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Simulation of rainfall-runoff in Qaraso Basin, Iran

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ABSTRACT

This paper provides a method that by using hydrologic models we can determine risk and flood prone zones within basin and also determines flooding intensity at each sub-basin. First, the basin in the geographic information system (GIS) using ArcHydro amendment was divided into 14 sub-basins and then the physical characteristics of the basin and sub-basin using ArcHydro were entirely determined by climate and land use and using WEAP model required simulation of hydrological catchments and the total for each sub-basin have been done. Resulted calculations from the model indicate that the contribution level of the small and large sub-basins in the flood basin outlet does not depend on sub-basin discharge quantity and sub-basins with more discharge do not necessarily have more contribution in the outlet discharge. In other words, the sub-basins have shown a type of non-linear behavior. In this regard, the sub-basin A9 has the most critical condition among the sub-basins regarding impact on the basin outlet flood. On the other hand, among other effective factors on the basin outlet discharge and the sub-basins, the R.F.F was observed as the most important factor in terms of its impact on the basin outlet flood and control.

Key words : Flood, WEAP Model, Rainfall-Runoff, R.R.F

Introduction

Increasing trend of flood in recent years indicates that the most areas are vulnerable to periodic and destructive floods attacks and financial aspects of flood damages and human losses have increased. If the size and extent of flood impacts (direct and indirect) be assessed in terms of economic then study of issues such as flood takes place in the priority. Therefore, for prevention and flood control, primarily areas that have high potential to producing and creating floods are determined and production factors are identified. Several factors are involved in occurrence and severityof floods. These factors can be examined in the watershed and river. Generally, two types of climatic and basin factors are involved in floods. The origin of floods, especially in arid and semiarid regions is high intensity and relatively short continuity showers. Therefore, in study of showers, their continuity, intensity and spatial and temporal distribution in flood production should be considered. Of important basin factors, land use, geological conditions, vegetation, surface area, slope and drainage could be noted. In flood management, some of these factors are controllable and in flood control projects should be considered.

Issued related to flood are different and their nature is complex. Flood causes loss of facilities, human damage and disturbing in the use of highways and railroad. In addition, flood is a barrier for drain-

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age and effective useof land for agricultural and industrial purposes. Due to the high flowor runoff in the river watershed, huge erosions occur in basin surface and finally cause many problems in downstream due to sedimentation and sediment accumulation. Flood also damages to drainage ducts, bases, bridges, sewer canals and other structures. In addition, flood produces problems for shipping and hydro electric generators machinery. Though flood has many benefits, but we are looking to reduce the damages caused therefore, it may be broadly said that floods cause in convenience, hardship and suffering in life. In addition to human losses, flood has adverse economic impacts as well.

The main purpose of this paper is providing a method that using precipitation-runoff mathematical models (soil moisture model) considering interaction factors on flooding,can also determines risk and flood prone zones into the basin and in other words, prioritizes flooding intensity in each of subbasins.

Mckinney and Amato (2009) defined a project in order to develop a hydrologic model for Rio Conchos basin using WEAP model. Their final purpose was flood simulation in this watershed using WEAP and clarifying the accuracy of the model. The reason of Rio Conchos basin selection was its importance because of providing two-thirds of the water supply of catchment. They calibrated the WEAP model for monthly and annual flows with one year period. Finally the WEAP model results showed good accuracy and acceptable to be able to estimate monthly and annual flows. Hammuri and Daene McKinney (2008) studied effects of climate change on Ardan water resources. In this research Zarka and Yarmuk river watershed was studied. In order to simulation of runoff changes in WEAP model three scenarios of HADGEM1, GSIROMK3 and ECHAM5OM were considered. Results showed that the amount of surface runoff from precipitation will be affected severely by climate change. Mckinney and Eusbiolngol-blanco (2006) defined a project to develop a hydrologic model for Rio Conchos basin using WEAP. Their main purpose was simulating the flood in this basin using WEAP model and identifying of model accuracy. They chose the Rio Conchos basin because in this basin supplying two-thirds of the basin water resources is very important. They calibrated the WEAP model for monthly and annual flows with one-year periods. Finally, the results showed that the WEAP model is able to estimate monthly and annual flows with suitable accuracy. Mckinney and Eusbiolngol-blanco once again performed the Rio Conchos simulation that had been conducted by Charlotte and Amato (2009) but they considered the calibration period for a ten-year period from 1980 to 1989. The NASH coefficient and the used fitted hearts index to evaluate the efficiency of WEAP model showed high consistency between the simulated and real flows. They also concluded that uncertainties in the model hydrologic parameters may effect on water resources management and prediction of water supply.

Methods and Materials

The study area is a part of Qarasoo river watershed that in view of the general division of the Iran watershed is from the Persian Gulf basin and in administrative divisions of the state located in Kermanshah and Kurdistan provinces. Thes tudy area is located between North latitude of34° 0' 22"to 34°55'10"and east longitude of 46°22'12"to 47°22'12". This basin limited to Gavroud basin from the north to Rav and basin from the south to Zamkanbas infrom the west and to Gamasiabbas in from the east. Fig. 1 shows the study basin. The most important rivers within the basin are Qarasso, Razavar and Mereg.

WEAP: Computer tools for integrated planning of water resources. This tool provides a comprehensive, flexible and friendly framework for the analysis of policy. Stockholm Environment Institute is main supporter of the development of WEAP. Hydrologic Engineering Center of Society of American Military Engineers (HEC) has been allocated large budget to progress this model. A number of institu-

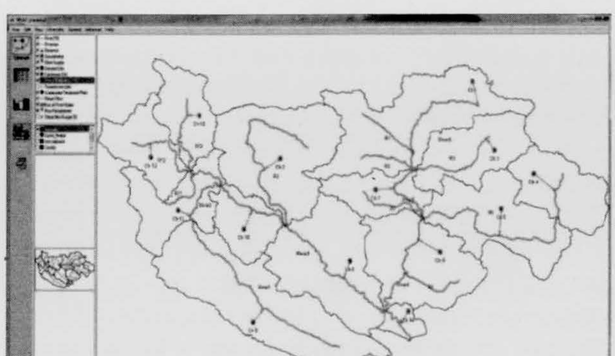

Fig. 1. Basins schematic in WEAP

tions including the World Bank, USAID and Global Fund of Japan have supported this project. WEAP acts WEAP based on fundamental equations of water budget and it can used in urban and agricultural systems, complex river systems or independent basins. In addition, WEAP can support a large range of issues such as required analysis of each sector, water protection, water rights and allocation priorities, surface water and groundwater simulation, operation of reservoirs, hydroelectric energy generation, the detection of pollution, ecosystem needs, vulnerability assessment and cost-benefit analysis of the plan.

Results and Discussion

In order to precipitation-runoff simulation one of precipitation-runoff simulation methods includes into the program should be chosen to perform calculations. For this purpose in data menu this is done by clicking on each basin name. In this paper Soil Moisture Method and Surface Runoff methods was chosen that Moisture Method Soil model has been named as the most perfect way.

Surface Runoff Method

First, attempt to import the required data for our simulation. Watershed physiography was calculated using ARC-HYDRO software that is in stalled as an auxiliary program on Arc GIS. This program stores locations of all elevations of the basin with in the cells with arbitrary dimensions.

The input data of this program are vector data layers of the basin that after performing different stages create the basin model for WEAP. In the next step determining of streams performed according to unit area or number of upstream cells and then vector layer of streams recalled by model Shape File format.

Then, after drawing of rivers and naming them, sub-basins introduced to the model using catchment view. In this paper Qaraso basin and its composed sub-basins introduced to the model. In next step, we determined the river that act as drainage for produced runoff in each sub-basin. In fact, we determined that produced runoff from each sub-basin flow into which river. Surface Runoff method was selected as the method of this stage.

Then, we need climate and physical data to run the model. Required physical data input manually using land use menu and climate data as 20 years' time-series input using climate menu. At this stage,the data entry is the effective rainfall and rainfall time series. Effective rainfall is a percentage of rainfall that is not subject to evapo transpiration and converted to runoff directly and flows into the river and is a function of the physiological characteristics of the region. After calculation, in results section you can see the flood for any of the rivers, infiltrated flow into the river in each sub-basin for desired year ina variety offorms.

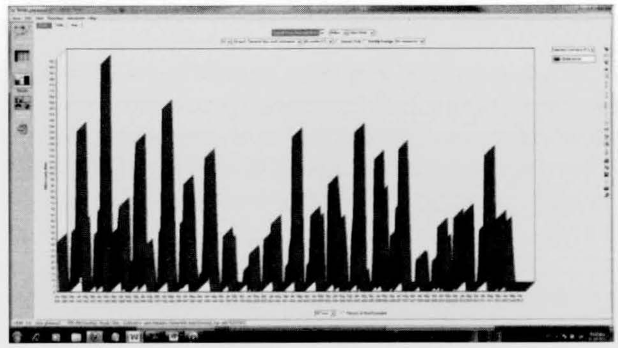

Fig. 2. Graph of runoff resulted from 20 years precipitation

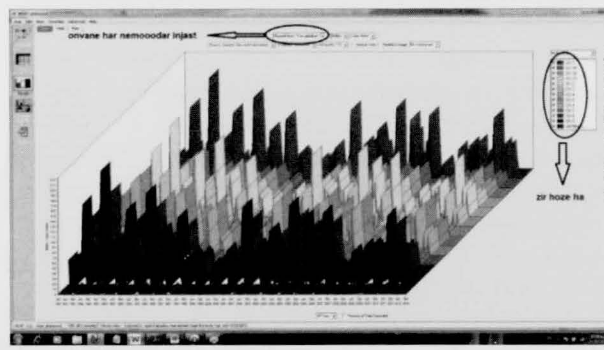

Fig. 3. Graph of runoff resulted from 20 years precipitation for each sub-basin

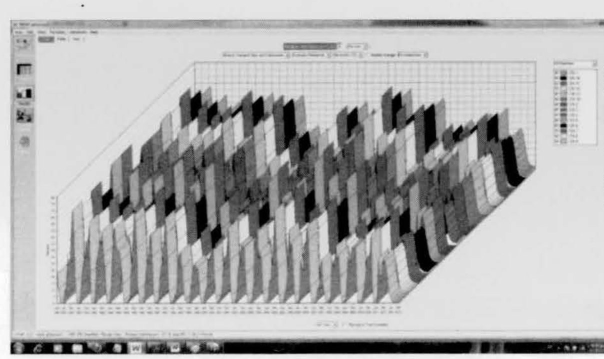

Fig. 4. Relative soil moisture in the top layer

Soil Moisture Method

After entering required data, in order to simulation, the model is run as the previous procedure.Figure 4 shows relatives oil moisture in the to player (available) during 20 years. As shown in the figure decrease in moisture occurs in both sections. Figure 5shows relative soil moisture in the lower layer (unavailable)during thepast 20years. As shown in the figure increase in moisture occurs in both sections.The way in determining the flood intensity of the sub basins with 50-year period in 24-hour rainfall pattern has been carried out as follows:

The 24-hour rainfall project with the 50-year return period in a 24 hour was measured and imported into the model. To complete and updating the data of the stations that their statistics are incomplete, the SPSS and SMADA software were used. In this study, annual, monthly and daily discharges of the rivers at hydrometric stations have been studied.

The physical characteristics of the sub basins, such as the area and the RRF (resistance against the flow), and also Kc and the soil parameters were imported into the model.

Using the related sub basins maps and considering the main rivers in the Arc GIS 9.3 and via the Arc hydro extension, the sub basin under study is divided into 14 sub basins and the whole rivers of the basin were determined. Then the inlet parameters accompanied by the degree of sensitivity for each of them in WEAP model will be inserted into the model.

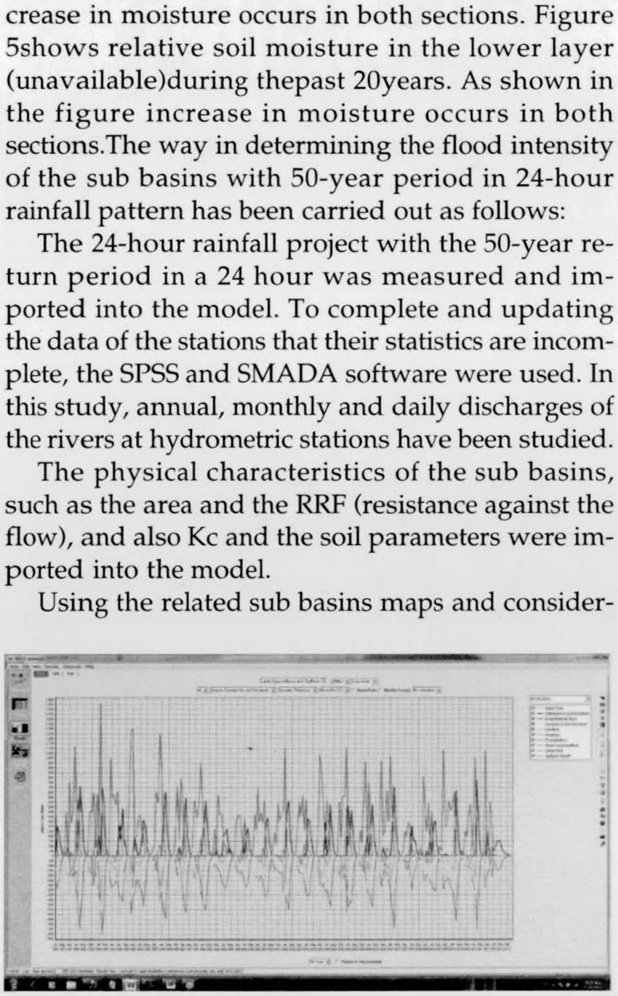

Fig. 5. Relative soil moisture in the lower layers

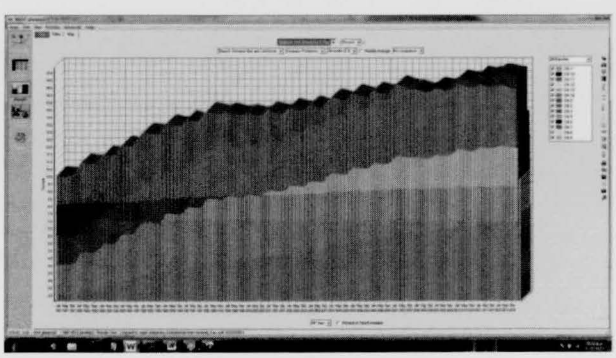

Fig. 6. Comparison graph of the input and output streams of the watershed in 20 years

After simulating the runoff through Soil Moisture method in each of the sub basins through the PEST (parameter estimation tool) software which is one of the internal capabilities in WEAP model we will manage to calibrate the model. The land use parameters play a leading role in the simulation process of soil Moisture Method. One of the most important parameters in simulating is the resistance principle against the runoff. The calibration of the model was performed in a 10-year period (1996-2005) in all of the sub basins. The nearest stations of the same river were used to calibrate the simulated run-off instead of the observable run-off in some of the sub basins since there are not many stations to measure the discharge.

Comparison of average slope of sub-basins in each basin outflow showed that peak output is very sensitive to changes in average slope of sub-basins. Meanwhile, the management and flood control operations in slope of sub-basins (which are possible only through terracing and similar operations) would be difficult and costly. The results also suggest reducing flood basin production for increasing temperature (climate change). If by optimizing the agricultural or reforming operation of the pasturing and the low costs, for example the enclosure of the ranges by changing the third class ones into 2nd and 3rd class ranges, then the output flood peak will accordingly decrease more than what were shown in the above mentioned values, and there will not by any necessity in having some costly mechanical and structural operations.

In addition and with respect to the sensitivity diagrams of the sub basins in proportion to the mean sloping principle of the sub basins, one must necessarily pay attention to this important point that in some cases the sloping decrease operation might have anadverse effect on the output peak discharge. Therefore, with respect to all the principles affecting the surface sub basins on the output flood, carrying out the proposed method in this research project in order to set some priorities for the sub basins and also their importance separation and the way the effective factors influence the basin's maximum discharge are hereby recommended in order to control the flood.

Conclusion

The results suggest little importance of crop coefficients in the calibration of (Kc) and the highest sensitivity in the calibration resistance to flow factor was observed. Other factors of land use can be important in model calibration.

Results obtained using this model indicate that the combination of several physical and climatic factors of basin are involved in the runoff production rate and never a factor alone can significantly associated with runoff output in all the sub-basins. It can be said that factors of precipitation, surface area, moisture, vegetation and slope in each sub-basin is different and distinct. It seems that the output runoff against the area shows the most reaction and rainfall, vegetation, slope and moisture cause the lowest sensitivity of the basin respectively.

The study concluded that a series of climatic factors and the characteristics of the different sub-basins influence on the basin output flood discharge peak differently. Since control of climatic factors for flood management in the sub-basins and output of whole watershed is impossible therefore should pay more attention to the physical characteristics of sub-basins although it's not possible to control some of physiography factors of watershed and sub-basins. Therefore, in such studies should pay more attention to factors that their control in flood management is possible. In this study in addition to evaluating of each factor in each sub-basin their effect on output discharge of watershed have been considered.

Acknowledgements

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