CHAPTER 10
HARIKE WETLAND VULNERABILITY ASSESSMENT

10.1 Introduction

Wetlands occur in intricate ecological environments that observe rapid changes both spatially and temporally in terms of their function and ecological diversity. Wetland ecosystems are predominantly vulnerable to changes occurring in the surrounding water quality and quantity, as these changes may damage or sometimes improve their physical, chemical and biological status (Alegria et al., 2006). The major adverse consequences for these changes may include water pollution, depletion of groundwater, soil erosion, sedimentation to open water area of wetland and loss of biodiversity (Atapattu and Kodituwakku. 2009). Wetlands are also threatened by the human-induced changes in land use/land cover and indirectly increase their risk of vulnerability to climate change. Therefore, wetlands have been under wide range of anthropogenic as well as natural forces that exposed them to wide range of threats. Thus, in order to develop suitable conservational and management strategy, their understanding and assessment is necessary.

In this part of the study, an attempt has been made to assess the different physico-chemical changes and processes occurring in the wetland catchment and their possible influence on the vulnerability of Harike wetland.

10.2 Data and Methodology

In the present study, Remote Sensing data and GIS approach have been employed for spatio-temporal assessment of the Harike wetland and its catchment. Multi-temporal satellite data of Landsat 5 (1995), Landsat 8 OLI (2016) and IRS P6 LISS-IV (2016) have been used to prepare the LULC map of the Harike wetland and its catchment and was subsequently used for the change detection analysis. As the soil erosion in the wetland catchment has been considered as one of the factors on which the wetland vulnerability is based, methodology for soil erosion assessment using RUSLE has been given in the section 7.4 of Chapter 7. Also, water quality of the Harike wetland has been considered another parameter on which the wetland vulnerability was assessed. The materials and methodology used for its water quality assessment has been described in detail in section 5.2 of Chapter 5.
For vulnerability assessment study, besides the above mentioned factors, other parameters such as land use/land cover change occurring in wetland and its catchment from the last 20 years, water quality of the rivers (Beas and Sutlej) and adjacent catchment area and the average soil erosion loss in the wetland catchment area has been considered as the basis for performing the study. The methodology flowchart for the present study has been shown in the Figure10.1 below:

Figure 10.1: Flowchart methodology adopted (for vulnerability assessment)
Figure 10.2. FCC Landsat-5 satellite Image (1995)

Figure 10.3. FCC Landsat-8 satellite Image (2017)
10.3 Results and discussion

10.3.1 LULC dynamics and human encroachment of wetland

The Harike wetland and its catchment has experienced major land use land cover changes during the study period from year 1995 to 2016. The satellite images (FCC) of the whole study area have been shown in Figure 5.1 and 5.2 in section 5.2, of Chapter 4. The supervised raster maps have shown in Figure 4.4 and 4.5 in section 4.4 of the same chapter.

In order to have a detailed account on vulnerability of Harike wetland to LULC dynamics, Land use/land cover of Harike wetland was prepared using satellite images of Landsat 5 (19-February, 1995) and Landsat 8 OLI (15-February, 2017). The classified images have shown in Figure 10.4 and 10.5, and their statistical data has been given in Table 10.1. The results reveal that Harike wetland is facing problems of human encroachment as indicated by the increase in the agricultural land (18.87%) and reduction in the water area (18.97%) and waste/barren land (2.3%). These changes in the LULC are due to the increasing demand for more food that require conversion of non-agricultural land to agricultural purposes. Ladhar (2002); Mabwoga and Thukral, (2014) have also reported Harike wetland area shrinkage due to the rapid conversion of wetland area into agricultural purposes; which finds agreement with our study.
Figure 10.4: Supervised Classified Image of Landsat-5 (1995)

Figure 10.5: Supervised Classified Image of Landsat-8 (2017)
### Table 10.1: LULC change data of Harike wetland (1995 to 2017)

<table>
<thead>
<tr>
<th>Class</th>
<th>Year 1995 Km² (%)</th>
<th>Year 2017 Km² (%)</th>
<th>Change decrease/increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>29.75 (40.01)</td>
<td>15.72 (21.14)</td>
<td>-18.87</td>
</tr>
<tr>
<td>Wetland vegetation</td>
<td>25.72 (34.59)</td>
<td>27.95 (37.59)</td>
<td>3</td>
</tr>
<tr>
<td>Agricultural land</td>
<td>9.19 (12.36)</td>
<td>23.29 (31.33)</td>
<td>18.97</td>
</tr>
<tr>
<td>Waste land/Barren</td>
<td>9.69 (13.04)</td>
<td>7.39 (9.94)</td>
<td>-2.3</td>
</tr>
<tr>
<td>Total</td>
<td>74.33</td>
<td>74.34</td>
<td>—</td>
</tr>
</tbody>
</table>

Source: Computed from Landsat 5 (1995) and Landsat 8 TM (2017) satellite data

### 10.3.2 Soil loss in the catchment and sedimentation of wetland

Assessment of soil erosion is one of the most important parameter for soil and water conservation practices in the wetland catchment. Sediment accumulation in wetlands from their catchments may significantly cause the shrinkage in their volume, and also cut the time duration that wetlands can retain water (Jurik et al., 1994; Wang et al., 1994); which in turn can adversely affect the ecological function of the wetlands (Johnston et al., 1984). At Harike Lake, a bathymetric survey carried out in year 2010 showed that the Harike wetland has lost more than 83% of its water holding capacity over the past five decades as a consequence of rapid siltation (Domini et al., 2013).

In the present study, soil erosion rate for more than 1000 km² area of the wetland catchment have shown average soil erosion rate greater than 5 t/ha/year, and the soil eroded from Harike catchment finally gets deposited in the Harike wetland replacing open water and subsequently resulted in the reduction in water area particularly at Harike wetland. These changes in the area covered by water is obvious from the supervised images of Landsat 5 and Landsat 8 shown in Figure 10.4 and 10.5.

As per the reports, out of the total soil eroded from a catchment, about 10% of it gets deposited in reservoirs (Kirurhika et al., 2011). A small waterbody fed by muddy water and eroded soil from the catchment will rapidly lose its open water area.
This Harike wetland is silted up particularly through the Beas river catchment as it has many areas that are highly degraded having deep gullies that has resulted from soil erosion (Figure 10.6A and 10.6B). Heavy silt load is observed into Harike wetland due to soil erosion particularly from the northern side of the wetland. Consequently,

**Figure 10.6A and 10.6B:** Soil erosion problems in the Harike catchment.

this led to the decline of storage capacity of Harike Lake (reservoir) and is one of the biggest threat to biodiversity and ecological functioning of the Harike wetland. Chopra
et al. (2001); Ladhar, (2002). Tiwana et al. (2008) have also reported that Harike wetland is vulnerable to soil erosion and siltation.

10.3.3 Weed infestation, as the result of nutrient input to the wetland

Weed infestation is one of the major problems facing the global wetlands and lakes. Wetlands are more vulnerable to invasion as these are the sinks that receive supplies such as sediments, water with excess nutrients, salts etc., that augment the weed invasion (Zedler and Kercher, 2004). As the results of the present study have also shown, certain water quality parameters such as nitrates, phosphates and BOD in Sutlej water have relatively higher values. Presence of these nutrients (nitrates and phosphates) in the aquatic environment enhances the weed growth, particularly of Water hyacinth. In Harike wetland, Water hyacinth is the most dominant weed. As the results reveal, the wetland vegetation of the Harike wetland has increased by 3% from 1995 to 2017 (Table 10.1), indicating high input of nutrients from wetland catchment. The nutrients are supplied by the various non-point and point sources, including the Sutlej River that receives huge quantity of sewage and industrial effluents from Buddha Nalla in Ludhiana. Therefore, the various nutrients along with nitrates and phosphates from Sutlej water and adjacent catchment areas of the Harike wetland are thought to be responsible for huge weed growth, especially Water hyacinth at Harike wetland.

Therefore, all the results concluded that Harike wetland is vulnerable to silt deposition, human encroachment that led the shrinkage of the actual wetland area, and weed infestation which resulted in the rapid growth of wetland weeds, especially the Water hyacinth. Hence, suitable measures should be employed at local and regional for the conservation and management of Harike wetland.