Application of Remote Sensing and QGIS on Change Detection in Coastal Zone of Pyanj Amu River – Kunduz – Afghanistan

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Abstract

Mapping and analysis of change detection zone using remote sensing and GIS techniques is an area of interest that has been attracting increasing attention. In this paper the attempts have been done to assess and recognize the change in land detection and eroded along the Pyanj Amu river in Kuduz province in the north of Afghanistan over a 5 years' period. The study made by use of LandSat imageries of 2013 and 2018. The Landsat images were classified by Quantum GIS software using maximum likelihood classification method. The result show that the costal changes which almost 3163 m^2 has been ducked and lots of people become homeless. If this situation continues it will make problem for transboundary of Afghanistan also. These changes were attributed mainly to the control of the Amu River flooding and the land use changes.

Key words: Pyanj Amu River, Change detection zone, Remote sensing, QGIS

Introduction:

In sustainable development and environmental protection coastal zone monitoring is an important task, it also important for political boundaries for countries which have common borders. Coastal zone management and its environmental management is required information about coastlines and their changes. Coastline extraction in various times is on of fundamental works for this subject. The coastline is defined as the contact line or line of contact between land and the water body. Due to having two quite different climate surface these areas are seeing mixed reactions. Because of these areas have micro-climate double that have influenced by two water and land natural environments. Costal zones are in tension because they are defined as the commissure and the connector between processes over land and seal due to various using of human (Li et al, 2001:34). The sea processes are played role by movement of and land process are played rule by transferring of water and river sediment to seas (Cooka at al. 1990). due to various reasons such as environment changes, global warming, and issues regarding human activities, studies and quantitive measurements from periodic changes are beneficial for the environmental management of shores (Kroon.et al. 2007:493) and (LI et al. 2010:554).

Remote Sensing data is used as the most efficient source of information to investigate and interpretation of coastal landforms nowadays, tidal levels, coastal zone changing, water depth and like that (Simon, 2010:154). Lots of sutydies using the satellite images have been taken to the field of study shoreline changes and their reasons.(Yin et al. 2004 Huang and Fan. 2004, Chang et al. 2004 and Xu et al. 2007). The basin principle behind using digital data is that any suble change in land cover use results in a change in the radiance of that object and can be detect by soensors of satellite (Mass 1999) in different spatial, spectral and radiometric resolutions. For example, the conversion of land use for rural to urban land causes change in the visible portion of the spectrum (Brightness) arriving to the sensor from this new land use. The changes from vegetation to non vegetation land use cause difference in the near infrared (NIR) radiation or greenness detected by the sensor, and the change in the shortwave infrared (SWIR) reflects change in moisture content or wetness of and object (Lunetta and Elvidge 1998).

Some change detection techniques using digital images has been reported in the literature (Singh 1989 and Lu et al. 2005) and (Herehere 2010) are applied on screen digitizing upon TM satellite images for mapping spatial changes in sand dune location in the western Desert of Egypt between 1986 to 2000 years. Frihy et al. 1998) has applied and unsupervised classification upon MSS and TM data acquired between 1987 and 1998 to estimate the area change of

Manzola lagoon. The most common methods applied for change detection include band differencing, band ratio, vegetation index differencing, principal component analysis, and post-classification change detection. Water indices are mathematical models enhancing the water signals for a given pixel at images obtained from visible or near infrared scanning sensors. The models and samples are calculated from two bands usually from the visible and near infrared portions of the spectrum. The normalized difference water index (NDWI) is common among the water indices (McFeeters 1996) and the modified normalized difference water index (MNDWI) (Xu 2006). The Normalized difference water index or NDWI is calculated as (Green – (Green ? MIR), which MIR refers to the reflection in the middle infrared bands. Both NDWI and MNDWI were applied in some previous studies (Gao 1996; Ouma and Tateishi 2006; Xu 2006).

Study Area:

The Amu Darya River as the longest river in the central Asia extends over 2400 Km from the mountains across Kara–Krum desert and into the Areal sea, (Macklin, 2000). Known as the Oxus in the Greek world, the Jayhun in the Arab World and, it has marked the history of the region for centuries (Fig.1). This River is formed by the confluence of the Vakhsh and Pamir Rivers.

Since ancient times the Amu Darya Rive has not only been the source of life for vast arid lands but has also served as a border and a line of communication. This River runs along the border of Afghanistan, Tajikistan, Uzbekistan and Turkmenistan and erosion risks have become an issue of significant mutual concern between Afghanistan and Tajikistan borders. In Tajikistan side extensive system of flood protection was construct to protect the irrigation system and property. But in the Afghanistan side of the border has many low-lying, densely populated islands where the river reaches the flood plain for the mountains. The soil is soft and very productive in the delta and along the bank, but few formal flood protection works have been undertaken, and unfortunately instead of using the resource and benefits of this river, it causes loss of life and billions of dollars in damage and being lost annually a part of its lands due to uprising volume of water and shipping which is cause coastal destruction and consequently the river's path is being changed kilometres to Afghanistan orientation and it makes serious problem also for its international boundaries. According to studies the negative impacts of bank erosion and flood in the Amu River regions is

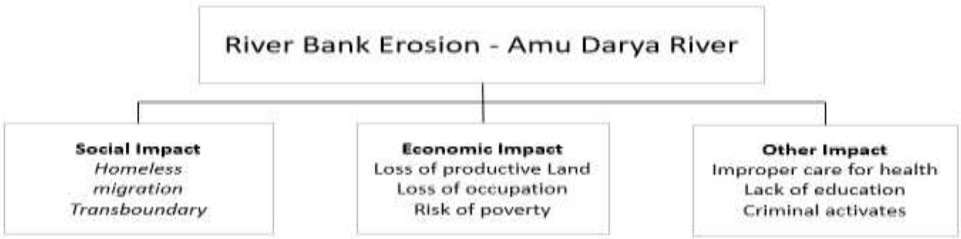


Fig1: Impact of bank erosion

illustrated in Fig.1.

Topography, precipitation patter, glaciers, and climate variability are the most important factors which greatly influence the flow of water in Amu River Basin, which consists of the three main zones. i) an up steam mountainous zone the mountains of Pamir – Aral and Hindu Kush rising to 7495 meters generate 90% of the flow, ii) a midstream region with several distinct large irrigated oases, and iii) a downstream zone of flow depletion with delta and discharge into the former Areal Sea. The other two zones consist of mainly; deserts, arid forests, fragments of grassland, and plain at elevation no greater than 300 – 500 meters.

In the long term the average flow of Amu Darya River is about 74.8 Km^3 per year. The actual flow depends on the climate condition in the centre year. The amount of snow, spring rainfall and the intensity of glaciers melts in summer play a decisive role in the formation of water resources, when flow significantly increases and in extreme cases causes flooding. The Amu Darya River's main tributaries, after it springs as the Wakhan from the Wakhan glacier, are the Pamir and other rivers of Badakhshan and the Kokcha, Panj, Kunduz, Vakhsh, Kafirnigann, Surkhandarya, and Sherabaddarya River. All of thoses are mountain tributaries as the Amu Darya has no significant tributaries along the 1200km length that flows through the plains. The Kashkadarya and Zarafshan rivers (flowing through Uzbekistan) used to flow into the right bank of the Amu Darya River, but no longer reach it (Ahmad and Waseq 2004). Table 1. Shows the average annual flow of Amu Darya River by riparian countries (Ahmad and Waseq 2004).

Country	Average Annual Flow Generated (bcm)	Percentage of Total
Tajikistan	46.6	66%

Afghanistan	17.1	23%
Uzbekistan	5.1	7%
Kyrgyz Republic	1.6	2%
Turkmenistan	1.5	2%
Total	74.8	100%

Table 1: Average annual flow of Amu Darya River by riparian countries

Remotely sensed, basin wide precipitation analysis and modelling (Nezlin 2004, Shikloomanov 2009) reveal that, although in some recent years (1990 – 1992, 1998 and 2009 – 10) precipitation over the Amu Darya watershed was higher than normal, water formation potential in the Amu Darya River basin could decline in the future (Shiklomanove 2009). More worrying is a trend toward low water years, when water level reach the absolute minimum, as in 2000, 2001 and 2008. As a consequence, water availability in Amu Darya River is becoming increasingly vulnerable. The rising temperatures of air will contribute to intense and increase glacier and seasonal melting and initially the flow of water and risk of floods would increase.

This study included amount of costal zones changes of Amu Darya relaying to Afghanistan bank at focused of Emam Saheb district of Kunduz province. However, as it is mentioned Amu Darya River has formed most of Afghanistan's northern border with Tajikistan, Turkmenistan, and Uzbekistan (Fig.2). Unfortunately, due to weak management and economy, Afghanistan government instead of using its water resources and benefits, every year Afghanistan is losing its lands cause of seasonal uprising water surface and sailing that is results coastal erosion and consequently coastal zones have washed kilometres on the Afghanistan bank and destroying farmlands and houses that concerns very citizen of this country in the past and at the present. The river washed away a large amount of farming land and pastures during 2005 flood (on the Afghan bank) and government has just built temporary embankments at some of most vulnerable points on the river, utilizing old military vehicles covered and sand bags. Fig.3

Fig 2: Geographical position of the Amu Darya.

Fig2: Temporary embankments at Kunduz province – Pyanj Amu River

Objectives:

The objective of the present study is to apply remote sensing and QGIS application in Mapping and addressing spatial changes occurred along the coastal are of Amu Darya River in Emam Saheb district between 2013 to 2018. Specific objectives include mapping coastline position changes surface area between 69º31˙46.7573˙˙ E, 37º09˙48.8356˙˙ N and 69º20˙22.2353˙˙E, 08º35˙35.6378˙˙ N at Emam Saheb district of Kunduz province in the north of Afghanistan.

Materials and Methods:

Satellite Data:

Two Landsat 8 ETM+ (30 m pixel resolution) images which is consist of one blue band (0.452 – 0.512 mm), one red band (0.636 – 0.673 mm), one green (0.533 – 0.590 mm), one band in the near – infrared (NIR) spectra (0.851 – 0.879 mm) and one band in the short – Wave Infrared (1.55 – 1.75mm). Acquired in July 2013 and July 2018 has been used to quantify the changes along the coastal area of Pyanj Amu Darya River in study area.

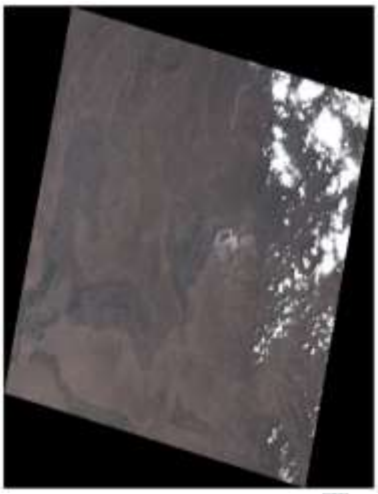


Fig 4: Landsat 8 ETM image 2013

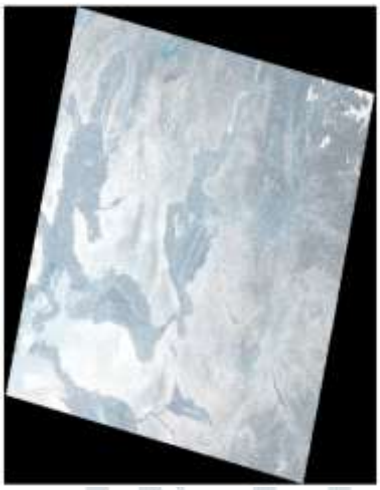


Fig 5: Landsat 8 ETM image 2018

Landsat 8	Bands	Wavelength (micrometers)	Resolution (meters)
Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) *Landsat 9 will have these same bands.	Band 1 - Ultra Blue (coastal/aerosol)	0.435 - 0.451	30
	Band 2 - Blue	0.452 - 0.512	30
	Band 3 - Green	0.533 - 0.590	30
	Band 4 - Red	0.636 - 0.673	30
	Band 5 - Near Infrared (NIR)	0.851 - 0.879	30
	Band 6 - Shortwave Infrared (SWIR) 1	1.566 - 1.651	30
	Band 7 - Shortwave Infrared (SWIR) 2	2.107 - 2.294	30
	Band 8 - Panchromatic	0.503 - 0.676	15
	Band 9 - Cirrus	1.363 - 1.384	30
	Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100 * (30)
	Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100 * (30)

* TIRS bands are acquired at 100 meter resolution, but are resampled to 30 meter in delivered data product.

Working Process and Observation:

Quantum GIS Software has been used for applying Image Processing. The process of this operation is described in the following.

1. All the images were warped to a specific map projection, namely the Universal Transverse Mercator (UTM/ZONE 42, WGS 84) using a first order polynomial transform algorithm in order to assure that each permanent feature is exactly at the same location in all images.
2. With using the Semi- Automatic Classification Plugin tool in QGIS, The images were then corrected for any atmospheric interference caused by haze, dust, smoke, etc.
3. Clipping operation is applied due to making focus on the specific area, as shown in (fig.5.2a and fig.5.2b).
4. The clipped images then converted to surface reflectance. Meta data file is required to convert the land sat image to reflectance. In the downloaded land sat folder include the meta data file in "txt" format. In this process also the atmospheric correction can be applied, this correction should done only for blue and black bands.

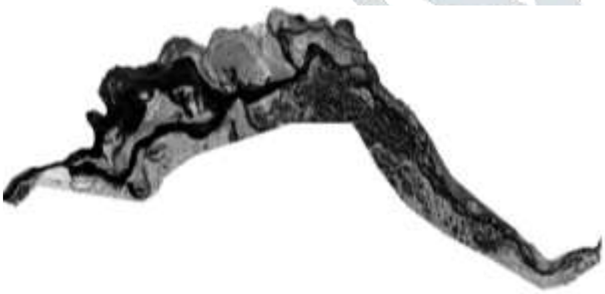


Fig. 6: Clipped images of composite bands of 2013.

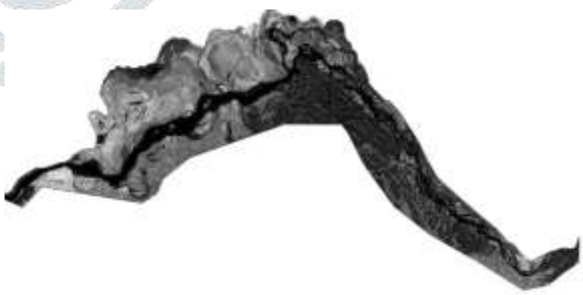


Fig. 7: Clipped images of composite bands of 2018

Landsat 8 – 2013 metadata						
Satellite		Landsat _ 8	**Date (YYYY-MM-DD)**	2013-06-20	**Sun elevation**	67.6260
Band	Radiance_MULT	Radiance_ADD	Reflectance_MUT	Reflectance_ADD	Radiance_Mximum	Reflectance_Maximum
B2	1.2461E-02	-62.30543	2.0000E-05	-0.100000	754.33185	1.210700
B3	1.1483E-02	-57.41392	2.0000E-05	-0.100000	695.11035	1.210700
B4	9.6829E-03	-48.41465	2.0000E-05	-0.100000	586.15625	1.210700
B5	5.9255E-03	-29.62735	2.0000E-05	-0.100000	358.6983	1.210700
B6	1.4736E-03	-7.36805	2.0000E-05	-0.100000	89.20502	1.210700
B7	4.9669E-04	-2.48343	2.0000E-05	-0.100000	30.06687	1.210700

Table 1: 2013 metadata

Landsat 8 – 2018 metadata						
Satellite		Landsat _ 8	**Date (YYYY-MM-DD)**	2018-06-20	**Sun elevation**	68.2260
Band	Radiance_MULT	Radiance_ADD	Reflectance_MUT	Reflectance_ADD	Radiance_Mximum	Reflectance_Maximum
B2	1.2461E-02	-62.21749	2.0000E-05	-0.100000	753.26715	1.210700
B3	1.1483E-02	-57.33288	2.0000E-05	-0.100000	694.12921	1.210700
B4	9.6829E-03	-48.34632	2.0000E-05	-0.100000	585.32886	1.210700
B5	5.9255E-03	-29.58554	2.0000E-05	-0.100000	358.19208	1.210700
B6	1.4736E-03	-7.35765	2.0000E-05	-0.100000	89.07911	1.210700
B7	4.9669E-04	-2.47992	2.0000E-05	-0.100000	30.02443	1.210700

Table 2 : 2018 metadata

The upon Tables contains data for the conversion of Landsat data to surface reflectance.

Fig 8.: Classification Training Image 2013

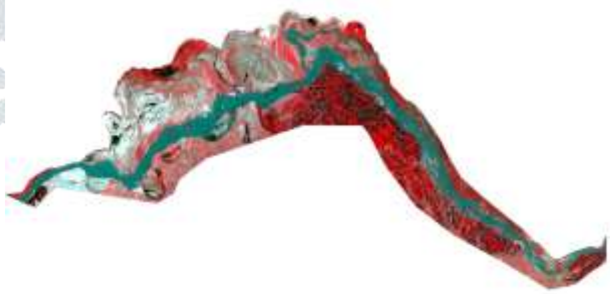


Fig 9.: Classification Training Image 2018

5. The process of defining the reflection band set is required for creating the training input files for classification.
6. Semi-automatic classification plugin tool is used for supervised classification of the region. Supervised classification consisting of 9 different classes according to major covered features of the area such as: river class, mountainous class, low elevation mountain, high elevation agricultural classes, low elevation agricultural classes, residential class, low elevation lands class, low elevation lands in danger and industrial

class. But in this project the region is classified only in two classes; River class and Land cover classes. Land cover classes is consisting of agricultural and residential areas. (Fig. 5.4a and Fig.5.4b).

7. Maximum likelihood calculates the probability that a given pixel belongs to a specific class. It builds for each class a discriminate function for each pixel in the image, this function calculates the probability that the pixel is a member of that class and also takes into account mean and covariance of training set. According to this method each pixel is assigned to the class for which it has the highest probability of membership (Khalid Soofi, 2005).

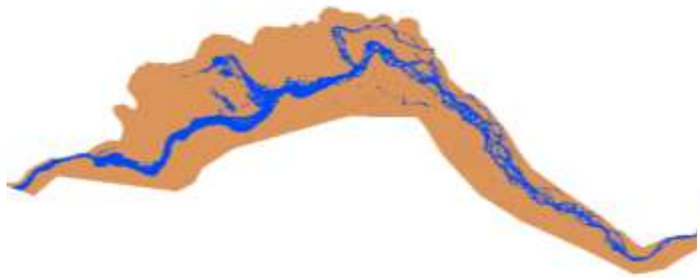


Fig.10 : Maximum likehood classification of 2013 image

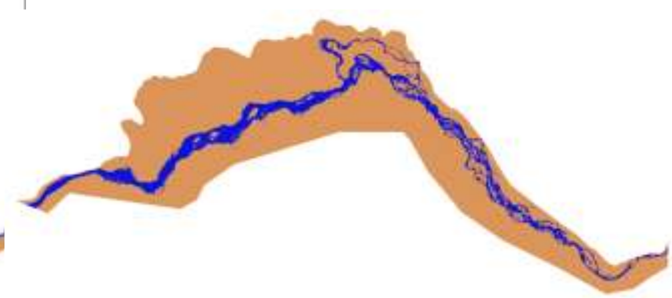
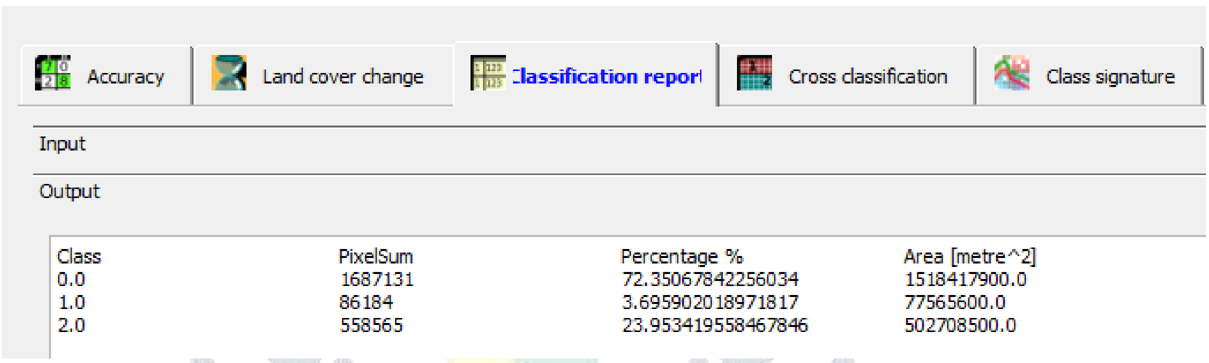


Fig 11. : Maximum likehood classification of 2018 image.



Class	PixelSum	Percentage %	Area [metre^2]
0.0	1687131	72.35067842256034	1518417900.0
1.0	86184	3.695902018971817	77565600.0
2.0	558565	23.953419558467846	502708500.0

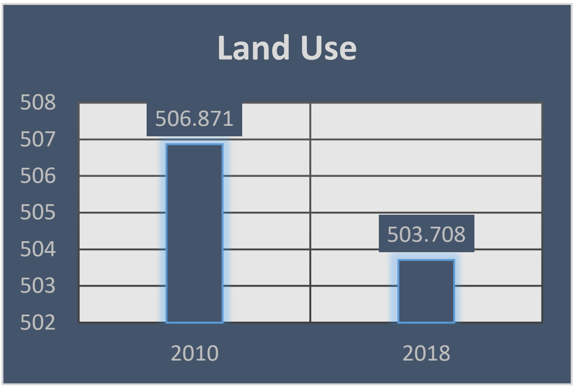
Classification report from QGIS Software

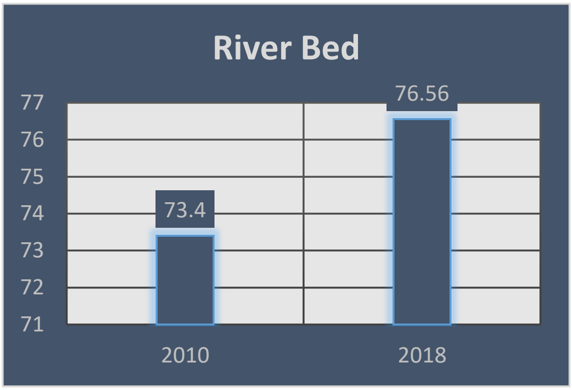
3.2.2- Result:

The final product provides an overview of the major land detection and change in coastal zone of Pyanj Amu river for 2013 and 2018 (Fig 3.4a and 5.4b). The area of each classes has been calculated by using geometry and basic statistics tools of QGIS and Excel software and it has been graphically represented in (Graph 1). The result shows that Pyanj Amu river in Afghanistan side eroded and washed almost 3.163 Km^2 in 5 years from the total study area of 580.777740 Km^2. **The increase is mainly due to poor bank and flood protection works.**

Classification Result								
2013					2018			
Class	Pixel Sum	Percentage %	Area Km^2		Class	Pixel Sum	Percentage %	Area Km^2
1	81560	12.65	73.404		1	86184	13.71	76.566
2	563189	87.35	506.871		2	558565	86.290	503.708

Table 3: The result of calculation from QGIS





Graph 1: (a) Land detection from 2010 to 2018, (b) River bed detection

Discussions and conclusions:

During the last 60 years' right banks Amu River have been applied protection operation for prevent erosion by other countries along the Amu Darya basin, but in Afghanistan band due to lack of management and facilities by the government, it have caused massive damage to precious arable land and buildings every year when the snow melt in the mountains where it originates (Geldi M, 2015). Also the majority of frit and mountain forests in north of Afghanistan were cut or depleted in the last 30 years. Unsustainable use of forests and human pressure on forests greatly exceed the rate of their natural regeneration and tree planting (Environment and Security in the Amu Darya Basin, UNEP 2011). Pyanj Amu river banks erosion also caused primarily by high flow velocity, wind driven waves and to a minor the wind velocity and duration and the expanse of open water <fetch>, the wind which blows over has the predominant factor generating waves that attack and erode the river banks. However, there has performed and undertake some measures to deal with a widespread problem but were not so much effective and satisfy, for example the Afghanistan government build temporary embankments at some of most vulnerable and defenceless points on the river, utilizing old military vehicles covered and sand bags (Fig.11). many villages at Emam sahib district because of non-appropriate proceeding by the Afghanistan government to stem the massive annual erosion that is denying work to thousand and creating homeless and destitute people (Fig. 13 and 14). Furthermore, the river traffic is also contributing the erosion of the river banks. It is going to be a serious problem for Afghanistan northern border due to extending the way of river.

Fig. 11 Gabion embankment baskets to arrest bank erosion

Fig. 12 Amu Darya river erosion at Emam Sahep district of Kunduz of Afghanistan

In other hand other states of Amu Darya also have faced different problems by the river due to non-appropriate proceeding by the Afghanistan government for example a belt of sand dunes in Afghanistan lies to the south of Amu Darya, extending over 250 km in length and u to 30 km in breadth. Dust storm formation and dune movement has been increased in recent years due to luck of forest and vegetation management which causes the loss of vegetation and cutting the woods by human for fuel purposes. Sand and dunes move into agricultural lands in the small alluvial strip beside the Amu Darya in northern provinces of Afghanistan. Dust winds from these sand dunes as well as from the dry areal sea affect the visibility and safety of road and air traffic and other activities in southern part of the Amu Darya basin. The Green Belt Program which has been undertaken by Turkmenistan and countries experience in combating desertification and biodiversity protection including the areas which has border with Afghanistan is considered by many experts as a good practice that could be expanded across borders (UNEP, 2001). Natural disaster will continue to affect the Amu Darya river basin in the future. Even though their impacts usually call for solidarity and cooperation, such events may strain relations between neighbouring states, especially if there is no understanding or common agreement on what constitutes adequate preventive measures (Fig 15). The need to prevent or control such events and to reduce their effect offers a genuine opportunity for cooperation between the relevant authorities, notably the ministries of emergency situations. It requires local authorities, disaster response organizations and the communities in the areas at risk can further increase the benefits of cooperation, particularly for industrial sites or radioactive waste deposits with a high risk transboundary pollution. Also the result show erosion is critical and the governments should employ particular protection method as the short term and long term reconstruction goals in order to prevent of more erosion that is resulting damage of hectares of agricultural lands, residential lands and political problems with its neighbours.

Fig 14. : Amu Darya River erosion at Emam - Saheb of Kunduz - Afghanistan

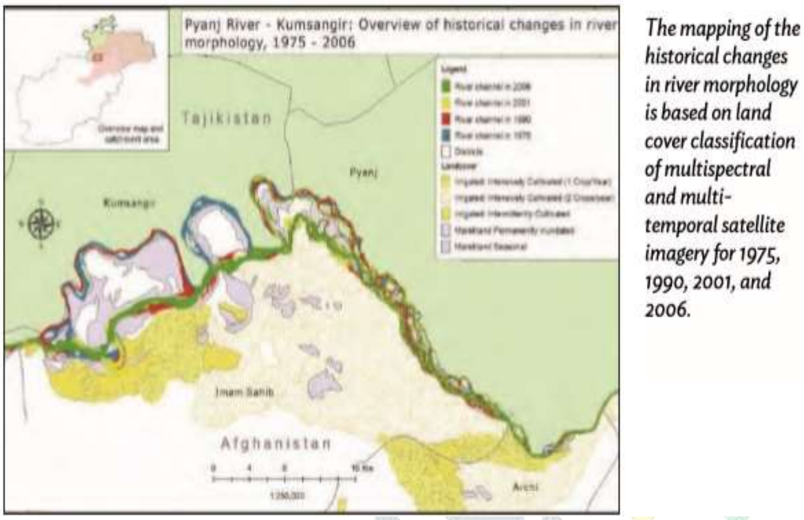


Fig 15 : The position of active channels on the Kumsangir Fan between 1975 and 2006.

Flood and erosion control management plans throughout Amu Darya river basin should undertake to reduce flooding and erosion in the zones within which natural channel migration generally occurs. A team of expert is need to carry out a feasibility study, based on the conditions of flow, nature of land, profile of the river, types of soil, and the availability of construction material, individual and relevant bank improvement types have to be chosen, designed and implemented. After the construction and completion of the river bank improvement at different parts of the river regular maintenances have to be carried out.

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