



A temporal study of changing dynamics of Loktak Lake in Manipur using remote sensing and GIS techniques

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Abstract

Wetland are considered to be most important biologically productive ecosystem, so it is important to study the changing dynamics of the wetlands as it may lead to deterioration of the wetlands thereby disturbing the function of the wetland. The study is about Loktak Lake which is situated at Moirang subdivision in Manipur. The lake plays an important role but it is deteriorating due to many reason such as siltation, deforestation, soil erosion as well as the eutrophication, so it is important to study the changing dynamics of the Loktak Lake. The study is about analysis of changing dynamics of the lake where study of changes in vegetation cover have done using NDVI Index and land use and land cover using Google images by visual interpretation of different time period. For the study of vegetation cover detection, time period of 2001 and 2015 satellite image have used and for land use and land cover changes analysis time period of 2011 and 2017 have used. The results show changes in the vegetation cover as well as changes in the land use and land cover pattern.

Keywords: wetland, ecosystem, Loktak Lake, Manipur

Introduction

Wetland are the transitional lands between terrestrial and aquatic system that provides many services. They are considered to be one of the most important component of environment and plays important role in the ecosystem and also helps in maintaining natural ecosystem. Wetland are the most important biologically productive ecosystem of the biosphere. Wetland provides many ecological services such as regulation of the climate, purification of the environment, habitats for diverse species and also for the maintenance of water quality, nutrient content and for flood prevention also. It also provides recreational and aesthetic values. In terms of its economic value also, wetland is source of livelihood for many people.

Many people have done their study by using the technique of remote sensing and GIS as it is suitable and best techniques for the study of wetland dynamics and land use/land cover changes. Many scholars like Iverson and Risser (1997), Sarkar and Jain (2008), Kavyashree and Harmesh (2016) [3] have done their study about wetland changes with the help of GIS and Remote sensing technique. For the land use/land cover changes also scholar like Munyati (1997) [6], Ndzeidze (2008) [7], Steffen *et al.* (2010) [10] have done their study by using different remote sensing and GIS techniques.

Study of changing dynamics of wetlands have also been done using primary survey by scholars like Laishram and Dey (2014) [4], Kangabam (2015) [2] which they found out that pollution level has increased in the Loktak Lake. Disadvantages of primary survey for studying wetlands is that they can be used only to see the impact on human beings but exactly cannot be taken to study the changing dynamics of

wetlands as past data cannot be used in case of primary surveys.

Objective of the study

It is observed from the literature review that many aspects of Loktak Lake but studies using remote sensing and GIS techniques have not been undertaken by scholars so for the study this technique has been used. The present study deals with following objectives;

- To analyses the changes in the vegetation characteristics of the Loktak lake using NDVI index over a period of time.
- To observe the changes in the land use/land cover of the lake using satellite data over a time period.
- To analyses the impact of the changes occurring in the lake.

Study area

Manipur is a northeast state of India and is located in the easternmost part of the country. It also shares international boundary with Myanmar from the southern and eastern parts. In the center lies the valley region with oval shape and is surrounded by hills from all the sides having total area of 22327 sq. km. The latitudes and longitude is 23.80° N and 93.50° E. Imphal River, Iril, Thoubal, Nambol are the main rivers of Manipur. According to 2011 census report, the total population of Manipur is around 27 lakh having growth rate of 12.05. The literacy rate is of 79.85% and sex ratio of 987. More than half of the state is covered with natural vegetation that is around 64%. Average rainfall is 1467.5 mm. Loktak Lake falls under Bishnupur district and it has three sub division and the lake comes under Moirang sub division. The

total geographical area of the district is around 496 sq. km. According to 2011 census, total population of Bishnupur district is 2, 37,399 Out of share of total population of Manipur, Bishnupur district account of 12.03 %. The literacy rate is 75.9.

The Loktak Lake is located at 24° 35'N, 93° 50'E at a distance of 20 km southwest of Imphal in Bishnupur district, Manipur. The shape of the lake is oval and has a surface area of 287 sq. km and the maximum length of about 32 km and of width having 13 km. The average depth of the lake is around 2.7 m and maximum depth of 4.6 m. Climatic Condition is tropical monsoon climate and the average annual rainfall received is 1183 mm. Loktak Lake in the Bishnupur district is very famous for it's economic, ecological and socio-cultural importance. The lake act as a lifeline of many people as it provides many goods and services. It plays important role in the economy of Manipur. The lake has various benefits in terms of socio economic activities, environment, tourism and also source of for the irrigation. Loktak Lake is also under the Monteux Record since 16th June 1993. The lake has been under the list of international importance because changes are occurring and also in near future it will continue due to technological development, pollution or human interference. Loktak lake wetland was added in the Monteux Record (1993) largely because of the ecological problems it faces such as deforestation in the catchment area, infestation of water hyacinth and pollution. It is also under the list of Wetlands of International importance by the Ramsar convention in the year 1990.

The most unique feature of the lake is its floating mats locally known as Phumdis. These Phumdis are heterogeneous mass of soil, vegetation, and organic matter at various stages of composition and occurs in all sizes and thickness (Singh and Moirangleima, 2009) ^[9]. Tomba Singh and Shyamananda Singh (1994) remarked that about one-meter-thick Phumdis easily supports the weight of animal and human beings and large size of about 2-meter-thick with an area 150 sq. km easily supports one small hut with 4 to 5 people. The physical characteristics of the Phumdis is shown in table 1.

Table 1: Characteristics of Phumdis (Tomba singh and Shyamananda)

Surface area	287.0
Total volume	519
Open water area	43.9
Maximum length	3
Minimum width	13
Maximum depth	4.6
Mean depth	2.7
Shape	Oval

Table 3: Details of the data used for NDVI calculation

Sr. No.	Satellite Image	Time Period	DATE	Row	Path
1	Landsat Band 3 and 4	2001	March 31st	135	45
2	Landsat Band 3 and 4	2015	April 2nd	135	45

The index has been calculated in the QGIS software using raster calculator. For the land use land cover analysis time period of 2011 and 2017 of Google earth images have taken

According to Devi and Sharma (2008) Phumdis is composed of three vertical zones as given in table 2.

Table 2: Vertical zones in Phumdis

Zone 1	Zone 2	Zone 3
Uppermost zone	Mat zone	Peat zone
Thickness (10 to 15 cm)	Thickness (25 to 65 cm)	Thickness (10 to 15 cm)

Data and methodology

Data sources

For the study of changing dynamics of the wetland over time, satellite images for different band is used. Band red and near infra-red band (NIR) have been used as it is necessary for the calculation of the NDVI index for the analysis of changes in the wetland over different time period. Satellite data was taken from the USGS Earth explorer website. The study for the land use/land cover changes have been done using Google Earth images and analysis is done through visual observation. Impacts of the changes occurring in the lake has been done by field visit and through informal interviews of people living in the area. Other literature, magazines, internet articles and newspaper articles related to the changing nature of Loktak Lake have also been consulted.

Methodology

For the present study NDVI index has been calculated and land use land cover have been observed using Google earth image

NDVI index

Normalized differential vegetation Index (NDVI) is used to determine the green level or the density of the vegetation by measuring the reflectance portion of spectrum in red and near infrared region. In case of healthy vegetation, more visible light will be observed and there will more reflectance of near infrared where opposite in case of unhealthy vegetation. If there is only little difference between reflectance of visible and near infrared, then it is likely to be grassland or desert. NDVI index is calculated by near infrared radiation minus visible radiation divided by near infrared radiation plus visible radiation and it will be used to determine the vegetation. The range of NDVI is -1 to 1. The index value of 0 to -1 represents that there is no vegetated area and values from 0 to 1 represents vegetated area. For calculation of NDVI index, satellite data has been acquired from USGS earth explorer website in the month of March and April because of clear skies and better visibility. The details of the data used for NDVI calculation is given in table 3.

from the Google Earth application to observe the changes in land cover and land use by visual interpretation of the images.

Results and analysis

NDVI analysis

For the comparison and analysis of the changes images for 2001 and 2015 were taken where Band 3 and Band 4 from satellites images were used for calculation of the NDVI INDEX. For the 2001 images the NDVI INDEX value ranges from -0.528 to 0.465 and for 2015 it ranges from -0.382 to 0.628. The ranges for NDVI images values below 0 or

negative values shows the non-vegetated area and above 0 or positive values shows the vegetated area. From the comparison it has been shown that for the 2015 images the lake is shallow and shrunken in appearance, the impact that can be from are that of siltation and encroachment. So, proper demarcation of the lake boundary should be conducted. In the eastern side of the lake the vegetation covered has increased in 2015 as compare to 2011.

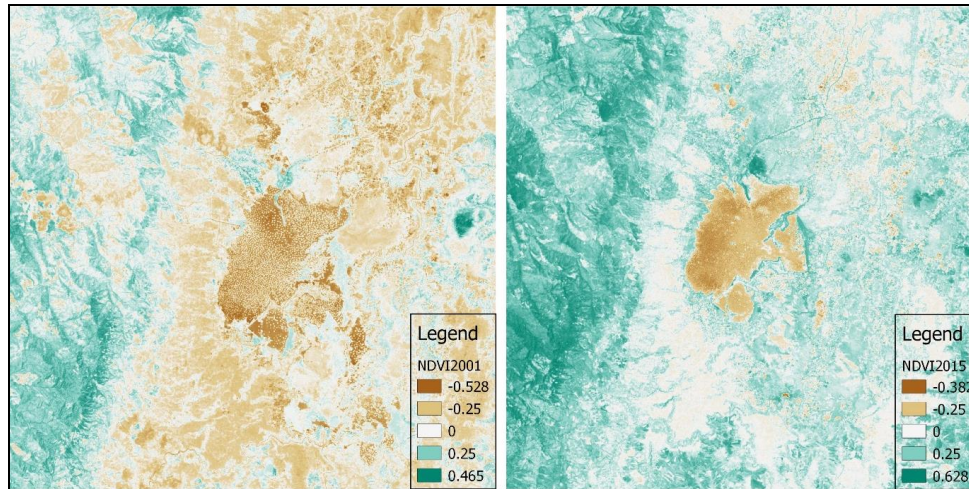


Fig 2: NDVI comparison of satellite imagery of 2001 and 2015

Land use land cover change

For observing the changes in land use land cover, images for 2011 and 2017 were extracted from USGS Earth Explorer website. From the downloaded satellite images, the false color

composite of RGB – Band NIR, Band Green and Band Red was generated in Envi software. Figure 3 and Figure 4 show the colour composite generated of year 2001 and 2015, respectively.

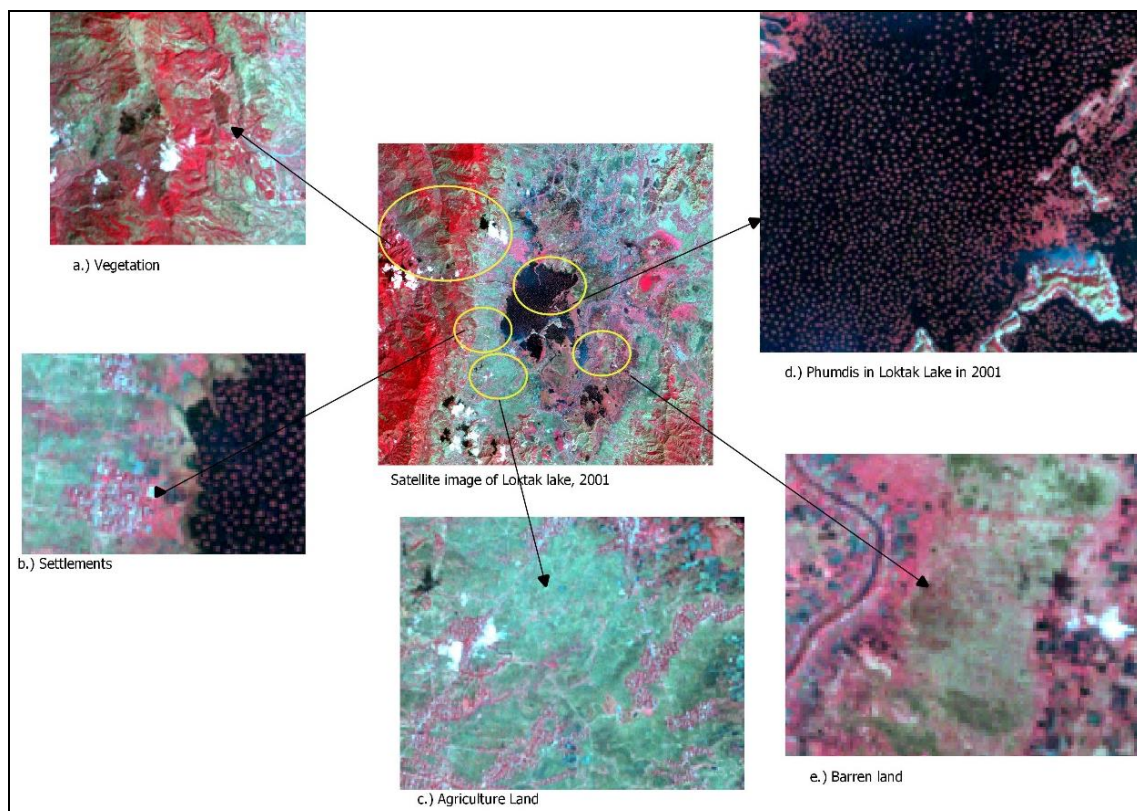


Fig 3: False colour composite of Loktak lake for year 2001

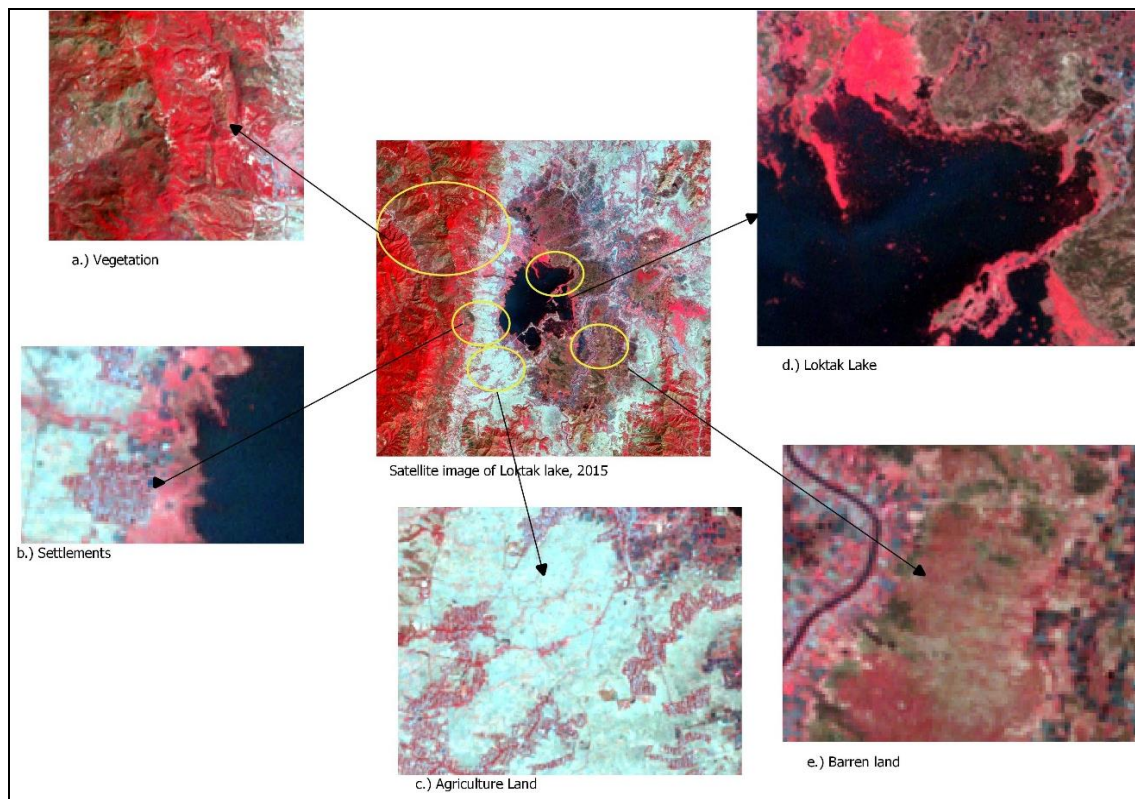


Fig 4: False colour composite of Loktak lake for year 2015

In the images of 2015 in the upper western side of the lake, new settlement area is being constructed and more built up area is observed if it is compared with the 2001 satellite image. And in the southern part of the lake also many new built up area can be seen in the 2015 images. Concentration of Phumdis has also decreased in the year 2015 because of the clearance done by the Loktak Development Authority in the year 2012. If the changes in the whole catchment area are taken into consideration, many changes are observed. The changes also observed that the area of the Lake cover area has decreased due to encroachment for the built up area as well as a result of siltation.

Impacts to the lake

As a results from deforestation in the catchment area, direct discharge of tone of waste disposal, untreated sewage, draining of high concentration of nitrogen and phosphorus from the surrounding field, and loading of nutrients from athaphum fishing and increasing pressure on the lake has causes many negative impacts to the lake such as siltation due to deforestation, construction of roads, and soil erosion are few factors that causes siltation. This might resulted in the shrinking of the Lake area. Eutrophication due to high enrichment of nutrient that deteriorate the lake ecosystem. High enrichment nutrients flow from sewage, fertilizer, animal waste, domestic waste, erosion of nutrient rich top soil results the aquatic weeds and Phumdis to be heavily infested. Decreasing in the level of water quality: Pollutants from rivers which directly drained in the Lake, draining of pesticides and insecticides from the nearby agricultural fields and large amount of polythene and waste plastic items from the

periphery area, all these factors impact to the water quality. The size of the Phumdis has increased due to unchecked loading of nutrient and athaphum fishing by the local communities and high amount of fertilizer with higher concentration of nitrogen and phosphorus from the agricultural field leads to the proliferation of the Phumdis.

Conclusion

The present study on the changing dynamics of the lake was done using the remote sensing and GIS methods as it is one of the methods in which it is adopted for analyzing changing dynamics of the Lake. The reason for selection of this method is because not so many worked has not been done using remote sensing and GIS method. As the Lake has many environmental problems due to various factors the ecological conditions of the lake is deteriorating. The study was conducted to analyze the changing dynamics of the lake and to study the impacts of the same on the ecology of Loktak Lake. The steps which can be taken for the conservation of the Lake were also analyzed as the lake plays an important role for the people of Manipur particularly for the people who lives nearby lake as the lake gives livelihood to many people. The datasets used for the study are satellite images and other secondary sources. From the value from NDVI INDEX for both 2011 and 2015 there slightly increased in vegetation cover as the values had increased from 0.39 to 0.5. It was observed that Phumdi cover area in the Lake has decreases in the year 2015 and found that the lake area has reduce. For the land use and land cover there not that much change but for the 2017 new built area has shown in the southern and upper western part of the Lake as compare to 2015. As pressure on

Lake Increases there need for the conservation and management of the Lake because it is only natural habitat of Sangai deer which is only found in Manipur and is becoming endangered.

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