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The Effect of Human Activities on River Bank Stability (Case Study)

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Abstract: Problem statement: Investigation of interaction of human activities and rivers has become a important problem because they have essential role on rivers morphology. So, in this study Atrak River in North-East of Iran has been considered. **Approach:** The aim of this research was to determine human impact on the Atrak River morphology in the past and estimation of future outcomes. **Results:** We used MSS, Landsat and SPOT imageries, aerial photographs with conjunction fieldworks to determined banks erosion about 40 Km along Atrak River. Therefore, banks erosion rates are analyzed for 2 time periods: 1956-1967 and 1967-2000 respectively. Comparison results of five periods showed significant changes in land use around the Atrak River. River meanders were completely varied during the last 50 years within the study region. Also, the river plan gradually went out of meander shape and the river became straight in direction. The quantified average bank erosion rates were found to be slow, ranging from 0.36-3.5 m year^{-1} for the first and second analysis period, respectively. **Conclusion/Recommendations:** Based on this study, for changing and development of Atrak River bank must consider the flow volume, erodibility extent of the river banks, river material, conditions and variations of land cover near the river, organic material of soil and type of land.

Key words: Alluvial river, bank erosion, human activities, atrak river

INTRODUCTION

Riverbank erosion is a natural process, but often human activities can have a significant impact on the rate of morphological change (Chakraborty and Choudhury, 2009). Anthropogenic on rivers like; sand mining, infrastructure building, artificial cutoffs, bank revetment, construction of reservoirs and landuse alterations change the morphology and natural dynamics of rivers. Human activities are stronger than natural events such as floods, droughts and landslides for changing. These human-induced channel changes may result in various environmental and social-economic consequences in navigation, loss of riparian land and infrastructure, flood hazard and the alteration of aquatic and riparian ecosystems. Therefore, a better understanding on river channel changes is of great importance for river engineering and environmental management (Lawson *et al*. 2011; Lara *et al*., 2001; Al-Shami *et al*., 2011; Alexander and Windom, 1999).

Recompense increasing of bank erosion along Atrak River has been frequently reported. For example; villages damaged, numerous infrastructure such as bridges, roads and buildings were destroyed in recent decades. In this research we try to assess; first, how much the banks of the river in the Qazanqayeh-Maraveh Tappeh section has changed over time as a result of land use changes. And secondly, discuss the possible causes of the changes in bank erosion rates, especially over the latest 44 years or so.

Studying area: In this study, we take our knowledge of a portion of Atrak River which is located in the middle of Atrak catchments about 40 km in the Golestan province in the NE of Iran. The study area has about 35 km length, expands from Qhazan Qhayeh to Marave Tappeh (Fig. 1).

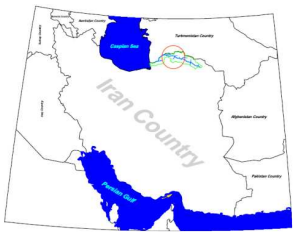

Fig. 1: Geographical situation of the study area

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This potion of the river has experienced increasing of riverbank erosion over the last years. The Atrak River fountains from Hezar Masjed Mountains range. It flows from east to west and ends to Caspian Sea. The annual Caspian climate dominates the hydrology of the Atrak is a seasonable river which its yearly runoff is 300-500 mm^3 averagely. The mean annually discharge varies from 2.1 m^3 sec^{-1} (e.g., 2000 y) to 23.1 m^3 sec^{-1} (e.g. 1970 y). The mean annually discharge in case study hydrometric station is 9.3 m^3 sec^{-1}. The reach study of the Atrak River had been had a meandering channel plan form in accord with the definitions of (Leopold and Wolman, 1960; Simpson and Smith, 2001; Dury *et al*., 1972; Walling *et al*., 2011) and (Walling *et al*., 2011; Gurnell and Petts, 2011; Peters *et al*., 2011; Mulder, 2011; Karanis, 2011; Li *et al*., 2011).

MATERIALS AND METHODS

This investigation based on prior mapping, works and combines these with analysis of the new data to explore its use in characterization of the alluvial geomorphology of Atrak River. A number of datasets are used in order to quantify the riverbank changes. The main datasets used in this study consist of; aerial photos (scale: 1:20 000-1:40 000), Landsat TM satellite images (acquired on 23 June 1987) and SPOT5 satellite images (acquired on 4 December 2000). These imageries are used to extraction of landuse maps. The GIS data are erosion banks has Sarcheshme and Sangane formations, which form the large part of the river surface and been intensified. Regarding the erodablity of around lands, changing the cultivation pattern form wheat and barley to rice has increased the bank erosion. Rice cultivation as a new product has begun in the region since1975. Rate of population increasing also has been ascending. Population of inhabited regions of the river around has increased from 3000 people in 1966-12000 people in 2006 based on statistical estimation of SCI (Statistical Center of Iran).used for background maps, supportive layers and results illustrations as country boundaries, roads, rivers. The land use maps digitized from these satellite images and aerial photos and converted into a new shape files for used in GIS software.

In the analysis, the land use changes from the five different datasets, presented above, were compared by using the ERDAS 8.4 and ArcView 3.3 softwares and its extensions. The comparison of the landuse changes was carried out in the four phases 1956-1967 (11 years), 1967-1972 (5 years), 1972-1987 (15 years) and 1987-2000 (13 years). This analysis was made in order to measure the changes in landuse that have occurred over time.

Table 1 : Situation of land use surfaces of Atrak River (1956-2000)

Land use year	1956	1967	1972	1987	2000
Active bed river (Hectare)	240	280	355	430	610.0
Agriculture (Hectare)	750	875	1010	1220	1460
Garden (Hectare)	50.0	45.0	30.0	80.0	170.0
Vegetation (Hectare)	670	810	800	750	440.0
Inhabited (Hectare)	115	125	185	155	235.0
Land poor (rang land) (Hectare)	2300	1990	1745	1490	1210

As in any GIS and remote sensing work, the possible inaccuracy of our results are inherited from both local and positional errors, as a result of employing maps obtained in various times and with various (Kummu *et al*., 2008; Walling *et al*., 2011), (Blazejewski *et al*., 1995). Situation of land cover and land use of the Atrak around in studying area has changed in the past 44 years. Land use maps of the studying region are provided using the analysis of the satellite images and aerial photos for 5 different periods which are shown in Table 1.

The comparison of the provided maps shows that active bed of the river has increased from 240 hectares in 1956-610 hectares in 2000 which shows increasing about 150% (Table 1).

But land cover has decreased from 850 hectares in 1956-500 hectares in 2000 which shows decreasing about 70% and also the area of the unused field have reached from 2120 hectares in 1956-1150 hectares in 2000 which indicate decreasing 70-84% respectively.

Also the area of agriculture and gardening in the study area has reached form 800 hectares in 1956-1630 hectares in 2000 and inhabited lands have increased from 115 hectares in 1956-235 hectares in 2000 which shows more than 100% increase (Table 1). Since 1956 year to 2000 year Tamarix sp. in around of the river has decreased and land use has increased. So the process of

RESULTS

During the past 44 years, because of extensive changes of land use at the round of the Atrak river and destruction of Tamrix sp. bank erosion has increased. So that rate of replacement of bank has reached from 0.36 m in 1956-3.5 m in 2000 (Table 2). This shows increase in bank erosion and destruction of agriculture farms of the river around.

Also regarding the depth and width of the river during the past 50 years (Table 3) almost the weight of erosive soil during period of 11 years (1956-1967) have been 75600 tons and in periods of 33 years(1967-2000) have been 757272, that is has an increase about 2656 tons.

(a) (b)

Fig. 2: The Floods' impact on meanders geomorphology of Atrak River (2006-2007) (a) Before and (b) After

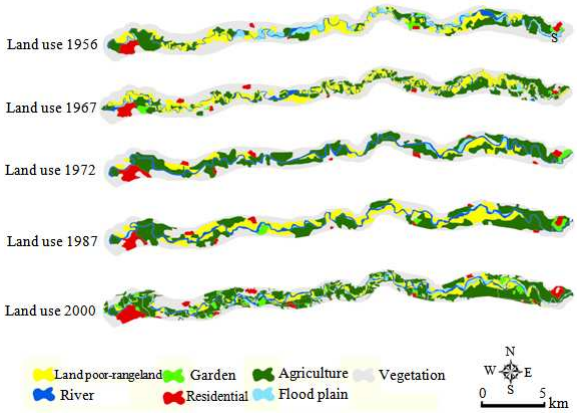

Fig. 3: Morphological evolution of Atrak River during ~50 years (1956-2000)

Table 2: Variations of the Atrak River during In 5 periods

Year	1956-1967	1967-1972	1972-1987	1987-2000
Area (hectare)	40	75	85	180
Width (m)	4	35	38	46
Rate of bank Erosion (m y^{-1})	0.36	3.65		3.6

Table 3: Evolution of physical properties of Atrak River (1956-2000)

Year	1956	1967	1972	1987	2000
River area (h)	240.0	280.0	355	430	610.0
River area (h)	240.0	280.0	355	430	610.0
Average depth (m)	3.0	3.0	-	-	3.0
Width/depth	15.0	17.0	-	-	56.7

Hydrologic changes in water and sediment discharge of Atrak River are the major contributing factors of hydraulic geometry change. The occurrence of many floods during the past 44 years with minimum discharge 43.5 $m^3 sec^{-1}$ and maximum discharge 755 $m^3 sec^{-1}$ and as a result of it occurring the secondary flows in the river and also existing the bed protecting layers cause the diversion of water to the walls, therefore the rate of bank erosion becomes more than bed erosion. As the rate of bank erosion in external arc of meanders is more than their internal arc, land use and established installations in external arc is at risk more. For example regarding the photos of Gavandar village surrounding in period of 10 months from 6 November 2006-6 August 2007 the external arc have expanded about 15 m toward the Gavandar (Fig. 2). Based on hydrology and meteorology studies by TOOSSAB (TOOSSAB Consulting Engineers Company, 2007) it can be noticed that most floods of Atrak River happen between the period January and February to June and July the Fig. 3 these changes.

The changes of cultivation pattern from wheat and barley to rice after 1970 also affect in extent of the erosion. In addition erodable formation of the region such as Sangane and Sarcheshme and population growth has been intensive factors of this issue. Hydrological changes, graining the bed material and walls, land use changes and cultivation pattern especially expanding the rice cultivation in flood of river plain are the most important factors in changing the area plan and bank erosion of the studying area.

Growth of population of the studying area to fourfold in the past 44 years, is an indication of increasing the population force on the land use and as a result expanding the agriculture activities and inhabited in the round of the river.

CONCUSION

The influence of human's activities on river morphology is very complex in spatial and temporal scale. The situation in the Atrak River, as in the case of the active river in the NE Iran, is a striking example which demonstrates that the human activities have interplayed on rivers morphology. This profound human influence on the river morphology and morphodynamic needs to be taken into consideration before, during and after new exploitations of rivers. However, such impacts of man must also be taken into account when designing bank zone/area management plans for sustainable development.

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