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Effects of different vegetation cover types on stability of river banks in dry land (case study of Hirmand River)

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Key words: Hirmand River, Sistan region, Vegetation cover, Erosion, River banks.

Abstract

This study was conducted on comparing erosion on Hirmand River banks in Southeastern Iran. Sistan region covers the Southeastern part of Iran along the borders of Afghanistan and Pakistan. Average annual rainfall of the region is 60 mm. The soil of this area is heavy with Silt clay loam texture and tends to salinity. Aim of this research was of vegetation analysis and it effects on sustainability of Hirmand River's banks. Hirmand River with about 1150 Km length has its rise among the east-central Afghanistan Mountain. This research has done on 14.7 kilometers mentioned river length (from Zahak city until Iran - Afghanistan border). The results of this study showed that 8% of the river has been influenced by bank erosion and bed erosion take place not in area mentioned. Wind erosion starts first summer season following water dried on main part of the river and beginning 120- days wind. The wind erosion has appeared in two locations. However, there was an inverse relationship between erosion and vegetation cover. As, has been fixed the areas with suitable vegetation cover of Tamarix and area with shrub vegetation cover less than 20% has been influenced to the erosion. In addition, the survey results shows that the area with *Aeluropus littoralis* canopy covers more stability than the same area with *Alhagi maurorum*, canopy cover, as 30 and 70% of the erosion has occurred in *Salsola, Aeluropus littoralis, Tamarix* and *Alhagi maurorum* habitat, respectively.

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Introduction

Soil is a main part of the natural environment that plays a major role in products and in the development of the countries. But, a major problem in many areas is soil erosion as annual loses major part of the suitable agriculture land. River bank erosion is an erosion type that occurs naturally, but be accelerated by human activities. Bank river stability influences by factors such as composition of the bank matters, temperature, hydraulic forces, presence or absence of permafrost, and vegetation for a description of bank erosion processes and mechanisms (Thorne, 1982). This kind of erosion rates can vary according to the type of riparian vegetation that is present. Different vegetation life forms (herbaceous, woody shrub, tree) and species can have different root-shoot architectures and biomass—both above and below ground—which influence the ability of vegetation to stabilize river banks (Mallik and Rasid 1993). Banks are often characterized by bare sediment, live vegetation, or snags (Roy *Et. al.* 2003). In an ecological context, riverbanks are main component of riparian regions. Bank erosion is a natural process that occurs during or soon after floods. River banks are transitional boundaries, or ecotones, between the aquatic and terrestrial ecosystems, and they frequently change under naturally dynamic hydrologic conditions. Piegay *Et. al.* (1997, 2005) suggests that bank erosion is a necessary ecological process. Vegetation effects on bank stability (Simon and Collinson 2002) since the type and density of vegetation cover and the roots that stabilize banks reduce bank erosion (Pizzuto and Mecklenburg 1989, Abernethy and Rutherfurd 1998, 2000). Generally, riparian forests keeping bank stability, but flow that scours around individual pieces of large wood derived from riparian forests may accelerate bank erosion rates locally this contrast highlights the importance of considering scale in assessing bank erosion (Montgomery 1997). During floods, bank erosion delivers large woody rubbish to rivers (Sudduth and Meyer 2006). The large woody changes bed and bank morphology and increases river complexity (Ralph *Et. al.* 1994). Chukwuka *Et. al.* (2008) reported that speedy growth of certain plant species results in increased sediment accumulation, decreased dissolved oxygen levels and reduced seed banks resulting in reduction of re-vegetation potential of invaded water body. Beeson and Doyle (1995) found that the during flood events, river bends lacking riparian vegetation can experience up to five times greater erosion than vegetated bends, and non-vegetated banks may experience up to ten times greater erosion than vegetated banks. Connor and eat al (2011) suggested that the river bank characteristics of soil properties, length of rainfall periods, matric suction, geometry and vegetation cover play important roles in bank impair and erosion-risk assessment. Millar (2000) print out that the bank vegetation also exerts significant control over alluvial channel patterns. Vegetation also affects soil moisture and stability, freeze-thaw cycling, and erosion, especially in sticky soils. Gurnell (2013) demonstrated that the growth rate and reproduction of vegetation in river environments responds to and affects fluvial processes by adapting to stream-flow variations, erosion, and burial stresses. Pollen *et al* (2009) observed that the flow disturbance has an influence on river banks vegetation, but established vegetation cover hinders erosion and increases the stability of deposition river banks. The roots of plants able firm river banks together, preventing erosion. River banks bare soils are weaker and there is a far greater chance that the bank will be increases eroded by the river. Ashworth (2000) demonstrated that the vegetation cover has an important factor in determining bank stable and therefore has a main role in determining river morphology. It has also a complex relationship with river morphology. It can substantially alter flow velocities and direction, as well as change the cohesion and physical resistance of bank material. Thorne (1990) observe that the many effects vegetation such as reduce soil erodibility, increase bank strength though soil reinforcement and lead to accretion at the base of the bank can have on river bank erosion. Hey and Thorne (1986) pint out that the widths of rivers with high canopy density vegetated banks were approximately 50% narrower

than analogous to each other but thinly scattered vegetated rivers. Hupp and Osterkamp (1996) reported that in semiarid regions, areas of vegetation cover of river banks are plenty related to patterns of moisture availability. River bank erosion is an important soil degradation process in the Sistan region and has a substantial negative impact on the ecosystem in this region. These studies have focused emphasis on important of vegetation cover to stability of river banks. These studies also have been presented that the rote plays an important role in low river bank erosion. But, they haven't given useful information about effect of amount each vegetation cover type. Aim of this research was study of effects Vegetation cover type on Sustainability of River's banks in Sistan, Iran.

Materials and Methods

Study area

This study was conducted on comparing erosion on Hirmand River banks in Southeastern Iran. Sistan region covers the Southeastern part of Iran along the borders of Afghanistan and Pakistan (Fig.1). The Sistan plain is arid, with high average annual temperature (2°C-50°C), low rainfall (62mm) and high velocity (100 to 120 km/hr) wind. The region includes an area of about 8000 km² and is mainly dryland. The study area is nearly flat and featureless arid plain with an average altitude of 475–500m above the sea level. The soil of Sistan area is heavy with Silt clay loam texture and tends to salinity. Aim of this research was of vegetation analysis and it effects on sustainability of Hirmand River's banks. Hirmand River with about 1150 Km length has its rise among the east-central Afghanistan Mountain. This river flows southwest across more than half of its length in Afghanistan before flowing northward for a short distance through Iran territory and discharge into the Sistan Lake on the Afghan-Iranian border (Fig. 2).

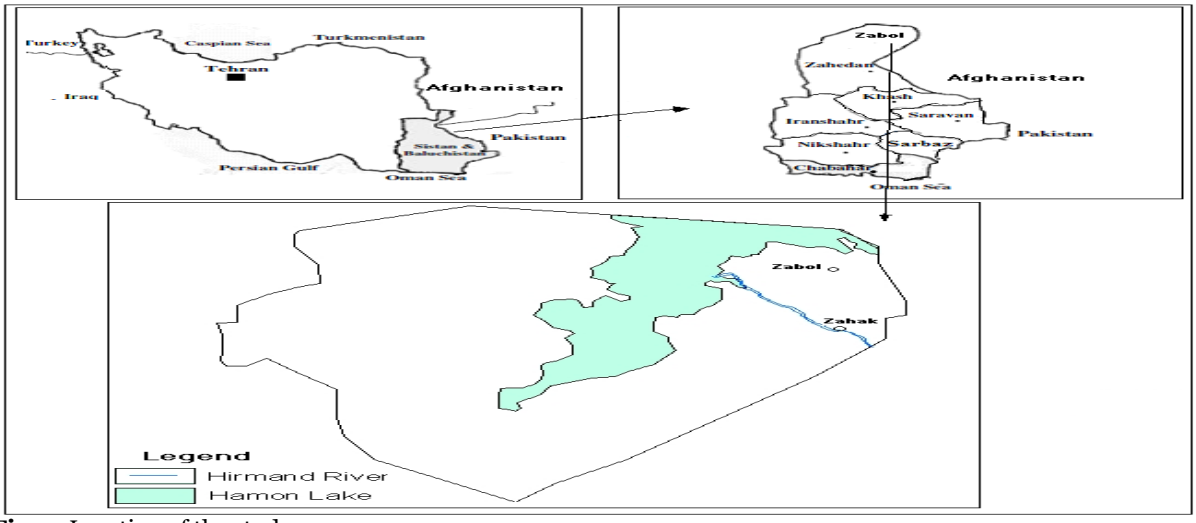

Fig. 1. Location of the study area.

Method

In this study, we have used available scale of 1:50,000, 1:250,000, Geologic maps, research works, field observation and global positioning system (GPS).The maps information cheeked with field work. At each Side bank river 10 m x 10 m plots were randomly selected at each site. The parameters measured included canopy surface area density and bare soil area percentage of River's-banks. The predicted vegetation cover map of river banks. The measured amount and type of soil erosion. We have found and relationship between soil stability and vegetation cover. This research has done on 14.7 kilometers mentioned river length (from Zahak city until Iran - Afghanistan border).

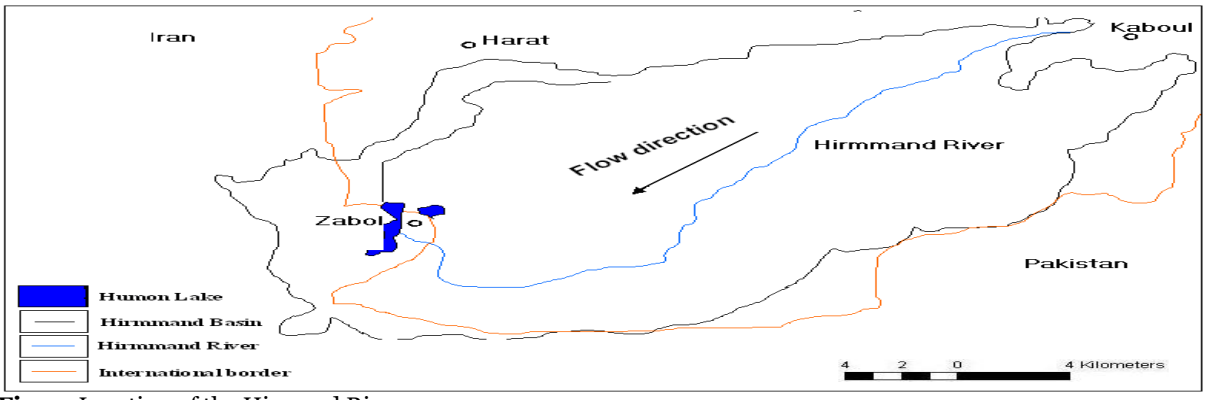

Fig. 2. Location of the Hirmand River.

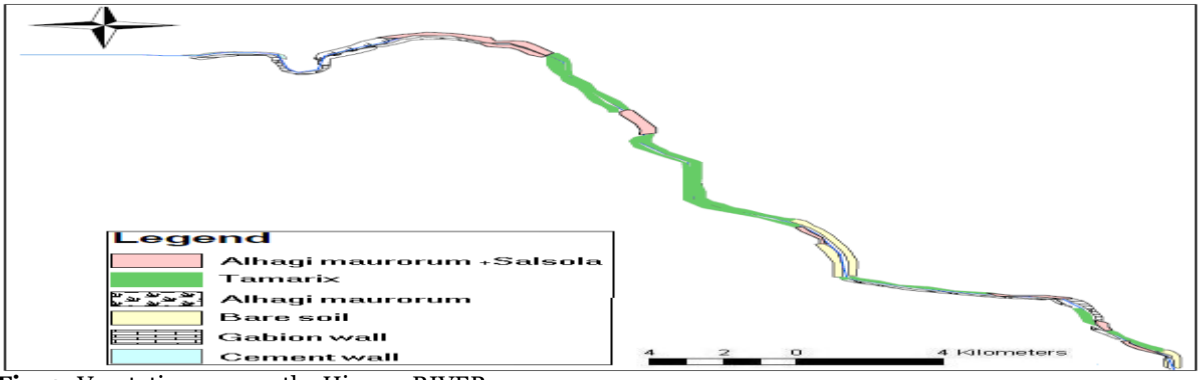

Fig. 3. Vegetation map on the Hirman RIVER.

Results

The date shows that the initial right bank of Hirmand River has low vegetation cover and some parts covered by bare soils. The study area vegetation are consist four type. Part banks of the river are occupied by plant of Tamarix, as goodly protects from banks in opposite the pressure of water forces. In addition, in good session grows kinds of annual spices such as grasses and forbs.

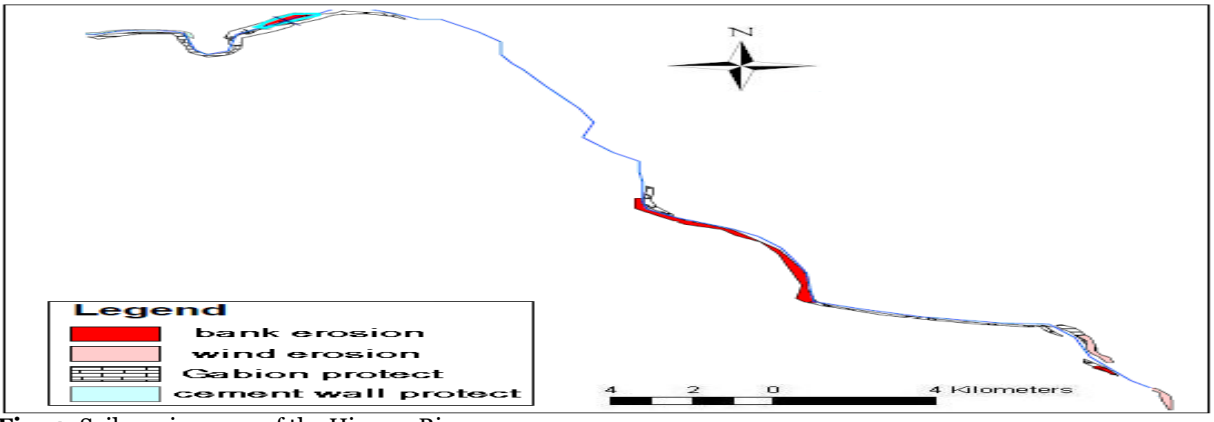

Fig. 4. Soil erosion map of the Hirman River.

The study presented that the *Phragmites australis*, *Phragmites communi*, *Cyperus longus* in Hirmand River. The spices *Alhagi maurorum* , *Aeluropus littoralis* and *Salsola* spp presents in low deep of river. The river right bank inside has more vegetation cover of Tamarix than the left bank side. Average right and the left insides of the river vegetation cover are 15 and 12 percentage, respectively. In generally,

Average vegetation cover and bare soil the right inside are 15 and 85 percentages, respectively in this area. While average vegetation cover and bare soil the left insides are 12 and 88 percentages, respectively in study area (table 1). Survey the bank of river shows that the most part of vegetation cover were consist *Alhagi maurorum, Aeluropus littoralis* and *Salsola* spp.

Table 1. Analysis of vegetation cover bank inside of the Hirmand River.

Parameter / No	Right bank side			Left bank side		
	Name of plants	Vegetation Cover %	Bare soil %	Name of plants	Vegetation Cover %	Bare soil %
1	-	-	100	-	-	100
2	T	10	90	T	10	90
3	T	23	83	T	20	80
4	T	25	85	T	15	85
5	T-P	35	70	T-P	25	75
6	T	31	69	T	20	80
7	T	32	73	T	20	80
8	T	15	90	T	10	90
9	T	10	90	-	-	100
10	-	-	100	-	-	100
M	-	18	85	-	12	88

T= Tamarix P= Phragmites communi.

Table 2. Analysis of vegetation cover bank of Hirmand River

Parameter / No	Right bank side			Left bank side		
	Name of plants	Vegetation Cover %	Bare soil %	Name of plants	Vegetation Cover %	Bare soil %
1	AL-A	12	88	AL-A	17	83
2	AL-A-S	45	55	AL-A	15	85
3	AL-A-S	45	55	AL-A-S	40	60
4	AL-A-S	54	46	AL-A-S	48	52
5	AL-A-S	64	36	AL-A-S	60	40
6	AL-A-S	57	43	AL-A-S	50	50
7	AL-A-S	38	62	AL-A-S	40	60
8	AL-A-S	46	54	AL-A-S	50	50
9	AL-S-A	47	53	AL-A-S	47	53
10	AL-A	10	90	AL-A	15	85
M	-	43.3	58.7	-	37.7	62.3

AL= Alhagi maurorum A= Aeluropus littoralis S= Salsola.

The maximum, minimum and average of vegetation cover canopy of Right Bank River were 64, 10 and 43.3 percentages, respectively. But bare soil area decreased in bank ratio to inside the river from 85 to 62.3 percentages. The area grown *Alhagi maurorum* and *Salsola* has maximum vegetation cover canopy. However, there was a direct relationship between high vegetation cover percentage and this species. In the left bank site, maximum, minimum and average canopy cover was 60, 15 and 37.7 %, respectively. The results show that *Alhagi maurorum* presents in all plots and *salsola* was less. The recovery of the plant species was curtailed when moisture less during the drought period or when Afghanistan limited to flow water to Iran. The results also show that the amount of bare soil area was between 40-85% and its average

was 62.3% (table 2). The salsola growth period was low, when temperature increased this plant was drought. The main part of the river with *Alhagi maurorum* vegetation cover got over grazing. Therefore the vegetation cover severely has been destructed. The tamarix grow up in company the *Alhagi maurorum* in major part of the river. A part of the river was bare soil area and has grown annual species such as forbs and grass that was drought in warm season and no stability opposite to the erosion (Fig: 3). Our study indicates that in Hirmand river has occurred two type erosion consist bank and wind erosion. The erosion has been occurred in three locations of the river. The main part of the erosion events on the left bank equal to 2850m. Also, Many areas of the river have low and to be in first stage of the erosion. In generally, the erosion has happened on right and left bank of the river 3130 and 430m, respectively in this area (table 3). The river banks intense stabilization through method of using gabion and cement walls (Fig 4). The results of this study showed that 8% of the river has been influenced by bank erosion, but bed erosion take place not in area mentioned. Wind erosion starts first summer season following water dried on main part of the river and beginning 120- days wind. The wind erosion has appeared in two locations. However, there was an inverse relationship between erosion and vegetation cover. As, has been fixed the areas with suitable vegetation cover of Tamarix and area with shrub vegetation cover less than 20% has been influenced to the erosion. In addition, the survey results show that the area with *Aeluropus littoralis* canopy covers more stability than the same area with *Alhagi maurorum*, canopy cover, as 30 and 70% of the erosion has occurred in *Salsola, Aeluropus littoralis, Tamarix* and *Alhagi maurorum* habitat, respectively.

Table 3. Location erosion of the Hirmand river.

No	Type of Erosion	Sitution of Erosion	Coordinat		Coordinat		Length (m)	Vgetation		Bare Soil (m)
			attitude	longitude	Attitude	longitude		Type	%	
1	Bank	Left bank	30° 49' 42"	61° 45' 42"	30° 49' 48"	61° 45' 36"	280	AL.s	18	150
2	Wind	Center	30° 49' 17"	61° 46' 02"	30° 49' 33"	61° 45' 56"	515	AL.s	15	400
3	Wind	Center	30° 49' 52"	61° 45' 40"	30° 51' 52"	61° 43' 22"	660	AL.s	19	550
4	Bank	Left bank	30° 50' 34"	61° 44' 15"	30° 50' 11"	61° 45' 31"	2850	AL.s	13	1980
5	Bank	Right bank	30° 45' 05"	61° 41' 50"	30° 54' 00"	61° 41' 33"	430	AL.s	19	320
Total	-	-	-	-	-	-	4735	-	-	3400

Discussions

Vegetation is a perfect part of the riparian perspective and plays a main role in fixing river banks and decrease erosion. The results of this study showed that the regions with high density vegetation cover have excess stability against the erosive force. Vegetation fixed banks firstly by increasing shear ability of the soil reducing water speed, and resistant the bank. The reason is due to made changes on chemical and physical soil properties. The armoring of vegetation to stabilize a bank is dependent to factors such as kind of plant, density and rooting depth. Variety vegetation the growth form (woody shrub, tree) and species can have different root-shoot and biomass up and under ground that affects the strength of vegetation to stabile banks of river and channel. High root accumulation has been occasioned lower erosion rates on river banks. This study observes that in Hirmand river banks *Alhagi maurorum* and *Salsola* no play main role in erosion control. This is due to have not root density and resistant vegetation cover in opposite of erosion. As, Hirmand river flood comes late winter that during dead plants such as *Salsola* and *Alhagi maurorum*. But, *Aeluropus littoralis* play important role in stability of river banks which hasn't occur erosion in resident of this plant, as reported by Hickin (1984) indicating that root growth through the depth of flood plain is a very firm fortification mechanism. The existing of vegetation cover growing on a river bank

has the faculty to influence both the rapidity and expanse of bank erosion. Therefore increase vegetation cover changes the soil organic-matter content; texture and reduces water velocity which stability against erosion.

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