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Evaluation of surface water resources using WEAP model (Case study: Qaraso basin)

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ABSTRACT

This paper provides a method that by using hydrologic models determines risk and flood prone zones into the basin and also determines flooding intensity at each sub-basin. First, the basin in the geographic information system (GIS) using Arc Hydro amendment were divided into 14 sub-basins and then the physical characteristics of the basin and sub-basin using ArcHydro entirely were determined by climate and land use and using WEAP model which required simulation of hydrological catchments and the total for each sub-basin have been done. Resulted calculations from model run 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, sub-basins have shown a kind of non-linear behavior. Also, this paper also examines quantitative comparison of peak discharge changes of the basin outlet per watershed, average slope changes, stream, Runoff Resistance Factor (R.R.F) in each of sub-basins, take action to identify most important effective factors on watershed flooding and also critical sub-basin. For this purpose, each of desired factors in specific range separately changed at each of sub-basins and amount of this change obtained in the whole basin outlet discharge. In this regard, among sub-basins the sub-basin A9 has the most critical condition regarding effect on the basin outlet flood. On the other hand, among other effective factors on outlet discharge of the basin and sub-basins the R.F.F was detected as the most important factor in terms of its impact on the basin outlet flood and control. For example, if using flood control operation in the stream path of the critical sub-basin its slope decreases to 30% of initial slope only about 8% of the outlet peak discharge decreases and it requires a lot of spending. But in these sub-basins if the value of Kcreduced to 10% of initial value about 24% of peak output will be reduced.

***Key words :** Basin, Priority, Flooding, WEAP Model, ArcHydro, R.R.F*

Introduction

Increasing trend of flood in recent years indicate that the most areas are vulnerable to periodic and malicious floods attacks and financial aspects of flood damages and loss of life has 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 place in the priority. Therefore, for prevention and flood control is a must for areas that have high potential of producing and creating floods and determine and production factors. Sev-

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eral factors are involved in the incidence and severity of floods. These factors can be examined in the watershed and river. Generally, two types of climatic and basin factors are involved in the floods. The origin of the floods, especially in arid and semiarid areas is high intensity and relatively short continuity showers. Then in the study of showers continuity, intensity and their spatial and temporal distribution in flood production should beconsidered. Of important basin factors land, geological conditions, vegetation, surface area, slope and drainage could be noted. In flood management, some of these factors are controllable and in the most flood control projects should be considered.

Issued related to the flood are different and their nature is complex. Flood infestation causes loss of facilities, human damage and disruption to the highways and railways. In addition, flood is a barrier for drainage and effective use of land for agricultural and industrial purposes. Due to the high flowor runoff in the river watershed, huge erosions occur in basin surface and finally result in many problems in the down stream due to sedimentation and sediment accumulation. Flood also damages drainage ducts, bases, bridges, sewer canals and other structures. In addition to the above produces problems for shipping and hydroelectric 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 humanlosses, 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) can also considering interaction factors on flooding; determine risk and flood prone zones into the basin and in other words, prioritize flooding intensity in each of the sub-basins.

Mckinney and Amato (2006) defined a project of development of 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.

Purkey *et al.*, (2006) studied effects of climate change on Ardan water resources. In this research Zarka and Yarmuk river watershed was studied. In order to simulate 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.

Materials and Methods

The study watershed 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. The study area is located between North latitude of 34 degrees and 0 minutes and 22 seconds to 34 degrees and 55 minutes and 10 seconds and east longitude of 46 degrees and 22 minutes and 12 seconds to 47 degrees and 22 minutes and 12 seconds. This basin is limited to Gavroud catchment from the north to Ravand watershed from the south to Zamkan watershed from the west and to Gamasiab watershed from the east. Figure 1 shows the study basin. The most importants rivers within the basin are Qarasso, Razavar and Mereg.

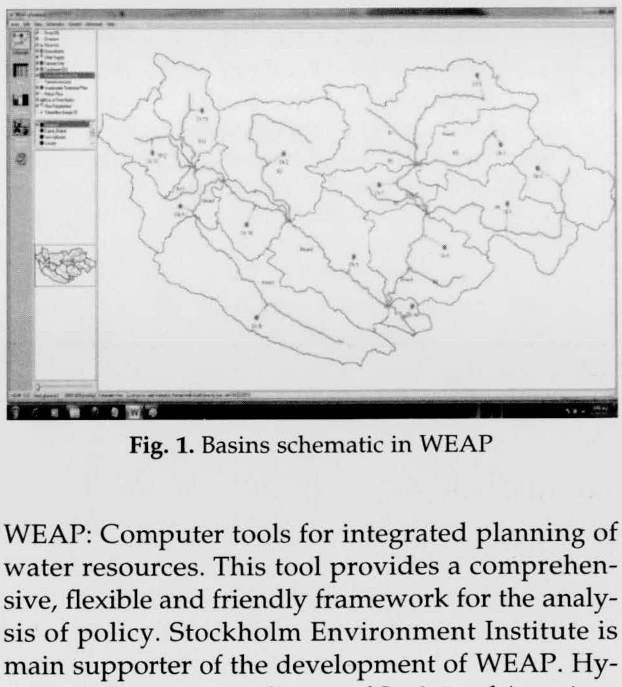

Fig. 1. Basins schematic in WEAP

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 institutions 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

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

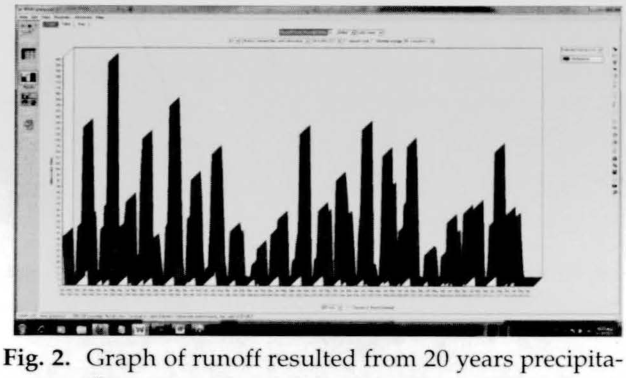

Fig. 2. Graph of runoff resulted from 20 years precipitation

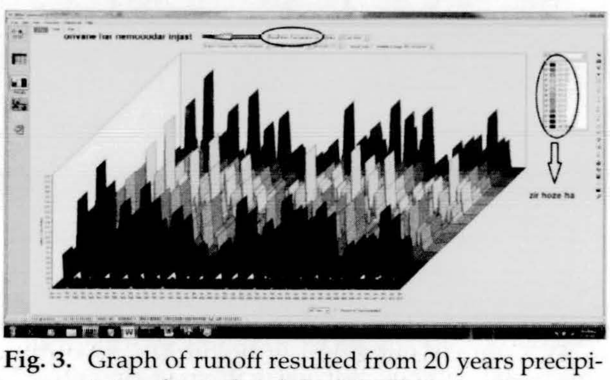

Fig. 3. Graph of runoff resulted from 20 years precipitation for each sub-basin

Surface Runoff Method

First, attempt to enter these quired data for simulation. Watershed physiography was calculated using ARC-HYDRO software that is installed as an auxiliary on Arcgis. This program stores the location of all elevations of the basin within 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 determination of streams was 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 a 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

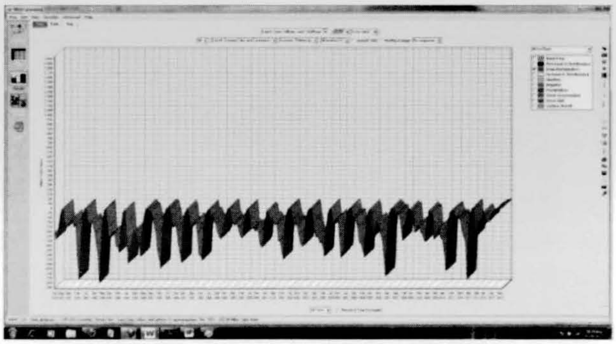

Fig. 4. 20 yearsevapotranspiration chart

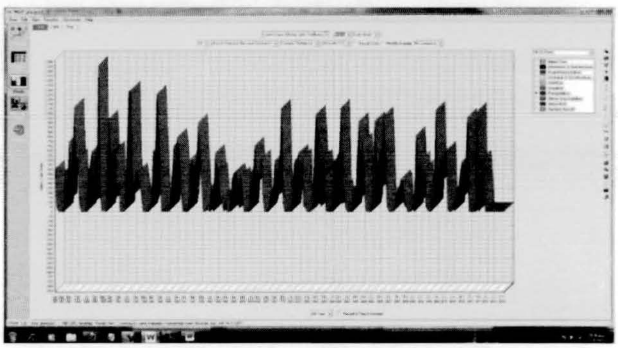

Fig. 5 Chartof precipitationin 20 years

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 evapotranspiration 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 years in a variety offorms.

Soil Moisture Method

After entering required data in order to simulation run the model as prior procedure. Figure 6 shows relative soil moisture in the to player (available) during 20 years. As shown in the figure decrease in moisture occurs in both sections.

Figure 7 shows relatives oil moisture in the lower layer (unavailable) during the past 20 years. As shown in the figure increase in moisture occurs in both sections.

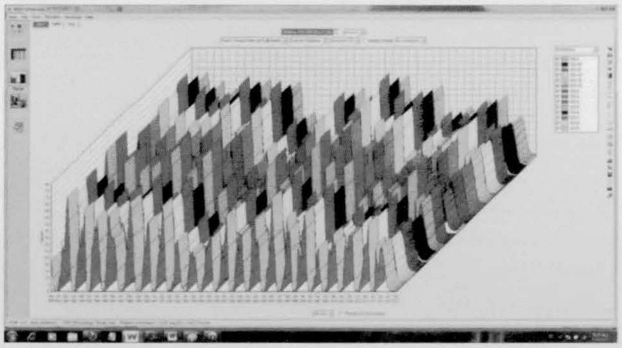

Fig. 6. Relative soil moisture in the top layer

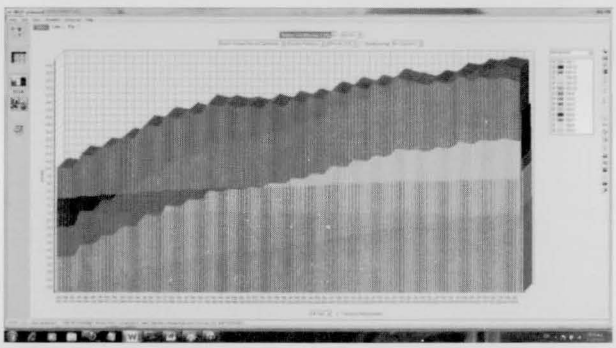

Fig. 7. Relativesoilmoisture inthe lowerlayers

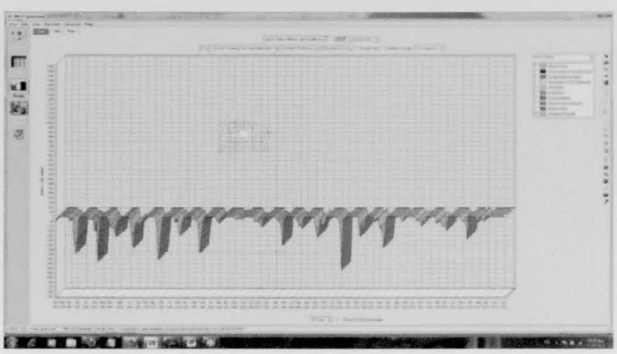

Fig. 8. Graph of surface runoff produced in 20 years

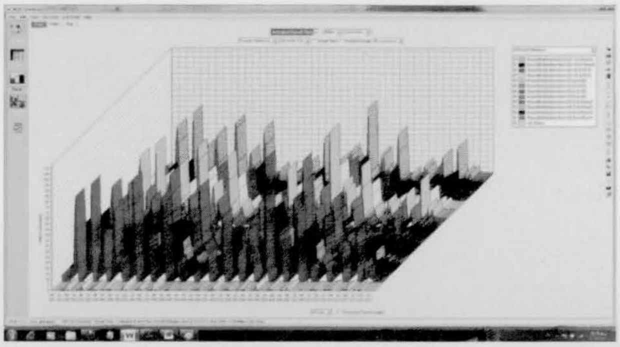

Fig. 9. Participation of each basin in formation of river runoff

Fig. 10. Comparison graph of the input and output streams of the watershed in 20 years

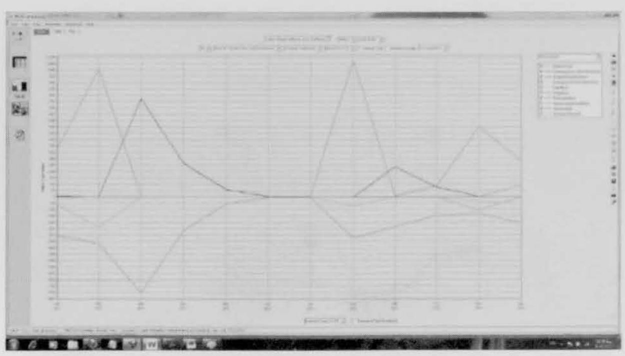

Fig. 11. Comparison graph of the input and output streams of the watershed in 2011

Discussion and 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. 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 be 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 be 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. 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).

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