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Arc changes in arid area rivers (Case study: Qomrood river in Iran)

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Abstract
Qomrood river is one of the rivers that located in arid and semiarid area which has a seasonal fluvial. The river is faced many changes, because of floods or natural-human factors. This study, as a geomorphologic study, tries to survey and identify geometric changes between Kocherey dam and 15-Khordad dam. The study method is a mix of library research and field studies. In library method all papers in journals and sites that related to this topic were collected. In field studies, the data were collected through direct and indirect (satellite image) observations. For this goal, TM (1989), ETM (2000) and IRS (2009) satellite images were used. Accordingly, the tree central lines belonging to different periods of study were extracted. Then these lines separated to 6 parts with emphasize on geological and geomorphologic base. In order to change detection, fitted tangent circle model was used. This research showed that the curves of the river face to decrease, while in some parts that are located on harder geological segments, or always have water, face to increase. It means in these parts all curves and meanders are more than previous. Sinus numerical coefficient in all intervals indicates approximately 1.5 that indicates the average sinus condition of the river at present intervals, and this factor has not changed in these 20 years.

Keywords
geometric changes, geomorphology, Qomrood river.

1. Introduction
Many factors affect the geometry of the rivers which are flow, movement of litter, sediment, erodibility side, issues related to geotechnical side, the side vegetation, erosion of zircon in the leg edges human interference, etc.

Geomorphologists want to recognize the causes of land forms appearance and its complexity, and changeable forces base on the time and place. On the other hand they want to understand that how these changeable forces can leave an effect on environmental engineering and human impact. Among these situations, rivers are one of the factors that shape and change the surface of the Earth, and they are the most important geomorphologic scenery. Evaluation of landforms and their structures in Earth surface during the history of its formation are the most essential part of geomorphological studies. Today geomorphologic studies are the best methods for

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assessment of the long-term behavior of the river. It is also important to find major changes on morphology of waterway (Motamed & Moghimi, 1999: 33).

Also, rivers are one of the most sensitive and changeable natural ecosystem sand because of their vital role in the development, and promotion of human civilization. Surveying and recognizing river environment change factors have been always investigated in different studies. In order to sustain the economic and cultural development in adjacent areas of a river, understanding of the process of rivers is essential (Moghimi, 2009: 40).

In this regard, the study of river bend can provide information to the researcher in relation to sedimentation and erosion which has been occurred, and their effects on the environment. Generally, we must said that the modified geometry provide a lot of information about the events happening in the environment for the researcher.

A look at the literature shows that different variables in similar studies were done by the researchers is effective. In the meantime, Schumm (1977) divided rivers to sustainable basis channel (stability, erosion or sediment) and sediment transport ability. Timothy (1995) studied the flooding occurred in the Alberto storm in Three Rivers, and determined that increasing flood depth in the upstream bridges and leaching around the base are the main factors of destroyed. Lim (2001) concluded in their study that in the event of a flood, existing structures by raising the level of water, increases the depth and level of flood zones.

Randall and Edward (2003) found that the number of base can be decisive effects on water and the depth of flood flows has Rejection phenomena. Habibi and Javahery (2003) presents mathematical model to predict changes in river morphology. Yamani and HossainZadeh (2002) studied changes on the Talar river in the coastal plain of Caspian Sea. Mahmoodi and Nohegar (2002) studied the effects of harvesting aggregates (gravel and sand) on the river bed of Minab river. Nohegar and Yamani (2003) studied the geomorphological conditions of meanders and its role in Minab river bed erosion and sides' erosion. Yamani and HossainZadeh (2006) studied the hydrodynamics of Babol and Talar river, and its role in variability and change in their geometrical characteristics studied. Nohegar et al. (2010) studied the change of longitudinal and transverse geomorphologic profiles in Minab river.

This study focuses on Ghomrood river. This river runs through arid and semiarid areas and has seasonal flow. In addition, it has many changes due to floods, and human and natural factors. Therefore, it is necessary to study these changes in order to reduce the probable risks that might cause problems on land use of river sides. After that, we can manage environment effectively and academically.

This study, as a geomorphologic study, aims to survey and study geometric change of Qomrood river between Golpayegan dam and 15-khordad dam.

2. Study area

Study area is a part of Qomrood river, located in 33° 57´ to 33° 23´north latitude and 49 ° 42´ to 50° 20´ east longitude. It has 123 km in length with average slope of 1.04 (Fig. 1).

Some factors such as exposure to relatively high mountains around the basin and its average elevation of about 1840 meters are causing special climate conditions in the region, and makes relatively cold winters, and mild summers.

The maximum summer temperature is 36.4 degrees Celsius in August, and the minimum winter temperatures in January is 10.6 degrees below zero.

Based on Ghosen method, the area located on cold steppe climate and also located on cold semi-arid region as Ambergeh method.

Geologically, in aspect of tectonic events and its phenomena, the area is a part of eastern Sanandaj- Sirjan zone. This zone is the most active structural zone in Iran.

Generally geomorphological conditions in this area, as most other place, follow more or less of the geological condition of the area. Qomrood and valleys overlooking to this river located on uplifted collection in Golpaygan, Khomein and Mahalat that includes shale, sandstones, limestone and volcanic material influence. In this area, where the groundwater flows in the permeable layer of upper rock, chemical weathering and springs are observed.

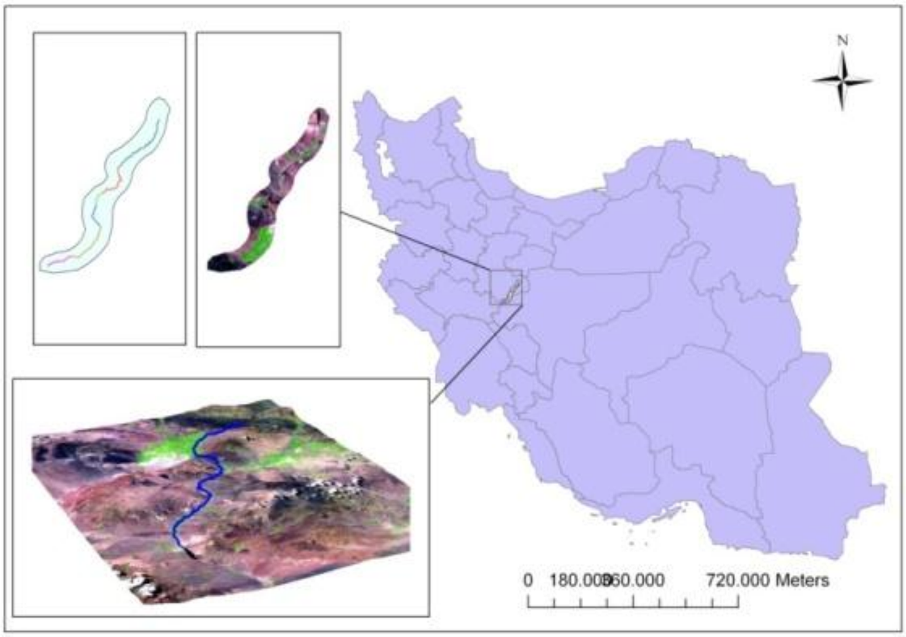

Fig. 1. Location of study area in Iran

3. Materials and Methods

In this study, the researchers try to identify the main and affective factors with a systematic approach. The data that are used in this study include:

- Geological map of the study area in scale of 1:100000
- TM 1989 satellite images taken from the GLCF site
- ETM 2000 satellite images taken from the GLCF site
- IRS 2009 satellite images. Lis III sensor, Geographical Organization of the Armed Forces.

Based on proposed method, this study employs a combination of library research and field studies. In the library phase, all papers in journals and sites that related to the topic have been collected. In field studies, data were collected through direct and indirect (satellite image) observations. For this goal TM (1989), ETM (2000) and IRS (2009) satellite images were used. In order to detect geometric changes of Qomrood River, first satellite images were prepared, then necessary corrections were implemented (Fig. 2).

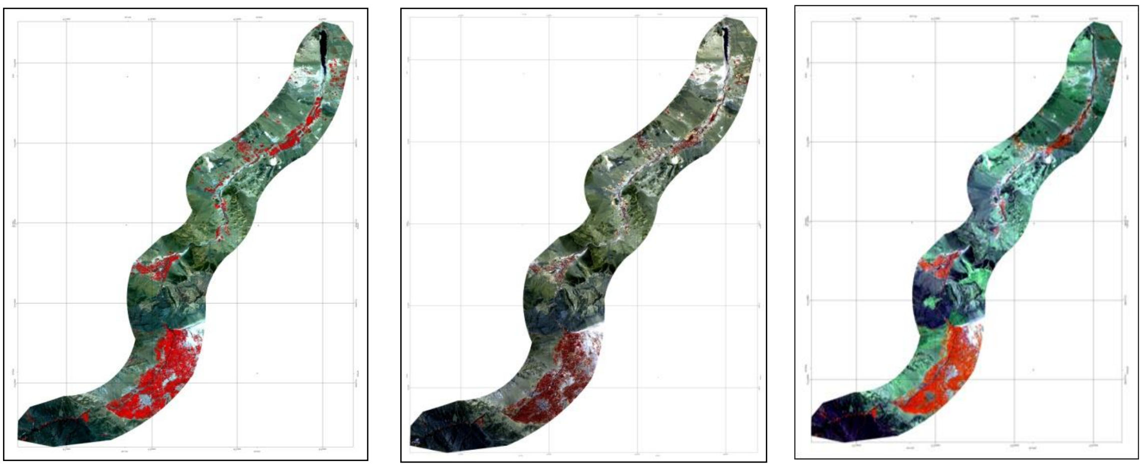

Fig. 2. Satellite image from left: IRS- ETM- TM

At the second, employed Arc GIS (geographic information system) software was used to digitize the river. Accordingly, the three central lines belonging to different periods of the study were extracted.

In third step, these lines were divided into 6 parts with special emphasis on geological and geomorphologic base (Fig. 3).

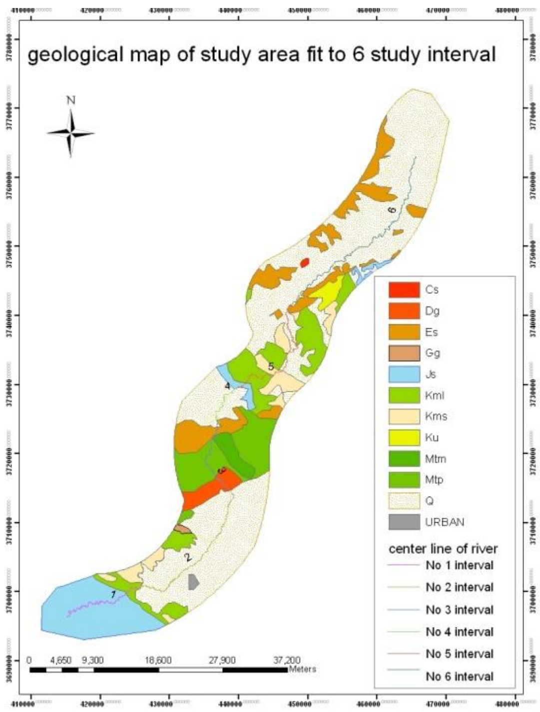

Fig. 3. Intervals of studies based on geological map

In order to change detection, fitted tangent circle model was used.

So in step 4, based on the proposed model, each arcs of the river fitted with the best circles that match with each arc and tangent it (tangent circles were about 1000; Fig. 4).

Then in next step, during separate intervals, the center point of these circles and its radius in three images were determined and calculated. With putting together (add three images) of three images, we can compare changes and extract each change in each interval (Fig. 5).

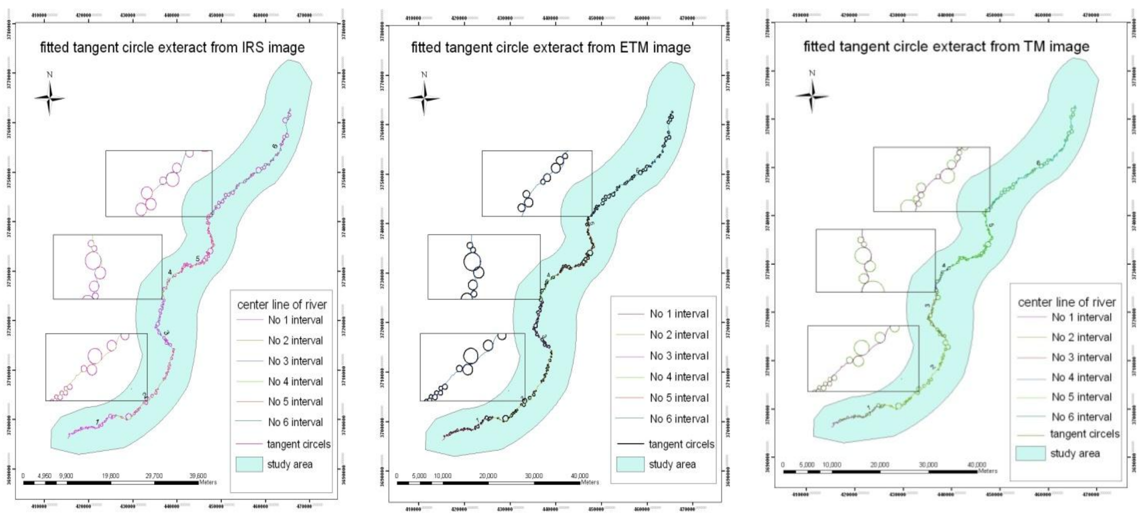

Fig. 4. Fitting tangent circles in three image

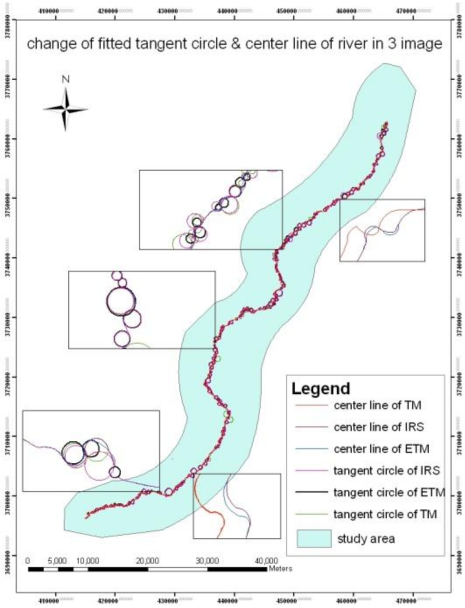

Fig. 5. Fitting tangent circles in three images for compare

In step 6 and in order to further investigate Sin index was calculated from the following formula.

Sin = THAL / VL

Thal: the length of river

VL: the length of valley.

Finally, the results were averaged in Excel software.

Figure 6 shows the study method step by step.

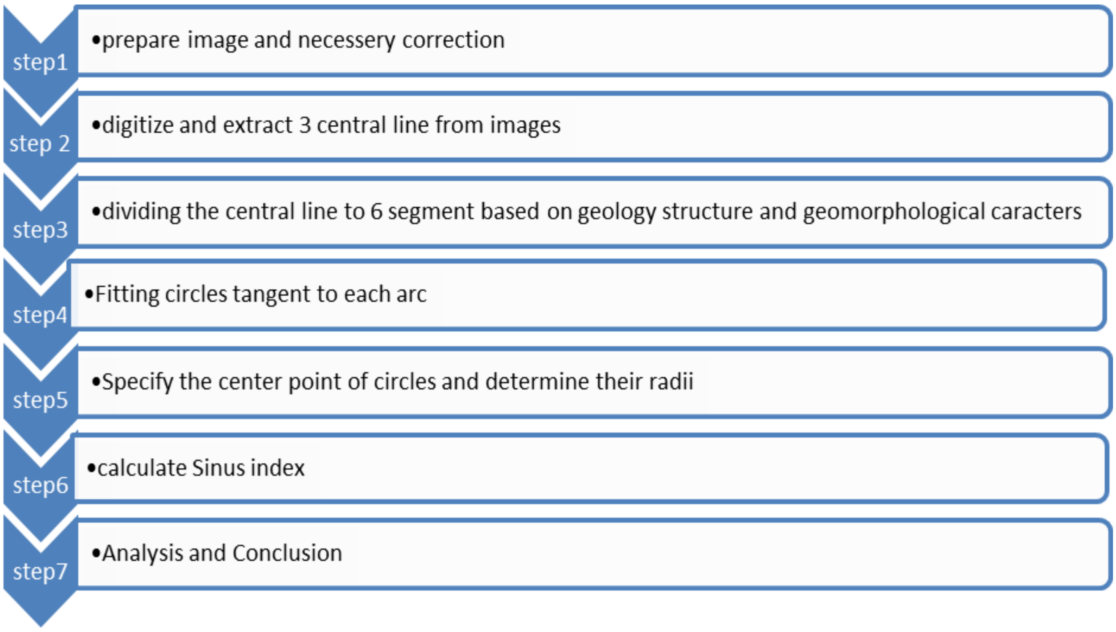

Fig. 6. The study method step by step

4. Results and Discussion

Arc radius calculation of the River. The radius of the arc, or circle radius, is the radius of a circle that is so matched with the meander of the river (Moghimi & Morshedi, 2008: 121). For this, central point was determined, and radius of each arc was calculated in separated intervals inside three images.

Table 1. Calculating the mean of radius of arc in six interval

Under mean data (%)	Mean	Max	Min	Number of circle	Images	Intervals
35	47,215	349,54	39,407	57,14	TM	
35	47,215	349,54	35,669	57,14	ETM	1
36	46,919	347,351	33,206	58,33	IRS	
39	65,51	603,717	87,94	66,66	TM	
45	64,608	603,717	61,235	66,66	ETM	2
45	64,203	599,936	62,689	68,88	IRS	
31	64,211	535,695	91,64	64,51	TM	
32	64,211	382,699	85,587	59,37	ETM	3
32	63,809	380,302	355,666	96,87	IRS	
51	63,316	309,227	52,973	46,66	TM	
51	60,061	309,227	42,85	60	ETM	4
61	62,934	307,29	45,705	56,25	IRS	
50	53,422	570,162	49,245	58	TM	
52	33,751	570,162	58,606	63,46	ETM	5
56	33,54	566,591	58,348	53,57	IRS	
71	40,058	419,283	64,728	60,56	TM	
66	47,633	419,283	77,559	59,09	ETM	6
61	47,344	570,311	88,16	65,57	IRS	

In the first interval, the mean of arc radius has reduced. So the arcs of the river are rising. The trend of the changes in 3 images indicates that this index was increased over the time.

In the second interval, the mean of arc radius has highly decreased, which shows a slight increase during the last 10 years. It means that, these arcs got to the opening with the passage of time.

In the third interval, the mean of arc radius has the highest level in IRS image. So the arcs of the river face to decrease. This interval had more change between the others.

In the fourth interval, an upward trend could be observed in the changes of arc radius from TM to ETM. So the river faces more twists. But, from ETM to the IRS, this mean has increased, and the curves of the river have widened in the last decade.

In the fifth and sixth interval, the mean changes of arc radius have increased regularly. This means the arcs have widened.

Table 2. Mean of radius of arc in total zone and all intervals

Mean (%)	Mean	Max	Min	Number of circle	Images
60,09	164,325	603,717	40,058	241	TM
47,34	164,374	603,717	33,751	245	ETM
60,5	165,29	599,936	33,54	246	IRS

Finally, the mean of arc radius in total interval is shown in table2. As it can be observed in the IRS image, that is the latest image in this research,

Calculating Sin index. Sin index is one of the river behavior indexes. This parameter is so important in river management. Because it is quite easy to understand for public, and also it is so stable engineering. Sin was obtained by linear distance along the river as a straight line of the river. This index for almost direct river is about 1.05 and for Sin river is more than 2 (Alizadeh, 2001).

Figure 7 shows measurement of this indicator on three images obtained by ArcGIS software.

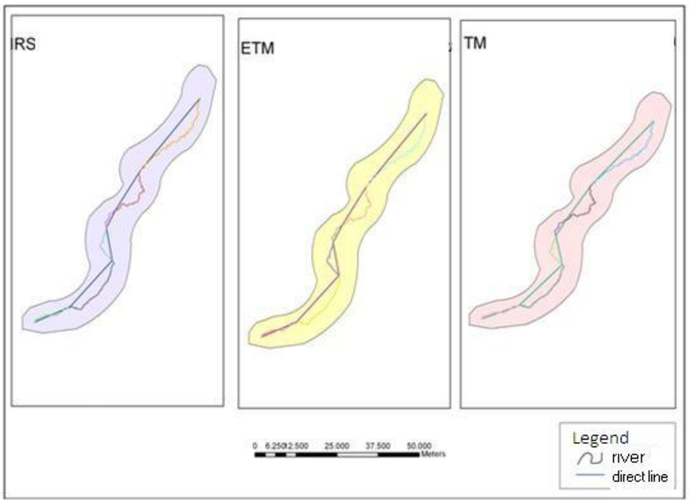

Fig. 7. Measurement of Sin index

Calculations of Sin index turned out to be around 1.5. It indicates that the river is considered to be average in terms of Sin index. Also, during these 20 years, we don't observe any inflection or swing in three images.

Table 3. Calculating Sin index in six intervals

Sin	Distance of direct line	Lengths of river	Images	Intervals
1.49	11.96	17.83	TM	
1.48	11.81	17.47	ETM	1
1.5	11.83	17.64	IRS	
1.28	18.73	24	TM	
1.3	18.81	24.43	ETM	2
1.3	18.81	24.25	IRS	
1.44	9.99	14.41	TM	
1.43	9.91	14.15	ETM	3
1.43	9.91	14.17	IRS	
1.38	6.02	8.3	TM	
1.43	5.87	8.38	ETM	4
1.4	5.88	8.24	IRS	
1.49	14.11	21	TM	
1.59	14.11	22.4	ETM	5
1.6	14.1	23.16	IRS	
1.3	28	36.43	TM	
1.28	28.17	36.04	ETM	6
1.27	28.17	35.87	IRS	

5. Conclusion

As stated, for the detection of geometric changes on Qomrood River (from Golpayegan dam-15-Khordad dam) TM (1989), ETM (2000) and IRS (2009) satellite images were used. In this study, at first, the tree central lines, which are belonging to different periods of the study, were extracted. Then these lines were divided into 6 parts with special emphasis on geological and geomorphologic base, and then 2 geometrics indices were extracted.

The comparison of parameters in three periods is as follows:

- Evaluation of the arc radius of the river showed that in IRS image from 2009, the mean of radius of the arc came to highest range and this means that the intensity of the arcs of the river has reduced and widened in general.

In number 1 and number five intervals, that are located on harder geological segments, the mean of arc radius was decreased. Therefore, the severity of the arc in two rivers ~~is~~ increased, and as a result, the river had more twist than the past. Of course, this can be justified by the permanent water in this segment.

- Calculation of Sin index turned out to be around 1.5. It indicates that the river is considered to be average in terms of Sin index. Also during these 20 years we don't observe any inflection or swing in three images. This shows that 20 years in arid area is a short period for Sin changes on the rivers to be formed. Also, no faults were observed in the view of geological map. The faults can make changes between level bases. This level bases change leads to increase Sin index. The second reason is that the study area is located between two dams so two artificial level bases which can be observed, and this leads to the stability in Sin index.

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