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Estimation of Land Use/Land Cover Change of Harike Wetland - A Ramsar Site in India, using Remote Sensing and GIS Approach

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ABSTRACT:*Wetlands play vital role in sustainable ecological development. Their benefits for man and conservation for biodiversity are manifolds. Nonetheless, their degradation particularly in developing countries have taken top gear. To safeguard the biodiversity and ecological balance, there is need to understand the wetlands transition process, taking into account measures for their conservation. The present study was carried out to predict the landcover changesin Harike wetland from the year 1995 to 2017 using Landsat Satellite data. Satellite data revealed that with the conversion of non-agricultural land to agricultural purpose actual wetland area has reduced significantly. Supervised classification of the satellite image also admits the rapid increase (153.5%) in the agricultural land area from year 1995 to 2017.*

Keywords: Harike, wetland, landcover, landuse, satellite, landsat, remote sensing

INTRODUCTION

In developing countries, resource depletion and stress are major growing problems (Repetto and Holmes, 1983). Due to lack of proper infrastructure, management and technology, these countries are recognized for their poor economics and poverty (Cohen, 2006). Moreover, due to their rapid population growth, these countries adversely affect the natural resources and local ecosystem. Large tracts of forests are deforested for different purposes including land for agriculture and cattle grazing, for production of building material, for the land to be used for urban development and for fuels to be converted into fuels and charcoal (Allen and Barnes, 1985). Deforestation makes the soil prone to erosion, disrupts the hydrological cycle in nature and is responsible for the loss of habitat and biodiversity (Evelyn et al., 2003).

Wetlands are characterized by soils that remain waterlogged or under shallow water permanently or for periods long enough to cause certain changes in their physico-chemical and biological characteristics and to allow the growth and development of plant and animal communities specifically adapted to the particular hydrological regimes (Mitsch and Gosselink, 2000). These wetland ecosystems occupy about 6% of the total land mass at global level (Maltby and Turner, 1983). India being a tropical country and due to its geography it supports a rich diversity of inland and coastal wetland habitats. The latest and updated wetland inventory called as “National Wetland Atlas” of India was carried out on the behalf of Ministry of Environment and Forests by Space Applications Centre (SAC), Ahmedabad in 2011 and their survey revealed that there are total 201,503 identified wetlands in India that have been mapped on 1:50,000 scale (Space Application Centre, 2011). As per the estimates, India has about 15.3 million ha of total wetland area, which accounts for 4.7% of the total graphical area of the country (Bassi, 2014).

Wetlands play a vital role in ecological balance of a region. Their role in biogeochemical and water cycling are evident and their services to human life are manifold. They also protect and improve the environment and ecology and keeps the local weather moderate. Wetlands constitute a major class of aquatic ecosystems. Being physically sandwiched between the terrestrial and open water systems they act as transitional zones in nature between these systems (Gopal, 1994). Nonetheless, the wetlands throughout the world has recorded degradation since from the last three decades. With the increase in the world population more and more land are being converted to agriculture and industries to full fill their needs. Satellite Remote Sensing and Geographic Information System (GIS) as a geospatial technology have been widely used for assessment, monitoring and classification of wetlands. Satellite data can provide repeated coverage, and thus multi-temporal data of the same area, which is very useful in detecting the various changes occurring with time and space for the same area.

THE STUDY AREA

Harike wetland is one of the largest freshwater wetland of north India. In 23/03/1990 it was declared as Ramsar site in India owing to the compliance of criteria 2, 5 & 6 as described below (Space Application Centre, 2011)

•Harike Wetland supports threatened ecological communities.

• More than 20,000 water birds are regularly supported by Harike wetland.

• Wetland regularly supports 1 % of the individuals in a population of one

species or sub-species.

Harike wetland bears the Indian Ramsar sites code 1201. It is shared by the districts of Amritsar, Ferozepur, Jalandhar and Kapurthala in Punjab India between the latitudes of 31^{o}06'

N and 31^{o}12' N and longitudes 74^o 55' E and 75^o 05'E.The wetland lies 55 km south of the Amritsar and supports various rare, vulnerable, and endangered faunal species that come across the different countries such as Eastern Europe and Siberia, and a large population of avifauna visit Harike wetland during the winter season. Figure 1 below gives the location and geographical extent of Harike wetland.

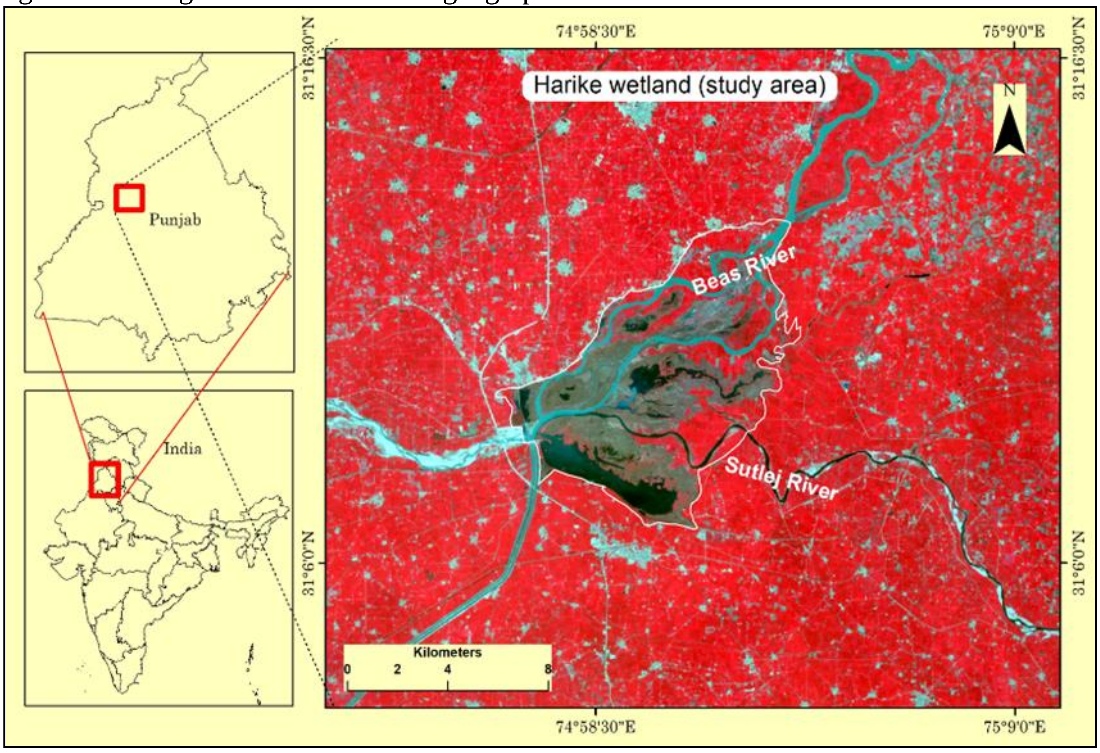

Figure 1: Location of the Harike Wetland

MATERIALS AND METHODS

Satellite image processing

Satellite images of Landsat-5-TM and Landsat-8-OLI scenes covering the study area were obtained from the United States Geological Survey) USGS *(https://earthexplorer.usgs.gov)*.The multi-temporal Landsat images acquired on 19-02-1995 and 15-02-2017 had cloud cover of 10%. Both the Landsat images were processed for

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haze removal and atmospheric correction in Rolta Geomatica 15.Unsupervised classification was carried out using ArcGIS 10.3 version. During the ground truthing *etrex 30*, Garmin Global Positioning System (GPS) receiver was used to determine the geo-coordinates of a given area in terms of its latitude and longitude.

The Landsat images used in this study have been orthorectified to remove distortion due to topographic variation. The images were subset to limit image processing to the area of interest (AOI), to make image processing easier and to extract the wetland area. Figure 2-A and 2-B represents the pre-classified of Landsat-5-TM and Landsat 8-OLI respectively.

Image classification

Satellite images from Landsat 5 (19-feberuary, 1995) and Landsat 8 OLI (15-feberuary, 2017) were classified in ArcMap 10.4 using unsupervised image classification technique.Having the good knowledge and familiarity of the study area, each image was classified into 5 different classes namely water, wetland vegetation type I, wetland vegetation type II, agricultural land and barren land. Usingvisual interpretation.Water class represents both the surface river water (Beas and Sutlej rivers) as well as wetland open water Wetland. The Wetland vegetation type I includes the green vegetation growing on the wetland water such as *Eichhhornia crassipes* (water hyacinth). Due to its high chlorophyll content this class exhibits radiometric reflections that are sometimes similar to that of the agricultural crops and hence cause interference with their measurements. The vegetation grown on the wetlands swampy areas with less water content has been categorised as wetland vegetation type II e.g. *Typha* species.Barren land includes bare soil and river sand that cause high reflection in the visible region.

The output classified images as thematic maps have been given in the figure 3-A and figure 3-B respectively. The classified images were compared with information obtained from topographical sheets, available wetland maps as well as the data from ground truthing as GPS coordinates of the study area to confirm the thematic classes on the classified images. Finally boththe images were compared to measure the change detection in land use land cover over the various classes and prediction for the wetland total area shrinkage.

RESULTS AND DISCUSSION

Results of the classified images have been summarised in the figure 5. Results revealed that total area of Harike wetland in including agricultural land area was 7434 hectares. However, since from 1995 there was tremendous change in the landcover of the Harike wetland. In the year 1995 class water constituted40.1% (2975 ha) of the total area of Harike wetland which was subsequently reduced to 21.14% (1572 ha) in 2017. However, results shown that there was huge conversiontowards the agricultural land from year 1995 (919 ha) to 2017 (2329 ha) accounting an increase of 153 percent. From 1995 to 2017 the barren land was reduced

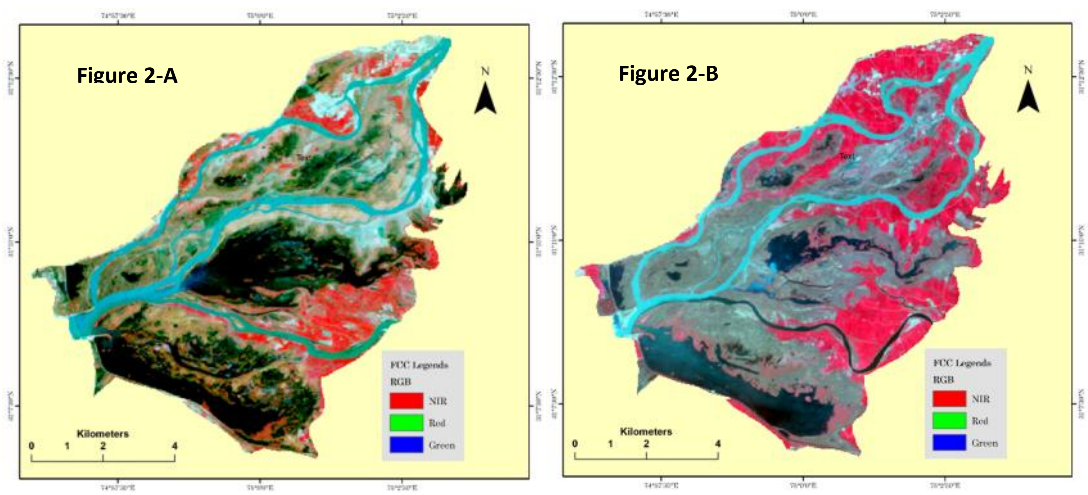

Figure 2-A and 2-B, Harike wetland from Landsat satellite images for year 1995 and 2017 respectively

from 969 ha (13.04%) to 739 ha (9.94%) with decrease of 23.8%. Wetland vegetation type I and Wetland

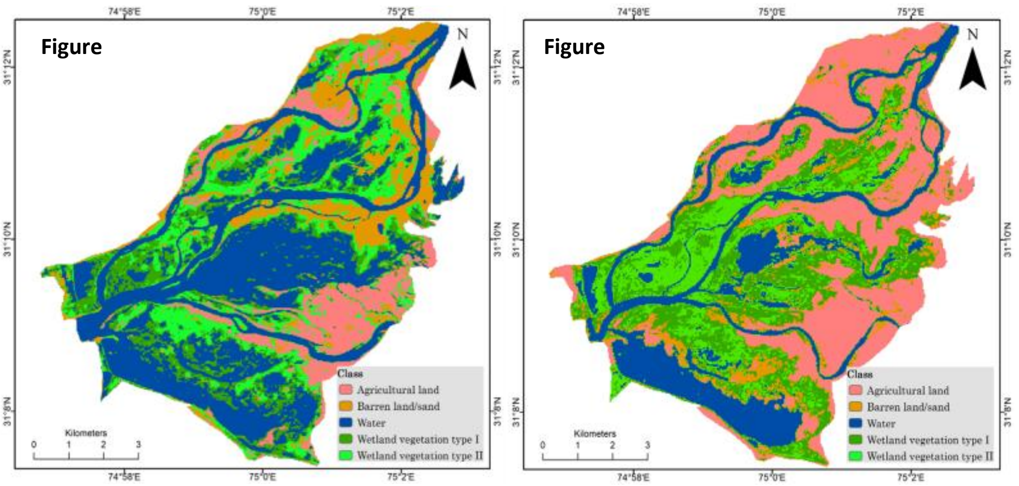

Figure 3-A and 3-B classified images of Landsat for year 1995 and 2017

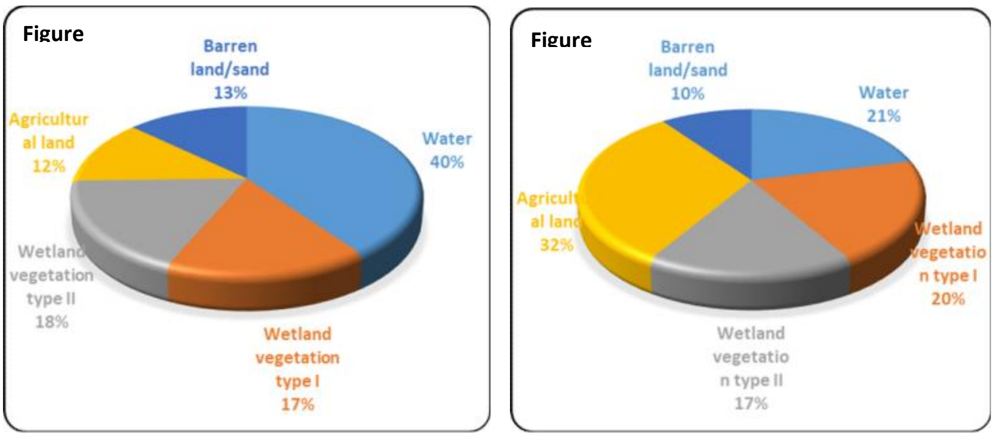

Figure 4-A and 4-B shows the percentage area of the different landcover in 1995 and 2017 respectively

vegetation type II were changed from 1230 ha (16.55%) and 1342 ha (18.04%) from 1995 to 1511 ha (20.32%) and 1284 (17.27%) in 2017 respectively.

Landcover changes in percentage from year 1995 to 2017 has been summarised in the figure 6 which clearly indicates that in agricultural land there was highest increase (153%) whereas, water class indicates the highest decrease (-47.2%) in the land cover change.

Land-use activities often affect the overall function of wetlands. Diversion of wetland areas for agriculture, commercial and residential development and change in the hydrology of the wetland are the major factors responsible for the Harike wetland degradation. The decrease in the water from 40% to 21% of the total area of the wetland in 1995 and 2017 respectively is the indication of hydrology change of the wetland. Soil erosion and siltation are the other major issues responsible for the rapid landcover changes in the Harike wetland. The river Beas flows across the mountainous region of Himachal Pradesh carrying portion of sediment that ultimately finds its way to the wetland and there by replacing the water with swampy patches which further undergo succession.Further weed infestation such as *Eichhornia crassipes*(covers roughly 50% area of wetland),*Typha* species (dominant emergent marsh vegetation of Harike wetland) and *Nelumbo nucifera*worsen the situation.Uncontrolled discharge of waste water, industrial effluents carried by the water of river Sutlej and the surface run-off from the agricultural fields proliferate the aquatic weeds.

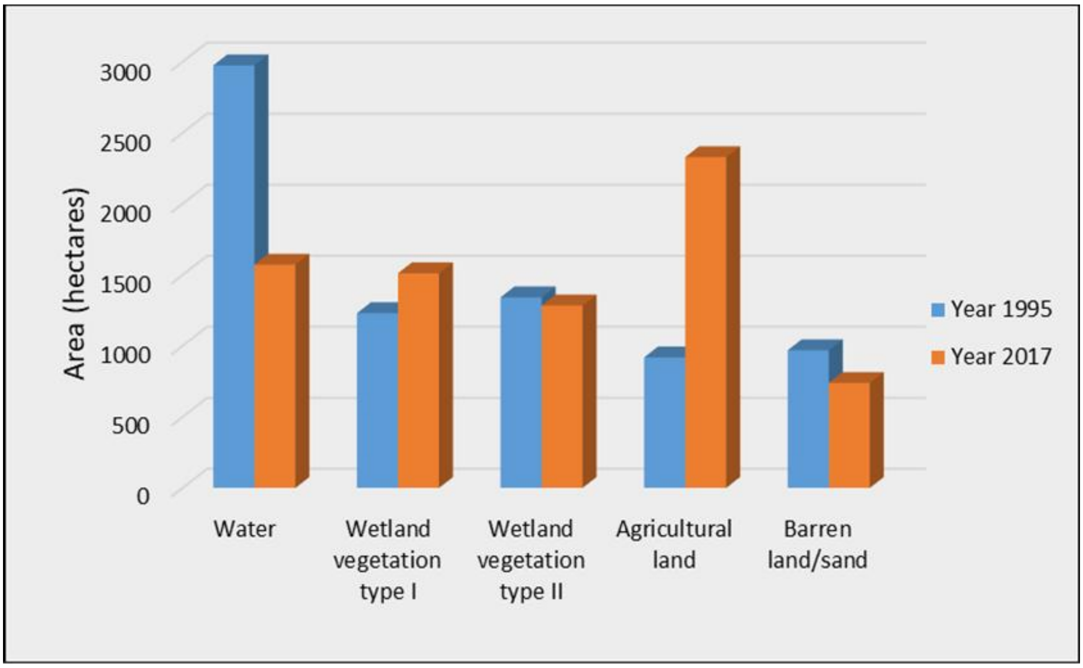

Figure 5: Landcover area under different classes of Harike wetland in year 1995 and 2017

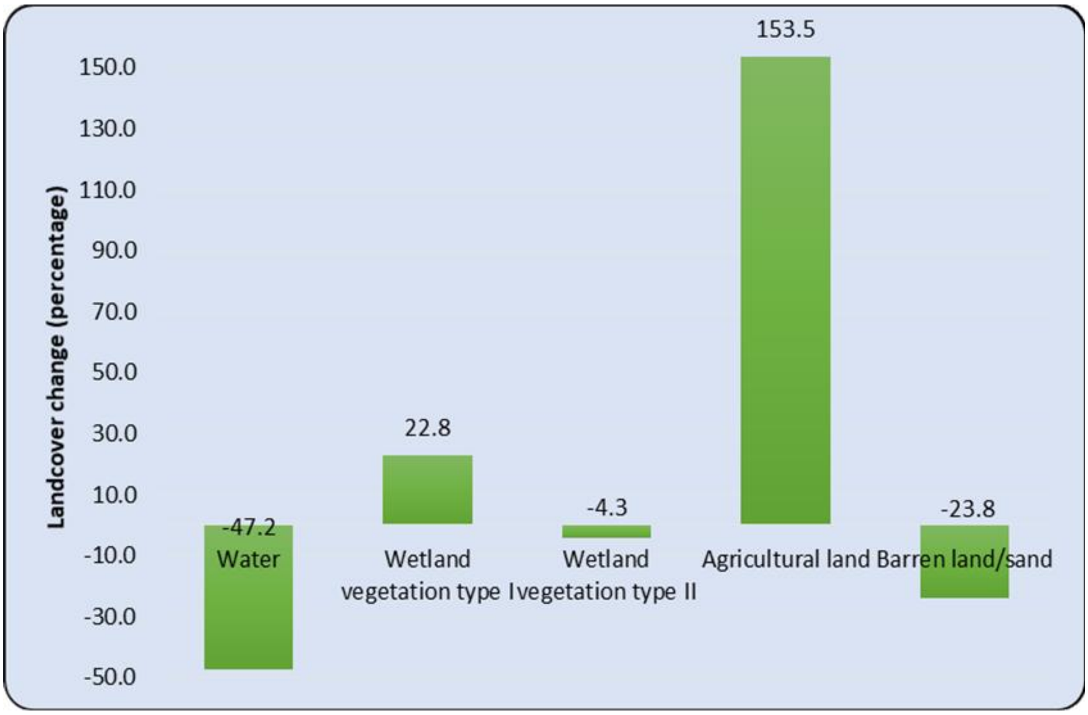

Figure 6: Landcover changepercentage from 1995 to 2017

CONCLUSION

The area under water showed a highest marginal decrease (47.2 %) and agricultural land area highest increase (153.5%) from 1995 to 2017.Vegetation type II and barren landcover also got reduced from the year 1995 to 2017. However, landcover of wetland type I showed a trend of increase in the total area. Most of the barren land area has been converted particularly to agricultural Land. With the diversion of different landcover classes to agricultural land the actual wetland area has shown the signs of degradation.Weed infestation particularly *Eichhornia crassipes*and *Typha* species, change in the lake hydrology and soil erosion and siltation problems of the wetland were responsible for Harike wetland degradation. Therefore, in order to protect and conserve this valuable resource there is need to adopt the integrated watershed management approach and the local people should be conveyed by governmental and non-governmental organisations about the benefits of the natural resources and the effects of their degradation on social, economic and environmental aspects.

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