# Impact of floods 2010 in coastal area of Pakistan – a case study of Kharo Chann, Thatta District

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K E Y W O R D S

Coastal areas
Floods and cyclones
SPOT 5
Satellite images
Object Based Image Analysis
Mangroves
Climate Change
Kharo Chann

A B S T R A C T

With the increasing impacts of climate change, coastal areas have become more vulnerable to extreme events like tsunami, floods and cyclones. The ‘2010 Pakistan Floods’ brought disastrous impacts through destruction of property, livelihood and infrastructure. This study has been conducted by using space borne data and Satellite Remote Sensing (SRS) techniques to assess the ecological impacts of the floods at Kharo Chann, District Thatta, Sindh province. For this purpose, SPOT-5 satellite images dated 26th March and 28th September, 2010 of the study area were used for pre and post flood assessment. Detailed field survey data have been integrated with the satellite images and topographical data in a GIS environment to highlight the overall changes caused by the floods. Object Based Image analysis (OBIA) technique was used to map the eleven major land cover classes of the area. The study reveals that flood has a positive impact on density classes of ‘*Mesquite* / *Tamarix* spp. / Reeds, which has been increased from 1,225 ha to 3,341 ha within a time span of 6 months. In a few low depression areas, where the flood water remained stagnant, *Mesquite* has been damaged. The study also highlighted a decrease of 1,171 ha of ‘Closed to open Mangroves Canopy’. The recent floods also resulted in land erosion in some of the areas of Kharo Chann. The land cutting due to water pressure was high near Atharki, Saleh Dandal, Jamnasar and Chor Goju villages. Approximately 38 ha land was lost around these communities. During the 2010 floods, the agriculture fields were submerged resulting in a huge loss to the local economy.

## Introduction

Globally, the intensity of natural disasters has risen sharply over the past decades (Adger *et al.,* 2007). The 2010 Pakistan Floods caused by unprecedented monsoon rainfall has resulted in disastrous impacts by bringing a large part of the country underwater. Almost one-fifth of the country’s land, comprising of twenty-three districts, was severely affected in Pakistan (BBC News, 2010).

WWF – Pakistan as a nature conservation organisation developed a three tier Flood Response Strategy. The provision of relief goods and rescue efforts in flood affected project sites covered the first tier of the Flood Response Strategy. The second stage covered the flood impact and damage assessments of ecologically significant areas and the third stage supported ecological and social restoration in high priority ecosystems.

The current paper deals with the GIS/RS based component of the second stage of the Flood Response Strategy. In this study, space borne data and SRS techniques have been used for the flood impact and damage assessments of Kharo Chann District Thatta, Sindh. For land cover change assessment induced by floods, pre and post flood SPOT-5 images were acquired. Detailed *in situ* field survey data has been integrated with satellite images and topographical data in a GIS environment to highlight the overall change.

The present study aims to develop the landcover map of Kharo Chann area, District Thatta, Sindh Province, and to assess the landcover change analysis of flooded area by incorporating LCCS based legend.

## Material and Methods

### Study area

Kharo Chann *Taluka* lies in District Thatta covering an area of about 574 km$^2$. It geographically extends from 67° 43’ 42.35”E to 67° 29’ 58.82”E longitude and 23° 52’ 11.14”N to 24° 11’ 03.22”N latitude (Fig. 1). The population of this *Taluka* is about 30,500 and the people of the area are below the poverty line with fishing, subsistence agriculture and livestock as the major sources of livelihood (Singapore Red Cross, 2010). The creeks comprises of dense pockets of mangrove forests of the Indus Delta (Qureshi, 1996).

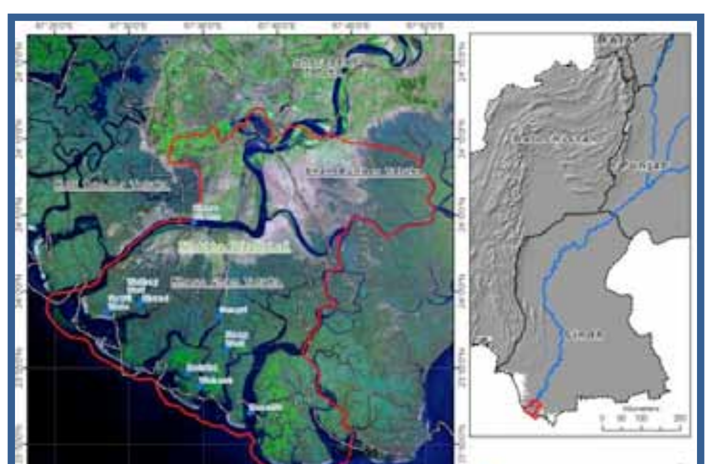

**Figure 1:** Location map of the study area

**Data Collection**

*Satellite Data and Software Used*

Pre and post flood satellite images of SPOT – 5 acquired on 26th March 2010 and 28th September 2010 have been used for the study. All the images were transformed to Universal Transverse Mercator (UTM) coordinate system, Zone 42 with Spheroid and Datum as WGS 84.

For the extraction of meaningful land cover classes, *Histogram Equalize* and *Standard Deviation Stretches* were applied. High Resolution Merging was done on multispectral (10 m) with panchromatic (2.5 m) images in order to sharpen and improve level of details within the satellite image. The high resolution image significantly helped in the selection of training samples and defining the rule which was set to extract the smaller objects and to map the features which are difficult to identify in the other conventional classification techniques.

For interpretation, processing and rule set developlment, Digital Image Processing Software ERDAS Imagine 8.7® and Definiens Developer 7.0® were used respectively. All the maps were developed in ArcGIS 9.0®. Microsoft Word and Microsoft Excel were used for documentation and graphical analysis. Field maps, Garmin GPS 76 CSX receiver and Canon PowerShot SX1 IS digital camera were used for field data collection, navigation and recording.

*Ground Truthing*

Ground truthing refers to the gathering of information about the study area by *in situ* observation from field (Sabins *et al.,* 1997).


**Figure 2:** (a) Field photographs of Mixed *Mesquite* spp. and *Tamarix* spp. (b) Mangroves

In order to collect Global Positioning System (GPS) coordinates of the land cover classes and its corelation with the spectral values of the satellite images, different hotspots and confusion areas were identified on satellite image and verified on the ground. Garmin 76CSX GPS receiver was used to collect 81 GPS points. Land vehicle and boat were used to navigate in the study area. During the ground truthing, it was observed that inland area, along the Indus river, consists of *Tamarix* and *Mesquite* spp. alongwith *Saccharum* and *Typha* spp., whereas, mudflat areas consist of dense patches of mangroves mostly *Avicenna marina* (Fig. 2a & 2b).

*Classification – Object Based Image Analysis*

In OBIA, segmentation is the first and most important step as the accuracy of the land cover is dependent on the quality and details of initial segmentation. Segmentation is a process of defining discrete objects or classes of object on the satellite image. Multiple image object levels were created and layered above the basic pixel level. Two or more image object levels build the 'Image Object Hierarchy'. It served as a storage rack for all image objects levels which represent different shelves storing the image objects. Thus, the image object hierarchy provided the working environment for the extraction of image information. All the image objects were organised into a hierarchical network of image objects. Such a network is called image object hierarchy. Muti-resolution Segmentation algorithm with parameter values i.e.

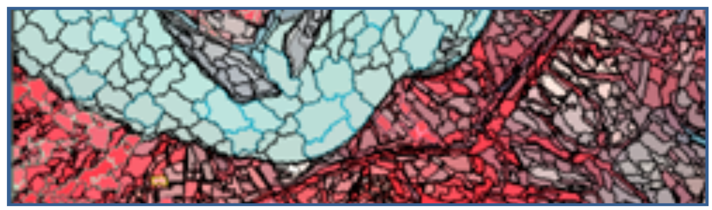

**Figure 3:** Image segments

scale - 40, shape - 0.1 and Compactness - 0.025 was used to get a segmented layer. The object hierarchy and segments defined for the SPOT-5 satellite images of Kharo Chann are shown in Fig. 3. Detailed fundamental steps involved in the OBIA are shown in Fig. 4.

*Thematic Layers Generation:* Temporal thematic maps were generated by using SPOT - 5 images (Fig. 5). The output land cover comprised of eleven classes. The area of each class was also calculated after the accuracy assessment of the output land cover maps. Definiens provides about 95 % accurate results of the output relative to the ground knowledge and samples along with the rule set.

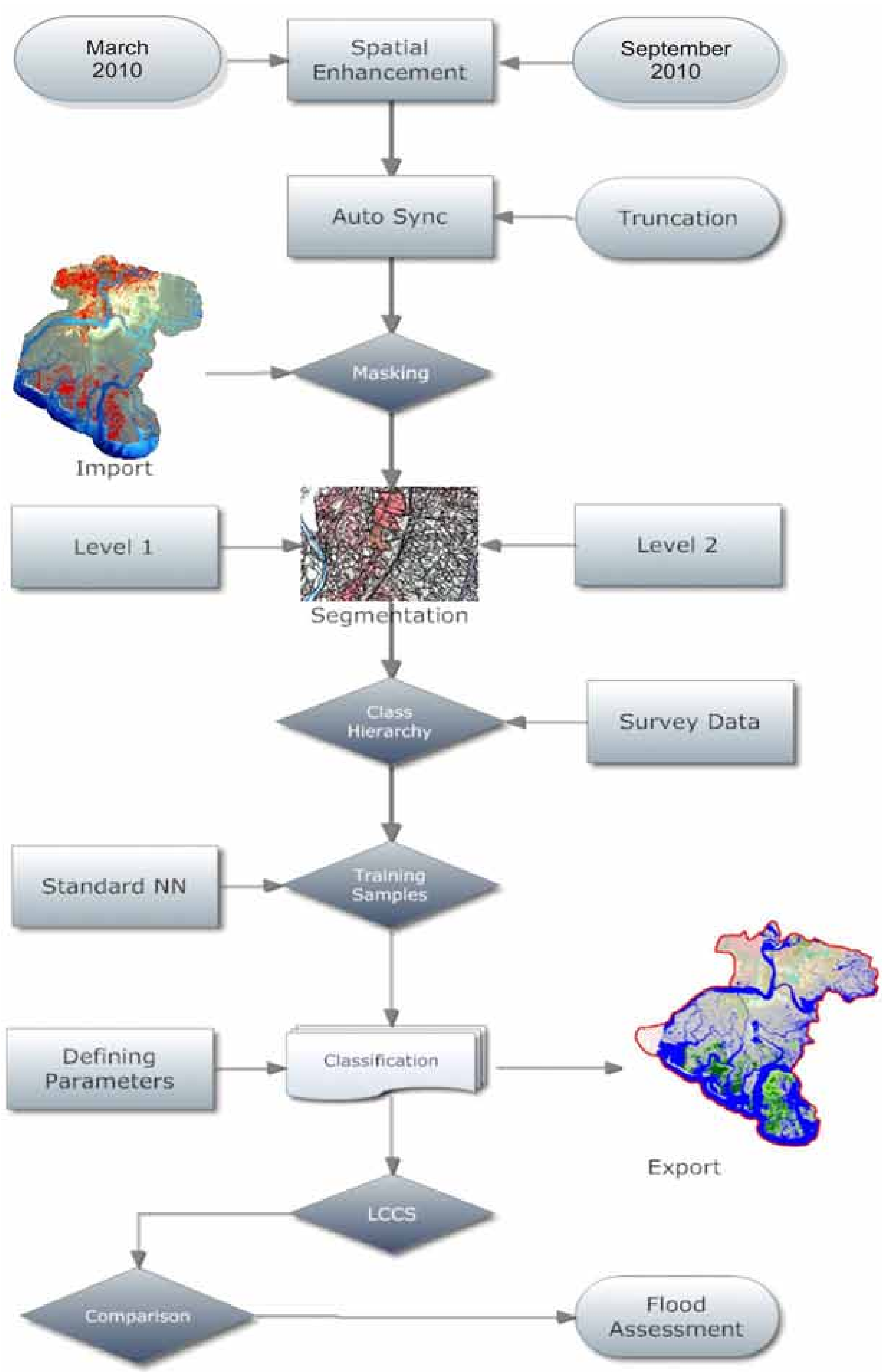


Figure 4: Flow diagram showing the detailed fundamental steps involved in Object Based Image Analysis

*LCCS Legend Definition:* Legend can be defined as the translator of the abstract land cover. It should be therefore scale and source independent which can lead integration of land cover of diverse areas in the same database. For land cover legend standardisation, Food and Agriculture Organisation (FAO) and United Nations Environment Programme (UNEP) introduced a Land Cover Classification System (LCCS) for legend definition (Di Gregorio and Jansen, 2000). LCCS provides harmonised and standardised legend for the land cover (Table 1). The classification legend follows the dichotomous structure which can be identified and recognised anywhere in the world. The classification system leads to mutually exclusive land cover classes, which comprise of the following:

- Unique numerical code
- Unique Boolean formula (coded string of classifiers used)
- Standard name [7]

Land cover legend of the Kharo Chann was developed using LCCS software (Table 2).

## Results and Discussion

The output land cover maps contain the following three categories of the vegetation types of Kharo Chann.

1 Deltaic vegetation comprises of mangroves and salt bushes

2 Riparian vegetation is along the Indus River and its outshoots. It mainly contains *Tamarix* and *Mesquite* spp., Reeds and at a few places, some trees of *Acacia* spp.

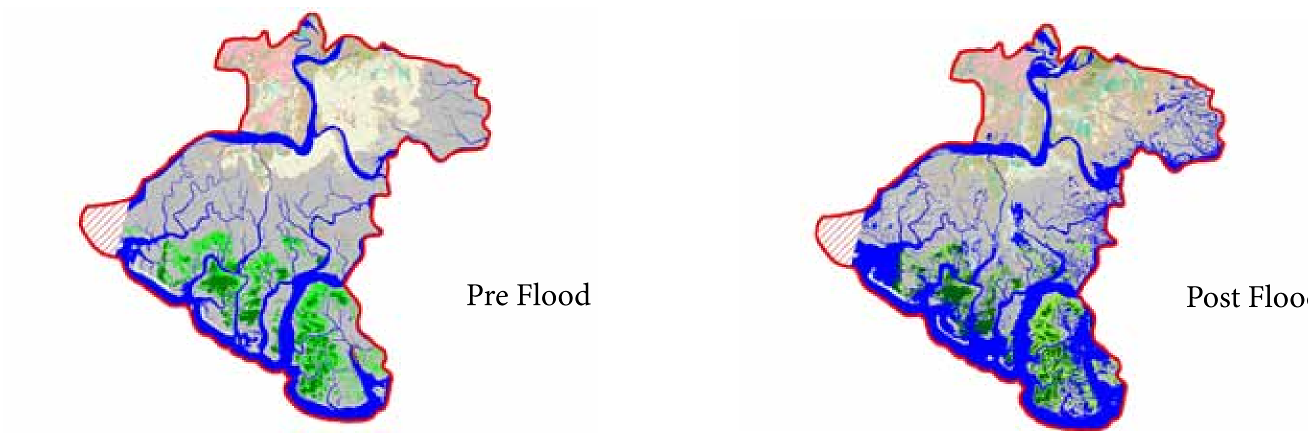


**Fig. 5:** Land Cover/ Land Use maps of Pre and Post Flood

**Table 1:** LCCS Classification

| LCC Code | LCC Level | LCC Label |
|---|---|---|
| 11239-11376 | A3B1XXC2D3D9-B3C3C7C19D4 | Permanently cropped area with surface irrigated herbaceous crop(s) (one additional crop) (herbaceous terrestrial crop sequentially) |
| 40374-21348-325 | A4A13B3C3XXXXF1-A6A11B4XXE5F2F6F10G3-A12B13G9 | Open shrubs on waterlogged soil / open ((70-60) - 40%) short grassland with medium high shrubs |
| 20606-13376 | A3A10B2XXD1E2F2F6F7G3-B7F8G8 | Broadleaved deciduous low trees with closed high shrubs |
| 22575-13378 | A3A20B2XXD1E2F2F6F7G3-B7F9 | Broadleaved deciduous closed to open low trees, with open shrubs |
| 6005 // 6009 | A5 // A6B1 | Bare soil and/or other unconsolidated material(s) / shifting sands / dune(s) |
| 8003-49 | A1B2-A5B5B9 | Non-perennial natural water bodies (standing) (surface aspect: bare soil) |
| 20606-15058 | A3A10B2XXD1E2F2F6F7G3-F9 | Broadleaved deciduous trees with open shrubs |
| 41459 | A10A12C3F1 | Closed lichens on waterlogged soil. |
| 8001-1 | A1-A4 | Natural water bodies (flowing) |
| 41639-4841 | A3A20B2C1D1E1-B6C4 | Closed to open broadleaved evergreen medium high trees on permanently flooded land (persistent) |
| 40113-4841 | A3A12B2C1D1E1-B6C4 | Broadleaved evergreen medium high trees on permanently flooded and (persistent) |

**Table 2:** Quantitative comparison of temporal land cover mapping

| Legend | Class Name | Area (ha) Pre Flood | Area (ha) Post Flood |
|---|---|---|---|
| | Closed Mangroves Canopy | 3,249 | 3,215 |
| | Closed to open Mangroves Canopy | 4,884 | 3,712 |
| | Salt Bushes/Bushes/Grasses | 6,261 | 9,804 |
| | Dense *Mesquite* spp./*Tamarix* spp./Reeds | 177 | 843 |
| | Sparse *Mesquite* spp./*Tamarix* spp./Reeds | 1,049 | 2,498 |
| | Terrestrial Vegetation/Bushes | 719 | 1,498 |
| | Mud Flats/Wet Soil | 43,184 | 31,649 |
| | Saline/Sandy Area | 344 | 3,600 |
| | Land Soil | 12,858 | 6,541 |
| | Agriculture Land | 2,479 | 2,545 |
| | Water | 17,599 | 30,231 |
| | Algal Mat | 78 | 0 |

3 Terrestrial vegetation comprises of the roadside plantations, natural trees along the agriculture fields/tracks and other inland scattered vegetation.

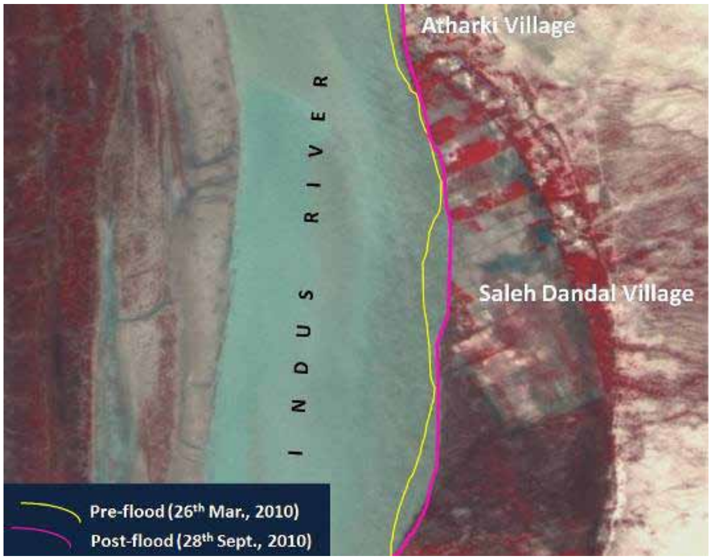


**Figure 6:** Land erosion status due to flood 2010

The flood intensity was reduced when it reached the study area, not much negative impact was observed (Fig. 6). However, the land cover changes observed during the temporal change analysis are mentioned in Fig. 5 and Table 2. The analysis of the thematic maps reveals an overall increase in the extent of the density classes of '*Mesquite/Tamarix* spp./Reeds (Table 2). The increase appears to be due to the positive impact of flood on this class especially on *Tamarix* spp. *Mesquite* spp., which is an exotic and perennial weed was present in the river bed and adjoining areas alongwith *Tamarix* spp. In low depression areas, where the flood water remained stagnant, *Mesquite* has been damaged.

These vegetative blocks have been taken away by flood waters in some of the areas. The dense patch of *Mesquite spp.* near Saleh Dandal village that appears as a maroonish red tone in the pre-flood satellite image has been dried and appears as blackish red tone in the post flood image. Although *Mesquite spp.* has been damaged in some low lying areas, but the overall contribution of the damaged class is minute compared to the healthier impact of floods on riparian vegetation.

Change analysis reveals a decrease of 1,171 ha of 'Closed to open Mangroves Canopy'. This might be due to the high tide height at the time of the post flood image acquisition or the clearing of sparse juvenile mangroves at the edges of the creeks. Climate Change By comparing the thematic maps of March 2010, and September

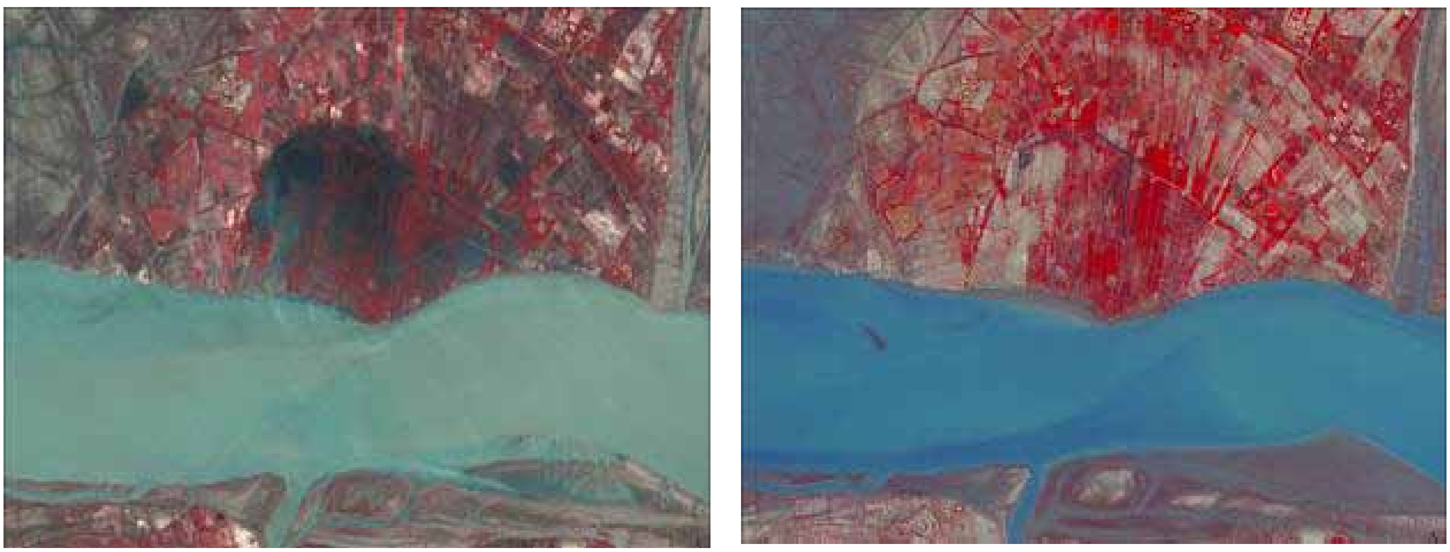

**Figure 7:** Pre and post flood image – *Mesquite* in low lying areas

**Figure 8:** Pre and post flood images - Agricultural fields submerged after the floods

2010, an increase in land cover classes of bushes and grasses has been observed. This is mainly due to the seasonal variation/post monsoon impacts. It was analysed by comparing pre (26th March, 2010) and post (28th September, 2010) flood satellite images and the land cover maps that recent floods have resulted in land erosion in some of the areas of Kharo Chann. The land cutting due to water pressure was high near Atharki, Saleh Dandal, Jamnasar and Chor Goju villages. Approximately, an area of 38 ha has been lost around these villages during the flood period. The areas near Atharki and Saleh Dandal villages have been facing land erosion since year 2000 but the floods of 2010 washed away some of the agricultural fields and houses as shown in Fig. 7.

## Conclusion

The study area, once heaven for the agriculturalists has now been transformed into the saline pools due to the imbalance between the fresh and brackish water. During 2010 floods, the agricultural fields were submerged with flood water and resulted in economic loss. Despite the fact, communities have greeted the 2010 flood with the belief that agriculture land will become fertile due to the dilution of salt by freshwater flooding.

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## References

Adger, W.N., S. Agrawala, M.M.Q. Mirza, C. Conde, K. O'Brien, J. Pulhin, R. Pulwarty, B. Smit and K. Takahashi (2007). "Assessment of adaptation practices, options, constraints and capacity." Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Eds. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson. Cambridge, UK: Cambridge University Press.

Di Gregorio, A. & Jansen, L. J. M. (2000): *Land Cover Classification System: LCCS: Classification Concepts and User Manual*. Food and Agriculture Organisation of the United Nations, Rome.

BBC News Online. "Millions of Pakistan children at risk of flood diseases". 16 August 2010. [http://www.bbc.co.uk/news/world-south-asia-10984477].

Qureshi, M.T. (1996). Restoration of Mangroves in Pakistan (pp: 126-142) in Restoration of Mangrove Ecosystems by Colin Field (Ed.), The International Tropical Timber Organisation (ITTO) and International Society for Mangrove Ecosystems (ISME). Okinawa, Japan.

Sabins, F. F. Jr. (1997). Remote Sensing Principles and Interpretation. 3rd ed. New York: W. H. Freeman & Co

Singapore Red Cross. "Pakistan Floods: The Deluge of Disaster - Facts & Figures as of 15 September 2010". [http://www.reliefweb.int/rw/rwb.nsf/db900SID/LSGZ-89GD7W?OpenDocument