Assessment of Land Use/ Land Cover Changes and Its Impact on Wetland Ecosystem of Loktak Lake using Remote Sensing and GIS Techniques – A Ramsar Site in Indo Burma Biodiversity Hotspot

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Abstract:
Land use/Land cover plays a major role in regional environment pressure leads desire on undesired alterations in landscape ecology. The Loktak Lake is a unique natural ecosystem with numerous national and international significances. The aim of the present study is to assess the changes in land use/land cover in Loktak Lake during the last 38 years. Landsat MSS images of 1977 and Indian Remote Sensing LISS III of 2015 were used to assess the LU/LC changes in the study area. The methodology adopted is the supervised classification using maximum likelihood technique in ERDAS software. Following land use class were delineated such as open water bodies, agricultural area, Phumdis with thick vegetation, Phumdis with thin vegetation and settlement. The result indicates that during the period of study, open water bodies, agricultural area and settlement have shown increased trend by 10.94%, 10.26% and 2.23% while Phumdis with thick and Phumdis with thin vegetation have decline trend by 3.48% and 28.89%. The change in land use pattern has severely affected the fragile wetland ecosystem of the Loktak Lake.

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With Post graduation in ecology background he has 21 years of experience in the field of Environmental remote sensing with special emphasis on ecological restoration. At present, he is working in the field of land use/land cover changes, climate change studies and health GIS. He has guided 10 Ph.D., 12 M.Phil. and 23 M.Sc. He has good number of publications in peer-reviewed National and International journals with impact factor in different areas of environmental studies. Also he completed national and international major research projects funded by DST-CO² Sequestration, ICMR, UGC, DST-NRDMS, DST-SERB, OPCF-Hong Kong and ongoing national major research projects is funded by MoEF & CC as principal investigator.
Introduction

Lakes are one of the most productive wetland ecosystems on earth (Constanza et al., 1997) and ecotone between aquatic and terrestrial ecosystems. The increase in human population and raise in urban sprawl has led to severe input on the wetland. The sprawl in the land use is driving an unprecedented change in ecosystems and environmental processes causing direct and indirect impact on biotic and abiotic components leading to change from local, regional to global scales. The human induced LU/LC is one of the most important factor for regional environmental changes and it impact significantly on natural resources. The present rate of change is a major concern for the human society such as climate change, biodiversity loss and pollution problems (Erle, 2013). The past few decades show an emerging trend in destruction of wetland leading to degrade in landscape diversity and increase in fragmentation rate leading to change in ecological function of wetlands. (Costanza et al., 1998; Chen and Lu, 2003).

Land use changes and hydrological disturbance due to human activities is the reason for the degradation of wetlands worldwide (Mitsch and Gosselink, 1993; Barbier et al., 1997). A significant changes in land cover has been observed during the last few century on spatial and temporal scale due to economic development and population growth (Mitsch and Gosselink, 1993). In India, the loss of wetland is mainly due to urbanization, land use changes, runoff from agriculture, infrastructure development and pollution from industrial effluent and climate change variability (Nitin et al. 2014).

The advantage of RS is that it can detect the changes in aerial of wetlands, percent cover of vegetation, as well as replacement of plant community by another (Tiner, 2004). Geographic Information system is a valuable tool for studying the nature of wetlands and the potential of their restoration (Gottgens et al., 1998). The objective of the present study is to identify the trend in land use/land cover changes in Loktak Lake and its impact on the wetland ecosystem during the last four decades.

Study area

It is an unique natural wetland ecosystem with numerous national and international significances designated under the Ramsar Convention (Fig. 1). It is the largest fresh water lake in North East India covering an area of 246.72 km² (National Wetland Atlas 2009) and located between $93^\circ 46'$ - $93^\circ 55'$ E and $24^\circ 0 25'$ - $24^\circ 0 42'$ N. About 12 towns and 52 settlements are located in and around Lake with a population of 2, 20,017 persons, i.e. 9% of the total population of the state of Manipur (Census Report 2011). The lake is famous for its floating island locally known as Phumdis. The lake is divided into three zones, the northern zone, central zone and southern zone. The central zone is the main open water area which was relatively free from floating island. The Keibul Lamjao National Park (KLN) covering an area of 40 km² located in the southern
zone is the world’s only floating national park and last natural habitat of highly endangered Manipur brow antlered deer *Rucervus eldii eldii* locally known by Sangai.

![Fig. 1 Location of the Loktak Lake](image)

**Fig. 1 Location of the Loktak Lake**

**Materials and Method**

**Land Use/Land Cover Classification**

The change in land use studies were obtained from Landsat TM and IRS LISS III images of February 1977 and 2015. The collected satellite images were geo-referenced using SOI Toposheet map 1977 in a scale of 1:50000. Study area was divided into five types including open water area, agricultural area, Phumdis with thick vegetation, Phumdis with thin vegetation and settlement. Based on the geo referenced images using ERDAS Imagine software, the images were interpreted by supervised classification using maximum likelihood technique. Using Arc GIS tool, the land use of Loktak Lake were extracted as the basic data for the land use/land cover changes analysis.

**Accuracy Assessment**

An equalized stratified random sampling was carried out in the study area to assess the accuracy of the classified land use/land cover changes. The overall accuracy and Kappa analysis was carried out to classify the accuracy level using the random points. For each land use class, 50 points were randomly selected and verified on the LU/LC map generated. The accuracy of the maps were assessed by analyzing the thematic map with ground observation points.
The classified images obtained from the analysis of multidated satellite imageries of Loktak lake are shown in Fig. 2, Fig. 3 and Table 1. Five different land use types were classified and delineated using image interpretation technique in ERDAS 11 and ArcGIS 10 software. The land use pattern in 1977 of Loktak lake are under open water bodies (74.76 km\(^2\)), agricultural area (10.33 km\(^2\)), Phumdis with thick vegetation (24.23 km\(^2\)), Phumdis with thin vegetation (132.24 km\(^2\)) and settlement (5.16 km\(^2\)). During 2015, the area under the land use categories are open water bodies (101.65 km\(^2\)), agricultural area (35.66 km\(^2\)), Phumdis with thick vegetation (15.64 km\(^2\)), Phumdis with thin vegetation (82.86 km\(^2\)) and settlement (10.91 km\(^2\)). The area under open water bodies increases by 26.89 km\(^2\) in 2015 due to the removal of Phumdis from the central zone by the government in order to retain the open water area which was almost covered by Phumdis after the construction of Ithai barrage and increase in aquaculture. The kappa coefficient assessment of overall accuracy of the classified images shows 86 % in the study area.
### Land Use Classes

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<tr>
<td></td>
<td>Km²</td>
<td>%</td>
<td>Km²</td>
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<tr>
<td>Open water bodies</td>
<td>74.76</td>
<td>30.30</td>
<td>101.65</td>
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<tr>
<td>Agricultural area</td>
<td>10.33</td>
<td>4.18</td>
<td>35.66</td>
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<tr>
<td>Phumdis with thick vegetation</td>
<td>24.23</td>
<td>9.82</td>
<td>15.64</td>
</tr>
<tr>
<td>Phumdis with thin vegetation</td>
<td>132.24</td>
<td>53.59</td>
<td>82.68</td>
</tr>
<tr>
<td>Settlement</td>
<td>5.16</td>
<td>2.09</td>
<td>10.91</td>
</tr>
<tr>
<td>Total</td>
<td>247.72</td>
<td>100</td>
<td>247.72</td>
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The Phumdis used to flow out of Loktak during the rainy season naturally, but the movement was prevented after the construction of Ithai barrage leading to an increase in Phumdi population. Agriculture area in the lake increases by 25.33 km² due to construction of Ithai barrage, which makes it a reservoir for hydroelectric project. This leads to inundation of low-lying areas, thereby depriving the people of their agricultural field. The local people rely on agricultural activities in the Phumdis. Settlement inside the lake also increases by 5.75 km². This is due to a rise in population and lack of employment opportunities. Thanga, Ithing, and Karang are the villages located inside the lake, which shows substantial growth in population. Phumdis with thick and Phumdis with thin vegetation recorded the maximum loss of area. Phumdis with thick vegetation reduce the area by 8.59 km² and Phumdis with thin vegetation by 49.38 km² during the study period. It has been converted to agricultural area, open water bodies, and human settlement. Decrease trend impact in Phumdis is a major concern as Keibul Lamjao National Park, the only floating National Park in the world, is made of thick and thin Phumdis. The change in the land use pattern is Loktak Lake is a serious concern for restoration and sustainable management of the lake resources as a change in land use pattern severely affects the fragile aquatic ecosystem thereby increasing the pressure on the lake.

### Conclusion

Landscape alteration of wetland ecosystem driven developmental activities around the lake by impact adversely on aquatic and wildlife habitat. Fragmentation of wetland area by human creates significant problems for maintaining biological diversity. There is a need for continues and consistent monitoring of the Loktak lake using spatial technology which are cost effective.
References


