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Comparison components of water balance in sub-basins of Talar Watershed(North of IRAN) Using semi-distribution of SWAT model

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Abstract— In this study, has been used soil and water Assessment Tool (SWAT) model for comparison of water balance components in Talar watershed of Mazandaran Province located of north IRAN. According to the available statistic for obtaining the output of the SWAT model, water year of 2003-2004 until 2006-2007 in 4 years, for model calibration and water year of 2008-2009 until 2009-2010 , in 2 years, for model validation.For examination accuracy, extracted data from the year of 2008-2009 until 2009-2010, in 2 years. As the results of this study, it was found about the amount of precipitation, with fluctuations, is distributed in all sub-basins of watersheds and Sub-basins 1 to 4 pay attention to rainfall regime in the end section of the catchment area , have volume of snow melting equal zero. In the rest of the sub-basins, the snow melting with fluctuations, are almost normal. Except for the sub-basin number 11, which melt snow more than the rest area. Potential evapotranspiration in the lower parts of the area is more than due to the higher average temperature compare of the upper areas. Therefore, this issue can be considered in terms of estimating about water balance of the area. In terms of sediment, the lower sub-basins of this region are less, which are more forest area. However, in the land use of forest, barren and pasture lands, the amount of sediment yield is higher, which should be consideration due to the soil condition and human factors.of the area.

Keywords— Water balance, SWAT model, Talar sub–basins, Rain regime, Sediment yield

I.INTRODUCTION

The use of semi-distributed and physical models is very efficient in estimating the flow components and hydrological balance. This models depend on complete and accurate information about soil characteristics, land use status and hydrological information of the area, that affects to quantity and quality of water Balance components[10].Determining the water balance of the plains and watersheds can help in the management and planning of water resources. It is noteworthy that the water balance at the level of a basin and plain is a complex process that needs to be thoroughly investigated, because there are many input and output parameters can be combined and has been more complex of determining the total balance of water [13].

One of the software models that has recently been used widely in different parts of the world to simulate the hydrologic factors of watersheds, quantitatively and qualitatively, is the hydrologic model of SWAT. The model is an analytical, qualitative and continuity model provided by the American Agricultural Research Service [5].Also, the above model is a semi-distributive model that runs continuously on a daily scale for simulation of the watershed. To predict the effect of different land management methods on the flow, sediment, nutrients and balance of chemicals in large agricultural areas with soil and Variable land use has been developed for long periods of Supplied and time. This model has a physical basis and has the ability to connect to the information system software (GIS) and has no limits on the input of a large amount of information on large watersheds. The development of GIS technology is very efficient and effectiveness. It has provided a great value for studying hydrological systems. This is due to the expansion of spatially distributed models in the context of GIS, in which spatial information is presented as homogeneous units along with hydrological data, as well as the power and possibility of perspective, scenario, simulation, prediction, and the comprehension and expression of complex and dynamic processes and Provides a significant contribution [6]. It is difficult to measure water balance components at intervals because of time consuming and costly. The methods of water balance compilation as one of the main topics in hydrology, represent the method of solving important theoretical and practical problems of hydrology. Based on the water balance, it will be possible to evaluate quantitative and qualitative (suspended sediment) water resources and their changes, mainly due to human activities. Therefore, it is important to simulate the flow components and also to properly understand the water balance for hydrological cycles.

II.RELATED WORK

In one study[10] used the SWAT model in the Itapemirim Basin in the Brazilian Equatorial Region. In this research, data from 1993 to 2000 were used to calibrate and validate the model. The results of the evaluation by the researchers showed that the model is very sensitive to the base flow in the initial calibration. The results of validation analysis with Nash-Sutcliff coefficient of 0.67 showed that application of the model in this area is satisfactory. Other studies[3,8] and others in Brazil, especially in watersheds with little environmental data, and elsewhere in the world by[18,7] achieved satisfactory results in using this model.In another study[19]used the SWAT model to evaluate the uncertainty of non-point pollutant sources in the Red Hill Creek and Grindstone Creek Canadian watersheds. The researchers generally suggested a method to reduce this uncertainty model in future uses of this model andresearch by [14] used the SWAT model to calibrate a forest area that was given to the change over range in the Cimarron Basin in northern Oklahoma, United States of America. The average NSC in the model calibration period for daily and monthly runoff in the catchment area was 0.96 and 0.97 for rangelands and 0.90 and 0.84 for forest areas, as well as for the average runoff coefficient for the monthly runoff in a 22-year period. 0.79. They used detailed biophysical and hydrological parameters for grassy meadows under moderate grazing and forest areas, which can be used to calibrate other models with their verifications in a set of hydrological models.Aanother research [11] conducted hydrological responses to climate change in the watershed of Mt.Elgon, Kenya. In this study, they investigated the potential of river flow hydrological responses to climate change in the Nsoia River Basin of Kenya. In this study, they used the SWAT water and soil resource assessment tool and the monthly temperature and rainfall changes under different scenarios for the upcoming periods of 2011-2040, 2041-2070, and 2071-2100. The results of these studies showed that the difference in the four areas of the regions. Their studies are in response to climate change due to their different sensitivities and uncertainties in potential regional hydrological effects. In another research[15] evaluated the optimization of rainfall and runoff parameters in a semi-distributive SWAT model in the ghasaghli watershed of Golestan province , north of iran, in 2012. The results of this study showed that after simulation, the P-factor was between 0.34-0.9 and R-factor between 0.51-1.14, which indicates low uncertainty and high accuracy of the model in the simulation, so that most of the data Observations were included in the uncertainty estimation range of 0.95.They concluded that this model could be used as a useful tool for water resource management, descriptive and optimal management of the area, and assessment of water resources systems. In addition to the above-mentioned studies, other studies on the use of the SWAT model within Iran can be mentioned as just the following: In study[4] by the title of "Soil and sediment simulation using SWAT model in Chehel-Chay watershed, Golestan province, Evaluation of the performance of the SWAT model in the Zayandeh rud watershed[1],Simulation of flow Determination of critical areas of sediment production in Chehel-Chay watershed in Golestan province using SWAT model in [4], estimation of real evapotranspiration in a year-watershed scale, using the SWAT model [2] has been mentioned.

III.METHODOLOGY

The study area is located in the central Alborz basin and on the two sides of the road of Tehran - Qaemshahr. The study area is 210088/7 hectares, which is in the coordinates of 52 35, 22 2 to 53 23 34 19 eastern and, 35 44 23 06 to 36 19 1 06 is located of the northern latitudes and is draped by a main river called Talar, which extends southwards to the north. The main river of this area has a total length of about 100 km and crosses the outlet of the basin with the river Kasilian. The highest elevation at the end of the northwest of the basin is the Shljmar Zardin peak with a height of 3910 m and the lowest point in the outlet of the area with a height of 215m above sea level. The shaped plain area has a south to north stretch. Low lands are about 22%, and average land is about 70.2% and highlands account for about 7.8% of the total area. The river basin reaches about 50 km in the Ghaemshahr-Babol plain and flows into the Caspian Sea. The rainfall regime of the studied region is completely Mediterranean. The annual snowfall coefficient of the study area is 21.9%. The highest recorded temperature was in the 46 degree range and occurred in July, with a minimum degree of heat in the study network of -35.6 ° C that occurred in February. Based on the climatic method of Embeger, the climatic condition of this area is classified into 5 climatic regions from semi-arid to moderate humid(Talar watershed combining project report,2001). Figure 1 shows the location map of the Talar area in Mazandaran province of Iran.

FIGURE (1): LOCATION OF THE THE TALAR WATERSHED IN MAZANDARAN PROVINCE,NORTH OF IRAN[17]

In the SWAT model, in order to achieve the modeling objectives, a watershed is divided into a number of sub-basins. It is useful to use watersheds in simulation, especially when different areas of the catchment are used by land use or different soils to evaluate the effects of hydrological characteristics. By dividing the watershed into sub-basins, the user is able to connect different areas of the Watershed with other locations. The input data for each sub-basin is divided into the following categories: Climate, Hydrological Response Unit (HRU), Lakes, Muds, Underground Water, Main drainage, or reach, Drainage Network. Hydrological response units are integrated zones in relation to sub-basins including vegetation cover, soil and management issues. The hydrological cycle of the SWAT model is simulated with the following water balance:

$$sw_t = sw0 + \sum_{i=1}^{t} (R_{day} - Q_{surf} - E_a - w_{sep} - Q_{gw}) \quad (1)$$

In this relations, SWt is the final value of soil water, SW0 is the initial value of soil water in day i, t times (days), Rday daily rainfall i, Qsurf daily surface runoff I, Ea daily evapotranspiration i, Wsep, amount The water fed into the unsaturated layer of soil profile and Qgw is the amount of water returned in the i-th day to millimeters. Dividing the watershed into sub-basins enables the user to calculate the difference in evapotranspiration for diverse products. Runoff is separately predicted for each HRU and its routine is calculated to the total runoff. These steps increase the correctness of the work and provide a better physical description of the water balance. Surface runoff is calculated using the modified equation of the SCS curve number (Soil Conservation Service; US Department of Agriculture using the Green-AmpT Permeability Equivalent Method [12], Surface Runoff in SWAT The use of the curve number method is calculated on the basis of the following equation:

$$Qsurf = \frac{(R_{day} - 0.2s)^2}{(R_{day} + 0.8s)} \quad (2)$$

$$R > 0.25$$

Qsurf, cumulative runoff or excess rainfall, millimeter Rday, daily depth of precipitation in millimeters, and S is the storage parameter in millimeters. The runoff occurs when Rday> 0.2S. The storage parameter is spatially varied based on soil characteristics, land use, the way of land management, slope and temporary changes in water capacity in the soil. The storage parameter is described on the basis of the following equation:

$$S = (\frac{1000}{CN} - 10) \quad (3)$$

Which CN is curve number a on a daily basis[16].

IV.RESULTS AND DISCUSSION

Following the preparation of the required maps and climatic information, the model was implemented for this watershed. The SWAT model initially begins the implementation of the model based on DEM and river network and identifying the outlet station. Then, by combining soil, slope and land use, the map of the baseline is plotted, and then HRU (hydrological response unit), which is one of the most important factors in the SWAT model prepares, based on the contribution , each of the slope, land use and soil factors. In this study, the total catchment area of the Talar watershaed was divided into 219 units of hydrological response unite in 23 sub-basins. According to the available statistics for obtaining the output of the SWAT model, the water year of 2003-2005 to 2006-2007 , 4 years for calibration and the water year 2008-2009 to 2009-2010, 2 years, was considered for model validation. Figure 2 shows the division of 23sub-basin of the Talar watershed by using the SWAT Model and Figure (3) shows the land use map of the Talar watershed.

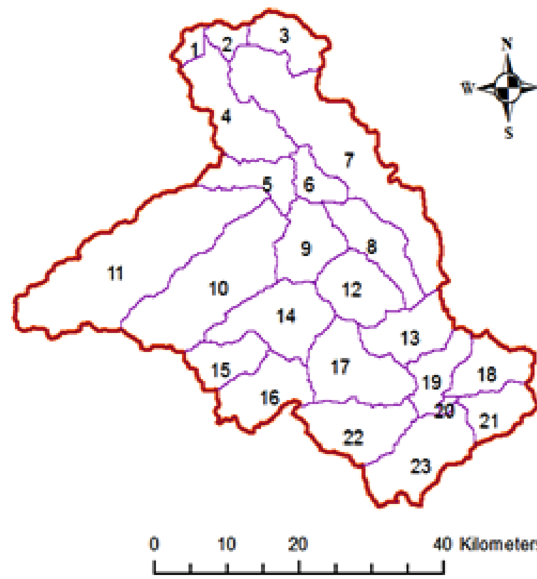

Figure (2): Dividing 23 sub-basins of Talar watershed using the SWAT model

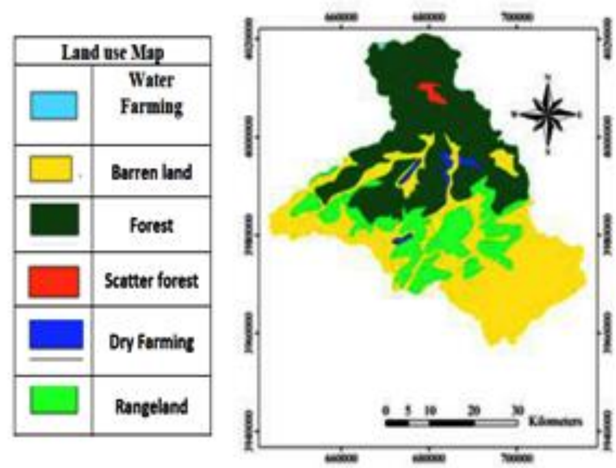

Figure (3): Land use map of the Talar watershed

Considering that the main objectives of this research was to review and compare the influential factors on the water balance of this area using the SWAT outputs and considering the input data in the SWAT model on a daily basis, therefore, the daily data of water balance components were extracted in the water year of 2008-2009 to 2009-2010 for 2 years. This data was considered for validation of the model for further analysis. Table 1 shows Extraction and The calculation of the daily average of 23 sub-basins of water balance components in two years of hydrological model validation. Figures 4 and 5 shows comparison amount of rainfall in sub-basins of Talar watershed . The percentage rainfall of Talar watershed in 23 sub-basins divided by SWAT software has been used for validation years from 2009 until 2010. By the study of Fig. 4, it can be seen that the amount of precipitation in sub-domains is distributed with equal fluctuations among sub-basins. Also, the percentage of precipitation is plotted as the prevailing rainfall in the upper area of watershed is more in the form of snow, which is noticeable. In sub-basin number 20, 21, 22 and 23, and considering that the snow with low Hydrological reactions can help to save groundwater and if snow is Mixture by precipitation in the late winter, early spring until mid-spring can lead to floods and increased sedimentation of rivers, then these factors can be noticeable.

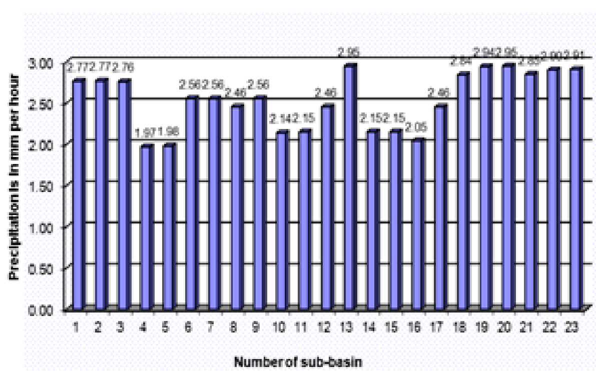

Figure (4): Comparison amount of rainfall in Talar watershed

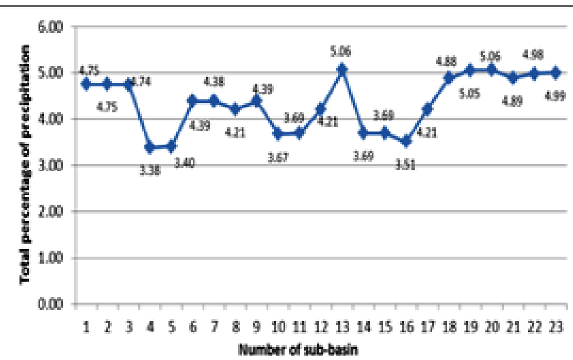

Figure (5): Percentage of rainfall in sub-basins of Talar watershed

Fig. 6 shows the amount of snow melting in the study period of the area. It is clear of this diagram that sub-basins 1 to 4 have a zero melting point with respect to the rainfall regime of the region at the end section of the area and is almost normal in the rest of the sub-basins with fluctuations in the melting distribution. Except the sub-basin of number 11, where snow melting that have been more than the rest. Of course, another factor in this regard that can be considered is the Area of sub-basin which can affect these results.

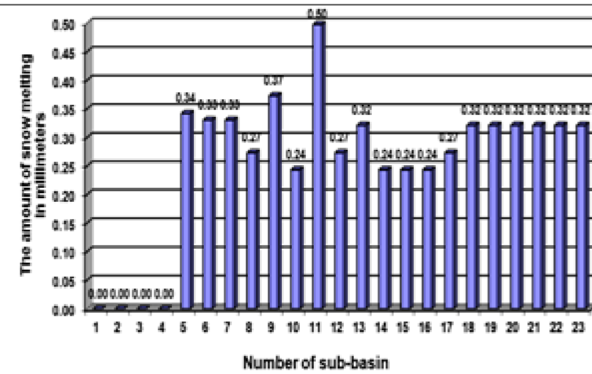

Figure 6: The amount of snow melting in 23 sub-basin of the the Talar watershed

All of the above diagrams can be used to describe the performance, status and share of sub-basin sediment content according to Fig. 7. It is also possible to examine this diagram as well as a comparison with the land use status (Fig. 3). In subsoil use, scatter forest, rangelands, forests, and forest with barren land, the amount of sediment has been increased in sub-basins. Considering that forest degradation or incorrect use of rangelands can exacerbate degradation and increase sediment load in sub-basins, there is a need for management strategy.

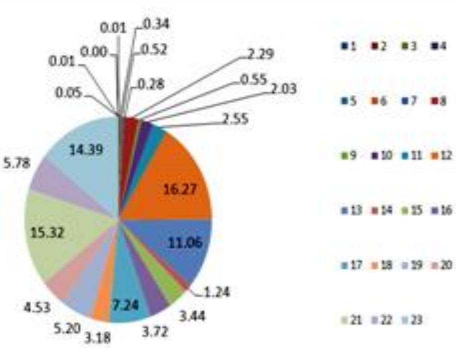

Figure 7: Percentage of sediment in Talar sub-basins

V. CONCLUSION

One of the important factors in the water balance that causes waste of water is evapotranspiration, which reduces the amount of water. In the aforementioned area, it is evident from Fig. 8 and Fig. 9 that potential evapotranspiration or evapotranspiration capacity in the lower parts of the region is due to its higher average temperature than the upper areas. Considering that most of the uses of the lower areas are in the forest land, and considering that the upstream areas are in the form of scatter forests, rangelands and barren lands with less evaporation and transpiration, then this can be in terms of Estimate of the water balance of the areas and the contribution of each sub-area in its status.

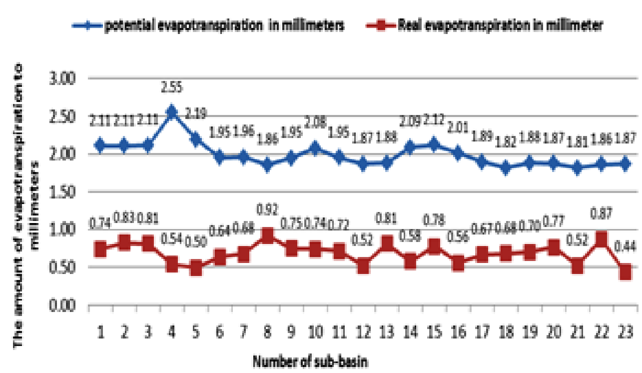

Figure 8: Comparison of potential and actual evapotranspiration of 23 sub-basins in the Talar watershed area

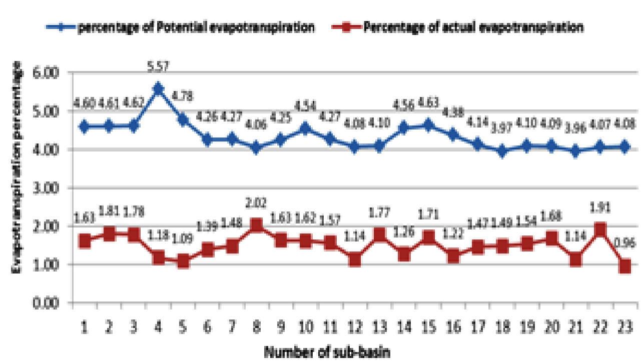

Figure 9: Percentage of actual and potential evapotranspiration in sub-basin of Talar watershed

Figure 10 shows the comparison of the 23 sub-basin sediment considered by the SWAT model in Talar watershed. This diagram, in relation to the situation of other charts, contains important view in this regard, so that the sub-basins of this region are more in the forest use area (Fig. 3) is less in terms of the amount of sediment, but in the use of scatters forest , barren lands and rangelands is more sediment yield, which should be considered due to the soil condition of the area and human factors. According to this diagram, in the sub-basin with a high sedimentation rate it is necessary to pay special attention of the natural resources in order to have more favourable conditions among the various factors affecting the water balance of the area.

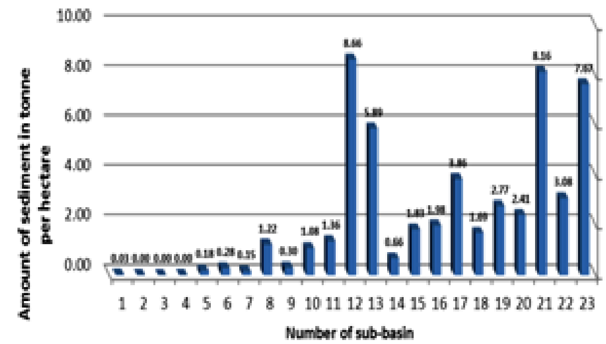

Figure 10: Comparison of the sub-basin sediment content in Talar watershed area

Regarding the results of this research and considering the area of about 2100 hectares for water resources management and water balance status, it is suggested that each of the sub-basins be considered a special management concern. For example, the sub-basins of the domain, which is the dominant use of the forest, are considered as a special unit, focus of attention and management. Ultimately at the macro levels of the area for a management unit in 23 sub-basins, to be formulated by the specific land use conditions, hydrological status of the area, climatic conditions, population pressure in sensitive area, and other factors affecting to water resources.

REFERENCES

[1] Ababei . B and T. Sohrabi . 2009.Assessing the performance of SWAT model in Zayandeh Rud Watershed. J. of Water and Soil Conservation, Vol. 16(3).

[2] Alizadeh A, A. Izady, K. Davary, A.N. Ziaei, S. Akhavan and Z. Hamidi..2013. Estimation of Actual Evapotranspiration at Regional – Annual scale using SWAT Iranian Journal of lrrigation and Drainage 7(2). 243-258.

[3] Andrade, M.A., Mello, C.R., Beskow, S.(2013) Hydrological simulation in a watershed with predominance of Oxisol in the Upper Grande river region,MG—Brazil. Rev. Bras. Eng. Agric. Ambient 17: 69–76 p (in Portuguese).Aragão, R., Cruz, M.A.S., Amorim, J.R.A., Mendonça, L.C., Figueiredo, E.E., Srinivasan, V.S. 2013. Sensitivity analysis of the parameters of the SWAT model and simulation of the hydrosedimentological processes in a watershed in the northeastern region of Brazil. Rev. Bras. Ciênc. Solo 37: 1091–1102 (in Portuguese).

[4] Arefi Asl, A. A. Najafinejad, F. Kiani and A. Salmanmahiny.2013. Identification of critical sediment production regions yield in Chehelchai watershed using SWAT model , J. of Water and Soil Conservation, Vol 20.No 5.193-205.

[5] Arnold, J.G., Srinivasan, R., Muttiah, R.S., Williams, J.R. 1998. Large area hydrologic modeling and assessment. Part I: Model development. J. Am. Water Resour. Assoc. 34 (1), 73–89.

[6] Bayat,b.matekan A,Zeyneevan h,mirbagheri b, arabi b.2001.Simulation spatial distribytion of precipitation using Interpolation with GIS (Case study:Central Watershed of kermanshah) collection of the first international conference about Modelling of plant,water,soil,wheather, kerman 23-24 November

[7] Brzozowski, J., Miatkowski, Z., Śliwiński, D., Smarzyńska, K., Śmietanka, M. 2011.Application of SWATmodel to small

agricultural catchment in Poland. J. Water Land Dev.Vol 15.157–166.

[8] Durães, F.,Mello, C.R.,Naghettini, M.2011. Applicability of theSWATmodel for hydrologic simulation in Paraopeba river basin, MG. Cerne 17:, 481–488.

[9] Fukunaga Danilo Costa , Roberto Avelino Cecílio ,Sidney Sára Zanetti ,Laís Thomazini Oliveira , Marco Aurélio Costa Caiado. 2015. Application of the SWAT hydrologic model to a tropical watershed at Brazil ,Catena 125: 206–213.

[10] Hosseini, M., 2010. PhD Thesis., Effect of landuse changes on surface runoff and suspended sediment yield of Taleghan catchment, Iran. UPM. PP: 10-57

[11] Musaua. J.,b, J. Sanga, J. Gathenyaa, E. Luedelingb.2015.Hydrological responses to climate change inMt. Elgon watersheds, Journal of Hydrology: Regional Studies .Contents lists available at ScienceDirect Journal of Hydrology: Regional Studies(IN PRESS)

[12] Neitsch, S. L., Arnold, J. G., Kiniry, J. R., Srinivasan, R. and Williams, J. R. 2000. Soil and water assessment tool user's manual – version 2000. Soil and Water Research Laboratory, Agricultural Research Service, Grassland, 808 East Blackland Road, Temple,Texas

[13] Pour mohammadi,samaneh, Dastoorani mohammadtaghi. Massahbovani alireza,jafari Hadi, Rahimian Mohammad Hassan 2015. one Model for water balance of surface and ground water in Toyserkan plain,water and soil science journal VOL. 25, NO. 3.281-296

[14] Qiao Lei, Chris B. Zou, Rodney E. Will, Elaine Stebler. 2015. Calibration of SWAT model for woody plant encroachment using paired experimental watershed data Journal of Hydrology 523 : 231–239

[15] Salmani,h.m.rostami khalaj,m.mohseni saravi,r. hamed and a. salajeghe .2012. Optimmization of afecte parameter on runoff-precipitatuion in SWAT model(case study in ghazaghely watershed of golestan province). QUARTERLY NATURAL ECOSYSTEMS OF IRAN.vol3(2).85-100.

[16] Singh Vishal, Niteenkumar Bankar, Sagar S. Salunkhe, Apurba K. Bera and J. R. Sharma..2013. Hydrological stream flow modelling on Tungabhadra catchment: parameterization and uncertainty analysis using SWAT CUP, CURRENT SCIENCE, VOL. 104, NO. 9

[17] Talar watershed combining project report.2001.watershed assessment and study registry ,watershed assistant of jihade-agricultural ministry of iran.300 p.

[18] Thampi, S.G., Raneesh, K.Y., Surya, T.V. 2010. Influence of scale on SWAT model calibration for streamflow in a river basin in the humid tropics. Water Resour. Manag. 24:, 4567–4578.

[19] Wellen ,Christopher ,George B Arhonditsis ,Tanya Long, Duncan Boyd. 2014.Quantifying the uncertainty of nonpoint source attribution in distributed water quality models: A Bayesian assessment of SWAT's sediment export Predictions ,Journal of Hydrology 519 : 3353–3368

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