Monitoring Land Use and Land Cover of Forest Ecosystems of Shendurney Wildlife Sanctuary, Western Ghats, India

Abstract

and natural phenomena is crucial to conserving and managing remnant forest resources. However, forest ecosystem assessment over a large and remote area is usually complex and arduous. The present study on land use and land cover change detection of the Shendurney Wildlife Sanctuary forest ecosystems was carried out to utilize the potential application of remote sensing (RS) and geographic information system (GIS). Moreover, to understand the trend in the forest ecosystem changes. The supervised classification with Maximum Likelihood Algorithm and change detection comparison approach was employed to study the land use and land cover changes, using the Landsat Enhanced Thematic Mapper (ETM±) Landsat 8 OLI-TIRS using data captured on July 01, 2001, and January 14, 2018. The study indicated the rigorous land cover changes. It showed a significant increase in the proportion of degraded forest with negligible gain in the proportion of evergreen forest from 21.31% in 2001 to 22.97% in 2018. A substantial loss was also observed in moist deciduous from 27.11 % in 2001 to 17.23 % in 2018. The result of the current study indicated the degree of impacts on forests from the various activities of their surroundings. This study provides baseline information for planning and sustainable management decisions.

Keywords: *Land Use and Land Cover, change detection, forest ecosystem, and forest degradation*

Introduction

Climatic and anthropogenic factors are nowadays considered the most critical factors that lead to the degradation and fragmentation of forest ecosystems. Fragmentation is a dynamic process that gradually reduces habitat into smaller patches that became increasingly isolated and vulnerable to edge effects (Echeverría et al., 2007). This phenomenon leads to the separation of habitat and impairing the potential ecosystem function, which imperils plant species, mammals, and birds. Assessing the forest ecosystem structure over a large and remote area is usually complex and arduous. Still, GIS provides essential information to model multiple-use forest management decisions. The knowledge of remote sensing and geographic information systems (GIS) are the modern tools for the assemblage and manipulation of remotely sensed data. The remote sensing imagery of a large variety of space-borne and airborne sensors provides vast data

about the earth's surface for detailed global analysis, change detection, and monitoring (Benz *et al.*, 2004).

The vegetation classification and mapping commonly generate a stable descriptive view of the vegetation resource. Therefore, it is considered significant in driving baseline information in ecosystem conservation (Ellenberg and Mueller-Dombois 1974, Wallace et al., 2006). Nevertheless, vegetation is dynamic, and its changes over time are the most crucial information for management decisions. The knowledge of specific vegetation changes helps identify and quantify challenges, set targets, and assess responses to management actions (Wallace et al., 2006). The knowledge of remote sensing and geographic information systems has been utilized to detect and monitor the changes in the forest ecosystem globally. This study examined the land use and land cover change in the 2001-2018 period using satellite imagery and a geographic information system (GIS) in the Shendurney Wildlife sanctuary, Kollam, Kerala. Landsat Enhanced Thematic Mapper (ETM±) Landsat 8 OLI-TIRS captured on July 01, 2001, and January 14, 2018, was used to achieve the current investigation. The Supervised classification with a Maximum Likelihood Algorithm and change detection comparison approach was utilized to study the land use and land cover changes. The land-use changes that occurred during the period in the forest ecosystems and the water body of the shendurney wildlife sanctuary were exposed.

Material and Method

Study Area

This study was conducted in Shendurney Wildlife Sanctuary, located between the geographical extremes of 8^0 44' and 9^0 14' N latitude and 76^0 59' and 77^0 16' E longitude in Thenmala, Kollam district of Kerala state (Fig.1). The Sanctuary is part of the Agasthyamalai Biosphere Reserve, one of the Western Ghats most biodiverse areas. The Sanctuary has notified an area of 171sq.km with well-defined natural boundaries. The vegetation was classified into West Coast Tropical Evergreen Forest, West Coast Tropical Semi-Evergreen Forest, Southern Hilltop Tropical Forest, and Secondary Moist Mixed Deciduous Forest. All the forest types differ significantly in species composition with a change in elevations. The study area was classified using clear and cloud-free Landsat images: July 01, 2001, and January 14, 2018. The Shendurney Wildlife Sanctuary area is entirely contained within the Landsat Path 143 and Raw 054. The overall image was rectified to geo-referenced to the Universal Transverse Mercator (UTM) projection zone 43 and WGS 84 datum using at least 205 and 94 well-distributed ground control points and nearest neighbor resampling. The root means square errors were 4.21 m for

the 2001 image and 8.41 m for the 2018 image. The image was processed using ARCGIS 10.1 and QGIS 2.18 versions. The land use and land cover mapping were successful by interpreting Landsat (ETM±) satellite images, 2001 generated and Landsat 8 OLI-TIRS images, 2018 generated.

Methodology

Image processing

Training

The present study adopted the land cover and land use classification developed by Anderson (1976) to interpret remote sensor data at different scales and resolutions. According to the Anderson land use and land cover classification scheme, land use and land cover are categorized as different forest land, waterbody, open forest, and degraded area. An unsupervised image classification system was used to assess strata for ground truth before the field visit. Fieldwork was conducted to gather data for training and validating land-use and land-cover analyses based on the 2001 satellite image and for qualitative descriptions of each land-use and cover class's features. A random selection of testing points was used to create a testing sample set.

Allocation

The ARCGIS 10.1 and QGIS 2.18 software was used for carrying out the image classification. Firstly, the supervised classification with a Maximum Likelihood Algorithm based on the 168 training samples, the 2001 image, and 168 samples for the 2018 images was employed. Secondly, the supervised image classification techniques appropriate to Maximum Likelihood Classifier (MLC) and 168 training samples were applied to produce the land use and cover maps of 2001 and 2018 (Richards and Richard 1999). Lastly, a 3*3 majority filter was utilized to each classification to recode isolated pixels classified differently other than the majority class of the window.

Accuracy assessment

For accuracy assessments, an error matrix was developed to ensure the consistency of information obtained from remotely sensed data. The sample points were collected and confirmed by comparing the remote sensing study results to reference or ground truth data. (Congalton and Green, 1999). An independent sample of 168 polygons with approximately 100 pixels per polygon was randomly selected from each classification to assess the classification

accuracy. Classification accuracy was assessed using error metrics such as cross-tabulation of mapped class vs. reference class (Congalton and Green, 1999).

Change detection

In order to analyse the changes in land cover in time intervals following the categorization of imagery from specific years, a multi-date post-classification comparison change detection technique was utilized, the most extensively used method of detecting changes. (Jensen 2004).

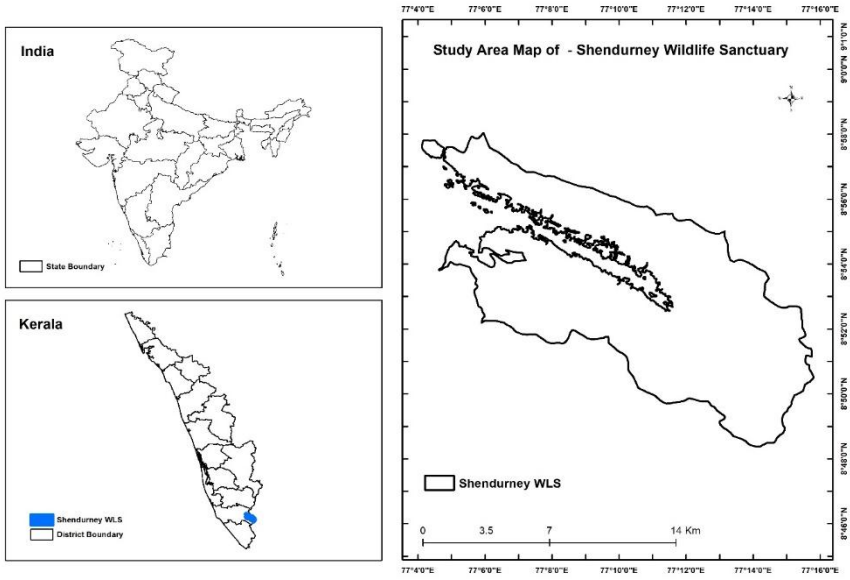

Figure 1. Study Area Map

Results and Discussion

Forest ecosystems change detection

The LULCC of the forest ecosystems were studied. Six land use and land cover classes (LULC) were established as evergreen forest, semi-evergreen, moist deciduous forest, hilltop forest, degraded forest, and open forest (Table 1). The spatial distribution and the estimated change of all the forest cover changes were represented in figures 3 and 4. The present study mapped all the forest ecosystems and figured out their change using Landsat (ETM±) and Landsat-8 OLI-TIRS. These findings demonstrated that the west coast tropical evergreen forest occupied the most significant land, followed by the secondary moist deciduous forest (Table 1 and Figure 2). However, the result indicated that a significant area of Shendurney Wildlife sanctuary is occupied by a degraded forest, followed by evergreen, semi-evergreen, and moist deciduous forest (Tab. 1 and Fig. 2). The little gain in the evergreen forest was noticed from 3722.02 ha in 2001 to 4011.61 ha in 2018, indicating an increased area of 289.53 ha during the

time interval (figure 2). On the other hand, a significant loss was observed in the moist deciduous forest from 4735.13 ha in 2001 to 3008 ha in 2018. The semi-evergreen forest showed a decline from 4699 ha in 2001 to 3313.9 ha in 2018.

The notable increases in open forest from 1028.5 ha to 2306.36 ha and hilltop forest increased from 235.48 ha to 341.44 ha in 2018 were also discovered. Moreover, degraded forests substantially increased from 14.93 % in 2001 to 23.62 % in 2018. However, the water body shrunk considerably from 418.05 ha in 2001 to 356.93 ha in 2018 (Tab. 1 and fig. 2).

Table 1. Summary of Landsat classification area statistics for 2001 and 2018

Forests Type	2001 (ha)	%	2018 (ha)	%	Changes
West Coast Trop. Evergreen	3722.02	21.31	4011.61	22.97	289.53
West Coast Trop. Semi-Evergreen	4699.02	26.91	3313.9	18.98	-1385.12
Southern Moist Deciduous	4735.13	27.11	3008.82	17.23	-1726.3
Southern Trop. Hilltop	253.48	1.45	341.44	1.96	87.96
Open Forest	1028.50	5.89	2306.96	13.21	1278.46
Degraded Forest	2607.97	14.93	4124.51	23.62	1516.55
Water Body	418.05	2.39	356.93	2.04	-61.11
Total	**17464.17**	**100**	**17464.17**	**100**	-

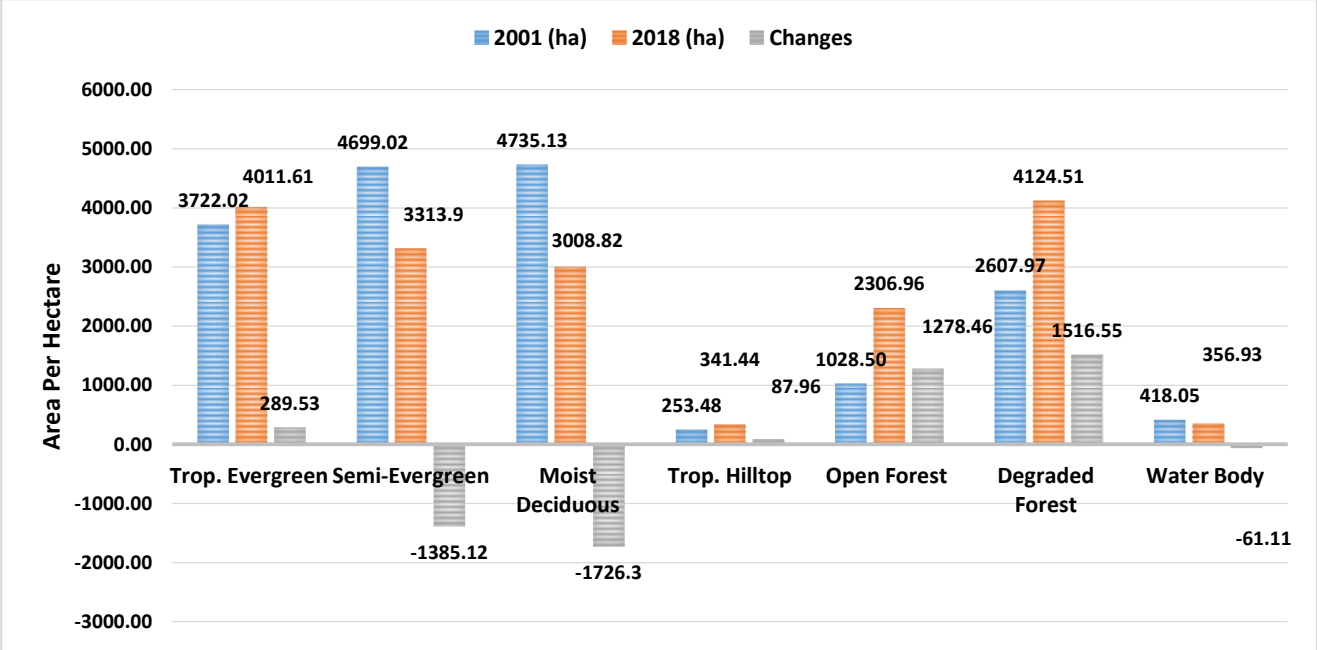

Figure 2. Summary of Landuse and land cover classification for 2001 and 2018

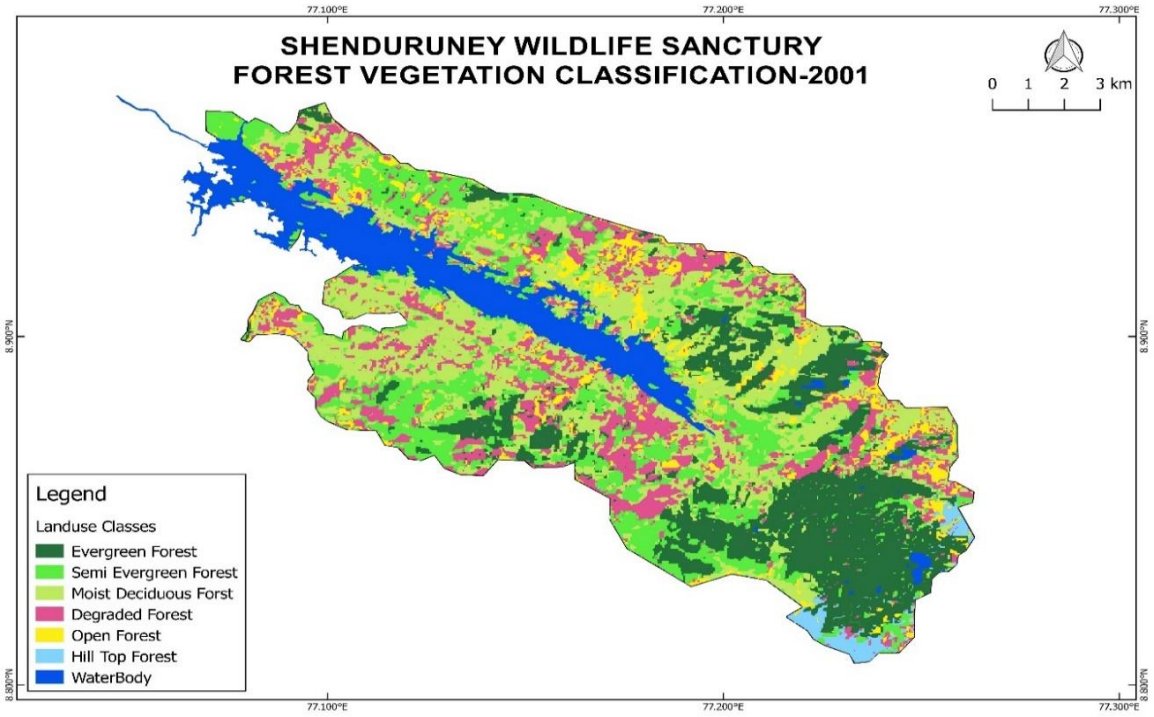

Figure 3. Spatial distribution of all the forests vegetation classification 2001

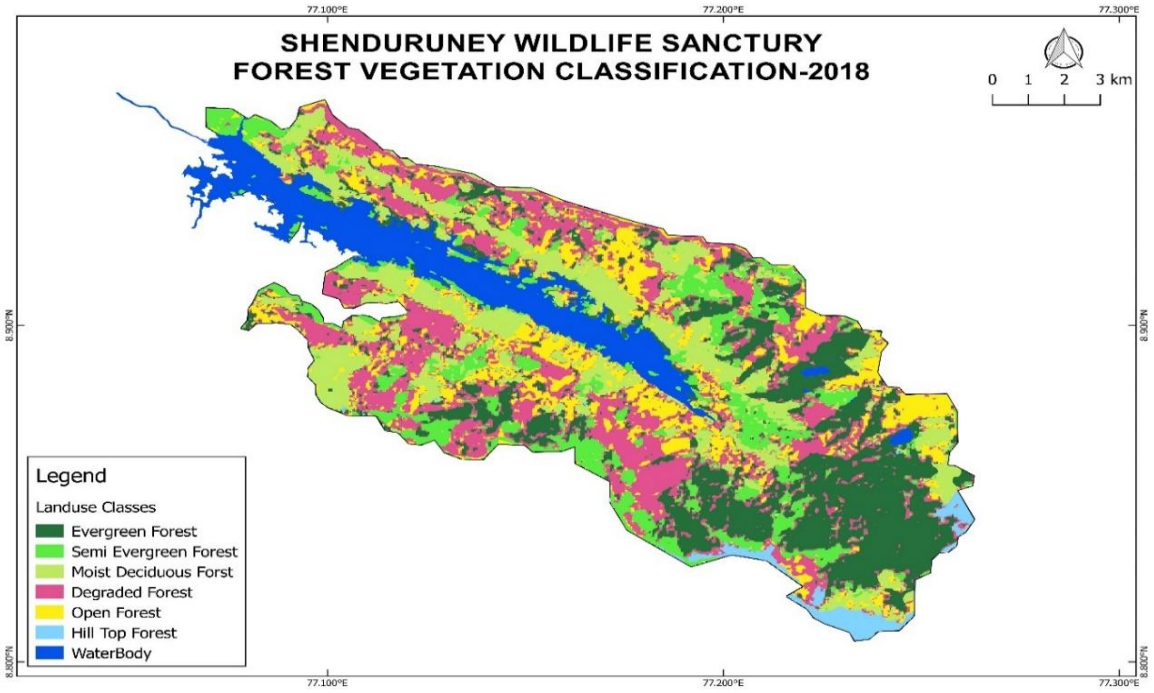

Figure 4. Spatial distribution of all the forests vegetation classification 2018

Forest land cover changes

Land use and cover change have become paramount for understanding and proper planning of productive ecosystems and biodiversity, environmental degradation, wetland deterioration, loss of aquatic organisms, and wildlife habitat (Mallupattu and Reddy, 2013). The Earth Resources Technology Satellite, which was later named Landsat-1, was launched in early 1972. Satellite remote sensing provided its potential benefit in assessing, planning, and monitoring natural resources (Roy et al., 1985; Kushwaha and Madhavan, 1989). Its ability to provide real-time data with contemporaneous and repetitive coverage provides distinct advantages over conventional methods. There is a common belief that forests in the Western Ghats are gradually shrinking because of increasing biotic pressure on the resources. Therefore, the study of forest land use and forest land cover (LULCC) changes is significant for proper planning, managing, and utilization of forest resources. This particular study was undertaken to evaluate the extent of change in different forest cover from 2001 to 2018 and show the use of multispectral Landsat data for identification, mapping, and change detection of Shendurney Wildlife Sanctuary of Southern Western Ghats, Kerala, India.

Similar to other findings of the Western Ghats forest, the present study on spatial changes of different ecosystem types of Shendurney wildlife sanctuary depicted that the forest is going through a gradual decrease with time. The tremendous decline in the major two forest ecosystems and the relatively insignificant gain in the evergreen forest and hilltop forest. Kushwaha (1989), in his study, reported the 5.66 % overall decrease with zero gain in the forest ecosystem types over twelve years. However, the present study report on the considerable increase in the degraded forest, which predicted the entire future of the forest ecosystems and its proximity to anthropogenic disturbance and other impacts associated with human and climatic change. The evergreen and hilltop forests are virtually secured and relatively stable and showed significant increases in their extent (Fig, 3 and 4). The stability and increased in the higher elevation forests could be attributed to the fact that these forests are located in the core zone areas far from human settlements. Unlike the semi-evergreen and moist deciduous forests, which are mainly low to medium elevation forests and close to human settlements, making them easily accessible. Therefore, they faced different types of disturbances. The substantial increase in degraded forests could be attributed to the expansion in the human settlements in the nearby locations and pressure on the demand for agricultural land by the inhabitants. The rapid growth of the human population close to forest ecosystems has increased the risk of degradation and fragmentation (FAO, 2001). In Lombok eastern Indonesia, Kim

(2016) reported a significant decrease in the extent of the forest land for the 20 years interval. He presumably attributed the loss by timber extraction, the pressure of land for agriculture and urban development, and poor governance institutions (Curran et al., 2004).

Land use and land cover change are not random and not constant spatially and temporally. Lira *et al*. (2012) studied the effect of LULCC on size, shape, and degree of forest patch isolation. They reported a significant increase in forest patches when deforestation outpaced forest regeneration and a significant decrease when forest regeneration outpaced deforestation. Kushwaha (1989) reported a marginal increase in the water body area. Contrary to the present study, despite the ongoing rehabilitation of the Thenmala Dam, the study reported a decreasing trend in the water body. Due to varying precipitation and temperature, the size of water bodies can change from year to year. Toorahi and Roi (2010) have a similar view on water bodies fluctuation in his study in study.

Poor forest management practices like forest fire management may increase open and degraded forests in the wildlife sanctuary. The strata formation of forest ecosystem types of Shendurney rendered it proximate to fragmentation and susceptible to anthropogenic disturbances. Most of the forest ecosystems of Shendurney appeared to be in irregular patches, exceptionally moist deciduous, semi-evergreen, and the myristica swamp. According to (Ewers and Didham, 2007), edge effects are more common in forest patches with irregular shapes than in patches with more compact shapes. They have been reported to negatively impact many species (Ewer and Didham, 2006).

Conclusion

The study of land use and land cover change is paramount to understand the shift in the forest ecosystems for setting up monitoring and planning tools for effective management decisions. The land cover of Shendurney Wildlife Sanctuary is reported changing. The main change observed in the Shendurney wildlife sanctuary was the significant increase in degraded forests, the decline in the extent of moist deciduous forests, semi-evergreen forests, and little gain in evergreen forests. The apparent changes in the forest ecosystems of Shendurney Wildlife Sanctuary reported in the present investigation are a phenomenon that requires an urgent and compelling managerial action to sustainably monitor various human activities, which are considered the major change actors. Additionally, improving the living standard of the forest fringe communities should be underscored.

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