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Evaluation Check Dams in Catchment for Conservation Water Resource via HEC-HMS Model

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Abstract: Assessment of watershed management activities is one of the main subjects for future planning of practical projects and natural resources management. Due to the lack of any tool for assessment of water resources processes in many cases, distributed hydrological models can be useful. Focus of this study is on assessing hydrological effects of Kushk-abad watershed study by HEC-HMS (Hydrologic Modeling System). The study area (85 square kilometers) located in north of Iran in Khorasan Province for this purpose, first by considering observed events, HEC-HMS model was optimized and calibrated. Then, for evaluating the effects of check dams on time of concentration, it was calculated before and after of check dam's construction by use of field observations and vegetation cover improvement was also estimated after the project. Catchment is an open System, there for we achieve Modeling due to its Complexity and to reach aimed goals. Modeling reduces Complex Systems costs, because doesn't experiments in vast are Costly and are impossible in some cases. Also we can Manage Catchment by analyzing the results of Modeling and by forecasting Catchment future. This Model enable used for most Catchments Science it needs to little information without considerable Cost or Time consuming. This Model needs to Rainfall and Temperature Data (for Runoff Simulation) and Observed Stream flow Data (for Calibration), therefore it can be used for the our Catchments with statically Data problems and at last can be used to Simulation of Hydrological process in Catchments without statistic Data. The model was calibrated and validated for Golabdare-Darband basin before and after watershed management. Two observed flood and storm events are used for calibration of model. Firstly, the 25-year flood peak (for the before watershed management) was selected as a flow threshold for flood warning. Then the basin floods were simulated in different return periods in both conditions of before and after watershed management. These parameters were imported to HEC-HMS to find out the effects of watershed practices and then flooding condition was simulated. For assessment purposes, peak discharge and flood volume were calculated for "before" and "after" construction conditions. Results showed that check dams as mechanical measures had low effect on time of concentration while biological practices lead to decrease in curve number with an average value of 3.1. This effects result in decrease of peak flow and flood volume meanly 28% and 16%, respectively. In this Study we first review Hydrological Model Classification Types and results of some engaged Models in Iran and at last we descriptions the IHACRES Rainfall-Runoff Model and its applications. The results of this research show that the land use change caused by watershed management, increases flood forecast lead time. Furthermore increasing in return periods causes reduction in forecast lead time.

Key words: Water Resources · HEC-HMS model · Watershed management · Assessment · Flood simulation

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INTRODUCTION

Evaluation of watershed management activities is one of the main subjects for future planning of practical projects and natural resources management. Due to the lack of any tool for assessment of watershed processes in many cases, distributed hydrological models can be useful. The purpose of this study was evaluation of watershed management activities in Kushk-Abad Watershed by HEC-HMS (Hydrologic Modelling System). Selection of a rainfall-runoff model is a compromise between model complexity and available input data. For this purpose, first by considering observed events, HEC-HMS model was optimized and calibrated [1, 2]. Then, for evaluating the effects of check dams on time of concentration, it was calculated before and after of check dam's construction by use of field observations and vegetation cover improvement was also estimated after the project. These parameters were imported to HEC-HMS to find out the effects of watershed practices and then flooding condition was simulated. For assessment purposes, peak discharge and flood volume were calculated for "before" and "after" construction conditions. Soil conservation service-curve number (SCS-CN) method is one of the most employed methods for computing discharge as well as surface runoff from watersheds [3-6]. Recent studies show that this much used method is susceptible to difference in curve number [7-9]. On other hand, estimation of time of concentration have important and considerable role in physiographic and hydrologic studies of watersheds. Especially it affects on estimation of peak discharge in hydrological studies of watersheds. So, in this study, beside of introduction of new straightforward method for sensitivity analysis of simple equations, four common applicable time of concentration in Iran, e.g. kirpich, California, Bransly Williams and SCS, have been surveyed by sensitivity analysis.

MATERIALS AND METHODS

Considering the rich background of watershed management in Iran, we come to the result that assessing the performed operations and the effects caused by these plans is a required operation in reaching successful activities. But lack of the required equipments to cite the changes in a variety of areas, it leads to the difficulty of work, considering the application of hydrological models simulating results in developing soil and water supplies and making decision in watershed area management and using them for hydrological studies of watershed area and their application in this filed [10].

HEC-HMS is a numerical simulator, includes a range of conceptual and experimental models to simulate rainfall-runoff processes, calculating direct runoff, determining basic flow and considering the flow in channel. Considering the selective methods in this model, model inputs were identified; Curve number or CN method was used to convert rainfall to runoff. To do this, CN plan of the area, was provided from integration of vegetative plans, soil hydrological and earth application groups in GIS and Arc View3.3 for before and after the performance of watershed management and weight CN were performed of the following areas. To estimate the Lag Time and Concentration Time of watershed basin as two other required variants to perform the model, the Kirpich method used with the description of 1, 2 relation [11].

To calculate the focus time, different methods are given. In this report, because of considering the changes of watershed management and estimating the CN effect on focus time, in order to estimating focus and delay time, modified kirpich method is used. The focus time in kirpich method gains of the following equation:

$$t_c = \frac{0.000325 * L^{0.77}}{S^{0.385}} \qquad \text{(Equation 1-1)}$$

T_c: Time of concentration (hour), L: length of main waterway (m),

S: Slope of main waterway (m x m).

Kirpich method will modify for areas including CN less than so by following equation:

$$T_c = t_c * (1 + (80 - CN) * 0.4) \qquad \text{(Equation 2-1)}$$

Tc: Modified time concentration (hour), tc: kirpich equation time concentration

CN: Curve number in SCS method.

In SCS method, it is assumed that the amount of the real soil water retention is equal with the runoff rate to potential of runoff occurrence which means:

$$\frac{F_a}{S} = \frac{Q}{P - I_a} \qquad \text{Equation (3-1)}$$

And using continuity equation we have:

$$P = Q + I_a + F_a \qquad \text{Equation (4-1)}$$

And with solving two above equations, we have:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad \text{Equation (5-1)}$$

Q = Runoff height
P = Precipitation
S = Is a parameter which shows the soil water retention in the surface of area and gains from the following equation.

$$S = \frac{25400}{CN} - 254 \qquad \text{Equation (6-1)}$$

CN: Curve number, Ia: Primary soil water retention

RESULTS AND CONCLUSIONS

Calculating the Time of Leg and the Time of Concentration: Using the presented equations Leg and Concentration time, these two parameters for each of the sub-watershed Kushk-Abad are calculated before watershed management and the results are presented in Table 1.1.

Providing the Input Information of Rain-Run off Model: Note that in Kushk-Abad sub-watershed hydrologic model, to calculate damages and to estimate hydrograph from SCS method and for routing, we used cinematic wave routing method. In field visits, the required parameters to develop Rain-Runoff model include qualitative properties, related to the area, soil type and the vegetation status of the region and also the related factors to route cinematic wave method like the mean wide and the channel side gradient in each river, the route and the Manning coefficient ins measure or estimated.

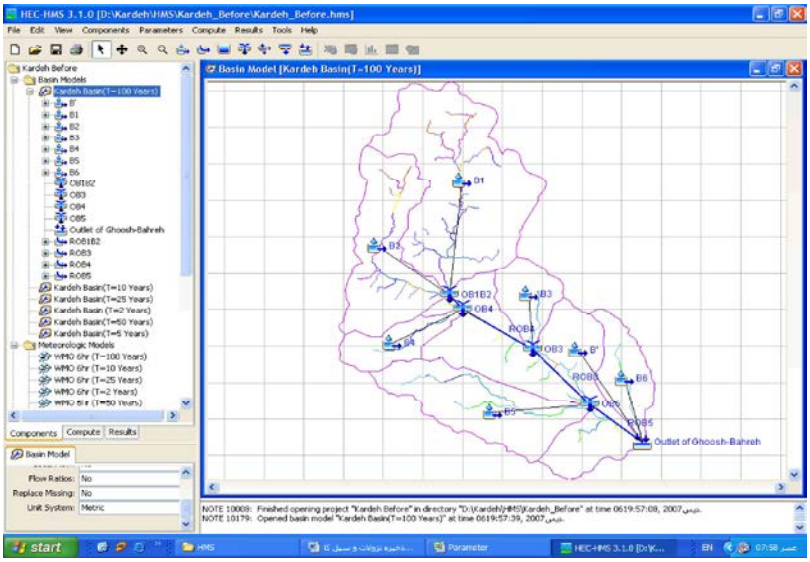

Fig. 1.1: HEC_HMS Model in Kushk-abad Basin

Table 1.1: Concentration time and lag time of Kushk-Abad Basin before watershed management operations

Sub-basin	Area (km^2)	Length of river (m)	Slope of river basin (m ×m)	CN	Concentration time (h)	Leg time (h)	Leg time (min)
B'	12/23	7080	0/062	81	0/87	0/52	31/4
B1	14/2	5650	0/096	84	0/62	0/37	22/4
B2	7/78	5080	0/083	84	0/61	0/36	21/8
B3	2/68	1750	0/263	84	0/17	0/10	6/1
B4	2/51	2620	0/191	88	0/26	0/16	9/5
B5	7/16	5460	0/066	86	0/70	0/42	25/1
B6	3/07	3130	0/141	81	0/34	0/20	12/2
Total	49/64	12730	0/047	84	1/53	0/92	54/9

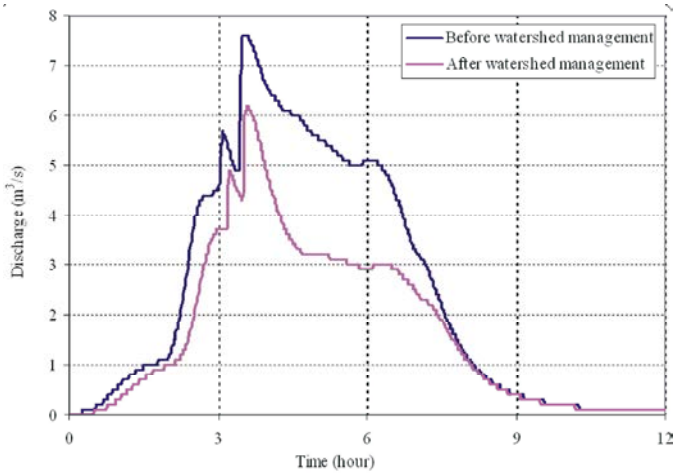

Fig. 1.2: Flood hydrographs in different returning period were compared before and after the watershed management

As, it is clarified in above tables and figures, the watershed management has an important role in decreasing flood and also, it considerably decreases the peak flow rate of flood. This reduction is more obvious in low returning periods and the maximum effect was on a five years period, as the peak flow rate of the area decreases 37%. Also, the flow rate reduction in a one hundred years period was about 27%. In B5 sub-basin, the maximum flood reduction and in B1 sub-area, the least flood reduction was observed (Figure 1.1 &1.2). For assessment purposes, peak discharge and flood volume were calculated for "before" and "after" construction conditions. Results showed that check dams as mechanical measures had low effect on time of concentration while biological practices lead to decrease in curve number with an average value of 3.1. This effects result in decrease of peak flow and flood volume meanly 21% and 11%, respectively.

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