A comparison of multi-criteria decision making techniques for prioritizing flood potential based on morphometric parameter analysis

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Abstract

One of the most important aspects of basin management is the prioritization of sub-basins. The flood potential of Kan sub-basins in Iran is prioritized in this study using morphometric parameters combined with model statistical correlation and multi-criteria decision-making systems. The Kan basin was studied using 17 morphometric parameters such as slope, elevation, curvature, ruggedness number, elongation coefficient, circularity coefficient, equivalent rectangle, drainage density, stream length, infiltration factor, time of concentration, duration-intensity of rainfall, land cover, land use, geology, bifurcation ratio, and length of overland flow. The relationship between parameters and weighting results revealed that climate and morphotopography (slope, elevation, curvature, and ruggedness number) were important factors in AHP flooding. Slope and time of concentration (0.11) duration-intensity of rainfall (0.12) have become one of the most critical factors in flooding in the ANP method. The Shannon entropy method identified stream length (0.15), elevation (0.11), and geology (0.11) as important flooding factors. Ranking in the AHP method revealed that the sub-basins of Imamzadeh Davood, Talun, and Doab had the highest score (0.74, 0.50, 0.41), and in the ANP method, the sub-basins of Imamzadeh Davood, Talun, and Sangan had the highest score (0.97, 0.51, 0.48). They were ranked first through third. Furthermore, Imamzadeh Davood, Talun, and Rendan rank first to third in Shannon entropy with points (0.97, 0.68, and 0.52). Other ranking methods, such as COPRAS, VIKOR, and TOPSIS, prioritized sub-basins. The TOPSIS method was deemed the best ranking method by Kendall and Spearman's correlation method. The results demonstrated that this model is highly accurate, and that morphometric sub-basins have a significant impact on flooding. Imamzadeh Davood and Sangan sub-basins are high-risk areas in this basin. There have been more floods in these areas. For validation, the HEC-HMS from the Natural Resources Organization's method was used. The HEC-HMS method yields results that are consistent with the Shannon entropy and ANP methods.

1 Introduction

Flood is one of the world's natural hazards that causes a lot of damage every year, including human, financial, and structural damage (Mukherjee and Singh,2019). Iran is suitable for intensifying and spreading floods due to the mountains' effects on the transfer and ascent of humid air masses and increased slope and runoff formation. Due to the unfavorable basin management conditions of the country's basins, runoff has a remarkable ability to produce floods and carry sediments. Abundant and resulting in the destruction of land cover and arable land and filling the reservoir of dams. Each year, floods cause enormous economic damage owing to the loss of cattle, human lives, and the ruin of agricultural and residential regions (Mohammadi, 2012). To achieve an overview of the drainage structure, it is required to investigate the morphometry of the basin, which is critical for basin ranking (Strahler, 1964). The parameters morphometry assists in identifying and comprehending the physical properties of the basin and its relevance to floods (Bhatt and Ahmed, 2014).

Morphometric analysis and statistical correlation were compared to conventional approaches. They benefit from having an expert perspective in the decision-making process. Priorities have no effect. Due to insufficient study on the impact of relevant factors, AHP and FAHP approaches based on pairwise comparisons performed by professionals lack scientific documentation. Prioritization is done in the morphometric analysis approach and statistical correlation based on information acquired from cultivar layers of critical basin characteristics and by constructing a correlation link between parameters (Aher, 2014). A basin is an appropriate unit for managing natural resources such as land and water, as well as mitigating the effects of natural disasters in order to achieve sustainable development (Rahaman et al, 2015). Therefore, prioritizing sub-basins is vital for basin management and flood control. In recent decades, many researchers have examined priority sub basins for risk potential utilizing morphometric characteristics and multicriteria decision making Gholami et al., (2019), for example (flood stage and floodplain partitioning of Kan basin), flooding levels in the Kan main branch were examined using HEC-RAS and the HEC-geo-RAS supplement for return periods of 2, 5, 10, and 20 years. The hydrodynamic model output shows that the rise in water level height upstream of the river was caused by an increase in flow, and there was less lateral expansion in floodplains. However, due to the decrease in water level, the river has more lateral development along the middle and lower slopes of the river's lower sections. The flood zones in these parts cover a larger area than the upper stages of the river.

Kumar et al., (2021) used morphometric characteristics to select Bamni Banjar sub-watersheds in the Madhya Pradesh districts of Balaghat and Mandla in India and compared two approaches, AHP and TOPSIS. They took into account morphometric characteristics including stream frequency, texture ratio, length of overland flow under linear aspect, form factor, shape factor, circulatory ratio, elongation ratio, compactness coefficient, drainage density, and channel maintenance constant under areal aspect.

Utlu et al., (2021) used GIS and statistical software to prioritize watersheds of the Aras River in Turkey's east Anatolian region based on geomorphological considerations that included the linear, areal, and relief morphometry properties of the investigated watersheds. Understanding floods highly depends on watershed morphometry. Elevation variations, drainage density, and stream flow are all factors in high basins. The results for frequency, surface runoff, initial stream order, and texture ratio were all rather high. High flood risk basins were those where river erosion causes and processes were active.

Obeidat et al., (2021) used geospatial technology to assess Morphometric and priorities basins for flood risk management in Jordan's Wadi Easal Basin. According to the results of the prioritization, about 71% of sub-basins are very vulnerable to floods. The relative relief ratio, stream frequency, circulatory ratio, basin slope, drainage density, and roughness number were the most relevant criteria. The study found that morphometric analysis combined with GIS might be a useful tool for understanding sub-basins linked to floods control. Mahammad et al., (2022) used morphometric characteristics to examine the flood potential of the Gumani River basin in Jharkhand state, India, and prioritized them using the TOPSIS approach. They calculated linear (stream order and mean bifurcation ratio), areal (form factor, elongation ratio, circularity index, drainage density, stream frequency, density, compactness coefficient), relief (basin relief, relief ratio, roughness number, slope, and etc.), and hypsometric integral characteristics. The very low class has five sub-basins, whereas the very high class contains three sub-basins. They discovered that relief features are the most important, followed by areal and linear aspects. They also determined that RS and GIS, combined with the statistical approach, are appropriate instruments for natural disasters. Kan basin is prioritized flood potential because to population increase along the river and uncontrolled construction in the river region, loss of natural resources, land-use changes, past floods, and major damage in this flood management basin. Sub-basins and the management of vulnerable sub-basins are critical. The goal of this study is to discover the morphometric characteristics influencing sub-basin floods utilizing multi-criteria decision-making approaches (AHP), ANP (network analysis method), and Shannon entropy.

Flood generation areas and sub-basin prioritization based on Topsis, Vikor, and Copras methodologies, with statistical correlation between them. As a result, the fundamental goal of this research is to identify flood-prone regions and morphometric characteristics influencing flood basins.

2 Materials And Methods

2.1 Study area

The Kan basin is 20571.04 hectares and connects to Tehran from the south, the Darkeh basin from the east, the Jajroud basin from the north, and the Karaj River basin from the west. Because of this, the basin rivers originate on high rangelands. They have a steep slope. The kan basin is the most major stream, which flows from the heights overlooking Imamzadeh Davood and continues to depart the basin. (residential areas of Kan). Other important basin channels are Lalon, Talun, and Keshar (Fig. 1).

The Kan basin is located north of Tehran and has the longest stream among the northern basins. Its drainage basin alone is more significant than 23 other rivers in Tehran, and it is divided into 10 minor sub-basins known as Imamzadeh Davood, Talun, Rendan, Kika, Sangan, Keshar, Sulqan, Middle Kan, Doab, and Harias.

2.2 Data analysis

First, basin area and sub-basins were determined using drainage network and altitude curves, 1:25000 topographic maps, and a digital elevation model of 10 m. The value of morphometric parameters for each sub-basin was then calculated in GIS (Table 1). The data were normalized once the morphometric parameters were obtained. Standardization involves maintaining consistency between all parameters. As a result, factors that are inversely connected to floods, such as minor flooding, increase the minimum value of the parameter between basins divided by other basin numbers. The number of floods increased the possibility of flooding in the higher parameters. Each parameter has been separated by the basin most significant parameter value. (Eq. 1) Software for making decisions Expert choice was utilized to balance the parameters in order to examine the parameters. After evaluating the Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), and Shannon entropy, flooding sub-basins were prioritized using TOPSIS, VIKOR, and COPRAS methodologies. (Fig. 2). The methods are described individually in Table 2. Eq. 1 Normalization of negative criteria

$$n_{=\frac{minx_i}{x_i}}$$

Normalization of positive criteria

$$n_{=\frac{x_i}{maxx_i}}$$

n: The normalized rate of the criteria

x_i : The quantity of each indicator in the desired basin

minx_i : Minimum index value between basins. maxx_i :Maximum index value between basins

Table 1
Methods for calculating morphometric parameters under basins

s.no	Morphometric parameters	formula	Description	references
A. Areal aspect				
1	Drainage density(Dd)	$D_{d=\sum L.A}$	Lu = total stream length of all orders,	Horton 1932
			A = area of the basin	
2	Infiltration factor (lg)	$lg = F_{s\times D_d}$	Dd = drainage density,	Faniran (1968)
			Fs = stream frequency	
B.Relief aspects				
3	Ruggedness number(Rn)	$R_{n=}\Delta H \times D_d$	Dd = drainage density	Melton (1957)
			H = Total relief of the basin	Moore et al., (1991)
C.shape aspects				
4	Elongation ratio (Re)	R_e=$1.128\left(\sqrt{A}.Lb\right)$	Lb = basin length	Schumm 1956
5	Equivalent		A = area	Alizadeh (2010)
6	Rectangle	I = $\frac{C\sqrt{A}}{1.12}\left[1-\sqrt{1-\left(\frac{1.12}{C}\right)^{2}}\right]$	I rectangle width	
		L= $\frac{C\sqrt{A}}{1.12}\left[1+\sqrt{1-\left(\frac{1.12}{C}\right)^{2}}\right]$	L rectangle length	
	Circularity ratio (Rc)	$R_{c=12.56\times\left(\frac{A}{p^2}\right)}$	A = area	Miller 1953
			P = perimeter	
	D.Linear aspects			
7	Bifurcation ratio (Rb)	$Rb_{=\frac{N_u}{N_{u+1}}}$	Nu = total number of stream segments of order 'u,' Nu + 1 = number of parts of the next higher order	Horton (1945)
8	Length of overland flow (Lg)	$Lg = \frac{1}{D\times 2}$	Dd = drainage density	Horton (1932)
9	Stream length (Lu)	Length of the stream		Horton (1945)
		E.basin aspects		
10	Time of concentration	$t_{c=0.949\left(\frac{L^3}{H}\right)^{0.385}}$	H Height dispute between the highest and lowest point of the basin,	Kirpich (1940)
			L The length of the main waterway	

Table 2
Methods studied and steps

Name of research method	Research method steps
1–1 Analytical Hierarchy process (AHP)	1. Hierarchical tree 2. Formation of a matrix of pairwise comparisons 3. Determine the weight and calculate the incompatibility rate
2 – 1 Analytic Network Process (ANP)	1. Model building and model structuring 2. Pair comparisons of priority vectors 3. Formation of Super matrix 4. Choose the best option
3 – 1 Shannon entropy method	1. Form a decision matrix 2.Normalization of the decision matrix 3. Calculate the ENTROPY of each index 4. Calculate the degree of deviation dj = 1-Ej 5. Weight calculation wj = dj. ∑dj
4 – 1 TOPSIS method	1. Form a decision matrix 2. Convert the decision matrix to a scale less matrix $r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i}^{m} =1 x_{ij}^{2}}}$ 3. Formation of weightless scale matrix V = w *r 4. Determining the ideal positive solution and the negative ideal solution 5. Obtain the distance of each option to the positive and negative ideals $d_i^{+} = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - V_j^{+}\right)^2}$ i=1,2,..... m $d_i^{-} = \sqrt{\sum_{j=1}^{n} \left(v_{ij-V_j^{-}}\right)^2}$ i = 1,2,..... m 6. Determine the coefficients of the proximity of an option to the ideal solution: $cl_i^{+} = (d_i^{-} d_i^{+} - d_i^{-})$

Name of research method	Research method steps
5 – 1 COPRAS method	1. Decision matrix formation technique. 2. Immeasurable decision matrix 3. Normalization of the linear method $\bar{n}_{ij} = \frac{x_{ij}}{\sum x_{ij}}$ 4. Normal rhythmic matrix $W_j \times N$ 5. Select the optimal option. $S_j^{+} = \sum d_{ij}^{+}$ $S_j^{-} = \sum d_{ij}^{-}$ 6. Calculate the utility rate $Q_i = S_j^{+} + \frac{\sum_{j=1}^{n} S_j^{-}}{S_j^{-} \sum_{j=1}^{n} \frac{1}{S_j^{-}}}$ $u_i = \frac{Q_i}{Q_{max}} \times 100$

Name of research method	Research method steps
6 – 1 VIKOR method	1. Formation of the decision matrix. 2. Normalization or scaling. $r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$ 3. Determining the ideal point of positive and negative $f^+ = \text{Max } f_{ij}$ $f^- = \text{Min } f_{ij}$ 4. Determining desirability and dissatisfaction. $S_j = \sum_{i=1}^{n} w_i \times \frac{f_i^* - f_{ij}}{f_i^* - f_i^-}$ $R_j = \max \left[w_i \times \frac{f_i^* - f_{ij}}{f_i^* - f_i^-} \right]$ 5. Calculation of Vickor index $Q_i = v \left[\frac{S_i - S^*}{S^- - S^*} \right] (1 - v) \left[\frac{R_i - R^*}{R^- - R^*} \right]$ S^-=MaxS_i R^-=MaxR_i S^*=MinS_i R^*=MinR_i In step 6, the best option is to have a minor Q provided the following two conditions are met: Condition one: If options A1 and A2 are ranked first and second among m options, $Q(A_2) - Q(A_1) \geq \frac{1}{n-1}$ If this condition is not met, a set of options top option A1, A2,... Am are the best alternatives. Calculate the value of m Q(Am)-Q(A1) < 1.(n-1)◊ Q(Am)<(1.n-1) + Q(A1) If condition one is met, condition number two must also be checked. Option A1 must be ranked first in at least one R and S group. When the second condition is not met, the two options, A1 and A2, are known as the top options. If both conditions are met, the rating will be based on Q. (Decreasingly: the lower the Q, the better the option.)

3 Results And Discussion

The AHP, ANP, and Shannon entropy techniques are used to determine morphometric parameter weights, as illustrated in Fig. 3. In the AHP method, the high parameters were related to the slope (0.43), bifurcation ratio (0.83), circularity ratio (0.58), infiltration factor (0.73), land cover (0.83), duration-intensity of rainfall, time of concentration and geology (1). In the ANP method, slope and time of concentration (0.11) and climate (duration-intensity of rainfall) (0.12) were among the most critical elements in flooding. In the Shannon entropy method, stream length (0.15), elevation (0.11), and geology (0.11) were among the essential factors of flooding.

A normalized morphometric parameters map is also created for each sub-basins Fig. 4 In each technique, the flooding map of the basin was generated using the normalized morphometric parameter. The risk of flooding in sub-basins was classified as low, medium, high, or very high Fig. 5. In Table 3, the TOPSIS, VIKOR, and COPRAS techniques use AHP, ANP, and Shannon entropy weights to prioritize the major sub-basins.

Table 3
Ranking of basin sub-basins based on TOPSIS, COPRAS, and VIKOR methods

	Results of TOPSIS method						Results of COPRAS method						Results of VIKOR met		
Criterion	cl_i^+	Rank in the method AHP	cl_i^+	Rank in the method ANP	WJ	Rank in the method Shannon entropy	u_i	Rank in the method AHP	u_i	Rank in the method ANP	WJ	Rank in the method Shannon entropy	Q	Rank in the method AHP	Q
Imamzadeh Davood	0.74	first	0.97	first	0.98	First	100	first	99.72	second	0.61	First	0.59	fifth	0.4
Keshar	0.34	sixth	0.40	sixth	0.38	eighth	93.35	fifth	81.06	ninth	0.46	ninth	0.77	seventh	0.7
Talun	0.50	second	0.51	second	0.69	second	95.90	second	100	first	0.57	second	0.14	second	0.1
Rendan	0.26	eight	0.38	seventh	0.53	Third	82.47	seventh	80.19	tenth	0.46	tenth	0.92	ninth	0.8
Kiga	0.19	tenth	0.20	tenth	0.40	seventh	87.92	sixth	91.35	fifth	0.51	Sixth	0.83	eighth	0.8
Sangan	0.38	fifth	0.48	third	0.51	Fourth	94.85	fourth	88.93	seventh	0.51	seventh	0.21	third	0.0
Sulqan	0.38	fourth	0.42	fourth	0.45	Sixth	95.87	third	90.86	Sixth	0.52	Fifth	0.47	fourth	0.4
Middle Kan	0.29	seventh	0.30	eighth	0.50	Fifth	72.78	ninth	92.03	fourth	0.53	fourth	0.96	tenth	0.8
Doab	0.41	third	0.42	fifth	0.28	Tenth	74.69	eighth	97.69	Third	0.55	Third	0.10	first	0.2
Herias	0.24	ninth	0.22	ninth	0.37	ninth	67.91	tenth	84.07	eighth	0.48	eighth	0.72	sixth	0.9

The TOPSIS method calculated the distance between each choice (sub-basins) using the positive and negative ideal, and the sub-basins were ranked. The findings of this ranking in the AHP technique revealed that the sub-basins of Imamzadeh Davood, Talun, and Doab with the greatest score (0.74, 0.50, 0.41), and sub-basins of Imamzadeh Davood, Talun, and Sangan with the highest score (0.97, 0.51, 0.48) are in ANP the first to third rankings. Flooding intensity is higher in them than in other sub-basins. Imamzadeh Davood, Talun, and Rendan were ranked first through third in the Shannon entropy technique, with points (0.98, 0.69, 0.53). In contrast to the AHP findings, Rendan, Harias, and Kiga sub-basins with the lowest score (0.26, 0.24, 0.19) and Middle Kan, Harias, and Kiga sub-basins with the lowest score (0.30, 0.22, 0.20) rank eighth to tenth in ANP. Keshar, Harias, and Doab, who have the lowest Shannon entropy (0.37, 0.36, 0.28), are ranked eight through tenth. The only difference between these three techniques was in the Doab, Sangan, Rendan, Middle Kan, and Keshar sub-basins. The COPRAS ranking method results in the AHP method reveal that the sub-basins of Imamzadeh Davood, Talun, and Sulqan have the greatest score (100,95.90,95.87), while in the ANP method, the sub-basins of Talun, Imamzadeh Davood, and Doab have the highest score (100,99.72,97.69). The intensity of flooding in them is higher than in other sub-basins. Imamzadeh Davood, Talun, and Doab (0.60, 0.56, and 0.55) have the highest flood potential in the Shannon entropy method. In contrast to the AHP results, the sub-basins of Doab, Middle Kan, and Harias have the lowest score (74.69, 72.78, 67.91), and in the ANP method, the sub-basins of Harias, Keshar, and Rendan have the lowest score (84.04,81.06,80.19) in the eighth to tenth rank, and Shannon entropy Harias, Keshar, and Rendan have the lowest scores (0.48, 0.47, 0.46). The top selections in the VIKOR technique were chosen from a collection of possibilities. According to the findings of this ranking in the ANP technique, Talun and Sangan sub-basins are first, but in the AHP methodology, Sangan, Talun, and Doab are first (Table 3). The Shannon entropy method sub-basins of Talun, Imamzadeh Davood, and Sangan have higher flood intensity than other sub-basins. In all three techniques, Imamzadeh Davood and Talun are sub-basins with a higher risk of flooding than other sub-basins. These sub-basins are the most vulnerable to flooding because of the values directly related to flooding.

Table 4
Spearman and Kendall Correlation Coefficient

The correlation	**ANP VIKOR**	**AHP VIKOR**	**ANP VIKOR**	**ANP COPRAS**	**AHP COPRAS**	**ANP COPRAS**	**ANP TOPSIS**	**AHP TOPSIS**	**ANP TOPSIS**
Spearman	0.44	0.42	0.52	0.48	0.56	0.45	0.41	0.65	0.66
Kendall	0.36	0.39	0.43	0.40	0.48	0.33	0.34	0.58	0.55

The correlation between the three ranking techniques is shown in Table 4. The Spearman correlation technique has a strong correlation with the ANP (TOPSIS) method, as does the Kendall correlation method with the AHP (TOPSIS) method. Therefore, the TOPSIS technique was the most effective and accurate way for ranking.

The slope is one of the factors that contribute to the number of floods. Sub-basins of Talun and Imamzadeh Davood, located on slopes ranging from 40–60%, are classified rainfall. They are classified as susceptible regions in terms of flooding. In regarding the land use, vulnerable sub-basins are frequently found in residential areas, with low-density pastures as land cover. The susceptible regions are formed mostly of shale with sandstone, siltstone tuff, micro gabbro, and diorite. The infiltration of these formations is limited, leading in runoff in the basin. One of the parameters that the relationship analyzes is drainage density. Due to the obvious steep slope and strong rainfall, there is direct flooding; as a result, the flood potential is higher. The high number of streams in the basin is due to high drainage density. It indicates the intensity of erosion and wastewater in different regions of the basin, which is influenced by the basin's climate and lithology. Basins with high stream density are characterized by rapid floods that arise rapidly after rainfall. The ruggedness number represents the area's hydrological and topographic factors and is directly related to floods (Amiri, 2017). It is one of the factors used to assess the risk of flash floods (Patton and Baker, 1976). The circulatory ratio is controlled by the basin's lithology, stream frequency, and gradients of various orders. Excess water reaching the basin outflow is determined by the form of the basin, which is determined by the area's geology, slope, and land cover (Strahler, 1964).

The bifurcation ratio is one of the crucial parameters in basin hydrographs, and it is inversely connected to basin infiltration. High bifurcation ratios imply limited infiltration, which increases erosion and waste of the basin's natural resources (Sharifi Kia, 2017). The elongation ratio, which value varies between 1 for circular basins and 0 for elongated basins, assists in understanding the hydrological properties of the drainage basin. Its high values suggest the basin circle's form, a high peak discharge, and a significant flood potential (Singh, 1997). Due to the low number of rocky regions and their ease of access, the Sulqan and Keshar sub-basins have received more attention in terms of basin management activities. Rendan sub-basins have received less attention to basin control activities because of their rocky terrain. The majority of the flood-prone locations in this region are in the basin's northern portions, which have a high slope and elevation. In this regard, (Gholami, 2019) study of Flood stage and floodplain partitioning of Kan basin with the HEC-RAS model, which is consistent with the findings of this study, revealed that an increase in discharge in the river upstream caused an increase in water level and expansion in the floodplain surfaces. However, because to the lower discharge, the river has a greater lateral extension downstream of the river, and the flood regions are more effective than those upstream of the river. According to surveys, Spearman and Kendall statistical correlations improved the accuracy of the research results. The TOPSIS approach was the most effective ranking method. However, (Kumar, 2021) contradicts himself by prioritizing Bamni Banjar sub basins using morphometric criteria and comparing two approaches, AHP and TOPSIS. They stated that the AHP technique exceeded the other models in terms of prediction. The average elevation sub-basin influences the amount and type of rainfall, evapotranspiration, and land cover of the basin, hence influencing the runoff coefficient (Mahdavi, 2016). Flood-prone sub-basins are found at elevations ranging from 2500 – 2000 meters, which is consistent with Utlu's research 2021. The Aras River's prioritized basins in Turkey are based on linear, areal, and relief morphometry properties. In flood-prone basins, elevation, drainage density, stream frequency, surface runoff, initial stream order, and texture ratio values were comparatively high. Remote sensing and GIS techniques are the most effective instruments for basin development, management, and sub-basin priority for soil and water conservation. Basin characterization and geomorphometric study of drainage basins and stream networks both need quantitative investigation of drainage basins. (Farhan, 2016; Javed, 2011; Patel, 2013) which used GIS as an efficient tool to study the morphometry of the basin in research. In addition, (Obeidat,2021) used geospatial technology to assess morphometric data and select basins for flood risk management in Jordan. They concluded that morphometric analysis combined with GIS may be a useful tool for flood control. The relief aspect is essential for flood potential in all three methods (AHP, ANP, Shannon entropy), consistent with the research (Mahammad, 2022) evaluated Flood potential Gumani River basin utilizing morphometric characteristics prioritized them using the TOPSIS method. They computed linear, areal, and relief dimensions. They discovered that relief aspects are the most important, followed by areal and linear aspects. The flood routing results in the HEC-HMS model verified the multi-criteria decision-making procedures, according to the Natural Resources Organization. It has the greatest potential for floods. The findings of the HEC-HMS technique computed from natural resources are similar with the results of the weighting of the analytic network process and Shannon entropy methods. The Natural Resources Organization derived flood routing results in the HEC-HMS model based on the Equation of flow continuity and the link between flow and reserve, as shown in Table 5.

Table 5
Flow volume in HEC-HMS model

Sub-basin name	Drainage area (sq. Km)	Maximum flood flow (cubic meters per second)	Flood volume (million cubic meters)	Maximum flood flow (cubic meters per second)	Flood volume (million cubic meters)	Maximum flood flow (cubic meters per second)	Flood volume (million cubic meters)	Maximum flood flow(cubic meters per second)	Flood volume (million cubic meters)	Maximum flood flow (cubic meters per second)	Flood volume (million cubic meters)	Maxi flooc (cubi mete per seco
	Return period (y) 2	Return period (y) 2	Return period (y) 2	Return period (y) 5	Return period (y) 5	Return period (y) 10	Return period (y) 10	Return period (y) 25	Return period (y) 25	Return period (y) 50	Return period (y) 50	Retu peric (y) 100
Sulqan	13.6	0	0	0	0	0.2	0.08	0.4	0.24	0.9	0.56	1.3
Keshar	7.8	0	0	0	0	0.1	0.08	0.3	0.24	0.6	0.56	0.8
Talun	33.7	0	0.09	0.2	0.63	0.04	1.24	1.7	1.94	3.4	3.12	4.9
Imamzadeh Davood	10.9	0.2	0.09	0.8	0.63	1.6	1.16	2.7	1.74	5.3	2.56	7.5
Sangan	14.8	0	0	0	0	0.2	0.08	0.5	0.24	1	0.56	1.4
Kiga	6.5	0	0	0	0	0.1	0.08	2.7	1.74	0.5	0.56	0.7
Rendan	5.7	0	0	0	0	0.1	0.08	0.2	0.24	0.4	0.56	0.6
Doab	5	0.1	0.09	0.4	0.63	0.7	1.16	1.2	1.74	2.1	2.56	2.9

4 Conclusions

Floods are one of the hazards that displace millions of people each year. Prioritizing sub-basins and investigating the morphometric characteristics influencing flooding is undoubtedly one method of flood control.

In this study, Kan with Multi-criteria decision-making systems and morphometric parameters such as slope, elevation, curvature, ruggedness number, elongation ratio, circularity ratio, equivalent rectangle, drainage density, stream length, Infiltration factor, concentration-time, duration -intensity of rainfall, land use, land cover, geology, bifurcation ratio, length of overland flow were compensated to survey prioritizing sub-basins. The weights of morphometric parameters were calculated using network analysis, hierarchical analysis, and the Shannon entropy technique, as well as the TOPSIS, VIKOR, and COPRAS methods. AHP requires slop, elevation, curvature, and a ruggedness number. Slope and concentration-time (0.11) and duration- intensity of rainfall (0.12) are critical parameters in floods according to the ANP technique. The Shannon entropy approach identified stream length (0.15), elevation (0.11), and geology (0.11) as important flood variables. This ranking in the AHP method, according to the TOPSIS approach, shows the sub-basins of Imamzadeh Davood, Talun, and Doab. Furthermore, the ANP technique considers the sub-basins of Imamzadeh Davood, Talun, and Sangan, as well as the Shannon entropy of Imamzadeh Davood, Talun, and Rendan. It was ordered from first to third. The ANP technique VIKOR ranking revealed that the Talun and Sangan sub-basins in AHP Sangan, Taloun, and Doab were first. The Shannon entropy approach shows that the sub-basins of Talun, Imamzadeh Davood, and Sangan are more inundated than others. This ranking in the AHP technique indicated the sub-basins of Imamzadeh Davood, Talun, and Sulqan in the COPRAS approach. The sub-basins of Talun, Imamzadeh Davood, and Doab were ranked first to third in the ANP technique. In the Shannon entropy approach, Imamzadeh Davood, Talun, and Doab have the highest flood potential. The degree of correlation is calculated between three different ranking techniques. The TOPSIS approach has a strong correlation in the Spearman and Kendall correlation techniques. The TOPSIS approach was considered the best and most accurate technique for ranking, according to this finding. In all three techniques, Imamzadeh Davood and Talun are among the flood-prone sub-basins. Due to the obvious high values of these morphometric parameters (circularity ratio, equivalent rectangle), aerial parameters morphometric (drainage density), morpho photographic parameters (elevation, slope, curvature, ruggedness number), linear parametric morphometry (length of overland flow), geology (lithology), climate (duration-intensity of rainfall), and basin morphometry (time of concentration) that are directly related to flooding, these sub-basins known as the most critical sub-basins to floods.

To verify multi-criteria decision approaches based on flood results from the Natural Resources Organization's HEC-HMS model, which has the greatest potential for flooding. The HEC-HMS approach provides findings that are consistent with the analytic network process and the Shannon entropy weighting method.

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Figures

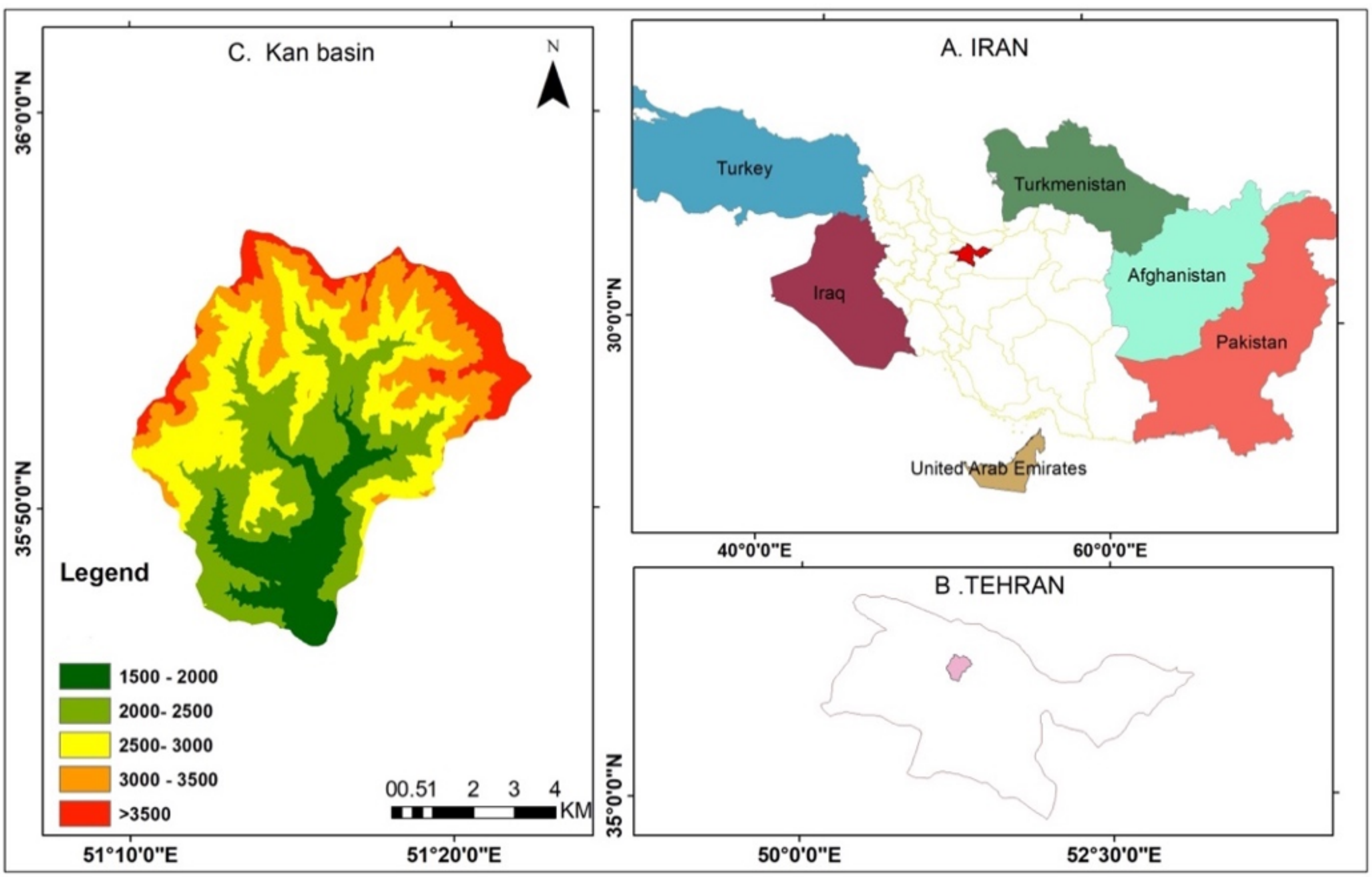

Figure 1

A: Location of the study area in Iran B: Location of the Kan basin in Tehran C: The

elevation map of the Kan basin

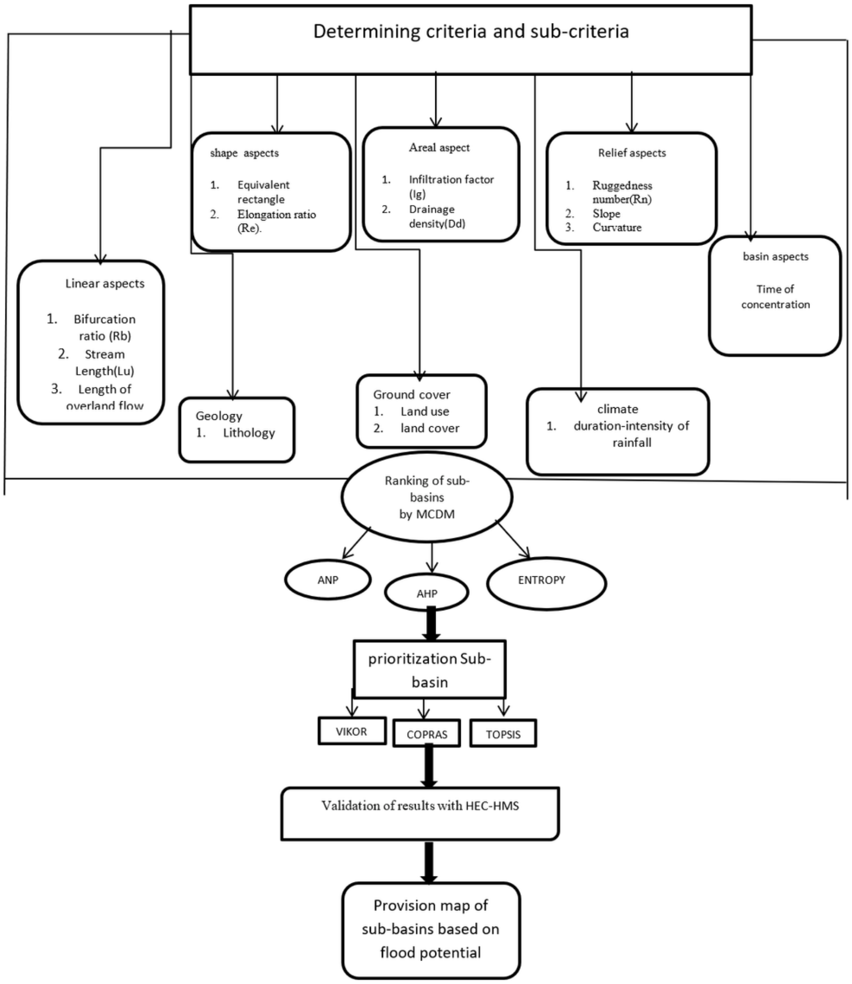

Figure 2

Flowchart of research method

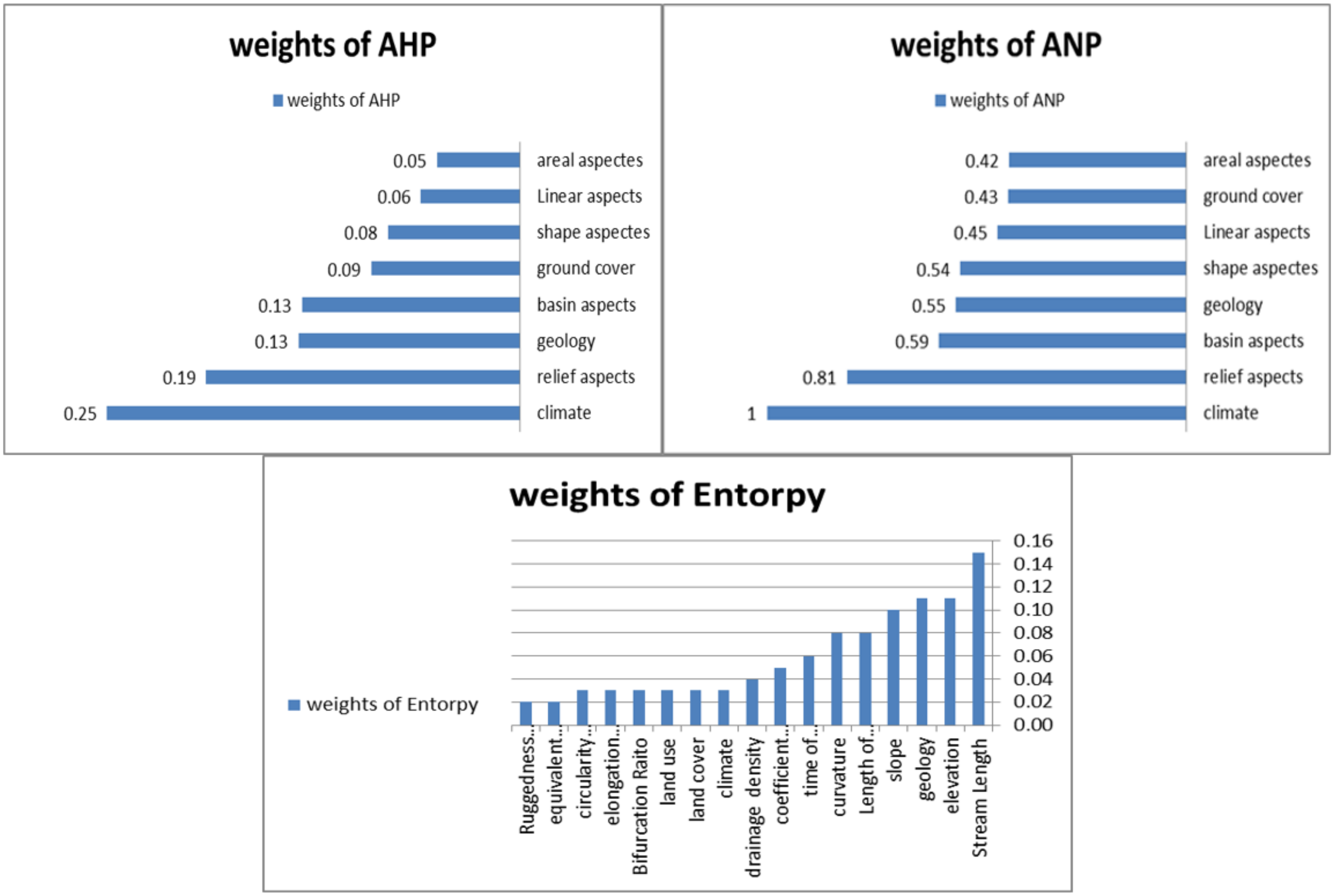

Figure 3

Weights of morphometric parameters in AHP, ANP, and Shannon entropy methods

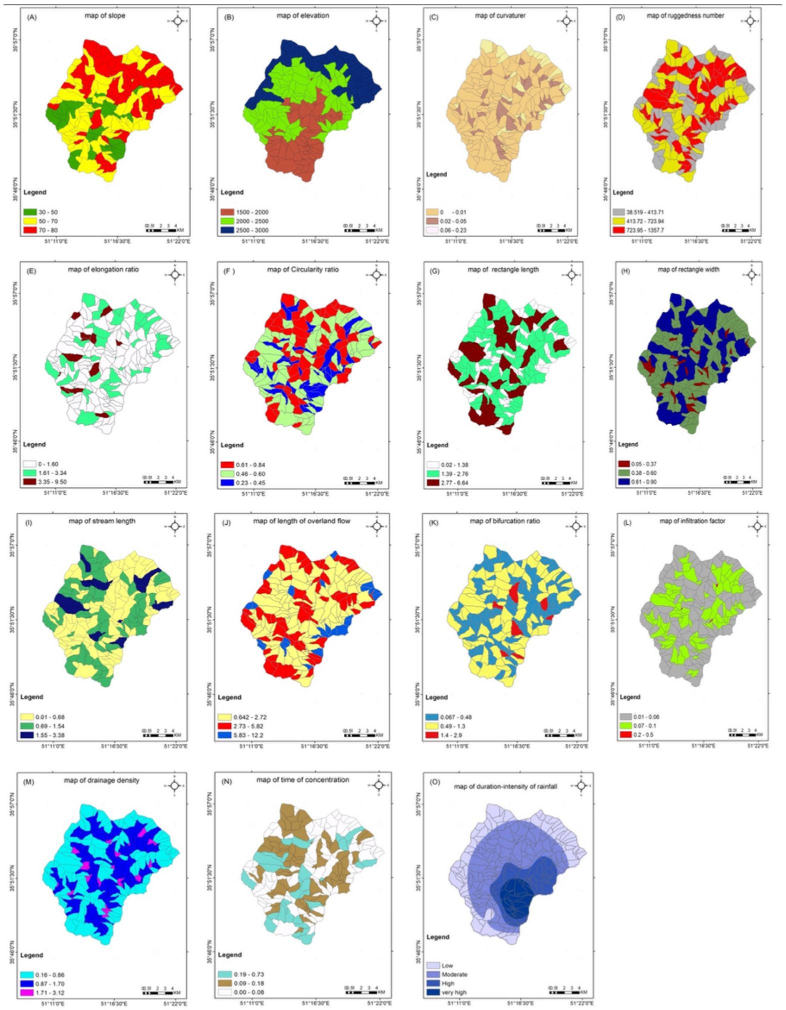

Figure 4

Map of normalized morphometric parameters sub-basins Kan:(a) slope, (b) elevation , (c) curvature, (d) ruggedness number, (e) elongation ratio,(f) Circularity ratio, (g) and (h) equivalent rectangle, (I) stream length, (j) length of overland flow , (k) bifurcation ratio, (L) infiltration factor, (M) drainage density, (N) time of concentration , and (o) duration-intensity of rainfall.

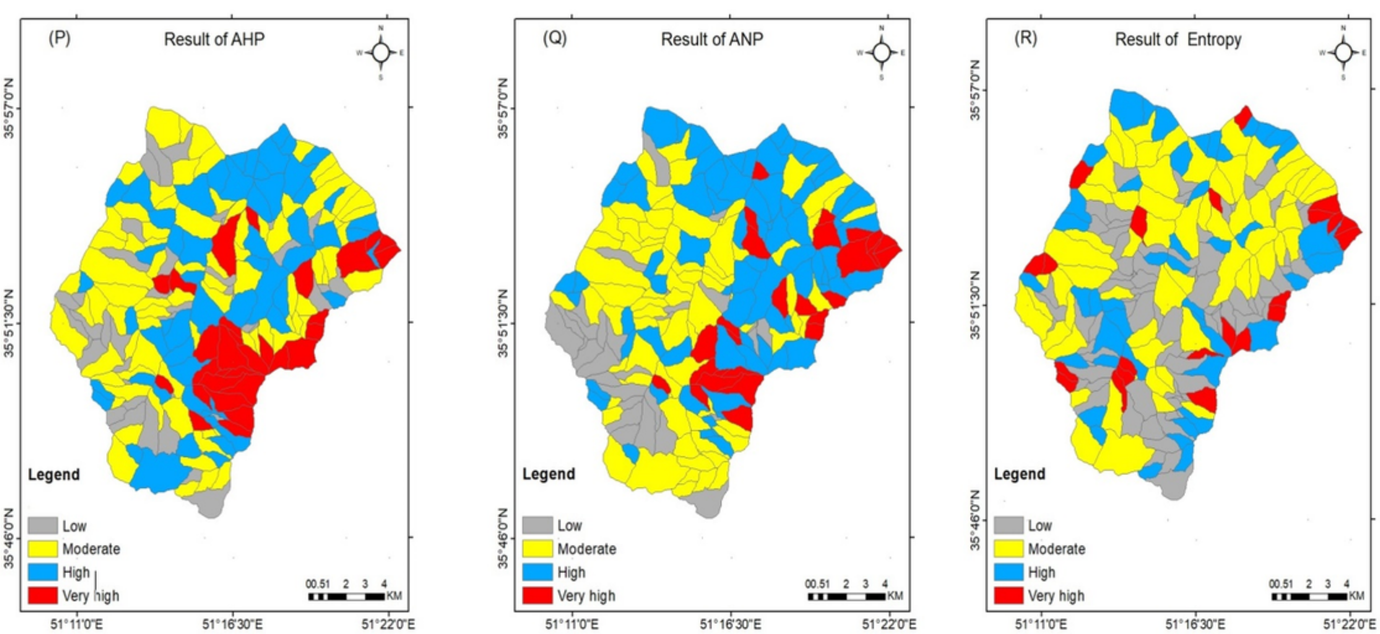

Figure 5

The output of morphometric parameters by AHP(P) and ANP(Q), and Shannon entropy (R)