International Journal of Geology, Earth and Environmental Sciences ISSN: 2277-2081 (Online)
An Online International Journal Available at http://www.cibtech.org/jgee.htm
2012 Vol. 2 (2) May-August, pp.349-359/Kazemi et al.
Research Article

THE USE OF GIS, HEC-HMS IN ZONING FLOOD-PRODUCING REGIONS AND PRIORITIZING FLOODING POTENTIALS CASE STUDY: WATERSHED BASIN OF EAST DAMGHAN, SEMNAN PROVINCE, NORTH OF IRAN

***Mohammad Kazemi[1], Ahmad Nohegar[2] and Peiman Rezaei[3]**
[1]*Watershed Management; Hormozgan University*
[2]*College of Natural Resources, Hormozgan University*
[3]*College of Geology, Hormozgan University*
**Author for Correspondence*

ABSTRACT
Zoning flood-producing regions and prioritizing sub-basins with regard to flooding play an important role in the management of large watershed basins. In this research, having combined GIS and HEC-HMS hydraulic model, flooding intensity or in other word, the participation of sub-basins in the output flood of the whole basin was determined. For this purpose, the sub-basins of East Damghan watershed basin has been prioritized with regard to flooding with the use of unit flood response method in HEC-HMS modeling environment. Waterways routing factors and geometric positioning of sub-basins affects output flood of the basin. Accordingly, in order to implement flood control programs in the upstream of large watershed basins, we should firstly study the quality of the sub-basins influence on the basin flood, and then prioritize them according to their portion of output in flooding using SSSE method with consequent and one-to-one deletion of the sub-basins from the very proceedings of inner basin routing. In each instance of carrying out the modeling to accomplish this purpose, the hydrograph on the part of one of hydrologic units was simulated through the deletion of inner basin routing and the output flow of the basin not bringing into consideration that very same unit. The results indicate that the sub-basins A3 and A4 are the most efficacious in bringing out the basin flow output in such a manner as not to be necessarily in proportionality with the sub-basins maximal flow.

Key Words: *Flooding, GIS, HEC-HMS Model, East Damghan Watershed Basin*

INTRODUCTION
The revival of watershed land is not practicable in a unit project due to the vastness of the watershed basins in addition to executive and economic limitations: it might even cause reversal effects. Flooding control projects are of managerial nature in decision-making which ought to be confirmed by the study of economic, social and physical circumstances thereof not to mention the evaluation of effects arising from the effectuation of programs (Bruck & Djordjevic, 1998). It is vital to determine the flood-producing areas and prioritize their sub-basins from the stand point of flood controlling projects and the comprehensive watershed management since there is some trend of increase in any typical basin’s occurrence of flooding with its concomitant damages. The relationship between the amount of flooding and the watershed basin would have been confirmed by experience to be the result of the interaction of a large number of physical trends controlling the production and channeling of flood (Witzar *et al.*, 2001). It appears necessary to recognize flood-producing areas on the upper flow in watershed basins in order to avert flood risk in the down-flow areas (Smith and Ward, 1998, Saghafian and Khosroshahi, 2005). Singh (1996) with check time and place Changes in rainfall, the basin of behavior change on the flood hydrograph shape, continuity and flow moment to review the flood hydrograph.

Melesse and Shih (2002) to estimate the spatial distribution of runoff height, were used of satellite imagery for land use changes and CN of Kissimmee watershed in south Florida. Results showed that change and consequent changes in flooding, the use of satellite images to study the reactions of the flooded area is useful. A number of models have been applied to simulate water current in recent years which would be helpful in case they should be used in the current manner for purposes of flooding routing specifically for cases of input hydrographic into river channels from the up-flow resultant of instantaneous showers (Chi Yen, 1995). The locality, distance, or proximity to the basin's outpouring is effective on the total outflow of the basin's flooding and determine flood-originating zones (Wan *et al.*, 2010). It seems far from practicality to deduce the intensity of sub-basin's flooding only through the analysis of the present data in virtue of the shortage of hydrometric stations all over the sub-basin's area and the shortage of the recorded statistics and data relating to flooding in Iran's watershed basin flooding zoning. Therefore, the role of hydrologic mathematical models in the determination of the basin's flooding would be absolutely prominent. All over Iran, the general studies to investigate the sub-basin's flooding do not only fail to put forward quantitative specific definition of flooding, but also the totality of the basin is considered to be a whole unit: no attention having been paid to the river's flooding routing effects and the location of the sub-basins. The land management department is changing the relationship between the hydrologic and climatic limits, not being ineffective on the mentioned limits (O'Connel *et al.*, 2007). Determining flood-producing areas and their prioritization according to flooding potentiality are important facets in land management. Worthy of notice is the fact that on the increase are flooding events and their concomitant danger (Wheater, 2006). To analyze Pajarto plain in Los Alamos, Mac Leen *et al.*, (2001) applied a combination of Arcview and GIS-HEC programming. The plain had gone under fire in 2000. The data concerning precipitation runoff before the fire was present through HES-HMS model. By means of calibrating the model on the basis of the 2000 summer precipitation data, it came out clear that there had been a good level of correspondence between the execution of the above-mentioned model with the region's flood data, the flooding hydrograph for a retrospective period of 6-hour precipitation on 100-year basis was designed. Barton (2003) launched an effort to prognosticate the degree of effect of urbanization expansion on basin flooding through GIS and the annexed program of CRWR-PrePro to transport the GIS data onto the HEC-HMS hydrologic modeling software while carrying into effect a project from the University of Texas in Salado and San Antonio watershed basins. Khosrowshahi and Saghafian (2005) used the HEC-HMS model in Iran to determine the sensitivity of some flooding in watershed sub-basins with the help of Damavand basin output hydrographic data around the Metropolis of Tehran. Aalami and Hassanzadeh (2005) used HEC-HMS model to determine the flood rise areas in Golestan dam watershed. The hydrological conduct of the sub-basins towards the outflow was proven to be of non-linear nature by the results. And, it would also be possible to recognize factors affecting sub-basin's flooding from the view point of the basin output flow effectuality in addition to the most critical sub-basin having again been recognized by the same method. East Damghan plain flood water to the north of Iran was studied in this investigation. In this research, the aim is to integrate GIS data and HEC-HMS hydraulic model to determine the degree of sub-basin's involvement in the totality of Damghan watershed basin outpouring flood, and recognition and prioritization over the sub-basins from the view point of flooding potential. The study could act as a basis to prioritize termporally-topolocally the flood controlling projects and the determination in a quantitative manner of their effect on the basin flooding regime, so as to prevent the probable negative effect of flood controlling operations in areas where they are not necessary.

MATERIALS AND METHODS

Introducing the Basin

The East Damghan watershed basin covering an area of 230788 hectares equal to 2307.88 square kilometers is located geographically in a position between 54°, 45′ to 55°, 00′ eastern longitude and 35°, 55′ to 36°, 30′ northern latitude. The political divisions of the nation put the area under study in the province of Semnan, to be more exact: in Damghan and Shahrood counties of the two, of course the portion of Damghan is larger than that of Shahrood. The mainroad from Tehran to Mashad traverses the basin under study in an east to west fashion, causing the larger section of the area to be accessible.

In this study, with the application of the numerical map scaling topographically 1.25000 the waterways numerical mapping, the high ridge points in the East Damghan watershed basin were divided into 33 sub-basins and three major water basins of A, B, C with due exactitude along the lines of the TIN informational layer and also the GIS capacity to put forward the layer in the shape of KML Layer (three-dimensional vision), transferring them all onto the Google earth software environment.

1- The sub-basin physiographic properties

Damghan watershed basin was topographically and in view of the waterways network was divided into 33 smaller basins in this study that are shown by figure (1). The digital height model (DEM) with the resolution power of 50m. along with TPSS algorithm based on that very topographic numerical mapping, brought out height points, waterways network, and the basin's border in the GIS environs to re-extract the needed physiographical characteristics from them.

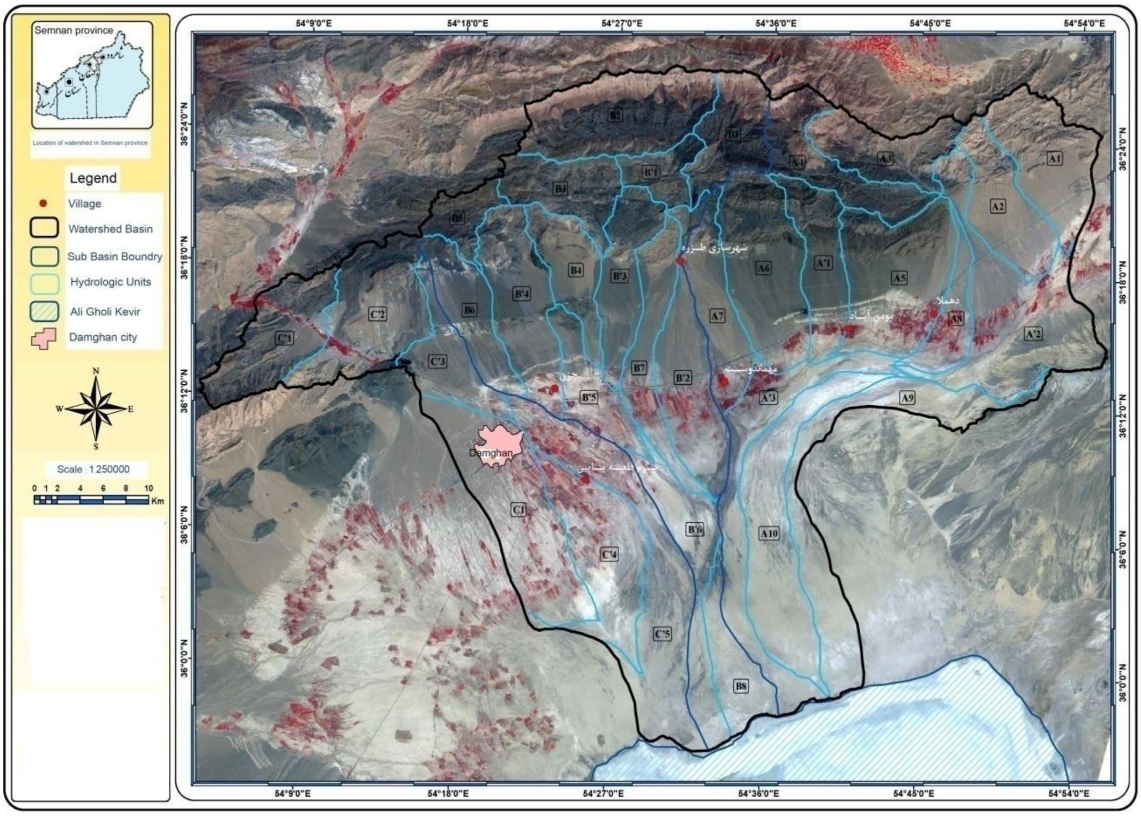

Figure 1: Damghan watershed and hydrologic sub basin

2- Determining the number of the curve under each basin

The next parameter would be the number of the curve applied in SCS method to determine the primary damages and the lag time period, all to be under the effect of the type of land use, the type of soil hydrology grouping, and the former moisture in the soil. The land use map of the area was prepared with remote sensing techniques plus maximum probability algorithm of satellite pictorial images to be fed into GIS environment. On the other hand, the soil hydrologic group mapping was extracted from throughout the basin homogenously applying the method of penetrability with double cylinders. Later land use maps and soil hydrologic groups were well integrated into each other in GIS environment to be prepared.

3- Precipitation runoff data observed and the determination of the locality and temporality distribution of showers

To calibrate the HEC-HMS model, it would be necessary to feed the observed data on precipitation and the concomitant flooding into the model. Hydrometric stations flooding hydrograph were prepared for this purpose to be followed by the use of daily recorded precipitation method in stations for this purpose around East Damghan watershed basin, all along with bringing out the locality distribution of showers applying the reverse distance-square method in GIS environment with a cell network of 25 meters. Worthy of mention is, also, the fact that in spite of daily recorded precipitation data and the height of the stations recording them on the top of the regressional relationship between height and precipitation, it is still feasible to draw out a map of isohyets area to, then, change it into the hourly precipitation, so that the location distribution of shower for various time slices could be obtained with the desirable cell size. The precipitation hyetograph for each sub-basin was designed by SMADA software to be nominated to the metrological department on a six-hour basis extracted from the daily pattern of rainfall. The temporal distribution of the showers was determined through hyetograph paper sheets in the stability station. However, frequency storm method was finally used in view of the watershed basin's circumstances and the probability of error sliding in either of the two methods because of having at hand the precipitation amount in various retrogression periods as well as their duration. This software has a capacity to simulate the precipitation-runoff process and to show flooding graphs because of its high graphic capability in all watershed basin elements. This very property would provide the possibility for routing of the flooding wave(s) and searching for the performance methodology in addition to co-layering of flooding wave(s) in such a manner that the sub-basins are actively engaged. The watershed basin model was rebuilt through HEC-HMS software comprising of the sub-basins (S), the ranges (R), and the joint points on the waterways (J). The first stage to simulate the process of precipitation-runoff is modeling which pushes forward on to understanding the relations in sub-basins, ranges, and the joint combination points on hydrographs. The model is presented in figure 2.

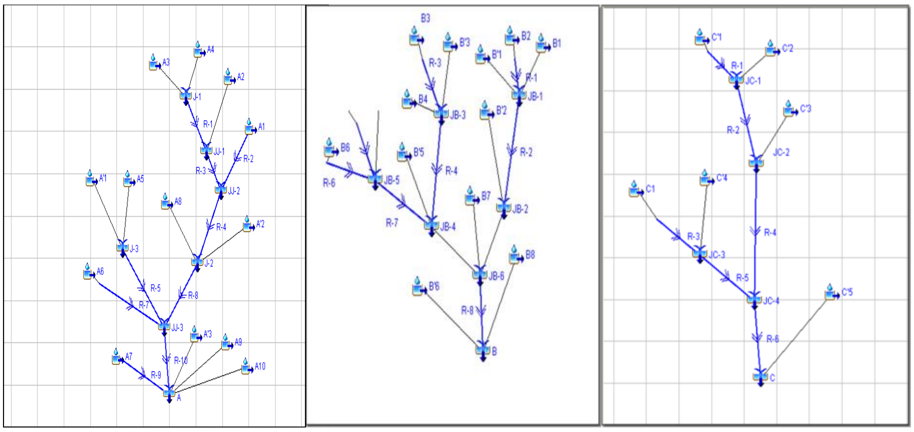

Figure 2: Relation in sub basins(C-B-A), Range and joint

4- Simulating the watershed basin hydrologic reaction with HEC-HMS model

The HMS model is one of the computer-mathematical ones to simulate the occurrence of precipitation-runoff, itself containing several sub-models in elements like runoff, surface currents, basis water, and the channel flow. The model consists of three main segments named the watershed basin model, the climatic model, and the control indices. The model is also able to self-calibrate automatically and to optimize the parameters (USACE, 2000). The numerical curve method was put to use in calculating the loss rate meaning the pastureland vegetation stems and leafage or that on the part of forestry, surface roughness, and precipitation penetration into the soil. The curve number was also used in order to make some evaluation of pure rainfall (runoff) through the SCS [USA Soil Conservation System]. The following relation is used in this method to convert precipitation into runoff:(relation1)

$$Q = \frac{(P-0.2S)}{P+0.8S} \qquad (1)$$

Where:
Q: pure rainfall height (runoff) in mm.
P: rainfall height in mm.
S: the potential for surface maintenance in mm. whose numerical value could be extracted by the following formula: (relation2)

$S= \frac{25400}{CN} - 254$ (2)

In the above relation, CN would be the curve number relating to the water wastage amount in the basin, whose range varies from zero to 100. The CN curve number is dimensionless determined by the typology of land use and soil hydrology grouping not deleting from view the prior moisture conditions. It is to be noted that land use type with remote sensing techniques mapping plus soil hydrologic groups were prepared by RS and entered into GIS environment in digital form and the weight curve number mapping gained by their combination. Then parameter P was calculated through the regression relationship of height and precipitation of rain polling stations and put the DEM map into the relation and finally the runoff rate was calculated in GIS environment by having these parameters. For calculating flood routing it is necessary to be mentioned that the flow hydrograph (flood) in point of river or stream is the function of reach upstream hydraulic properties or reach (es). Most methods meant for flood routing in HEC-HMS were based on the flow continuity equation or the relation between the flow and the storage.

The flood hydrograph form in downstream is almost does not change in small waterways due to the formation of minimal temporary storage (high slope and low-latitude). Hence, with regard to the watershed basin situation of east Damghan, the LAG method has been used in this study. The sub-basin lag-time is calculated according to relation **(3)** and the concentration time is calculated from the relation **(4)**. (3)

$Tlag = L^{0.8}\frac{(S+1)^{0.7}}{1900Y^{0.5}}$

Where

L would be the main stream length (foot)

Y would be the average slope of the basin

S would be the water retention index in basin (Inch) which is calculated by the following relation S= (1000/CN) -10

TC = 1.67 (Tlag) (4)

5- Model Calibration & Validation

The Simple Split Sample Test method was used in this research for validation and calibration. In this method, the observed flood divided into two groups. The model parameters calibrated with a group of data and using error minimization functions, afterwards the model validated through its implementation with optimized parameters for the second group of data and the observed hydrograph compared with the simulated one.

6- Zoning Flood-Producing Regions & Prioritizing Flooding Potentials

The precipitation-runoff model, after being validated, was implemented as a flooding base determination of sub-basins using 24 hour precipitation with 50-year return period. The flood hydrograph was obtained in each sub-basin's output, for this purpose the sub-basins of east Damghan has been prioritized with regard to flooding with the use of unit flood response (5) in HMS environment. Successive deletion—one by one—is imposed in this methodology on each sub-basin in each enactment of the model so that the outflow on the part of the totality of the watershed basin is determined next to flooding routing in the main river without taking into account any effects throughout the intended sub-basin. Thus, the degree of effect of each sub-basin in producing the outage flooding is obtained. In the first step, the sub-basin of the largest proportion of outflow of flood-production is recognized as the most flood-producing sub-basin. Other sub-basins are, then prioritized according to their level of participation in the outing flooding, respectively. Two indices to express flooding most generally used are defined as follows $f = \Delta QP/A$ & $F= (\Delta QP / QP) *100$ where F would be the degree of sub-basin's participation in the outflow discharge throughout the whole watershed basin in percentage, ΔQP would be the amount of decrease in the outflow discharge throughout the watershed basin as a result of the deletion of the respective sub-basin in cubic meters per second, QP would be the whole watershed basin's outflow discharge in cubic meters per second, f would be the portion of the sub-basin's participation in the outflow discharge of the whole watershed basin as per area unit, and A is the sub-basin's area in square kilometers. In the ending, with the introduction of sub-basins' network and routing directionality in addition to the feeding in of the necessary data into the model in a state of 50-year retrogression (the watershed basin's average

International Journal of Geology, Earth and Environmental Sciences ISSN: 2277-2081 (Online)
An Online International Journal Available at http://www.cibtech.org/jgee.htm
2012 Vol. 2 (2) May-August, pp.349-359/Kazemi et al.
Research Article

precipitation in that very 50-year retrospective period), the whole model was put into practice whose result have been presented in Tables and as sub-basins' hydrograph flooding. In Tables (3-4) to (3-21), presented are the amounts of peak flow discharge plus the total volume in all sub-basins, knots, and ranges—all having been routed. Furthermore, the floodwater hydrograph in East Damghan watershed basin as its discharge, and in some sub-basins as discharge flow in retrogressive periods of 50 years, have been put forward in table (1) .

RESULTS AND DISCUSSION

Exact investigation into the holistic set of eco-biological factors makes it clear that, as a result of humankind intervention in the natural water cycle added to atmospheric revolutions, the degree of

Table1: Sub basins Maximum wee discharge in 50 years return period

(year)Return Period	Area(Km^2)	Code	Sub basin name
50			
39	74.95	**A1**	**Cal Shor(A)**
37	60.00	**A2**	
36	52.54	**A3**	
37	58.72	**A4**	
43	104.31	**A5**	
42	97.69	**A6**	
36	54.17	**A7**	
34	31.80	**A8**	
42	98.12	**A9**	
43	108.83	**A10**	
37	54.41	**A1′**	
46	127.02	**A2′**	
41	89.82	**A3′**	
157	1012.38	**A**	
36	51.50	**B1**	**Tarzeh(B)**
42	98.72	**B2**	
36	51.30	**B3**	
35	44.89	**B4**	
33	25.31	**B5**	
36	48.16	**B6**	
37	55.42	**B7**	
35	41.17	**B8**	
33	25.16	**B1′**	
39	77.68	**B2′**	
37	54.61	**B3′**	
40	78.20	**B4′**	
35	42.41	**B5′**	
38	64.37	**B6′**	
125	758.90	**B**	
44	117.62	**C1**	**Damghan rod(C)**
38	68.47	**C1′**	
41	91.45	**C2′**	
35	43.80	**C3′**	
41	87.50	**C4′**	
46	127.76	**C5′**	
97	536.60	**C**	
320	2307.88	**Total Basin**	

probability of flooding has been on the increase in various areas through wetland zone vegetation destruction, land use not based on proper principles, expansion of impenetrable surfaces and the like. Meant by flooding potentiality is flood production all over sub-basins' area from the view point of effect and participation in flood water indices (the peak outflow discharge or the flooding total zonation) all in the watershed basin's outgoing flow. In other words, flooding spells as the disparation of hydrologic reaction in the whole watershed basin affected by a flood-producing precipitation period in proportion to the degree of sub-basins' participation with searching into the effect of dynamic parameters on the runoff process down to the basin's outflow discharge. Conditioned a sub-basin should possibly produce a higher peak of outflow discharge independently as contrasted with other sub-basins, reasonality is not, thus, gotten as for a higher level of flooding in that certain sub-basin. Conversely, the sub-basin participating more effectively in giving out flooding indications in the outflow discharge hydrograph within the main watershed basin (be it the totality of the basin or, otherwise, compared with the intended spot), is considered to be more of flood-production.
The flooding index is, by the same token, the degree of runoff effect produced all over the sub-basins in the increase or decrease of the total basin's out-flooding discharge (bringing into account all the sub-basins' characteristics). The mentioned increase or decrease could be determined by means of outflow properties and the water level or flooding zone for the level of input on the part of each one of the sub-basins within the watershed basin's outflow discharge. It has been shown by the flooding hydrograph drawing in various sub-basins comparison that the peak of flooding hydrograph would be wider in those sub-basins that are more elongated. In such sub-basins, the flooding discharge per unit area comes out to be less as compared with other sub-basins with the condition that the time spent for them to get to their peak(s) is longer in opposition to non-elongated sub-basins were the flooding discharge of theirs comes out to be higher in unit area while they have reached their peak(s) of outflow discharge in a shorter period of time, possessing sharper hydrographs (in order to counterbalance the effect of sub-basins, the flow per unit area has been applied as the benchmark since in large sub-basins, the runoff damages are more). The prioritization of the sub-basins in three branches of: Kalshoor, Tazreh, and Damghanrood (three disparate working units) were well searched into as the area under investigation. In Kalshoor watershed basin , sub-basins of A1, A4, and A3 , in Tazreh watershed basin , B1, B3, and B5 sub-basins , and in Damghanrood watershed basin , the sub-basins of C1 and C2 have been of the greatest amount of input participation of output flooding production. If B is considered to be the level of flow effect per unit area in the outage flooding in any sub-basin, A3 with an amount of 742.2 (square kilometers/seconds/liters) has the most significant effect in A sub-basin to be followed by A4 with the amount of 664.2 and A1 with 444.3; the same numerical outflow effect in the other two sub-basins would be as follows:
B2 with 522.4 (square kilometers/seconds/liters) and B1 with 522.3 to be followed by B5 with 521.5 (square kilometers/seconds/liters) in B sub-basins;
C′1 with 303.8 and C′2 with 170.6 (square kilometers/seconds/liters) are of greatest effect in C sub-basin;
in all of which A3 is of the most sizable participation in out-flooding in the watershed basin. It is to be mentioned that the sub-basins of A′1, A9, A8, A7, A6, A5, B′1, B2, C′4, and C′5 have had no significant participation effects in producing watershed basin flooding. It would, now, be facile to recognize those sub-basins in need of argent management to be put on the top of prioritization. Also, the results indicate that the sub-basin of B (Tazreh) needs higher managerial care as contrasted with the sub-basin of A (Kalshoor) and the sub-basin of C (Damghanrood). How the sub-basins took part in producing the out-flooding in the whole watershed basin was made clear by applying the methodology of sub-basins one-by-one deletion, bringing into consideration the routing effects in ranges. The quantitative order of deletion effect from the point of departure of the highest effect in producing the outflow discharge down to the lowest one—practicing sub-basins one-by-one deletion—has come out to be as follows:

A3- A4- B3- B1- B1- B5- A1- A2- C′1- B6- C′2- B4- B′4- B′3- A′2- B7- B8- B′5- A10- B′2- B′6- C′3- A′3- C1

The way sub-basins take part in the outage flooding—as observed—would not necessarily be in proportion to the sub-basin's peak outflow discharge in addition to the fact that those sub-basins with higher peak outflow discharge are, not by nature of necessity, of greater effect in the watershed basin's outing flood: i.e. , there are some sub-basins—as seen in Tables (2-4)—that are of maximal moment outflow discharge in differing retrogressive periods compared with the watershed basins mostly affecting the basin's production of flood water while they are of less sizable flooding potentiality participation in which case the larger amount of outflow discharge could not be construed as the reason for the basin's greatest devotion into the phenomenon of flooding and outgoing flooding. Furthermore, in case enough attention is paid to the factor of the sub-basin's area, it is not far from recognizing that—once again—this is not a good reason for prioritization of the flooding, either. Therefore, the waterways' routing and the location of sub-basins could bring about some change in the manner of "participation". As for flooding routing, a sub-basin with some high outgoing flow discharge might—as a result of its location combined with its hydrographic conditions with other hydrographs—not be of such a great effect producing the outgoing discharge in the watershed basin. It is to be noted that—the prioritized sub-basins' characteristics having been well paid attention to from the point of view of flooding and the flooding factor having been sensitively analyzed for concentration time, curve number, and the net ascendency or descendency—the ±12.5% range is to be suggested for the model's sensitivity towards such factors.

Table 2: The sub-basins' prioritization on the basis of the degree of sub-basins' participation in outgoing peak flooding discharge in the branch of Kalshoor—East Damghan watershed basin with Dr. Saghafian and Khosroshahi's methodology (2001)

No.	Sub-Basin Name	Area in sq/km	Be Outgoing Flooding	The level of Flooding Participation in the outgoing Discharge in Cubic Meters Per Second	The Degree of the Effect of the Discharge Per Unit Area within the Sub-Basin in the Outgoing Flow of Flood in Lit/Sec/Km^2
1	A3	52.54	136	39	742.3
2	A4	58.72	136	39	664.2
3	A1	74.95	141.7	33.3	444.3
4	A2	60	152.2	22.8	380.0
5	A′2	127.02	169.1	5.9	46.4
6	A10	108.83	173.5	1.5	13.8
7	A′3	89.82	174.9	0.1	1.1
8	A′1	54.41	175	0	0
9	A5	104.31	175	0	0.0
10	A6	97.69	175	0	0.0
11	A7	54.17	175	0	0.0
12	A8	31.8	175	0	0.0
13	A9	98.12	175	0	0.0

It was made obvious in the analyses that there is some relationship in between the area and the total outgoing discharge in the watershed basin in direct manner despite the fact that those sub-basins with greater area are not necessarily more effective in producing the total flood water discharge. This can well be observed in B2 sub-basin with greater area compared with B1 and B3 sub-basins with smaller area, bringing in less in flow flood participation in the totality of output flooding discharge. Added on top of all these should be the actuality that the above-mentioned prioritization method for specifically designed participation—usually used in wetland management and decreasing the flooding risk—might well vary with changes in retrogressive period or ongoing precipitation leading to changes in sub-basins' potentiality to beget flooding or displacing the location of peak outgoing flow discharge.

Table 3: The sub-basins' prioritization on the basis of the degree of sub-basins' participation in outgoing peak flooding discharge in the branch of Tarzeh—East Damghan watershed basin—with Dr. Saghafian and Khosroshahi's methodology (2001)

No.	Sub-Basin Name	Area in sq/km	Be Outgoing Flooding	The level of Flooding Participation in the outgoing Discharge in Cubic Meters Per Second	The Degree of the Effect of the Discharge Per Unit Area within the Sub-Basin in the Outgoing Flow of Flood in Lit/Sec/Km^2
1	B3	51.3	74.5	26.8	522.4
2	B1	51.5	74.4	26.9	522.3
3	B5	25.31	88.1	13.2	521.5
4	B6	48.16	92.8	8.5	176.5
5	B4	44.89	95.5	5.8	129.2
6	B′4	78.2	92	9.3	118.9
7	B′3	54.61	95.9	5.4	98.9
8	B7	55.42	99.7	1.6	28.9
9	B8	41.17	100.2	1.1	26.7
10	B′5	42.14	100.6	0.7	16.5
11	B′2	77.68	100.7	0.6	7.7
12	B′6	64.37	101.1	0.2	3.1
13	B′1	25.16	101.3	0	0.0
14	B2	98.72	101.3	0	0.0

Table 4: The sub-basins' prioritization on the basis of the degree of sub-basins' participation in outgoing peak flooding discharge in the branch of Damghanrood—East Damghan watershed basin—with Dr. Saghafian and Khosroshahi's methodology (2001)

The Degree of the Effect of the Discharge Per Unit Area within the Sub-Basin in the Outgoing Flow of Flood in Lit/Sec/Km^2	The level of Flooding Participation in the outgoing Discharge in Cubic Meters Per Second	Be Outgoing Flooding	Area in sq/km	Sub-Basin Name	No.
303.8	20.8	25.7	68.47	C′1	1
170.6	15.6	30.9	91.45	C′2	2
2.3	0.1	46.4	43.8	C′3	3
0.9	0.1	46.4	117.62	C1	4
0.0	0	46.5	87.5	C′4	5
0.0	0	46.5	127.76	C′5	6

It would, thence, be of necessity to prioritize flood-producing right in view of intended goals. E.g. , there would be different retrogressive precipitation periods designed for building a dam or , for example, materializing structural wetland workings. In short retrogressive periods—as shown forth by the results—the majority of sub-basins take no part in the outgoing flood water within the watershed basin (precipitation being from 6 hours, two years) while in long retrogressive periods as with showers or possibly some increase in the continuation of a fixed retrogressive period, more fixity would show up by the hydrologic units or sub-basins' prioritization. This is well obvious in areas with higher potential to beget flood. For instance, in the watershed basin under study with precipitation of a period of twelve hours and retrogression periods of fifty and one hundred years stability is relatively fixed on the prioritization of the hydrological units' participation level to give out flooding in the watershed basin. This shows that a retrogressive sensible period ought to be taken into consideration to decrease the effect of sub-basins in producing outgoing flood water in the whole watershed basin in such a manner as to bring about a higher degree of certainty for reducing flood water in the watershed operations. Results mapped out in the Table show this full well. The state of sub-basins' taking part in producing the total basin flood water discharge with retrogression periods of one hundred and fifty years is the same in spite of disparity in the amount of sub-basins' flood water in the two one hundred and fifty years period.

Conclusion

The total watershed basin has been considered "Lumped" in most of the methods concerning recognition, separation, and prioritization of regions with flooding potential; otherwise, they have been practiced on as regional grouping without taking into consideration the watershed basins' or the sub-basins' physical borders (Islam & Sado, 2000). Calculation resulting from the actualization of the model with the suggested methodology in East Damghan watershed basin showed that the manner of sub-basins' participation in the outgoing flooding would not necessarily be in proportion to the peak outflow discharge of the sub-basins: the sub-basins with greater outflow discharge are not, of necessity, bringing about more significant effects in the outgoing flood within the basin. Therefore, factors in routing waterways and the location of the sub-basins could cause changes in the state of participation. To accomplish flood control operations or to decrease the outflow discharge peak in the basin's output, the manner of bearing of each of the sub-basins should, therefore, be determined after routing them in the main waterways before separating and prioritizing them according to the portion they produce the outgoing flooding. This process of prioritization—in cases where the flood-production prioritization is affected by the sub-basins' area—could be carried out for each sub-basin unit area. The index indicating the severity of flood-producing per unit area within the watershed basin might be of greater efficiency while prioritizing the flood control operation planning considering the present facilities and costs. In the executive departments, too, the level of decrease on the part of outgoing flood per unit area gains more significant where the plans' economic difficulties are, actually, important determining factors. Our suggested method is to be well investigated for each climatic zone and each watershed basin whereby the carrying out of the method in the framing format of flood control is recommended: all indicating that the combination of GIS with hydrologic models can hand us some valuable investigation into reciprocal effects of physiographic and climatic factors in the potential within the watershed basin(s) to give out flooding in a manner that appears more suitable

REFERENCES

Amir Ahmadi A and Shirvan M (2010). The application of HEC-HMS model on the sensitivity analysis of the geomorphical variable effective on Karvan plain flood, *Journal of Geography and Development*. 7(**16**) 153-173, ISSN:1735-0735, *Available at: http//www.cresg.ir*.

Burton L (2003). Application of HEC-HMS and the Effects of Sub-Basin Size in Watershed Modeling, Texas A&M University Department of Civil Engineering CVEN689- CE Applications of GIS.

Chieyen B (1995). Hydraulics and effectiveness of levees for flood control, U.S.-Italy Research Workshop on the Hydrometeorology, Impacts, and Management of Extreme Floods Perugia (Italy).

Djordjevic B and Bruck S (1998). System Approach to the Selection of Priority Areas of Erosion Control With Implications of the Water Resources Subsystem, *Proceedings of the 4th International Symposium on River Sedimentation Beijing, China*,1547-1554.

Hassanzadeh Y and Aalami M T (2005). An investigation of reasons for the occurance of Golestan flood & the methods of its Preventation, In; *Proceedings of the International Conference on Geohazards, Natural Disasters & Methods of Confronting With them, Tabriz, Iran*, Sep.27-29, 2005;39-40.

Islam M and Sado K (2000). Development of flood hazard maps Bangladesh using NOAA-AVHRR images with GIS, *Journal of Hydrological Sciences* **45**(3) 337-355.

Melesse A M and Shih S F (2002). Spatially distributed storm runoff depth estimation using landsat images and GIS, *Journal of computers and electronics in agriculture*, *37*(1) 173-183.

Mclin S, Springer E and Lane L (2001). Predicting floodplain boundary changes following the Cerro Grande wildfire, *Journal of Hydrological Processes* **15**.2967-2980.

O'Connel E, Ewanj, O'Donnel G and Quinn P (2007). Is there a link between agricultural land-use management and flood risk? *Hydrology and Earth System Sciences* **11**(1) 96-107.

Saghafian B, Khosroshahi M (2005). Unit response approach for priority determination of flood source areas. *Journal of Hydrologic Engineering* **10**(4) 270-77.

Singh v p (1996). Effect of spatial and temporal variability in rainfall and watershed characteristics on stream flow hydrograph, *Journal of Hydrological Processes,* **11**(12)1649-1664.

Smith and Ward.(1998). Floods: Physical processes and human impacts, Wiley, New York, p.382.

Wan Nor Azmin, Sulaiman Heshmatpour A and Mohd.Hafiz R.(2010). Identification of Flood Source Area in Pahang river basin,Peninsular Malaysia, *Journal of Environment Asia*3 (special issue) 73-78 (Available: http://www.tshe.org/EA)

Wheater H S (2006). Flood hazard and management: a UK perspective. *Philosophical Transactions of the Royal Society A*, **364** 2135-2145.