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

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Abstract

Understanding forest degradation due to human 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±) and 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±) captured on July 01, 2001 and Landsat 8 OLI-TIRS captured on 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 locations of 76º 59' 30" and 77º 16' 30" East Longitude and 8º 44 ' and 9º 14' North Latitude in Thenmala, Kollam district of Kerala state. The sanctuary is part of the Agasthyamalai Biosphere Reserve, one of the Western Ghats' most biodiverse areas. The sanctuary has notified 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 selected 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, 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. The land use and land cover mapping were successful by interpreting Landsat Enhanced Thematic Mapper (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 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 processing. 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

The changes in land use and land cover for the time intervals were analyzed following the categorization of imagery from specific years. A multi-date post-classification comparison change detection technique was utilized, which is the most extensively used method of detecting changes. (Jensen 2004).

Results and Discussion

Forest ecosystems change detection

The land use and land cover (LULC) of the forest ecosystems of the Shendurney was studied. The 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 2 and 3. The present study mapped all the forest ecosystems and figured out their change using Landsat Enhanced Thematic Mapper (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 1). 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. 1). The insignificant gain in the evergreen forest was noticed from 3722.02 hectares in 2001 to 4011.61 ha in 2018, indicating an increased area of 289.53 hectares between the time intervals (figure 1). On the other hand, a significant loss was observed in the moist deciduous forest from 4735.13 hectares in 2001 to 3008 hectares in 2018. The semi-evergreen forest showed a decline from 4699 ha in 2001 to 3313.9 hectares in 2018.

The notable increases in the open forest from 1028.5 hectares to 2306.36 hectares and hilltop forest increased from 235.48 hectares to 341.44 hectares 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 hectares in 2001 to 356.93 hectares in 2018 (Tab. 1 and fig. 1).

Table 1. Summary of Land and land cover changes of Shendurney Wildlife Sanctuary for the period of 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**	-

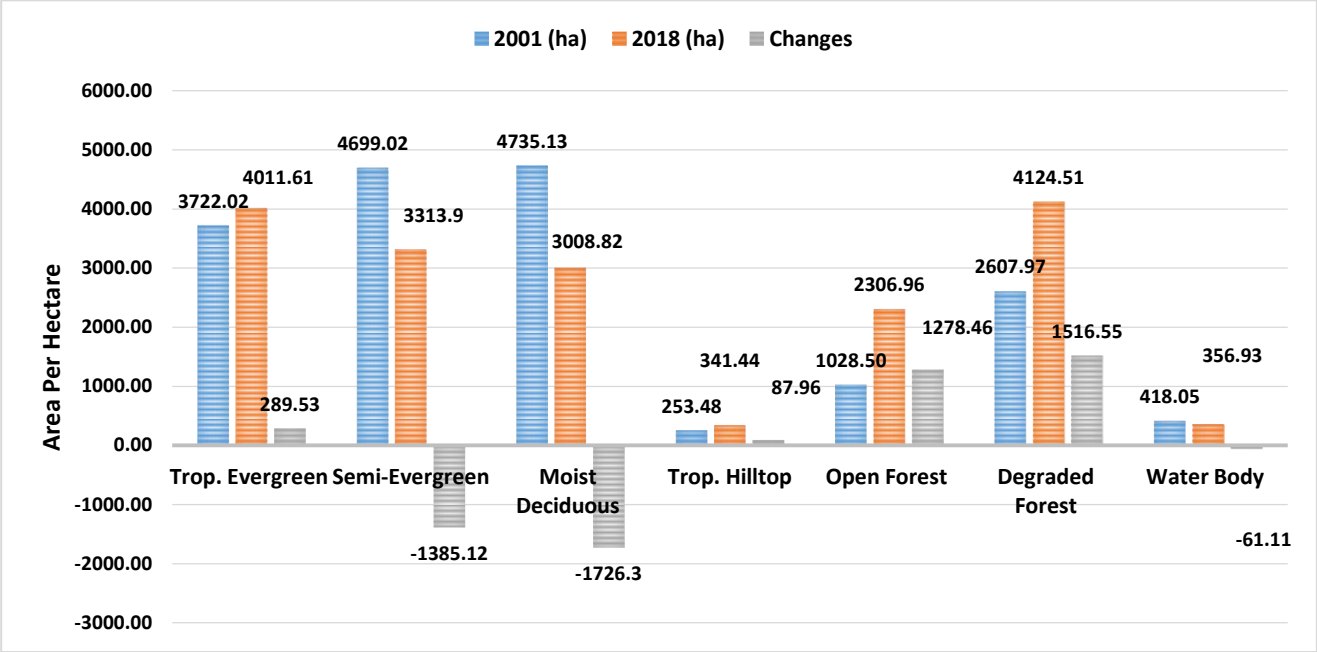

Figure 1. Summary of Land use and land cover changes of Shendurney Wildlife Sanctuary for the period of 2001 and 2018

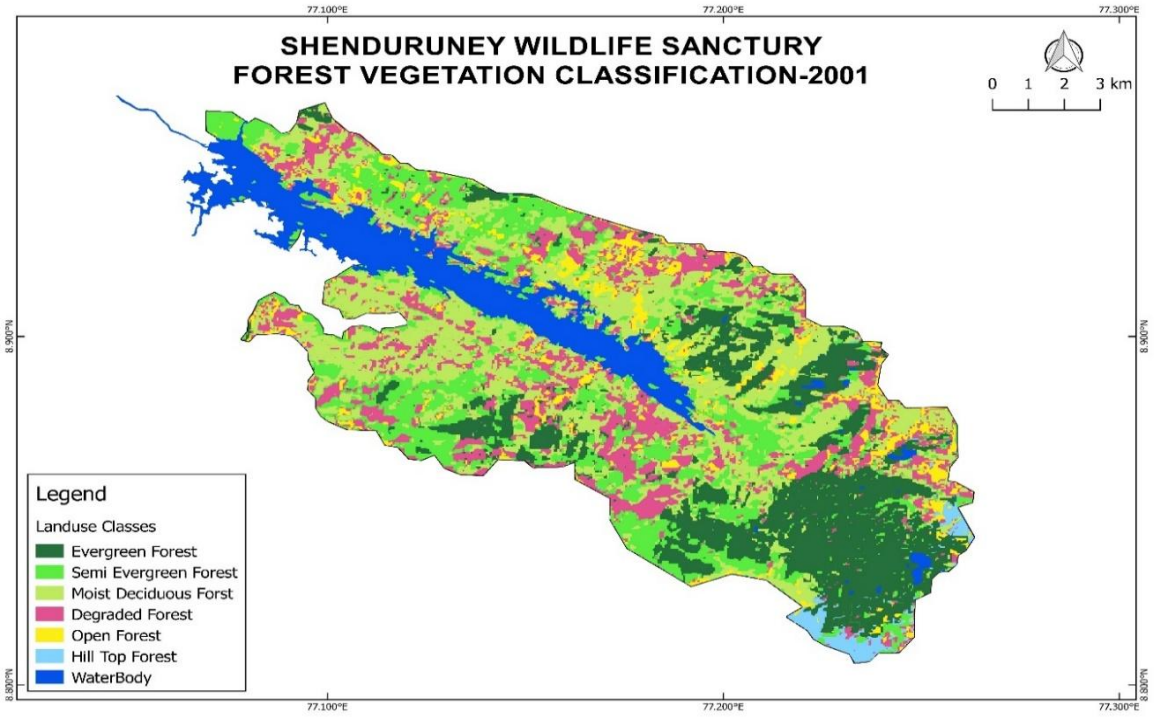

Figure 2. Spatial distribution of the land use and land cover classification 2001

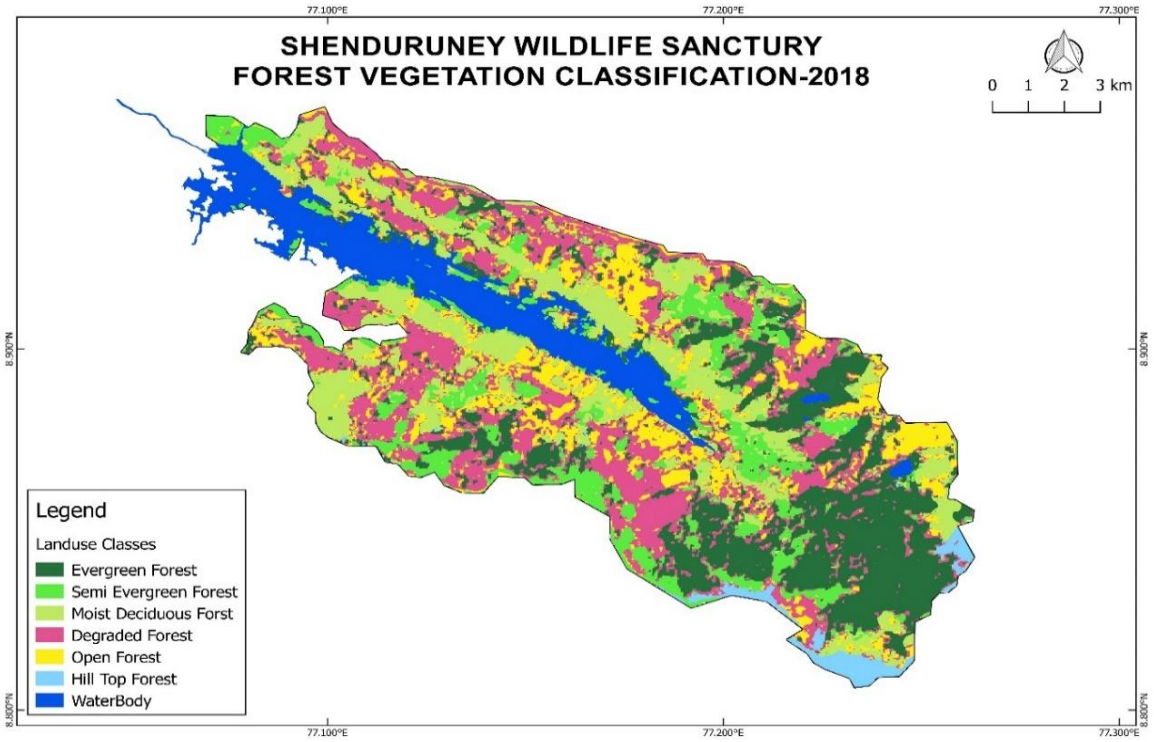

Figure 3. Spatial distribution of the land use and land cover classification 2018

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 land use and land cover changes (LULC) is significant for proper planning, managing, and utilization of forest resources.

Similar to the studies in the Western Ghats regions (Panigrahy et al., 2010; Dutta et al., 2016; Kale et al., 2016; Reddy et al., 2016). The current study of Shendurney wildlife sanctuary revealed that the forest is going through a gradual decrease with time. The tremendous decline in the major two forest ecosystems, and a significant increase in the degraded forest, and the relatively insignificant gain in the tropical evergreen and hilltop forest clearly showed the intensity of anthropogenic and climatic pressure on most of the forests. 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, 2 and 3). 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 due 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).

The changes in land use and land cover are not a random process. Lira et al. (2012) studied the effect of land use and land cover changes (LULC) on the size, shape, and degree of forest patch isolation. 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 (2011) 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

Monitoring the protected areas for sustainable management and conservation is considered crucial. 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 insignificant gain in evergreen forests. The apparent changes reported in most of the forest ecosystems in the present investigation emphasized the need for 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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References

Anderson, J.R., 1976. A land use and land cover classification system for use with remote sensor data (Vol. 964). US Government Printing Office.

Benz, U.C., Hofmann, P., Willhauck, G., Lingenfelder, I. and Heynen, M. 2004. Multi-resolution, object-oriented fuzzy analysis of remote sensing data for GIS-ready information. *ISPRS J. Photogramm. Remote Sens.* 58(3-4):239-258.

Congalton R. G., and Green, K. 1999. Assessing the Accuracy of Remotely Sensed Data: Principles and Practicesboca Rotan. Lewis Publishers, Florida.

Curran, L.M., Trigg, S.N., McDonald, A.K., Astiani, D., Hardiono, Y.M., Siregar, P., Caniago, I. and Kasischke, E., 2004. Lowland forest loss in protected areas of Indonesian Borneo. Science, 303(5660):1000-1003.

Dutta, K., Reddy, C.S., Sharma, S. and Jha, C.S., 2016. Quantification and monitoring of forest cover changes in Agasthyamalai Biosphere Reserve, Western Ghats, India (1920–2012). *Current Science*, 110(4):508-520.

Echeverría, C., Newton, A.C., Lara, A., Benayas, J.M.R. and Coomes, D.A., 2007. Impacts of forest fragmentation on species composition and forest structure in the temperate landscape of southern Chile. *Glob. Ecol. Biogeogr.*, *16*(4):426-439.

Ellenberg, D. and Mueller-Dombois, D. 1974. *Aims and methods of vegetation ecology*. New York: Wiley.

Ewers, R.M., Didham, R.K. 2006. Confounding factors in the detection of species responses to habitat fragmentation. *Biol. Rev*. 81:117–142.

FAO 2001. Global forest resources assessment 2000: main report. FAO forestry paper 140, Food and Agriculture Organization, Rome, Italy.

Jensen, J.R., 2004. "Digital Change Detection" Introductory digital image processing: a remote sensing perspective. Prentice-Hall, New Jersey.

Kale, M.P., Chavan, M., Pardeshi, S., Joshi, C., Verma, P.A., Roy, P.S., Srivastav, S.K., Srivastava, V.K., Jha, A.K., Chaudhari, S. and Giri, Y., 2016. Land-use and land-cover change in Western Ghats of India. *Environ. Monit. Assess. 188*(7):1-23.

Kim, M., Madden, M. and Warner, T.A. 2009. Forest type mapping using object-specific texture measures from multispectral Ikonos imagery. *Photogramm. Eng. Remote Sensing*. 75(7):819-829.

Kushwaha, S.P.S. and Madhavan Unni, N.V., 1989. Hybrid interpretation for tropical forest classification. *Asian-Pacific Remote Sensing J. 1*(2):69-75.

Kushwaha, S.P.S., 1990. Forest-type mapping and change detection from satellite imagery. *ISPRS J. Photogramm. Remote Sens. 45*(3):175-181.

Lira, P.K., Tambosi, L.R., Ewers, R.M. and Metzger, J.P., 2012. Land-use and land-cover change in Atlantic Forest landscapes. *For. Ecol. Manag.*, 278:80-89.

Mallupattu, P.K. and Sreenivasula Reddy, J.R., 2013. Analysis of land use/land cover changes using remote sensing data and GIS at an Urban Area, Tirupati, India. *Sci. World J.*, 2013:6.

Panigrahy, R.K., Kale, M.P., Dutta, U., Mishra, A., Banerjee, B. and Singh, S., 2010. Forest cover change detection of Western Ghats of Maharashtra using satellite remote sensing based visual interpretation technique. *Current Science*, 98(5):657-664.

Reddy, C.S., Jha, C.S. and Dadhwal, V.K., 2016. Assessment and monitoring of long-term forest cover changes (1920–2013) in Western Ghats biodiversity hotspot. *Journal of Earth System Science*, *125*(1):103-114.

Richards, J.A. and Richards, J.A., 1999. *Remote sensing digital image analysis* Berlin: Springer. 3, pp. 10-38.

Roy, P.S., Kaul, R.N., Sharma Roy, M.R. and Garbyal, S.S. 1985. Forest-type stratification and delineation of shifting cultivation areas in the eastern part of Arunachal Pradesh using LANDSAT MSS data. *International Journal of Remote Sensing*, *6*(3-4), pp.411-418.

Torahi, A.A. and Rai, S.C., 2011. Land cover classification and forest change analysis, using satellite imagery-a case study in Dehdez area of Zagros Mountain in Iran. J. Geogr. Inf. Syst., 3(01):1.

Wallace, J., Behn, G. and Furby, S. 2006. Vegetation condition assessment and monitoring from sequences of satellite imagery. *Ecol. Manag. Restor.*, *7*:31-S36.