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Regional model presentation for peak discharge estimation in ungauged drainage basin using geomorphologic, Synyder, SCS and triangular models (case study: Kan drainage basin)

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ABSTRACT

With regard to the importance of instantaneous peak discharge estimation for watershed management study, and due to the lack of and unqualified climatic and hydrologic data for estimation and measurement in countries such as Iran, researchers were obliged to establish a link between constant parameters (geomorphologic) and variables (hydrologic) to present models with minimum dependence on climatic and hydrologic data in hydrologic estimations. This research has made an effort to use synthetic unit hydrographs at the drainage basin of Kan (Soleghan River) and to compare these results with recorded peak discharge at the watershed outlet, in order to derive the best model. Comparison of study models using relative mean error (RME) and root of mean square error (RMSE) in the study drainage basin located in central Alborz watershed showed that RME for the Geomorphologic model was 17.99 and RMSE was 15.49, for Snyder RME was 59.66, and RMSE was 29.83, for SCS RME was 162.63 and RMSE was 76.002 and finally triangular RME was 165.82 and RMSE was 77.44. Therefore the best estimation belonged to the Geomorphologic model followed by the Snyder, SCS and Triangular models. Owing to the lack of recorded instantaneous peak discharges in the hydrometric station of the Kan drainage basin (11 events) at Kan-Soleghan, we are not able to derive an instantaneous peak discharge model. Hence by using factors in each of the studied models, other effective factors and 283 recorded events of daily peak discharges, the daily peak discharge model can be derived.

Keywords: *Peak Discharge, Triangular Model, Kan Basin, Watershed Management.*

INTRODUCTION

Considering the world average annual precipitation (860mm), Iran with an average precipitation of 240mm is classified as a semi-arid area. This amount of precipitation doesn't cover spatial agricultural needs (Hojjati and Boustani, 2010). To address this issue, it seems that the utilization of water should be modified according to the annual rate of precipitation. One of the reasonable ways to cope with drought is useful application of available water resources (surface and ground water). This strategy can not be practiced without identification of district hydrological phenomena. With regard to the biological significance of water and economic concern for its availability, a good understanding of hydrology or in other words the application of hydrology can prevent the occurrence of dangerous floods in any site of the country and droughts on these sites as well. In recent years more attention has been given to water crisis, however recorded data in this regard are still very scarce. It is clear that without studying geomorphology and hydrology of drainage basins, scientific plans for flood disaster cannot be successfully executed Studies on drainage basins with focus on geomorphologic characteristics are among the factors that affect discharge characteristics of main rivers and their upstream tributaries as well as sediment generation (Nazari Samani *et al*., 2009). Hence when there are no instruments to record essential data and subsequently in the absence of a natural

unit hydrograph, several methods can be used to determine a unit hydrograph.
Sherman, (1932), considered many factors affecting the shape of a hydrograph and in many cases relevant to the physical attributes of a drainage basin such as area, shape and slope, which were constant and found that the hydrograph shape must be the same for storms with similar attributes. Snyder, (1938) proposed a method based on some attributes of unit hydrograph. This method is the outcome of results of research on some drainage basins in the Apalachian Mountain. Measurements carried out by the soil conservation service (SCS) of the United States presented dimensionless hydrograph in different drainage basins, (Mockus, 1957).These studies showed that if the derived flood hydrograph axes in different conditions were dimensionless, all of them will have almost the same shape. The problems of geomorphologic instantaneous unit hydrograph (GIUH) were demonstrated in 1979 by Rodriguez- Iturbe. Recent progress in finding run off topographic was made by the aid of geomorphologic instantaneous unit hydrograph (GIUH). In the past two decades, using drainage basin attribute geomorphology in run off simulations interested many hydrologists (e.g. Gupta *et al*., 1980; Rodriguez- Iturbe *et al*., 1982; Krishen and Bars, 1983; Troutman and Karlinger 1985; Agnese *et al*., 1988; Chutha and Dooge, 1990; Yen and Lee, 1997; Olivera and Maidment, 1999; Berod *et al*., 1999). As stated, the primary idea for instantaneous unit hydrograph was derived. In Horton laws, construction and structure of drainage basins, engineering of stream networks and the results of geomorphologic response have been described as geomorphologic instantaneous unit hydrograph (Karvonen *et al*., 1999). A mathematical method and its efficiency were proposed by Lee and Chang (2005) as a result of a study in northern Taiwan. The results showed that since run-off primarily occurs in low portions of a watershed near streams, a precipitation- run-off model that considers only the surface run-off is recognized as being inadequate. It was further demonstrated that with correction of GIUH, better results can be derived. The surface-flow IUH of this study could adequately reflect the variations of surface roughness conditions, and the subsurface flow IUH could reveal different soil conditions. The concept of GIUH is utilized in calculating the influence of the channel network on the delay and the shape of the hydrograph (Karvonen *et al*., 1999). The quantitative analysis of drainage networks has gone through dramatic advances since the 1690s, mainly after Shreve’s, (1966) classical paper which led the way for a theoretical foundation of Horton's well-known empirical laws and provided a new perspective for many other problems in fluvial geomorphology (Rodrigues- Iturb and Valdes, 1979). Therefore, the purpose of the present study was to develop the best model of instantaneous peak discharge estimation. For this purpose four models including Geomorphologic, SCS, Snyder and Triangular were considered. Finally with regard to recorded peak discharges in the Kan basin and factors measured in the above mentioned models, a regional model for discharge estimation will be obtained.

MATERIAL and METHODS

Study area

The Kan drainage basin is one of the sub basins of the Central Alborz basin. Politically the Kan drainage basin is located in Tehran province between 51.950 and 51.374 east longitude and 35.950 and 35.775 north latitude with an area of 204.78 km2 (Fig.1). In the study area, a rain gauge station and a hydrometric station exist at the outlet of the basin, to record discharge and rain statistics simultaneously. Hence three rain gauge stations named Rendan, Sangan and Emamzade Davood, and one hydrometric station called Kan-Soleghan were considered in the Kan drainage basin (Fig. 2). The main precipitation in the study area is related to the Mediterranean circulation that influences the area from the west in autumn through spring. Since the watershed is located on the southern slopes of central Alborz, semiarid climate predominates. Different drainage patterns can be observed, the main one of which is dendritic and others are central patterns (Fig.2). The length of its main river is about 23 km. The maximum and minimum elevations are 3560 and 1460 m, respectively. The Kan drainage basin contains poor range lands and farming terrains and a small part of the watershed is garden. The total precipitation changes from 550 to 650 mm in the different places of the watershed.

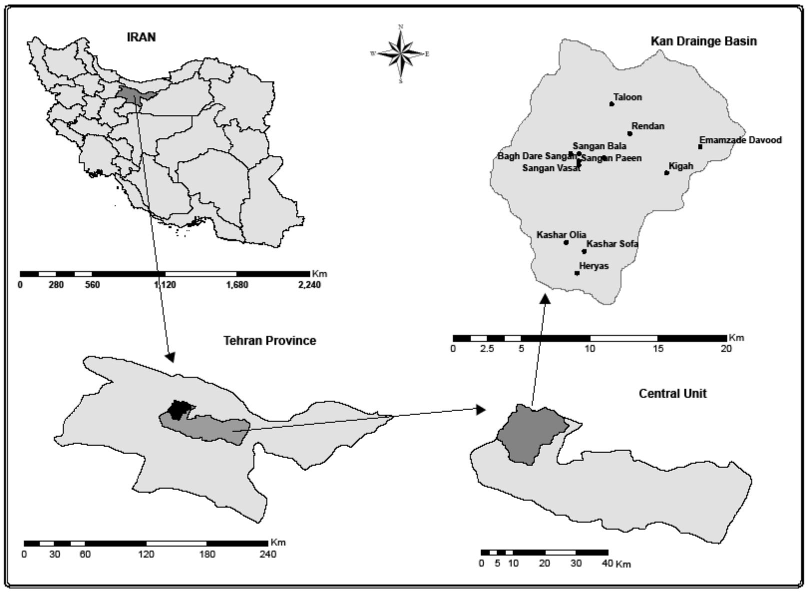

Fig 1. Location of Kan basin, Tehran province, Iran.

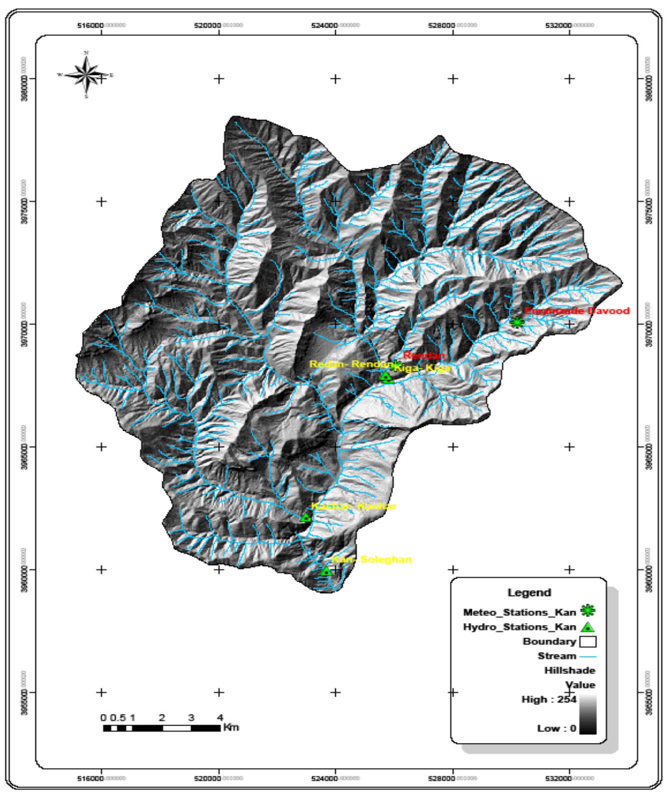

Fig 2. Location of rain gauge stations, hydrometric stations and channels network In Kan basin

Extraction of rain and discharge data coinciding with flood

Flood discharge statistics and recorded data for rain in stations of the local water Institute of Tehran Province and Iranian Research Organization of Water Resources were used to extract coinciding events (22 events) of rain and discharge for the Kan drainage basin, 11 events of which were considered good for this research.

Digital topographic map

Digital topographic map was obtained from the National Cartographic Center (N.C.C.). The extraction and perfection of the existing stream map of the study drainage basin, area, mean slope of drainage basin area, mean weighted slope of main stream in outlet of drainage basin, main stream length from centroid to outlet of drainage basin (Fig.3), slope of highest stream order, stream number in each order (for determination of bifurcation ratio, R_b), stream length in order (for determination of length ratio, L_u) and drainage basin area in each order (for determination of area ratio, A_u) were calculated using the topographic map. The estimation of these parameters can be handled easily and more accurately using GIS software which otherwise is very tedious using manual methods. It is observed that the design flood is more sensitive to the design storm pattern and its time distribution (Jain *et al*., 2000). Lin and Oghochi, (2006) referred to the Digital Elevation Model (DEM) they produced and concluded that most of the common methods often implemented using major commercial GIS software, assume minimum contributing area to determine channel head locations. However, minimum contributing areas should vary even within a small watershed according to local factors such as topography and lithology. The infinite form and variety of drainage basins respond to the known basic geomorphologic laws existing in nature. It is to be expected that in the structure of the hydrologic response of a basin a basic order should also exist which reflects the deep symmetry in formal relations between the parts involved in Horton's geomorphologic laws (Rodriguez- Iturbe *et al*., 1982).

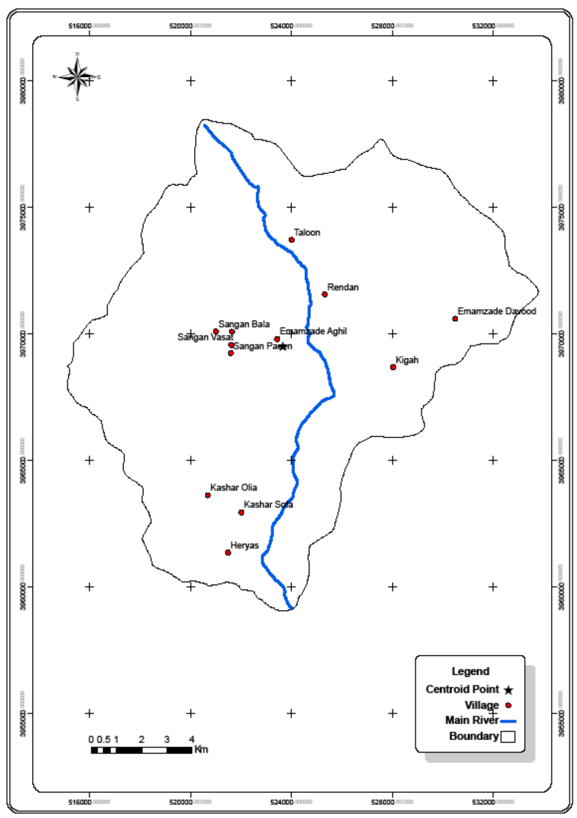

Fig 3. The main stream from centroid to outlet of Kan basin

It must be mentioned that bifurcation ratio (R_b) was calculated from this relation ($R_B=N_u/N_{u+1}$), Length ratio was calculated from this relation ($R_l=L_u/L_{u-1}$) and Area ratio Is calculated from this relation ($R_A=A_u/A_{u-1}$).

N_u, N_{u+1}: is the number of streams of order U and U+1

L_u, L_{u-1}: is the mean length of streams of order U and U-1

A_u, A_{u-1}: is the mean area of the basins of order U and U-1

A river basin is made up of two interrelated systems: the channel network and the hill slopes. The hill slopes control the production of storm water runoff which, in turn, is transported through the channel network towards the basin outlet. The runoff- contributing areas of the hill slopes are both a cause and an effect of the drainage network growth and development. This cause-and-effect relationship may be visualized through the following consideration taken from Gupta *et al*., (1980) and Rodrigues- Iturb, (1993). It must be noted that each of waterways including stream area with spatial order enter streams of the upper order, and then reach the outlet. For instance waterway 125 in the Kan drainage basin consists of a stream area of order one that enters streams of the order two and then enters streams of the order five. Therefore for each basin, maximum $2^{\Omega-1}$ waterways exist (Ω is the biggest stream order in each of basin) (Zhang and Govindaraju, 2003). In the Kan drainage basin there are 16 waterways. To determine the area of each waterway, the upper waterway area, that is entered, must also be considered (fig.4).

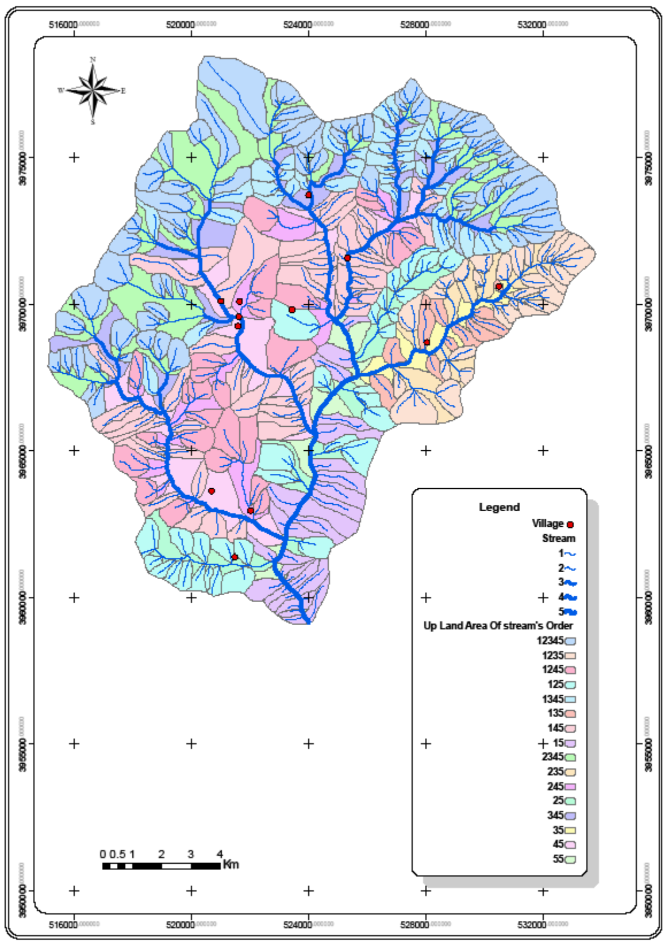

Fig 4. Up land area for each of stream's order

Flow velocity

Flow velocity determination for one special storm: To determine this parameter, kinematics wave relation presented by Rodriguez- Iturb *et al*., (1979) with the following formula was used (Formula1).

$$V_{\Omega}= 0.665\alpha_{\Omega}^{0.6}(i_r A)^{0.4} \quad \alpha_{\Omega}= S_{\Omega}^{0.5}/nB^{2/3} \quad (1)$$

V_{Ω}: flow velocity (m/s), i_r: rain intensity (cm/h), A: drainage basin area (km^2), S_{Ω}: slope of main river in drainage basin outlet (%), n: Mannig's roughness coefficient and B: mean flow width in outlet of drainage basin (m).

Instantaneous peak discharge estimation

The classical theory of the instantaneous unit hydrograph (IUH) relating the rainfall excess over catchments to the direct runoff at the catchments' outlet rests on three basic assumptions: lumped system, linearity, and time invariance (Rooso, 1984). Geomorphologic model and relations presented by Rodriguez- Iturb *et al* (1979) (Formula 2).

$q_P=1.31/L_\Omega[R_L^{0.43}V]$ (2)

L_Ω: biggest length of Main River (km), V: flow velocity (m/s), q_P: peak discharge in (hr^{-1}) (Formula 3).

$Q_p/Q_e=t_r*q_p(1-t_r*q_p/4)$ $Q_e=i_r*A$ → $t_b>=t_r$ (3)

Q_p: exited peak discharge (m^3/s), Q_e: effective discharge (m^3/s), q_P: peak discharge of geomorphologic instantaneous unit hydrograph (hr^{-1}), t_r: time of effective precipitation (h), i_r: rain intensity (cm/h) and A: drainage basin area (km^2).

Peak discharge estimation

Other studied models such as Snyder, SCS and Triangular were employed using relations presented in references such as Snyder, (1938) and SCS Engineering-Handbook. Washington. D. C., (1968).

Models calibration

Relative Mean Error (RME)

Relative Mean Error relation for calculated peak discharge from observed peak discharge presented in Formula (4, 5).

$RME= 1/n \sum RE_i$ (4) and

$RE_i=[(Q_{op}-Q_{cp})*100] / Q_{op}$ (5)

In which

RE_i: Relative error percent for each of events, Q_{op}: Observed peak discharge and Q_{cp}: calculated peak discharge

2.7.2. Root of Mean Square Error (RMSE)

Root of Mean Square Error relevant to peak discharge presented in Formula (6, 7).

$RMSE=[1/n(\sum^n_{i=1}SE_i)]^{1/2}$ (6) and

$SE_i= (Q_{op}- Q_{cp})^2$ (7)

In which

SE_i: Relative error for each of events, Q_{op}: Observed peak discharge and Q_{cp}: calculated peak discharge

Models presentation for daily and instantaneous peak discharge

Geomorphologic parameters can be derived from digital models easily and the other use of Geomorphologic parameters is in rainfall- run-off modeling (Fleurant and Ronald, 2006). Therefore in this section an attempt was made to present a regional model for peak discharge estimation by taking into consideration the factors in studied models and recorded rainfall and instantaneous peak discharge data in the Kan-Soleghan hydrometer station.

RESULTS

Eleven of the coinciding events of rain and discharge extracted were considered suitable for this research. The results of rainfall and discharge coincidence extraction are data of events amount and rain intensity (Table 1).

Table 1. Numbers and dates of events in study drainage basin

Date of events	Rainfall (mm)	Intensity (mm/hr)	Events Num.
12 Dec 2000	9.45	2.7	11
18,19 Nov 2001	7.84	3.92	
7, 8 Jan 2001	10.24	2.56	
2, 3 Apr 2002	12.27	4.91	
12, 13 Apr 2002	10.65	2.13	
17,18,19,20 Apr 2002	7.1	3.55	
26, 27, 28 Mar 2003	13.35	2.67	
16, 17 Apr 2003	8.55	5.7	
22 Apr 2003	5.52	2.76	
15, 16 Apr 2005	4.98	2.49	
26, 27 Apr 2007	9.45	2.56	

Geographic Information Systems (GIS) and Digital Elevation Model (DEM) were used and stream nets for the Kan basin were obtained (Table 2).

Table 2. Geomorphologic calculated parameters in Kan drainage basin

Streams order	Number of streams	Length of streams (km)	Mean Length of streams (km)	Upstream drainage basin area (km^2)	Mean Upstream drainage basin area (km^2)	Mean stream length from upstream to outlet (km)	Main stream distance from outlet to centroid of drainage basin (km)	Mean slope of drainage basin (m/m)	Mean slope of main stream in outlet of drainage basin (m/m)
1	359	232.54	0.647	137.85	0.3839	23	12.181	0.473	0.02
2	64	69.29	1.08	114.53	1.78				
3	13	30.649	2.235	99.92	7.68				
4	4	28.519	7.13	141.34	35.33				
5	1	12.295	12.29	204.78	204.78				

One of the advantages of the study models (especially Geomorphology model) is that besides geomorphologic factors, they also take flow and rainfall factors into consideration. Therefore the factors for geomorphology model such as Mannig's roughness coefficient, slope of the main river in the basin outlet, and mean flow width in outlet of basin were considered in the formula 1 to calculate flow velocity (Table 3).

Table 3. The required parameters for measurement flow velocity from kinematic wave parameter

Drainage basin	rain intensity I_r (cm/h)	drainage basin area (km^2)	slope of main river in drainage basin's outlet S_Ω (%)	Mannig's roughness coefficient (n)	mean flow width in Outlet of drainage basin B (m)
Kan	It's different for any events in drainage basin	204.78	2.36	0.52	10.04

After determining the factors of each study model they can be applied. In this section besides results of each model, date of events and observed discharge are presented for random comparison (Table 4).

Table 4. Date of events and peak discharge estimation (m^3/s) from four models in Kan drainage basin.

Events Date	Qp(Geo.)	Qp(Sny.)	Qp(SCS)	Qp(Tri.)	Qp(o.)
12 Dec 2000	48.58	67.175	118.38	119.77	49
18,19 Nov 2001	54.41	72.415	92.549	93.733	56.71
7, 8 Jan 2001	48.58	65.59	110.69	111.97	69.86
2, 3 Apr 2002	83.91	70.58	137.492	139.14	79.71
12, 13 Apr 2002	42.66	62.64	97.96	99.07	51.81
17,18,19,20 Apr 2002	47.865	72.41	149.56	151.39	44.41
26, 27, 28 Mar 2003	54.41	62.64	97.96	99.075	95.89
16, 17 Apr 2003	72.46	74.348	163.95	166	70.1
22 Apr 2003	34.59	72.415	149.56	151.39	35.08
15, 16 Apr 2005	30.143	72.145	149.561	151.39	30.02
26, 27 Apr 2007	41.735	68.835	83.48	84.522	22.74

(Qp(o.) is Observed peak discharge, Qp(Tri.) is Peak discharge calculated with Triangular model, Qp(SCS) is Peak discharge calculated with SCS model, Qp(Sny.) is Peak discharge calculated with Snyder model and Qp(Geo.) is Peak discharge calculated with Geomorphology model)

Error functions were calculated to determine precision of each model. Functions considered in this section are: Relative Mean Error (RME) and Root of Mean Square Error (RMSE) (Table (5). It is evident from the results of this table that the geomorphology model with an RME of 17.99 and an RMSE value of 15.46 RMSE has the minimum error among the study models.

Table 5. Comparison of study models in drainage basin with index of Relative Mean Error (RME) and Root of Mean Square Error (RMSE)

Study models	Kan Drainage basin	
	RME	RMSE
Geomorphology	17.99	15.46
Snyder	59.66	26.82
SCS	162.631	76.002
Triangular	165.821	77.444

The results of this research show that in the Kan drainage basin, because of the lack of sufficient recorded events, we are not able to create a regression model for instantaneous peak discharge. Therefore an attempt was made to model daily peak discharge. Thus 283 daily flood events, with regard to harmony between rain hyetograph and flood hydrograph were considered appropriate for the Kan drainage basin. Based on the factors calculated in the studied models in this research and other measured factors such as: daily peak discharge was considered as the independent parameter and flow velocity (V), discharge area (A), wetted perimeter (B), flow height in discharge area (H), Length ratio (R_l), Area ratio (R_a) and bifurcation ratio (R_b) were considered as dependent parameters in the regression equation (Formula 8). Within the last two decades or so, one of the simpler approaches to the problems of rainfall-runoff modeling has been through the application of linear theories (Dooge, 1973).

$$Q_p = 6.092V+1.2A-0.249B+0.015H-4.424 \quad (8)$$

$R^2 = 0.952$ $R=0.97$

DISCUSSION

According to data obtained it may be concluded that the best estimations were obtained using the Geomorphologic model followed by Snyder, SCS and Triangular models. The results of the Geomorphologic and Snyder models were the same results to some extent.

Kumar *et al*., (2002) using rainfall run-off data in some basins modeled unit hydrograph and correlated geomorphologic model parameters with Clark model parameters. In the present study, besides geomorphologic model parameters we used SCS, Snyder and Triangular models parameters to model peak discharge estimation. Mossa, (2008) studied hydrologic characteristics such as stream and slope nets, flow hydraulic and spatial rainfall distribution of geomorphologic model in seven basins in south west of France and reported that dividing the basin into sub basins in two points of stream nets is sufficient for geomorphologic model determination. However in the present study for more precision the basin was divided into 16 sub basin on the upper stream order ($2^{\Omega-1}=2^{5-1}=16$). Also responding analysis showed that the geomorphologic model is most sensitive to stream topology, spatial rainfall distribution and characteristics of flow hydraulics. Hence characteristics of flow hydraulics are in agreement with the present study.

In another study conducted in Paskohak drainage basin, Rahimian and Zare, (1995) compared the results of GIUH with SCS, Snyder and Triangular methods and found that GIUH showed positive correlation with the observed hydrograph. These results are similar to those of the present study. Jain and Sinha, (2003), studied Horton laws with their applications in geomorphologic model on UN gauged basin with fifth order in the Himalayan Mountains and reported that the discharge with 50 years return period shows good correlation with the observed data. These findings are in agreement with the results of the present study. Kumar *et al*., (2007) used the geomorphologic model to extract run-off hydrograph in the Ajar basin of India. Comparison of results from error functions (such as root mean of standard error) produced the best results in six events which was similar to that of the present study.

Ghiassi, (2004) used the GIUH and GCIUH methods to estimate the hydrograph of for two representing basins of Kassilian in northern Iran and Lighvan in the north west of Iran and compared them using other synthetic methods such as Snyder, SCS and Triangular Methods. This research stated that the GIUH by Rosso method was also required. No significant differences were detected on comparing these methods to the observed hydrograph. The results of this research showed that for peak discharge estimation, hydrographs of GIUH, Triangular, SCS and Snyder methods resulted in the best estimations, respectively. The results of Ghiassi, (2004) for GIUH complied with the results of the present study but do not agree with the results obtained using the second best estimation model in this research. Montazeri *et al*., (2004) found good correlation between the observed hydrograph and the Clarck synthetic unit hydrograph by using GIS technique to extract the needed parameters for the Clarck synthetic hydrograph and comparing it with the observed hydrograph at the outlet of the drainage basin. The present study also used this technique.

Based on the results obtained the Geomorphologic model is the best model for the estimation of instantaneous peak discharge. Data obtained for each of the events in the Kan drainage basin demonstrate that in nearly all of the events, the observed discharge (Qp_o) was greater than the estimated discharge by model (Qp_e). The reason for each of them is presented table (6). Only in one event that occurred on 26 and 27 Apr 2007, $Qp_o < Qp_e$. The use of the stream water for garden irrigation on 26 and 27 April 2007 is the reason for this.

Table 6. Events analyses of Geomorphologic model in Kan drainage basin

Model	Drainage Basin	Date of events	Problem	Reason
		7, 8 Jan 2001	Qpo>Qpe	Rainfall with up continuous (Rainfall excess)
		12, 13 Apr 2002	Qpo>Qpe	Snow melt and Rainfall with up continuous
		26, 27, 28 Mar 2003	Qpo>Qpe	Snow melt and Rainfall with up continuous
Geomorphology	Kan	26, 27 Apr 2007	Qpo<Qpe	Watering of streams

Sensitivity analyses of the factors of the daily peak discharge model (Formula 8) in the Kan drainage basin showed that factors such as V (flow velocity), A (discharge area) and to some extent B (wetted perimeter) are the most effective in model sensitivity. Hence accuracy and precision in the determination of these factors increases the efficiency and reliability of this model (fig.5).

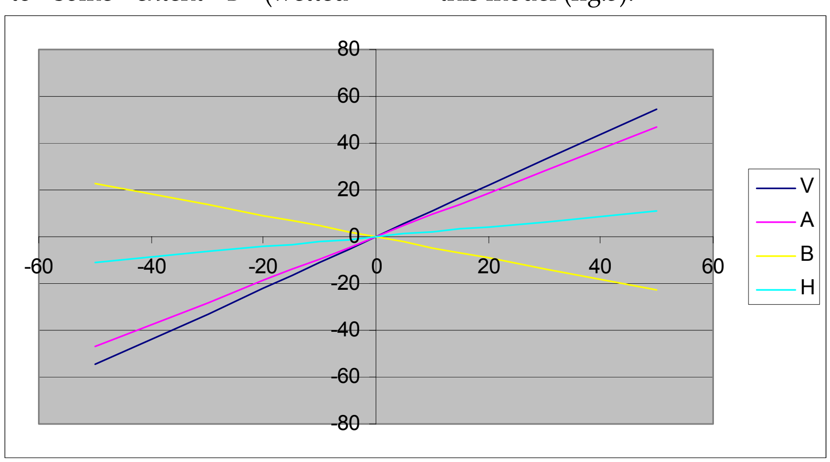

Fig 5. Sensitivity Analysis of factors of daily peak discharge model in Kan basin.

With regards to the many drainage basins in the world, that do not have a hydrometric station or which possess incomplete data, the use of the Geomorphologic model for peak discharge estimation is recommended if a rain gauge station exists in the drainage basin. However in the absence of data from hydrometric station and rain the use of the Snyder model is recommended.

For the same kinematical conditions the effect of size or scale in the Geomorphologic model does not come through the area on the basin but rather through the length of the storms reflected in the parameter L_Ω. Two basins may be considered hydro logically similar when they have identical $R_L^{0.43}/\ L_\Omega$ which controls q_p. Since for the values of R_L encountered in nature we may assume the $R_L^{0.43} \approx R_L^{0.38}$, two basins will be similar when they have equal values of $(R_L^{0.43}/\ L_\Omega)$ and (R_B/R_A), where L_Ω should be expressed in Kilometers when comparing different values of $R_L^{0.43}/\ L_\Omega$ (Rodriguez- Iturbe and Valdes, 1979). With regards to above mentioned problems for further confidence of Geomorphologic model, it is recommended that this model is used in other drainage basins in the world and the results analyzed.

In the end, with regard to the need for these models in the world, it is recommended that models with these characteristics are presented.

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ارائه مدل منطقه‌ای برآورد دبی حداکثر لحظه‌ای در حوضه‌های فاقد آمار مبتنی بر مدلهای ژئومرفولوژی، اشنایدر، SCS و مثلثی (مطالعه موردی: حوزه آبخیز کن)

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چکیده

با توجه به اهمیت دبی حداکثر لحظه‌ای برای مطالعات آبخیزداری، کمبود و عدم کیفیت داده‌های اقلیمی و هیدرولوژیکی جهت تخمین و اندازه‌گیریها در کشورهائی چون ایران، محققین را مجبور کرده است با ایجاد ارتباط بین پارامترهای ثابت (ژئومرفولوژیکی) و متغییر (هیدرولوژیکی) مدلهائی با حداقل وابستگی به داده‌های اقلیمی و هیدرولوژیکی را ابداع نمایند. لذا در این تحقیق سعی در استفاده از هیدروگرافهای واحد مصنوعی در حوزه آبخیز کن (رودخانه سولقان) بوده و مقایسه نتایج آن با دبی حداکثر ثبت شده در خروجی حوضه می‌باشد تا بهترین مدل بدست آید. مقایسه مدلها از طریق در نظر گرفتن توابع میانگین خطای نسبی (RME) و ریشه میانگین توان دوم خطاء (RMSE) در حوزه آبخیز مورد مطالعه واقع شده در حوضه البرز مرکزی می‌باشد. نتایج RME برای مدل ژئومرفولوژی 17.99 و RMSE، 15.49 برای اشنایدر RME، 59.66 و RMSE، 29.83 برای SCS، RME 162.63 و RMSE، 76.002 و در نهایت برای مدل مثلثی RME، 165.82و RMSE، 77.44 بدست آمده است. بنابراین به ترتیب مدلهای ژئومرفولوژی، اشنایدر، SCS و مثلثی دارای بهترین برآورد دبی حداکثر لحظه‌ای در حوزه آبخیز کن بوده‌اند. همچنین با درنظر گرفتن کمبود دبی حداکثر لحظه‌ای ثبت شده (11 واقعه) در ایستگاه هیدرومتری به نام کن- سولقان در خروجی حوضه، ما نمی‌توانیم مدل هیدروگراف واحد لحظه‌ای را بدست آوریم. به همین دلیل با استفاده از فاکتورهای موجود در هریک از مدلهای مورد مطالعه، سایر فاکتورهای موثر و 283 واقعه ثبت شده دبی حداکثر روزانه، مدل دبی حداکثر روزانه بدست آورده شد.