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The Settlement Pattern of the Ancient Sites of the Southeastern Sub-Basins of the Caspian Sea, from a Hydro Geomorphological Perspective

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Abstract

The presence of water resources, particularly rivers, significantly influences site selection. Throughout history, settling near rivers has brought numerous advantages, but it has also posed certain risks. This study focuses on the sub-basins southeast of the Caspian Sea. Initially, we explore the connection between the layout of ancient settlements and the drainage networks. Additionally, we analyze the relationship between flood risk and the settlement patterns of these ancient sites by estimating the flooding risk based on linear, areal, and relief aspects. This research marks the first time such an analysis has been conducted. The findings underscore the importance of proximity to rivers in site selection, with areas close to rivers with lower stream orders being the most favorable for settlements. The study reveals a decrease in the frequency of sites near higher stream orders in relation to flooding risk. Conversely, there is an increase in the frequency and density of ancient sites near the first stream orders and at greater distances from the rivers, coinciding with an elevated flooding risk in the sub-basins. These results indicate that the inhabitants of the southeastern areas of the Caspian Sea sub-basins were cognizant of the flooding danger and factored it into their decision-making when selecting settlement sites.

Keywords: Geoarchaeology, Settlement Pattern, Hydro-geomorphology, Flood, Southeast Caspian Sea.

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1. Introduction

Settlement patterns, which may be defined as “the arrangement of population upon a landscape” are the most powerful class of data to explain sociocultural contexts of a society (Price 1978). The relationship between nature and civilization is mutual; just as humans with their technical measures have completely changed the landscapes in some areas, every culture and civilization is also dependent on nature (Kardavani 2007: 46). Settlement patterns can provide insights into political control through space (Renfrew and Bahn 2000). Above all, they reflect the characteristics of the natural environment. In general, for examining the natural factors affecting the establishment of settlements, attention should be paid to the following factors: geomorphology, climate, vegetation, and finally, water and soil resources (Saidi 2007: 43).

Topics related to the settlement pattern and landscape-oriented approaches are among the topics raised in contemporary archaeology (Renfrew 2003; Kowalewski 2008). After the expansion of landscape archaeology, attention paid to settlement pattern of ancient sites also increased (Neely & Wright 1994; Ur, 2002). During the decades from the 1950s to 1970s, the settlement patterns of ancient sites in the centers of the most important regions were investigated, including Mesopotamia, the highlands of Mexico, the banks of the Aegean Sea, and also the southwest of the United States of America (Billman & Feinman 1999). In recent years, investigating the impact of the natural environment on the settlement patterns of ancient sites is one of the topics that have been welcomed by interdisciplinary researchers. Studies also have been carried out in this interdisciplinary mode in Iran, which can be seen in the studies of Maghsoudi et al.'s studies in Tehran Plain (2013), Varamin Plain (2014 and 2015), near Jayedar Lake (2015), west of Dasht-e Lut (2017), Seymareh Dam Lake (2016), the southern slopes of Alborz Mountain and the ancient northern lakes of the Dasht-e Kavir (2019), by Mousavi Kouhpar et al. (2011), Sharifi et al. (2014), Heydari et al. (2021) and Ehdaei et al.'s studies in Mazandaran province (2022).

The foundational prerequisite for sustaining life is water, and it is commonly asserted that where water is absent, culture cannot thrive. Throughout human history, reliance on water has manifested in diverse ways, encompassing the provision of sustenance through fishing, the facilitation of cargo and human transportation, and the supply of potable water for both humans and domesticated animals. Subsequently, with the ascendancy of agriculture, additional dependencies emerged to foster conducive conditions for cultivation (Kardavani 2007: 46). In the era preceding the advent of agriculture, humans demonstrated a limited concern for the earth and its biological capacities. However, with the gradual assimilation of agricultural practices, considerations such as settlement patterns, geomorphology, and soil composition assumed heightened significance. Generally, human settlements materialized in regions featuring relatively propitious soil and water conditions. The Persian terms "abad" and "abadi," which gained currency during the Pahlavi period, denote a locale abundant in water and vegetation, reflecting the significance accorded to these factors (Mahdavi 2008: 8). Over the course of millennia, rivers have emerged as pivotal sources of water supply. A river is delineated as a natural watercourse that traverses distinct catchment basins. Rivers, however, transcend mere linear flows, exhibiting intricate branching structures, characterized by sub-branches, thus constituting an interlinked system or network. The expanse drained by a singular river system is termed the watershed or basin of that river. The conceptual demarcation that separates the banks of a watershed from contiguous watersheds is designated as the drainage divide. This demarcation can be graphically delineated by connecting the highest points between adjacent basins on a map (Jedari Eyvazi 2007: 129).

As previously mentioned, the presence of water sources, particularly rivers, constitutes a pivotal factor in the selection of sites. Due to the paramount significance of this subject, studies have been conducted, highlighting the role of rivers in shaping the patterns of ancient settlements. In one investigation, the alteration in settlement patterns along the banks of the Rena River in the southeast of Norway was scrutinized in relation to the modifications in the river's course and the climatic shifts during the Holocene era (Balbo et al. 2010). Another study employed an examination of sedimentary ancient layers to reconstruct environmental events along the Big Fork River, delving into human activity within the dynamic environment of that region (Hill et al. 2011). Likewise, an article focused on 276 archaeological sites on the south bank of the Xar Moron River in Northeast China, exploring changes in prehistoric cultures and settlement patterns vis-à-vis factors such as climate changes, landforms, and livelihood strategies (Jia et al. 2016). A distinct research endeavor examined ancient sites in the Rio Ica watershed, Peru, employing quantitative methods to underscore the role of rivers as one of the foremost influencing factors in human settlement. The researchers concluded that environmental changes spanning from a millennium before Christ until 1532 AD contributed to alterations in the settlement patterns of ancient sites (Haburaj et al. 2017). Another study delved into the settlement patterns of ancient sites located in the dynamic landscapes of the northwest of the Nile Delta, employing geo-archaeological research methods (Ginau et al. 2018). While domestic studies in this domain are currently limited, they are burgeoning. For instance, an article titled "The Shileh River and its Impact on Human Settlements in the Region" investigated the distinctive characteristics of this river and explored how these natural features influenced the formation of human settlements across different ancient periods (Mousavi Haji et al. 2010). Further examinations include a study of the Jajroud alluvial fan in Tehran plain and the Haji-Arab alluvial fan in Varamin plain, analyzing the role of alluvial fans in the distribution of prehistoric settlements. The findings indicated that as canals shifted, ancient settlements followed suit (Maghsoudi et al. 2012). Another article delved into the significant role of ancient canals in determining the location of the Chaltasian ancient site in Varamin plain (Maghsoudi et al. 2014). Utilizing the HEC RAS model, an investigation simulated the flooding of the Sivand River with a return period of ten thousand years and assessed its impact on the ancient sites of Persepolis and Nagshe Rostam (Nadderi et al. 2014). Lastly, a study examined the effect of natural landscapes on changes in settlement patterns and the cultural response to these changes, underscoring the importance of geoarchaeological investigations in Iran (Rashidian 2020).

Throughout history, the establishment of settlements along rivers, despite its myriad benefits, has also entailed inherent risks. Millennia ago, the human mind grappled with questions surrounding these dangers, propelling individuals to explore hazardous phenomena and gradually transforming this curiosity into science. However, in numerous instances, the inability to comprehend such perilous occurrences led to the formation of superstitions (Moghimi 2015:1). The early understanding of dangers in ancient times was imbued with mythological elements, fostering a constant sense of fear. According to myth, storms were deemed insurmountable—a deterministic notion that permeated the early human psyche. The fundamental inquiry arose: Are risks an inescapable destiny, or can they be endured? Over time, evolving from the foundational knowledge of mythology, humans realized the necessity of not merely fleeing from dangers but instead developing strategies to avoid harm and subsequently overcome it (Jahani et al. 2015). This imperative arises from the perennial human need to comprehend ways to safeguard both personal health and the surrounding environment (Moghimi 2015:1). From ancient times to the present, one hazard that has significantly impacted human populations across various dimensions, causing substantial damage, is flooding. Floods are characterized by a flow of water exceeding the average along a river. Inland river floods arise from precipitation or dam bursts. Rapid downslope water flow resulting from snowmelt, rain-on-snow, or diverse rainfall types combines with the baseflow from sub-surface water, augmenting runoff and leading to floods as discharge increases (Goudie 2004: 378). In this research endeavor, the focus lies on studying the sub-basins of the southeastern regions of the Caspian Sea. By examining their physiographic and hydrological characteristics, the aim is to ascertain the most suitable places for settlement establishment based on stream order and distance from the river. Initially, the investigation delves into the relationship between the settlement patterns of ancient sites and drainage networks. Subsequently, for the first time, the analysis extends to estimating the flooding risk of the sub-basins, considering linear, areal, and relief aspects. The research thus pioneers an exploration into the interplay between sub-basin flood risks and the settlement patterns of ancient sites.

2.Materials and Methods

The study area in this research comprises the southeastern sub-basins of the Caspian Sea. Using a 30m resolution DEM (SRTM), the study area was divided into four sub-basins: Neka-Tajan, Talar-Babolroud, Haraz, and Behshahr (Fig. 1). The Neka-Tajan sub-basin is located to the south of the Caspian Sea. Its geographical boundaries are limited by the Caspian Sea to the north, the Central Iranian Plateau to the south, the Gorgan River sub-basin to the east, and the Talar-Babolroud sub-basin to the west. Among the important rivers of this sub-basin are Neka Roud, Tajan Roud, Zam Roud, Sefid Roud, Darab Kola River, and Shirin Roud (Armed Forces Geographical Organization 2003: 237). The geographical boundaries of the Talar-Babolroud sub-basin are limited by the Caspian Sea to the north, to the Central Iranian Plateau to the south, the Neka-Tajan sub-basin to the east, and the Haraz Sub-basin to the west. The Talar, Babolroud, Siyahrud and Kelarud are the most important rivers in this sub-basin (Armed Forces Geographical Organization 2003: 225). The geographical boundaries of the Haraz sub-basin are limited by the Caspian Sea to the north, the Central Iranian Plateau to the south, the Talar Babolroud sub-basin to the east and the Chalus sub-basin to the west. Its important rivers include the Haraz, Nowrud, Lar and Kari (Armed Forces Geographical Organization 2003: 211). In addition, a number of documented ancient sites are located in the western part of the Gorgan Rud sub-basin. For this reason, using ArcGIS software and based on topographic features, the western part of this sub-basin was identified as a catchment and investigated as the Behshahr sub-basin. The Behshahr and Tirtash rivers can be mentioned among the independent rivers of this sub-basin that flow into Behshahr city (Armed Forces Geographical Organization 2003: 254).

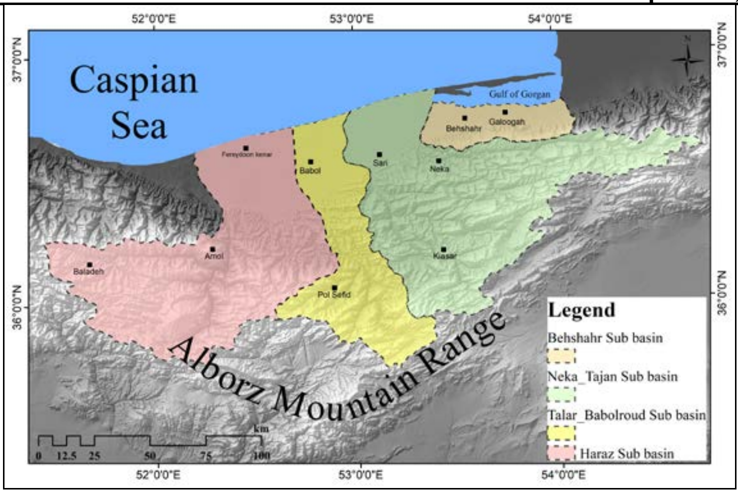

Fig 1: The Study Area

Following the identification of sub-basins, the distribution map of ancient sites was meticulously prepared using Arc GIS software, incorporating the geographical coordinates of these sites obtained by a group of archaeologists (Mousavi Koohpar 2008) as depicted in Figure 1. Subsequently, Arc GIS software was employed to generate maps illustrating stream order and distance from the river. The dispersion, abundance, and density of ancient sites were then scrutinized concerning factors such as the order of the nearest stream to these sites and the distance of settlements from rivers across different historical periods. To explore the potential for flooding in the study area, the effective factors within each sub-basin were systematically calculated. Given the research objective of analyzing the correlation between the location of ancient settlements and the occurrence of floods, emphasis was placed on factors that have exhibited relative constancy over several millennia. Among the parameters considered in these calculations, notable items (Table. 1) encompassed the linear aspects of sub-basins (perimeter (km), stream order, stream length (km), main stream length (km), bifurcation ratio, length of overland flow), areal aspects (area, stream frequency, drainage density, drainage texture, shape factor, form factor, compactness ratio, circularity ratio, constant of channel maintenance, time of concentration), and relief aspects (basin relief, mean height, longest stream height, ruggedness number) (Apaydin et al. 2006; Waikar et al. 2014; Aher et al. 2014; Sukristiyanti et al. 2018; Choudhari et al. 2018; Abdide et al. 2011; Rahmati et al. 2015; Choubin et al. 2018).To estimate the time of concentration of the sub-basins, several points should be considered. including the possibility of determining the variables for most of the sub-basins, the variety of parameters in the formula, and the popularity among specialists, designers, and hydrology books. In this research, Giandotti's equation was used to estimate the time of concentration since this equation is suitable for large mountainous sub-basins (Mehrabi 2005: 4&5).

In order to produce a map of flooding risk potential zones, after extracting information related to the study area, the layers were prepared using ArcGIS software and due to the Gaussian nature of some layers and their normalization, fuzzification was performed on all layers. Afterward, the flooding risk map was prepared. The studied sub-basins were classified into four categories with low, medium, high, and very high flooding risk. Then, the location of ancient sites in relation to the flooding risk in each sub-basins was analyzed.

Table 1: Methodology adopted for computations of morphological parameters

Morphometric parameters	**formula**	**Definition**	**References**
Stream frequency	$F_s = \frac{total\ number\ of\ stream}{asin\ area\ in\ square\ kilometers}$	———	Horton (1932)
drainage density	$D_d = \frac{total\ length\ of\ channels}{Basin\ area\ in\ square\ kilometers}$	———	Horton (1932)
Bifurcation ratio	$BR = (\frac{n1}{n2} + \frac{n2}{n3} + \cdots + \frac{ni-1}{ni})\frac{1}{i-1}$	n1, n2, … = The number of stream of order 1, 2, … i = the order of main stream	Horton (1932)
Texture ratio	$T_r = \frac{total\ number\ of\ stream}{Perimeter\ of\ basin}$	———	Horton (1945)
Length of overland flow	$L_O = \frac{1}{2D}$	Drainage density = D	Horton (1945)
Shape Factor	$S_f = \frac{L^2}{A}$	L = Basin length A = Area of basin	Horton (1945, 1932)
Form Factor	$F_f = \frac{A}{L^2}$	L = Basin length A = Area of basin	Horton (1945, 1932)
Compactness	$C = \frac{0.28P}{\sqrt{A}}$	A = Basin area in square kilometers P = Perimeter of basin (KM)	Horton (1945)
circularity ratio	$R_c = 4\pi\ \frac{A}{P^2}$	A = Basin area in square kilometers P = Perimeter of basin (KM)	Miller (1953) Strahler (1964)
Constant of channel maintenance	$C = \frac{Basin\ area}{Stream\ Length}$	———	Horton (1945) Schumm (1956)
Pilgrim McDermott Time of concentration	$T_C = 0.76A^{0.38}$	A = Basin area in square kilometers	Pilgrim McDermott (1989)
Giandotti Time of concentration	$T_C = \frac{(4\sqrt{A}+1.5L)}{0.8\sqrt{H_{mean}}}$	A = Basin area in square kilometers H = Mean elevation (m) L = main Stream Length (km)	Giandotti (1934)
Basin relief	$R = H - h$	H = The highest point of the basin h = The lowest point of the basin	Hadley and Schumm (1961)
Ruggedness number	$R_n = \frac{Basin\ relief}{drainage\ density}$	———	Strahler(1957)

In the next step, in order to increase the accuracy of the results, the four main sub-basins were divided into 31 smaller sub-basins to be recalculated. Based on this, the Haraz Sub-basin was divided into 10, the Neka-Tajan Sub-basins into 7, the Talar-Babolroud sub-basins into 6 and the Behshahr Sub-basins into 8 smaller sub-basins. Sub-basins No. 7 and 8 in the Behshahr, No. 4 in the Neka-Tajan and No. 2 in the Haraz sub-basin do not have ancient settlements, due to this, despite the calculation the flooding risk, they were removed from the analysis part of this research and the other sub-basins were taken into consideration. Since the area of the sub-basins are different and some of them are spread only in coastal areas, the Pilgrim-McDermatt equation was used to estimate their time of concentration. And after estimating the flooding risk in these sub-basins, the settlement pattern of the ancient sites in relation to the distance of the rivers, the nearest stream order to the sites, and also the flooding risk of the sub-basins were analyzed.

3. Discussion and results

Due to the enhancement in the accuracy of the obtained results and a better understanding of the effect of the characteristics of streams on the location of sites, in order to create the map of distance to the rivers (Fig. 2), ten intervals were considered and the frequency and the density of sites in each of these intervals were obtained (table. 2).

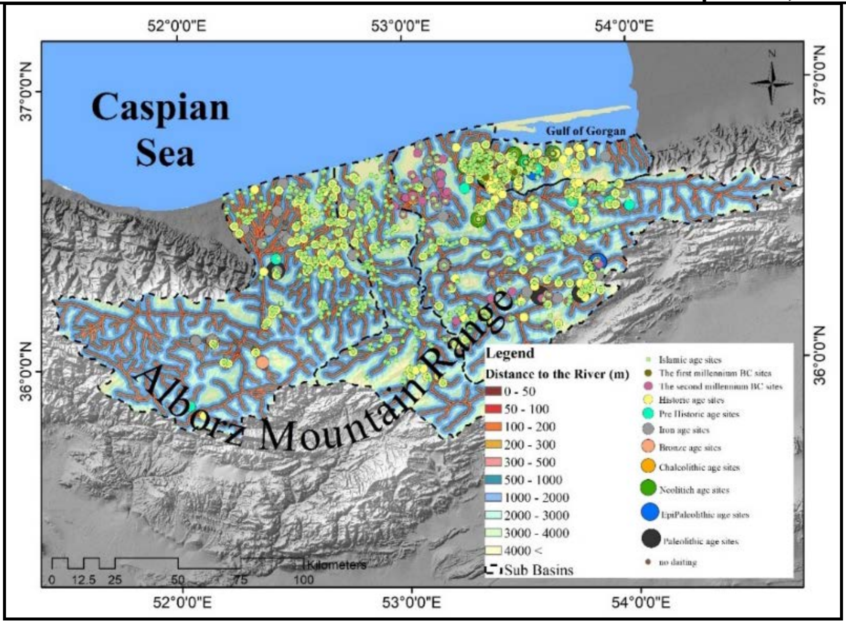

Fig 2: Dispersal of ancient sites at different distances from river

Table 2: Densityl of ancient sites at different distances from river

	Distance to the River (m)									
Age of Sites	**0 - 50**	**50 - 100**	**100 - 200**	**200 - 300**	**300 - 500**	**500 - 1000**	**1000 - 2000**	**2000 - 3000**	**3000 - 4000**	**4000 <**
Islamic age	45	41	67	65	93	180	265	112	25	6
the first millennium BC	2	4	3	1	9	11	17	14	5	1
the second millennium BC	2	3	1	7	5	4	4	8	2	2
Historic age	12	15	17	28	41	78	123	40	10	4
Prehistoric age	1	0	3	0	1	7	1	1	1	0
Iron age	4	3	7	9	8	25	23	10	2	0
Bronze age	0	0	1	2	0	2	1	2	0	0
Chalcolithic age	0	0	1	0	0	1	2	1	0	0
Neolithic age	0	0	1	1	2	1	4	7	1	0
Epipaleolithic age	0	0	0	0	1	2	0	1	0	0
Paleolithic age	0	0	1	0	0	2	0	1	0	0
No Dating	5	3	5	8	11	9	8	6	0	0
Total Number	71	69	107	121	171	322	449	203	45	13
Percent (%)	4.52	4.39	6.81	7.70	10.88	20.50	28.58	12.92	2.86	0.83
Area (km^2)	482.744	461.708	807.116	894.647	1579.282	3692.755	5496.358	2932.973	1158.891	606.139
Density	0.147	0.149	0.133	0.135	0.108	0.087	0.082	0.069	0.039	0.021

The results demonstrate the importance of proximity to the rivers in the site selection. As it is clear in figure 3, the density of ancient sites in the sub-basins, with increasing distance from the rivers, has a downward trend and reaches its minimum in the last interval. The densest interval is not the closest interval to the rivers (0-to-50 meters), but the 50-to-100 meter interval.

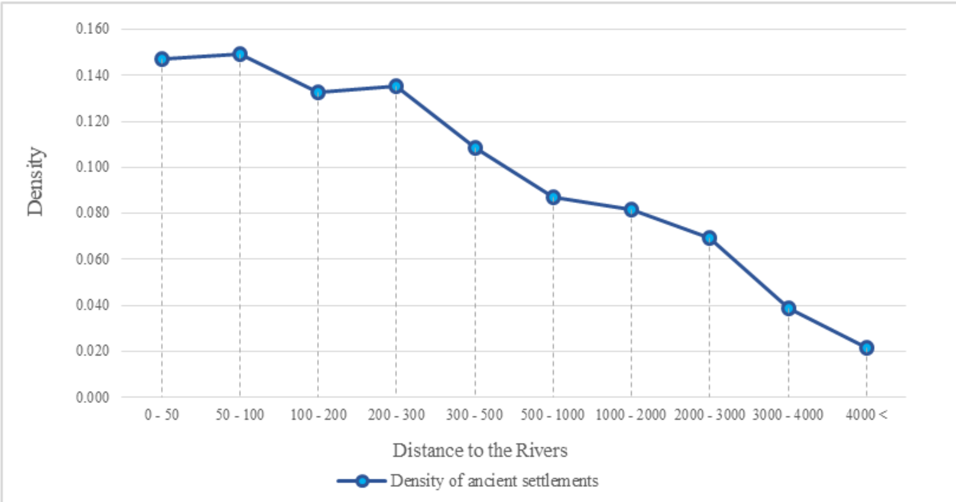

Fig 3: The Density of ancient sites at different distances from river

Examining the location of settlements in relation to the orders of the streams showed more than 56% of the settlements have been located near the first-order streams (table. 3). The frequency of settlements has a negative correlation with the increase of the stream orders so that as the order of the streams increases, the number of ancient sites located near them decreases, and only 0.76% of the sites are located in the vicinity of the 6th order (fig.5).

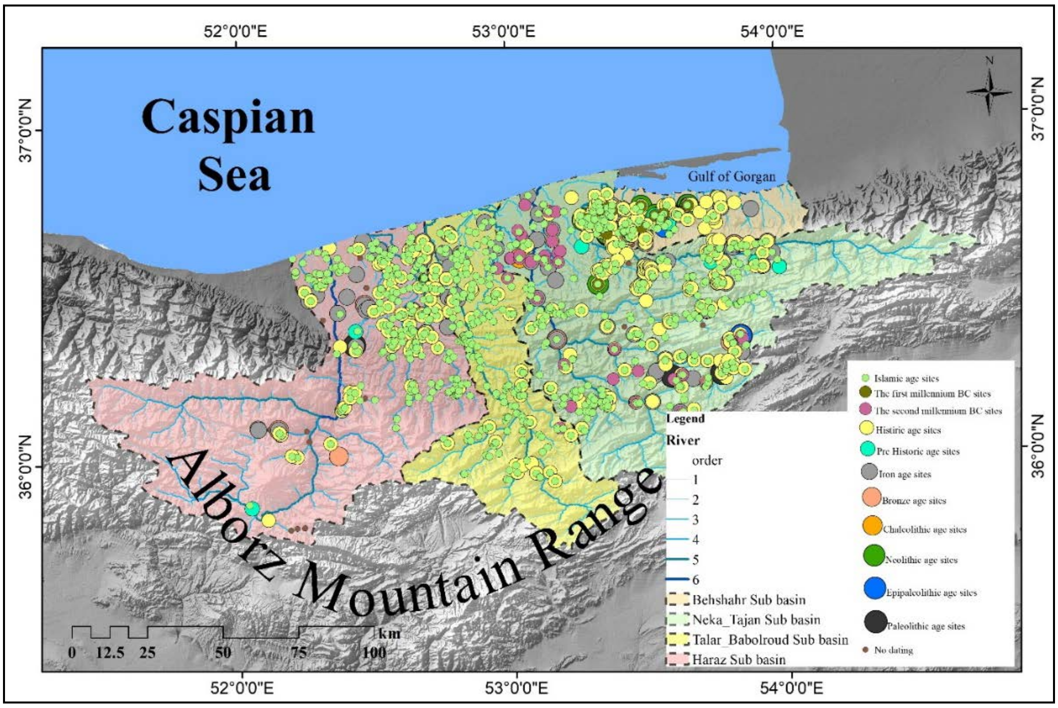

Fig 4: Distribution of ancient sites in relation to the stream orders

Table 3: Frequency of ancient sites in relation to the stream orders

	Strahler Stream Order					
Age of Sites	**1**	**2**	**3**	**4**	**5**	**6**
Islamic age	500	160	107	69	56	7
the first millennium BC	45	13	7	0	1	1
the second millennium BC	22	7	4	2	2	1
Historic age	206	77	39	32	13	1
Prehistoric age	8	6	1	0	0	0
Iron age	58	15	8	3	5	2
Bronze age	7	1	0	0	0	0
Chalcolithic age	5	0	0	0	0	0
Neolithic age	11	4	2	0	0	0
Epipaleolithic age	0	4	0	0	0	0
Paleolithic age	0	2	1	1	0	0
No Dating	27	12	8	5	3	0
Total Number	889	301	177	112	80	12
Percent (%)	56.59	19.16	11.27	7.13	5.09	0.76

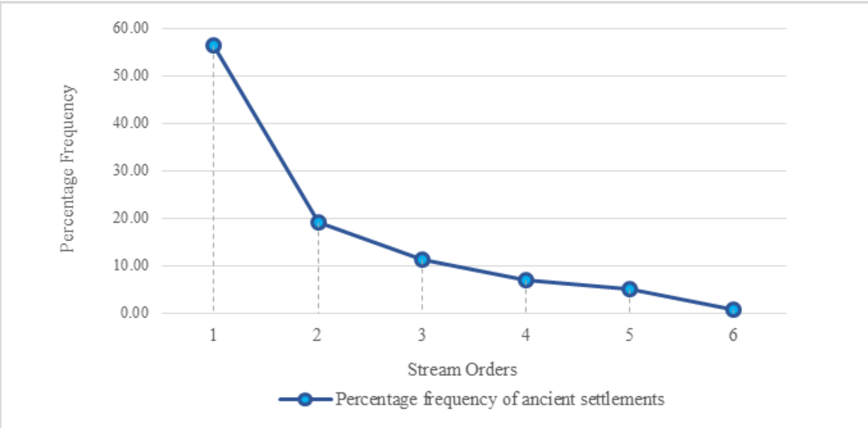

Fig 5: The percentage frequency of ancient sites in relation to the stream orders

3.1: Estimating the flooding risk

As stated earlier, morphometric analysis was performed through the measurement of linear, areal, and relief aspects of the basins (table. 4).

Table 4: Linear, Areal and Relief aspects of the morphometric analysis of the main sub-basins

	Sub basins			
Aspects	**Behshahr**	**Neka-Tajan**	**Talar-Babolroud**	**Haraz**
linear Aspects				
Primeter (km)	201.97	554.79	375.97	472.28
Stream Length (km)	773.847	3681.004	1851.354	3809.106
Main Stream Length (km)	24.36	157.44	165.10	190.44
Bifurcation ratio	3.42	4.06	5.17	4.10
Length of overland flow	0.699	0.940	0.892	0.889
Areal Aspects				
Area (square kilometer)	1082.04	6922.13	3302.70	6772.67
Stream frequency	0.256	0.211	0.226	0.207
Drainage density	0.715	0.532	0.561	0.562
Drainage texture	1.37	2.64	1.98	2.96
Shape Factor	0.55	3.58	8.25	5.36
Form factor	1.82	0.28	0.12	0.19
Compactness ratio	1.72	1.87	1.83	1.61
Circularity ratio	0.333	0.282	0.293	0.381
Constant of channel maintenance	1.398	1.880	1.784	1.778
Time of consentration	6.31	16.50	13.71	14.62
Relief aspects				
Basin relief (m)	2336	3834	3914	5638
Mean height (m)	257.83	1231.58	1183.02	1755.75
longest stream heigh (m)	174	2484	2785	3562
Ruggedness number	1.671	2.039	2.194	3.171

3.1.1: The linear aspects of the sub-basins

Basin Perimeter

The perimeter of a basin is the length of the drainage divide, which separates the watershed from the adjacent watersheds (Alizadeh 2008: 479). Like the area index, in the study area, the Neka-Tajan Sub-basin has the largest, and the Behshahr Sub-basin has the smallest perimeter.

Stream Order

Several stream-ordering functions have been devised since Horton’s original attempts (Horton 1932) but Strahler’s modification of the Horton system is the most widely used (Graf 1975). Strahler’s system has been followed because of its simplicity, where the smallest, unbranched fingertip streams are designated as 1st order, the confluence of two 1st order channels give a channels segments of 2nd order, two 2nd order streams join to form a segment of 3rd order and so on (fig.6). When two channels of different order join then the higher order is maintained (Waikar and Nilawar 2014). The highest order of streams in the Behshahr Sub-basin is 4, in the Talar-Babolroud Sub-basin is 5, and in the Neka-Tajan and Haraz Sub-basins is 6.

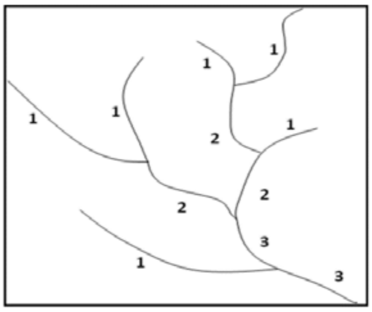

Fig 6: Strahler's Ordering Scheme (Kanti Ghose 2012)

Bifurcation Ratio

One of the most important effective factors in the Flood Hydrograph is the bifurcation ratio (Horton 1932). Theoretically, the bifurcation ratio is 2 and the natural drainage system has 3-5 in which geologic structures do not distort the drainage pattern (Strahler 1964). If the bifurcation ratio is less, it indicates plain terrain, permeable and soft bedrock where more water infiltrates, making for a better groundwater potential zone. The lower bifurcation ratios are also due to the presence of a large number of first and second-order streams in the sub-basins (Kumar et al. 2011). In addition, the smaller ratio indicates that the curve of changes in flood discharge related to time (hydrograph) will have a sharper peak compared to other basins (Alizadeh 2008: 472). The bifurcation ratio obtained from all the sub-basins varied between 3 and 5. The Behshahr sub-basin has the lowest and the Talar-Babolroud Sub-basin has the highest bifurcation ratio. The approximate lowness of this ratio in the study area could be the result of the existence of a large number of first and second-stream orders as well as the existence of extensive coastal and low-slope areas in the sub-basins. This ratio is almost the same in the Haraz and Neka-Tajan sub-basins, and the Talar-Babolroud sub-basin has a broader-shaped peak than the other sub-basins (table. 4).

Length of Overland Flow

It represents the length of the flow of water over the ground surface before it becomes concentrated in defined stream channels (Horton 1945). is one of the most important independent variables affecting the hydrologic and physiographic development of drainage basins. This factor is related inversely to the average slope of the channel (Waikar et al. 2014). The shorter length of overland flow indicates a quicker runoff process and vice versa (Aher et al. 2014). According to the results, the Behshahr Sub-basin has the quickest runoff process and the Neka-Tajan Sub-basin has the slowest runoff process (table. 4).

3.1.2: The areal aspects of the sub-basins

Basin Area

The most obvious feature of a basin is its area. The amount of runoff and flood discharge directly depends on the area of the basins (Alizade 2008: 478). Based on the obtained results, the Neka-Tajan Sub-basin is the largest, and Haraz, Talar-Babolroud, and finally the Behshahr Sub-basins are in the next rating (table. 4).

Stream Frequency

Generally, low classes of stream frequency mean high relief (Chandrashekar et al. 2015; Sukristiyanti et al. 2018). The highest stream frequency in the study area belongs to the Behshahr Sub-basin and on the contrary, the Haraz Sub-basin has the lowest one (table.

4). The reason is the existence of the least relief in the Behshahr versus the highest relief in the Haraz Sub-basin.

Drainage Density

Horton (1932) introduced drainage density as a pivotal indicator reflecting the linear scale of landform elements in eroded topography. This metric serves to gauge the proximity of channels, offering a quantitative measure of the average length of stream channels throughout an entire basin. Empirical observations from drainage density measurements across diverse geologic and climatic contexts have revealed that low drainage density is more likely to manifest in regions characterized by highly permeable subsoil material under dense vegetative cover and low relief. Conversely, high drainage density typically results from weak or impermeable subsurface material, sparse vegetation, and mountainous relief. The consequences of drainage density are observed in the drainage texture, with low drainage density yielding coarse texture and high drainage density yielding fine texture (Strahler 1964). Within the study area, the Behshahr Sub-basin stands out as the densest, while the Neka-Tajen Sub-basin exhibits the lowest density. The Haraz and Talar-Babolroud sub-basins display nearly identical drainage density. Upon initial examination of maps, there might be an inclination to perceive the drainage density of the Behshahr Sub-basin as weaker compared to other sub-basins. However, this apparent weakness is attributed to the significantly smaller area of the Behshahr Sub-basin in comparison to others, causing its density value to appear higher, as elucidated in Table 4.

Texture Ratio (Drainage Texture)

The texture ratio of any drainage basin depends on the climate, rainfall, rock types, relief, and stage of development (Horton 1945; Smith 1950). Horton identified permeability as one of the most important factors influencing the texture ratio of the basin. The less permeable the sub-basins, the more drainage lines, and the greater number of this index indicates the high probability of flooding in sub-basins. In the study area, the Behshahr Sub-basin has the coarsest and the Haraz Sub-basin has the finest drainage texture (Table 4).

Basin Shape

Shape is one of the most important topographic properties that can be measured with accuracy. This characteristic can affect the basin processes, particularly in that they may determine the potential efficiency of the basin, the network and also affects the streamflow hydrograph and peak flow rates (Gregory and Walling 1973; Linsley et al. 1988). In this study, the form and shape factors were used as measures of basin shape.

Form and Shape Factor

According to Horton (1932) the form factor indicates the flow intensity of a basin for a defined area and shape factor of a basin helps to analyze shape irregularity of the basin. These factors value range zero to one. The smaller the value of the form and shape factor, the more elongated shape of the basin (Yadav et al. 2014; Choudhari et al. 2018). In this study, all of the sub-basins can be characterized as elongated (Table 4).

Compactness Ratio

If the basin is perfectly circular, this ratio is equal to one. Otherwise, the value of this ratio will be greater than one, which indicates the deviation of its shape from the circle. This ratio is generally between 1.5 and 2.5 (Alizadeh 2008: 483; Harvey and Eash 1996). According to this equation, all studied sub-basins are elongated and the Neka-Tajan sub-basin is the most elongated one (Table 4).

Circularity Ratio

As the basin shape approaches a circle, the circulatory ratio approaches unity (Miller 1953; Chow 1964; Gregory and Walling 1973). The high value of the circularity ratio shows the late maturity stage (Waikar and Nilawar 2014) and the low value of that, indicates a young stage of topographic development (Choudhari et al. 2018). Moreover, the lower the circular ratio, the greater the elongation of the sub-basin. According to this equation, all the studied sub-basins are elongated and like the compression factor result, the Neka-Tajan sub-basin is considered the most elongated sub-basin. The low value of the circularity ratio of the sub-basins demonstrates the youth stage of the topography (Table 4).

Constant of Channel Maintenance

The number obtained from this equation indicates the degree of permeability and control of flow transfer to the outlet of the basin. The higher the value of C, the higher will be the permeability of the rocks of that watershed and vice versa. On the other hand, this constant decreases with the decrease in the basin area (Aher et al. 2014). Among the studied sub-basins, the lowest amount of this constant belongs to the Behshahr Sub-basin (Table. 4), which is due to the smaller area compared to other sub-basins.

Time of Concentration

The Time of concentration is the time required for a drop of rain to passes the longest path of the basin and reachs the discharge measurement station (Ziaei 1991). The results showed that the Behshahr Sub-basin has the lowest and the Neka-Tajan Sub-basin has the highest Time of concentration due to their areas (table. 4).

3.1.3: The relief aspects of the sub-basins

Basin Relief

Basin relief is the actual difference between the highest and lowest points of the drainage basin (Hadley and Schumm 1961). It is one of the morphometric parameters which helps to understand the denudational characteristics of the basin also it controls the stream gradient and influences the surface runoff and sediment also (Choudhari et al. 2018). Due to the presence of coastal and mountainous areas in all the studied sub-basins, there is a large height difference between the highest and lowest points, and in the meantime, the Haraz sub-basin has the highest and the Behshahr sub-basin has the lowest basin relief (Table 4).

Mean Height

As stated before, the elevation of the basins is one of the most important morphological parameters that affects the rate of erosion, sedimentation, and surface runoff because high and steep sub-basins have more potential energy than low-rise sub-basins. Among the studied sub-basins, Haraz, with an average elevation of nearly 1756 meters is the highest, and Behshahr with an average elevation of ca. 258 meters is the lowest sub-basin (table. 4).

Ruggedness Number

The greater the height difference and the higher the drainage density, the larger the roughness number (Strahler 1957). In the present sub-basins, the most ruggedness number belongs to the Haraz sub-basin and the least ruggedness number belongs to the Behshahr sub-basin (table. 4).

3.2: Preparation of Flooding Risk Map in the Sub-Basins

The results from the equations were transformed into layers in the ArcGIS software, and after fuzzification, the flooding risk map was prepared. The result showed that each of the four studied sub-basins has a different potential risk of flooding: The Behshahr sub-basin, with lower, the Talar-Babolrud sub-basin with moderate, the Neka-Tajan sub-basin with high and the Haraz sub-basin, with very high flooding risk (fig. 7).

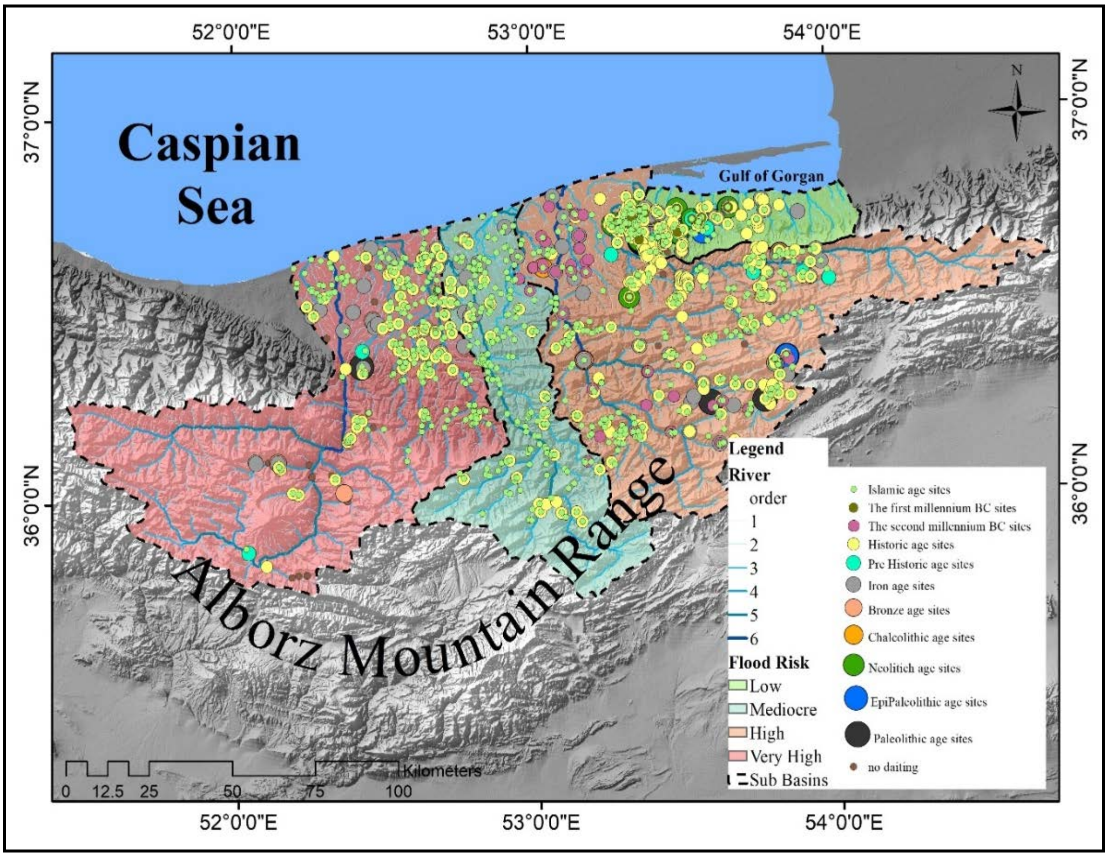

Fig 7: The flooding risk map in the sub-basins

The density of ancient sites at different distances from the rivers in relation to the flooding risk was also investigated. The results are notable and indicate the high relationship between these two factors. In the Behshahr sub-basin, where the flooding risk is lower than the other sub-basins, the density of ancient sites at a distance of 0 to 50 meters from rivers is highest, compared to other studied sub-basins. On the other hand, the Haraz sub-basin with the highest flooding risk has the least dense areas at 0 to 50 meters from waterways. The existence of this correlation is more obvious at a distance of 50 to 100 meters from rivers. The densest areas in this interval are in the Behshahr, then, the Talar-Babolroud, next, the Neka-Tajan sub-basins, and finally the Haraz sb-basin. And as the flooding risk of the sub-basins increases, the density of ancient sites in this interval has decreased (table. 5 & fig. 8).

Table 5: The density of ancient sites at different distances from the rivers in main sub-basins

	density of ancient sites, in relation to the distance from the river (m)									
Sub basins	0 - 50	50 - 100	100 - 200	200 - 300	300 - 500	500 - 1000	1000 - 2000	2000 - 3000	3000 - 4000	4000 <
Behshahr Sub Basin	0.244	0.326	0.444	0.020	0.149	0.178	0.224	0.155	0.059	0.032
Neka-Tajan Sub Bsin	0.225	0.143	0.096	0.178	0.125	0.101	0.085	0.073	0.063	0.026
Talar-Babol Roud Sub Basin	0.124	0.215	0.132	0.104	0.129	0.088	0.095	0.082	0.027	0.021
Haraz Sub Basin	0.083	0.111	0.125	0.126	0.082	0.062	0.052	0.038	0.003	0.000

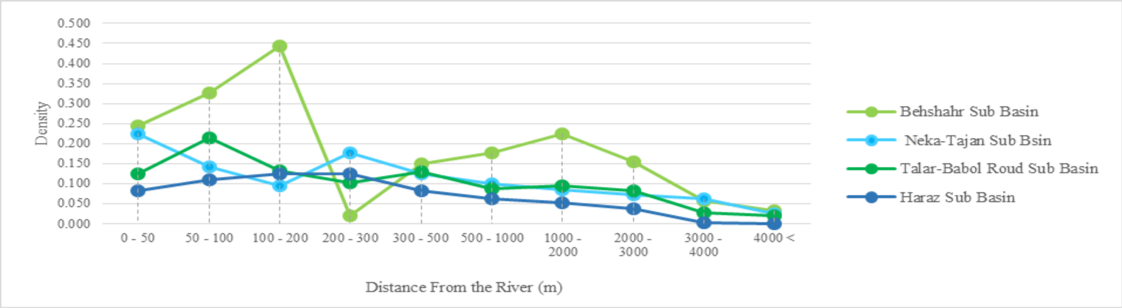

Fig 8: The density of ancient sites at different distances from the rivers in main sub-basins

In all of the sub-basins, more than half of the ancient settlements are located next to the first-order streams (Table. 6). What is more important, however, is the relationship between the order of streams adjacent to ancient sites and the flooding risk in the sub-basins, especially in relation to the location and frequency of settlements adjacent to roaring rivers and higher stream orders. The Behshahr sub-basin, which has a lower flooding risk, does not have fifth and sixth stream orders. In the other three sub-basins, the frequency of the sites located next to fifth-order streams is interesting, so the highest frequency belongs to the Talar-Babolroud, and as mentioned above, this sub-basin has less flooding risk than the other two sub-basins. The Talar-Babolroud sub-basin does not have the sixth order of stream, but the percentage of ancient sites adjacent to the sixth stream order has decreased sharply in the other two sub-basins. However, still, with a small difference, this frequency is higher in the Neka-Tajan sub-basin, which has a lower flooding risk than the Haraz Sub-basin (fig. 9).

Table 6: The Percentage frequency of ancient sites in relation to the stream orders in main sub-basins

	Percentage Frequency of ancient sites, in relation to the stream order (Strahler)					
Sub basins	**1**	**2**	**3**	**4**	**5**	**6**
Behshahr Sub Basin	64.02	23.81	9.52	2.65	0	0
Neka-Tajan Sub Bsin	57.42	20.76	11.21	6.36	3.03	1.21
Talar-Babol Roud Sub Basin	56.06	13.84	14.53	4.50	11.07	0
Haraz Sub Basin	52.42	18.24	9.93	12.01	6.47	0.92

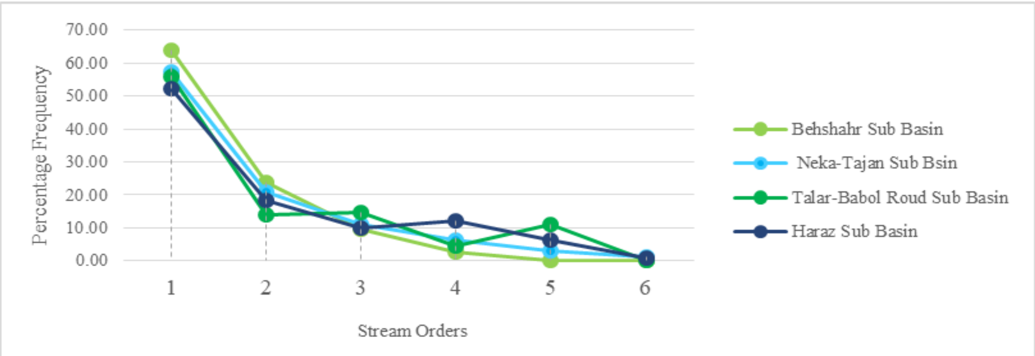

Fig 9: The Percentage frequency of ancient sites in relation to the stream orders in main sub-basins

3.3: Estimating the Flood Risk in the Smaller Sub-Basins

All the linear, areal, and relief aspects have been calculated (Tables 7, 8, 9, and 10) and after estimating the flooding risk, the settlement pattern of the ancient sites in relation to the distance from the rivers, the nearest order of stream as well as the flooding risk of all the smaller sub-basins was analyzed. After calculating the above aspects and creating the layer and finally, fuzzification of them, the flooding risk map of the study area was prepared (Fig. 10).

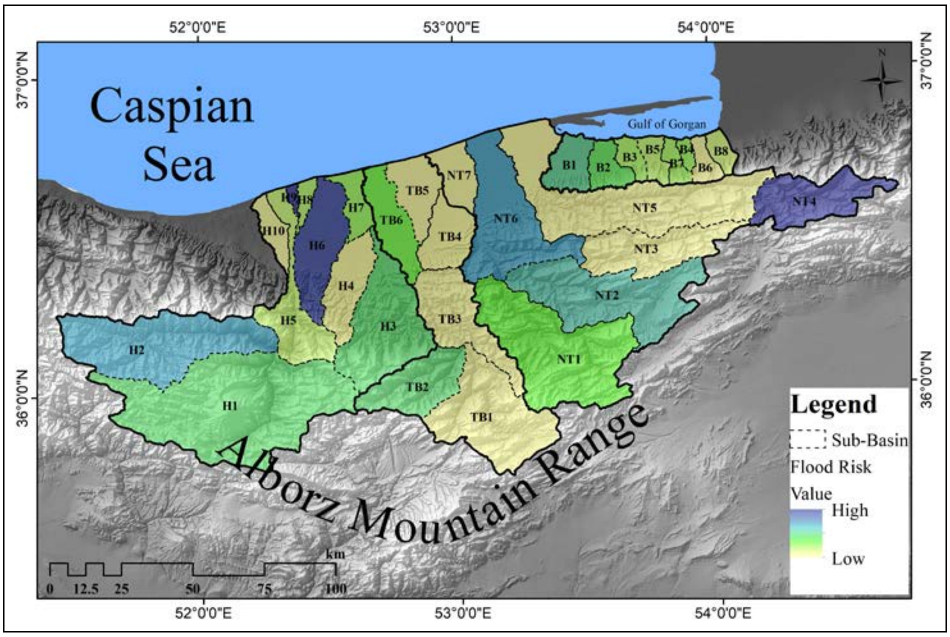

Fig 10: The flooding risk map in the smaller sub-basins

In the Haraz sub-basin (which is shown in the map with the abbreviation H), the highest flooding risk is for sub-basins number six and nine (Fig. 10). In H6, which has a larger area than H9, the least dense interval is between 0 and 50 meters, and the densest interval is 200 to 300 meters from the rivers. On the other hand, the majority of the ancient settlements of H6 (more than 36%) have been located near the first-order of streams, and only 1.5% of them are located near the streams of the sixth-order (Fig. 11). Since H9 is very small and expanded in the coastal area, and because the change of streams in these areas occurs very quickly and the subject under discussion is the relationship between ancient settlements and hydro geomorphological features, for the above reasons, the investigation discussed in H9 is not very scientific and defensible.

Table 7: Linear, Areal and Relief aspects of the morphometric analysis of the Haraz Sub-basin

	Haraz Sub basin									
Aspects	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**	**H8**	**H9**	**H10**
linear Aspects										
Primeter (km)	226.718	213.198	106.871	126.493	173.614	357.408	266.320	234.494	152.078	152.517
Stream Length (km)	516.422	330.436	263.946	248.616	300.546	1197.117	610.285	505.367	291.563	256.496
Main Stream Length (km)	77.314	69.444	45.439	39.144	53.485	113.075	93.787	71.849	52.480	49.315
Bifurcation ratio	3.931	4	3.150	3.939	3.675	4.435	4.175	3.590	4.230	4.986
Length of overland flow	1.023	0.980	0.692	0.702	0.688	0.956	1.055	0.958	0.732	1.092
Areal Aspects										
Area (square kilometer)	1056.362	647.488	365.399	349.089	413.506	2289.917	1287.478	968.105	426.992	560.170
Stream frequency	0.228	0.202	0.227	0.232	0.213	0.222	0.228	0.187	0.222	0.220
Drainage density	0.489	0.510	0.722	0.712	0.727	0.523	0.474	0.522	0.683	0.458
Drainage texture	1.063	0.614	0.777	0.640	0.507	1.424	1.104	0.772	0.625	0.806
Shape Factor	5.659	7.448	5.651	4.389	6.918	5.584	6.832	5.332	6.450	4.341
Form factor	0.177	0.134	0.177	0.228	0.145	0.179	0.146	0.188	0.155	0.230
Compactness ratio	1.953	2.346	1.565	1.896	2.391	2.091	2.078	2.110	2.061	1.804
Circularity ratio	0.258	0.179	0.402	0.274	0.172	0.225	0.228	0.221	0.232	0.302
Constant of channel maintenance	2.046	1.959	1.384	1.404	1.376	1.913	2.110	1.916	1.464	2.184
Time of consentration	3.306	3.754	5.397	12.341	10.065	4.460	4.420	3.187	3.396	2.381
Relief aspects										
Basin relief (m)	3227	3089	604	85	355	4876	3613	3715	2319	3493
Mean height (m)	2099.500	1633.780	278	1.525	137.508	3154.040	2520.166	1836.520	1131.723	2227.759
longest stream heigh (m)	2290	2012	267	59	167	2798	2787	3027	1393	2772
Ruggedness number	6.601	6.053	0.836	0.119	0.488	9.327	7.622	7.117	3.396	7.628

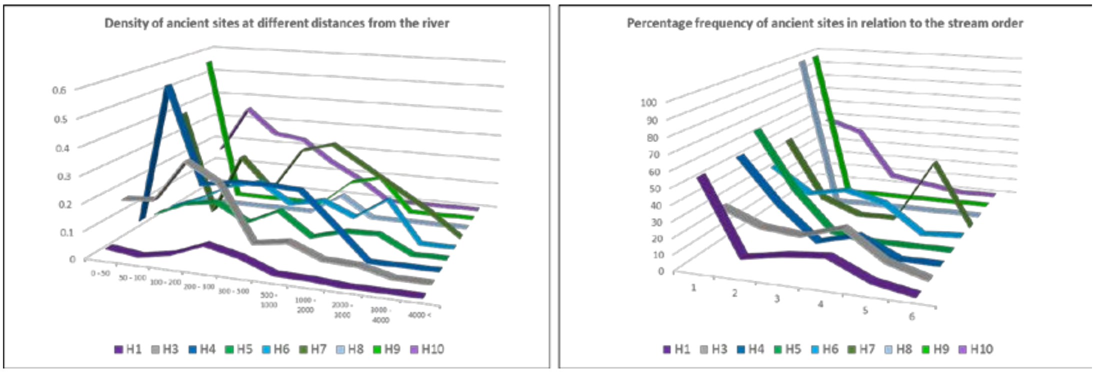

Fig 11: The Haraz Sub-basin, density of ancient sites at different distances from the rivers (right) and Percentage frequency of ancient sites in relation to the stream orders (left) in smaller sub-basins

Among the sub-basins of the Neka-Tajan (shown on the map with the abbreviation NT), NT6 has the highest flooding potential, and NT2 and NT1 are in the next ranks (Fig. 10). In NT6, the densest interval is the area with a distance of 200-to-300 meters from the rivers. Also, in the distance of 0-to-50 meters, after NT5, this sub-basin has the lowest density, and in the distance of 50-to-100 meters, it has the lowest density among all Neka-Tajan sub-basins. The relationship between the frequency percentage of ancient sites and proximity to the rivers is also noteworthy. In NT6, having the highest flooding risk, nearly 70% of the ancient sites are located near the first-order streams, which compared to the other sub-basins (with less flooding risk), this is the highest amount of ancient sites located near the first-order of streams (fig. 12).

Table 8: Linear, Areal and Relief aspects of the morphometric analysis of the Neka-Tajan sub-basin

	Neka-Tajan Sub basin						
Aspects	**NT1**	**NT2**	**NT3**	**NT4**	**NT5**	**NT6**	**NT7**
linear Aspects							
Primeter (km)	302.952	315.336	221.572	200.423	424.286	278.912	111.130
Stream Length (km)	714.173	631.451	307.304	322.440	892.174	622.688	182.943
Main Stream Length (km)	87.413	94.529	65.442	52.809	149.215	93.150	33.831
Bifurcation ratio	3.997	3.975	4.884	3.813	4.052	4.124	2.788
Length of overland flow	1.040	0.949	1.086	0.947	0.909	0.842	0.741
Areal Aspects							
Area (square kilometer)	1485.494	1198.535	667.682	610.840	1621.616	1048.916	271.191
Stream frequency	0.207	0.213	0.181	0.226	0.201	0.205	0.258
Drainage density	0.481	0.527	0.460	0.528	0.550	0.594	0.675
Drainage texture	1.017	0.809	0.546	0.689	0.768	0.771	0.630
Shape Factor	5.144	7.456	6.414	4.566	13.730	8.272	4.221
Form factor	0.194	0.134	0.156	0.219	0.073	0.121	0.237
Compactness ratio	2.201	2.550	2.401	2.271	2.950	2.411	1.890
Circularity ratio	0.203	0.151	0.171	0.191	0.113	0.169	0.276
Constant of channel maintenance	2.080	1.898	2.173	1.894	1.818	1.684	1.482
Time of consentration	4.385	4.661	4.021	3.341	6.633	5.837	10.663
Relief aspects							
Basin relief (m)	3488	2967	2599	2304	2652	1464	97
Mean height (m)	1966.503	1689.141	1880.633	2653.055	1285.498	687.002	-7.386
longest stream heigh (m)	2012	2205	1764	1627	1937	1148	57
Ruggedness number	7.255	5.632	5.647	4.365	4.820	2.466	0.144

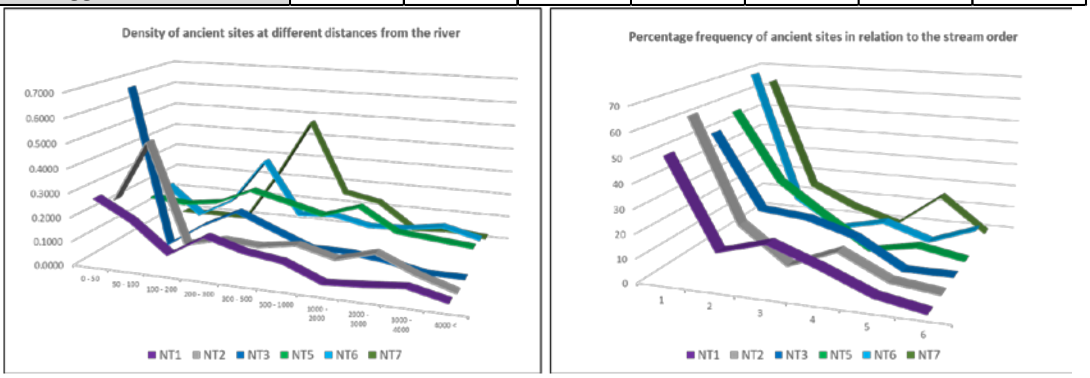

Figure 12: The Neka-Tajan Sub-basin, density of ancient sites at different distances from the rivers (right) and Percentage frequency of ancient sites in relation to the stream orders (left) in smaller sub-basins

The flooding risk estimation using linear, aerial, and relief aspects revealed that the Talar-Babolroud sub-basins (shown on the map with the abbreviation TB) have low or medium flooding risk. TB2 and TB6 have more flooding risk compared to others and the densest areas in these two sub-basins are located in distance of 200-to-300 and 1000-to-2000 meters from the rivers. While the densest areas in most sub-basins are located at a distance of 50-to-100 meters from the river, which is justified due to the low risk of flooding in the sub-basins (fig. 13).

Table 9: Linear, Areal and Relief aspects of the morphometric analysis of the Talar-Babolroud sub-basin

	Talar-Babolroud Sub basin					
Aspects	**TB1**	**TB2**	**TB3**	**TB4**	**TB5**	**TB6**
linear Aspects						
Primeter (km)	248.213	187.640	122.057	73.580	45.737	103.915
Stream Length (km)	301.916	472.290	134.026	55.049	22.777	142.129
Main Stream Length (km)	72.427	64.638	44.755	23.089	11.893	38.797
Bifurcation ratio	3.571	3.289	5.786	4.25	2.5	2.881
Length of overland flow	0.916	0.635	0.722	0.700	0.707	0.591
Areal Aspects						
Area (square kilometer)	552.946	599.787	193.588	77.074	32.208	167.910
Stream frequency	0.194	0.195	0.207	0.208	0.279	0.191
Drainage density	0.546	0.787	0.692	0.714	0.707	0.846
Drainage texture	0.431	0.624	0.328	0.217	0.197	0.308
Shape Factor	9.487	6.966	10.347	6.917	4.392	8.964
Form factor	0.105	0.144	0.097	0.145	0.228	0.112
Compactness ratio	2.956	2.145	2.456	2.347	2.257	2.245
Circularity ratio	0.113	0.214	0.163	0.179	0.193	0.195
Constant of channel maintenance	1.831	1.270	1.444	1.400	1.414	1.181
Time of consentration	3.943	4.480	15.610	8.387	5.834	5.763
Relief aspects						
Basin relief (m)	3291	1750	58	81	38	497
Mean height (m)	1608.5	834.15	-13.25	2.5	-17	215
longest stream heigh (m)	1965	1217	31	48	26	248
Ruggedness number	6.027	2.222	0.084	0.113	0.054	0.587

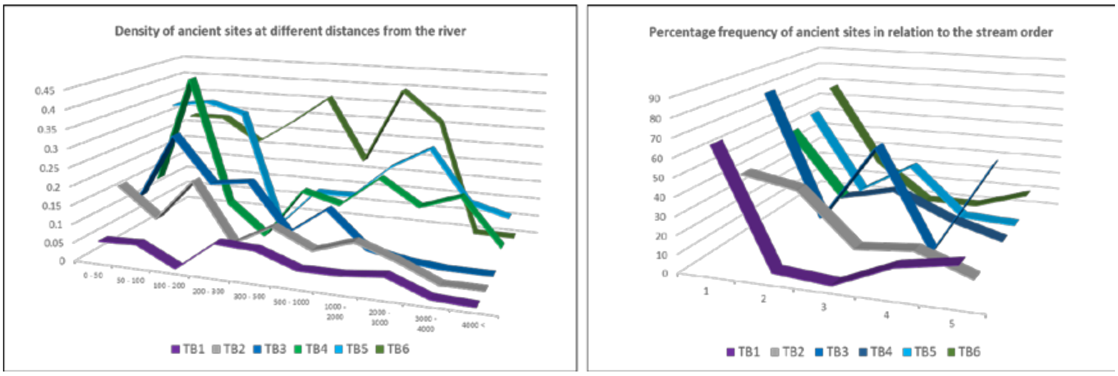

Fig 13: The Talar-Babolroud Sub-basin, density of ancient sites at different distances from the rivers (right) and Percentage frequency of ancient sites in relation to the stream orders (left) in smaller sub-basins

The results of flood zoning in the sub-basins of Behshahr (shown in the map with the abbreviation B), showed that the smaller area of the sub-basins has increased the flooding risk. Since the flood hydrograph reaches its peak faster in smaller basins than in large basins. B1 is more prone to flooding than other sub-basins, and on the other hand, the frequency of settlements close to different orders of streams in relation to the flood risk is very considerable. Because the majority of settlements (nearly 69%) in B1 are located near streams of the first order, this number is the highest among all the Behshahr Sub-basins. As you can see in Fig. 14, the percentage of settlements near to

1st order of streams in B5 and B6 is 100%, but this is due to the existence of only one ancient site in these two sub-basins.

Table 1: Linear, Areal and Relief aspects of the morphometric analysis of the Behshahr Sub-basin

	Behshahr Sub basin							
Aspects	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**
linear Aspects								
Primeter (km)	114.068	98.755	70.429	73.539	67.984	44.597	70.949	53.026
Stream Length (km)	196.098	145.523	71.151	89.620	67.434	37.056	74.018	82.796
Main Stream Length (km)	24.361	21.190	16.557	25.553	17.350	11.221	18.678	16.346
Bifurcation ratio	2.995	3.917	3.55	2.917	2.847	5.5	2.921	3.5
Length of overland flow	0.682	0.675	0.788	0.717	0.742	0.702	0.801	0.643
Areal Aspects								
Area (square kilometer)	267.498	196.580	112.079	128.537	100.111	52.029	118.637	106.488
Stream frequency	0.217	0.209	0.268	0.257	0.350	0.250	0.295	0.301
Drainage density	0.733	0.740	0.635	0.697	0.674	0.712	0.624	0.778
Drainage texture	0.508	0.415	0.426	0.449	0.515	0.292	0.493	0.603
Shape Factor	2.219	2.284	2.446	5.080	3.007	2.420	2.941	2.509
Form factor	0.451	0.438	0.409	0.197	0.333	0.413	0.340	0.399
Compactness ratio	1.953	1.972	1.863	1.816	1.902	1.731	1.824	1.439
Circularity ratio	0.258	0.253	0.284	0.299	0.272	0.329	0.296	0.476
Constant of channel maintenance	1.364	1.351	1.575	1.434	1.485	1.404	1.603	1.286
Time of consentration	3.360	1.636	1.685	1.774	1.444	1.895	1.281	1.108
Relief aspects								
Basin relief (m)	824	1375	1485	1642	1768	1037	2162	2336
Mean height (m)	379	641.45	691.48	780.04	853.01	481.83	1044.70	1129.63
longest stream heigh (m)	329	931	575	898	934	225	1302	1487
Ruggedness number	1.124	1.857	2.339	2.355	2.625	1.456	3.465	3.004

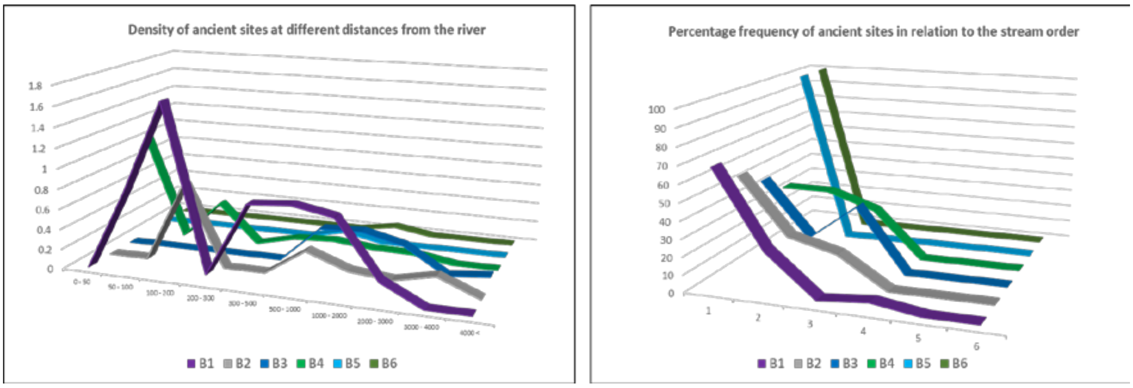

Fig 14: The Behshahr Sub-basin, density of ancient sites at different distances from the rivers (right) and Percentage frequency of ancient sites in relation to the stream orders (left) in smaller sub-basins

4.Conclusion

In contemporary archaeology, the exploration of settlement patterns and landscape-oriented approaches has become a prominent focus, as noted by Renfrew (2003) and Kowalewski (2008). A recent trend in interdisciplinary research involves investigating the influence of the natural environment on the settlement patterns of ancient sites. The settlement pattern is considered a direct reflection of natural environment characteristics, with water sources, particularly rivers, emerging as crucial determining factors (Saidi 2007: 43). Despite the numerous benefits of establishing settlements along rivers, it is essential to acknowledge the associated risks spanning from ancient times to the present.

This research delves into the southeastern areas of the Caspian Sea, specifically studying sub-basins and analyzing their physiographic and hydrological attributes. The primary objective is to discern, from an ancient human perspective, the most suitable locations for site selection based on stream order and distance from rivers. Initially, the investigation explores the correlation between settlement patterns of ancient sites and drainage networks. Subsequently, the research assesses the flooding risk of sub-basins by examining various linear, areal, and relief aspects. Notably, this study pioneers the analysis of the relationship between sub-basin flood risk and the settlement patterns of ancient sites.

The findings underscore the significance of proximity to rivers in site selection, revealing a notable optimal distance of 50 to 100 meters from rivers. This range provides relative immunity against river overflow and floods. Moreover, a noteworthy observation is that ancient sites predominantly cluster around first-order streams with seasonal water flow, as opposed to permanent rivers. The research scrutinizes the location of ancient sites at different intervals from rivers with varying stream orders concerning flood risk. For instance, in the Behshahr Sub-basin with lower flooding risk, ancient sites are densely concentrated at 0 to 50 meters from rivers, whereas the Haraz Sub-basin, with the highest flooding risk, exhibits the least density in this proximity. Additionally, an inverse relationship is noted, with higher flooding risk corresponding to a decrease in the concentration of ancient sites near higher-order streams.

To bolster result accuracy, the main sub-basins were further divided into 31 smaller sub-basins, confirming that the relationship between settlement patterns and flooding risk aligns with the outcomes from the larger sub-basins. In summary, the research concludes that areas close to lower-order rivers are most ideal for settlements. The decrease in settlement frequency near higher stream orders, coupled with increased frequency and density near first-order streams and at greater distances from rivers, reflects the ancient inhabitants' understanding of river flooding dangers. Notably, results obtained in mountainous sub-basins are deemed more authentic than those in coastal areas due to challenges in determining precise distances caused by changes in stream beds and high sedimentation rates. Specific intervals used in estimating this factor help mitigate errors in coastal and low-slope areas.

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چکیده

وجود منابع آب خصوصاً رودخانه‌ها، از مهم‌ترین عوامل در مکان گزینی محوطه‌های باستانی است اما از گذشته تاکنون، ایجاد سکونتگاه در کنار رودخانه‌ها، علیرغم مواهب بی‌شمار، دارای مخاطراتی نیز بوده است. در این پژوهش سعی شده است تا با مطالعه زیر حوضه‌های آبخیز نواحی جنوب‌شرق دریای خزر، در ابتدا رابطه بین الگوی استقرار سکونتگاه‌های باستانی و شبکه‌های زهکشی، بررسی‌شده و از طرف دیگر، با برآورد پتانسیل سیل‌خیزی زیر حوضه‌ها بر اساس ویژگی‌های خطی، سطحی و ارتفاعی، برای اولین بار، رابطه بین میزان سیل‌خیزی زیر حوضه‌ها و الگوی استقرار محوطه‌های باستانی، مورد تحلیل قرار گیرد. نتایج بازگوکننده اهمیت نزدیکی به آبراهه‌ها در مکان گزینی محوطه‌ها بوده و بر این اساس، فواصل نزدیک به آبراهه‌های رده‌های پایین‌تر، ایده‌آل‌ترین مناطق جهت برپایی استقرارگاه بوده‌اند. رابطه سیل‌خیزی و الگوی استقرا محوطه‌ها نشان داد که کاهش فراوانی استقرارگاه‌ها در کنار آبراهه‌های رده‌های بالاتر و از طرف دیگر، افزایش فراوانی و تراکم نقاط باستانی در جوار آبراهه‌های رده یک و در فواصل دورتر از آبراهه‌ها، همراه با افزایش خطر وقوع سیلاب در زیر حوضه‌ها، بازگوکننده درک ساکنان باستانی حوضه جنوب‌شرق دریای خزر از خطر طغیانی شدن رودخانه‌ها و در نتیجه، لحاظ کردن این امر در مکان گزینی است. به جهت افزایش دقت نتایج، چهار زیر حوضه اصلی به سی‌ویک زیر حوضه فرعی تقسیم‌شده و پس از برآورد پتانسیل وقوع سیلاب برای این زیر حوضه‌ها، رابطه بین الگوی استقرار و سیل‌خیزی زیر حوضه‌ها، موردبررسی قرار گرفت که نتایج در راستای نتایج به دست آمده از چهار زیر حوضه اصلی بوده است.

واژه‌های کلیدی: زمین‌باستان‌شناسی، الگوی استقرار، هیدرو ژئومورفولوژی، سیل، جنوب‌شرق دریای خزر.