol.1993; 142: 47-69.

Ebrahimi, M. Masoodipour, A. Rigi, M. Role of Soil and Topographic Features in Distribution of Plant Species (Case study: SanibTaftan Watershed)., J. ECOPERSIA., 2015; 3 (1), 917-932.

Eckhardt, K., Arnold, J. Automatic calibration of a distributed catchment model. J. Hydrol. 2001; 251: 103–109.

FAO/UNESCO-ISWC: The World Reference Base for Soil Resources, Rome, Italy. 1998.

Hosseini, M., & Ashraf, M. A. Application of the SWAT Model for Water Components Separation in Iran.Springer. 2015;97-98.

Hosseini, M., Tabatabaei, M. R., Sarreshtehdari, A., Khalkhali, S. A. and Goodarzi, M..Simulation of the surface runoffof large Karkheh Basin."Final Report of Research Project, Soil Conservation and watershed Management Institute. 2012; p 83.

Hosseini, M. PhD Thesis, Effect of Land Use Changes on Surface runoffand Suspended Sediment Yield of Taleghan Catchment, Iran.University Putra Malaysia. 2010; 32-36

Li, Z., Zou, S., Xiao, H., Zheng, C., Yin, Z., Wang, W. Comprehensive hydrologic calibration of SWAT and water balance analysis in mountainous watersheds in northwest China. J. Physics and Chemistry of the Earth. 2012; 79–82

Lu, Z., Zou, S., Yin, Z., Long, A., Xu, B. A new suitable method for SWAT model calibration and its application in data-scarce basins. J. Lanzhou Univ. (Nat. Sci.). 2012; 48: 1–7.

Mc Cornick, P. G., Kamara, A. B., and Girma, T. (Eds.): Integrated water and land management research and capacity building priorities for Ethiopia, Proceedings of a MoWR/EARO/IWMI/ILRIinternational workshop held at ILRI, Addis Ababa, Ethiopia, IWMI, Colombo, Sri Lanka, and ILRI, Nairobi, Kenya. 2002; 267 pp.

Motovilov, Y.G., Gottschalk, L., Engeland, K., and Rodhe, A. Validation of a distributed hydrological model against spatial observations.Agricultural and Forest Meteorology. 1999; 98-99, 257-277.

Neitsch, S.L., Arnold, J.G., Kiniry, J.R. and Williams, J.R. Soil and Water Assessment Tool Theoretical Documentation Version 2005. Grassland,

Soil and Water Research Laboratory, Blackland Research Center, Temple, Texas., 2005.

Niraula, R., Norman, L., Meixner, T., Callegary, J. Multi-gauge calibration for modeling the semi-arid santacruz watershed in Arizona–Mexico Border Area using SWAT. Air, Soil Water Resources., 2012; 5:41–57.

Norusis, M. J. SPSS regression models 10.0. Chicago: SPSS. Pizzey, E. 1974. Scream quietly or the neighbors will hear. Middlesex, UK: Penguin. 1999.

Quinlisk, J. A. Animal abuse and family violence. In F. R. Ascione& P. Arkow(Eds.), Child abuse, domestic violence, and animal abuse: Linking the circles of compassion for prevention and intervention; West Lafayette, IN: Purdue University Press. 1999; pp. 168-175.

Sanjay, K., Jaivir T. and Vishal, S. Simulation of runoff and sediment yield for a Himalayan watershed using SWAT model, J. Water Resources Protect. 2010; 2: 267–281.

Santhi, C., Arnold, J. G., Williams, J. R., Dugas, W. A., Srinivasan, R. and Hauck, L. M. Validation of the SWAT model on a large river basin with point and nonpoint sources, J. Am. Water Resources Associate. 2001; 37: 1169–1188.

Sathian, K. and Symala, P. Application of GIS integrated SWAT model for basin level water balance, Indian J. Soil Cons., 2009; 37: 100-105.

USDA, Soil Conservation Service. National Engineering Handbook, Hydrology Section 4 (Chapters 4–10). 1972.

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چکیده: بیلان آبی حوزه آبخیز قره‌سو در کاربری‌های متفاوت و خاک‌های متنوع با اسـتفاده از مـدل SWAT2012 در طول سال‌های ۱۹۹۵ الی ۲۰۰۵ برآورد گردید. داده‌های مورد نیاز اجرای مدل مشتمل بر نقشه خاک و خصوصیات آن، نقشه کاربری اراضی، نقشه رقومی ارتفاع و داده‌های روزانه هواشناسی و هیدرومتری حوضه می‌باشد. برای واسنجی و صحت‌سنجی مدل از نرم‌افزار SWAT-CUP و برنامه SUFI2 اسـتفاده شـد. ضـرایب تبیـین (R^2) و Nash-Sutcliffe (NS) بـــــه‌ترتیـــــب از ۰/۳۷ تـــــا ۰/۸۷ و ۰/۳۹ تـــــا ۰/۷۳ حـــــاکی از کـــــارآیی قابــــل قبــــول شبیه‌سازی مدل می‌باشد. آنالیز بیلان آبی نشان می‌دهد که مولفه‌های تبخیر و تعرق، جریان سطحی، جریان زیرسطحی، جریان زیرزمینی و حجم آب ذخیره شده در خاک به‌ترتیب معادل ۴۹/۳، ۱۴/۸، ۰/۸، ۲۹/۹ و ۵/۲ درصد می‌باشد. توزیـع ماهانه مولفه‌ها حاکی از رگبارهای شدید و ذوب برف در رودخانه در طول ماه‌های فروردین تا اوایل ماه خرداد می‌باشد. حاصل این تحقیق، ایجاد یک بانک اطلاعاتی از بیلان آبی سالانه و ماهانه برای حوضه قره‌سو می‌باشد که با موفقیت برای مدیریت منابع آب توسط دستگاه‌های دولتی و بهره‌برداران توسعه یافت است.

کلمات کلیدی: ایران، برنامه SUFI2، بیلان آبی، حوزه آبخیز قره‌سو، مدل SWAT