Forest cover change detection using Geo-informatics Technology: A Spatio-temporal Analysis based on Pottuvil and Thirukkovil Divisional Secretary Division in Ampara District, Sri Lanka

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Abstract

Forest resources are declining as the land use changes take place. There are opportunities to achieve sustainable development by maintaining the balance of forests when heading towards an integrated approach to protect the forest resources. Therefore, this study is to detect the spatio-temporal change in forest cover in Pottuvil and Thirukovil areas during the period from 2007 to 2020. Landsat 7 ETM+ imagery of 2007 and Landsat 9 OLI imagery of 2022 have been used to detect the forest cover change within the period with the aid of geoinformatics technology. The accuracy assessment was calculated to validate the data accordingly, the overall accuracy computed as 88.9% in 2007 and 89.6% in 2022. Also, the user accuracy is 80.4% in 2007 and 82.5% in 2022. The producer accuracy for these two years is 90.1% and 91.0% respectively. In this sense, in 2007, 23,769 hectares of forest cover were identified in the study area. However, by the beginning of 2022, it had decreased to 22,020 hectares of which had been converted into Agricultural lands (1,709ha), Buildup lands (18ha.), Wetland (7ha.), and Barren lands (16ha). It has been found that deforestation in this region, mostly due to the agricultural expansion, is causing various challenges to ecology and biodiversity. Legal action should be taken against this increasing deforestation through concerned authorities. Integrated approach is a must to protect the endangering forest resources in the study area.

Keywords- sustainable development, forest cover, Geo-informatics, Temporal Analysis, Deforestation

Introduction

Forest resource is an inevitable part of human life which supports in various ways and acts as a green blanket while preserving the natural resources (Sakthivel et al 2010). Human counts on forest resources for goods and ecosystem services (Vijitharan et al, 2022) viz. shelter, water, food, nutrient cycling and sssrecreational values (Sajjad et al, 2015). However, grazing, industrial activities, unplanned land use practices and urbanization lead to the loss of forest and desertification (Aigbe & Oluku, 2012). Also, the forest resource is extracted for various commercial purposes such as timber, paper and pulp industries and other industrial activities (Ranagalage et al, 2020).

The rapid population growth and technological advancement demands increasing natural resource consumption. In particular, the situation is rife in developing countries where natural resources are being indiscriminately consumed. According to the World Population Prospects report, the world population was approximately 7.3 billion in 2015 and is expected to increase to 9.7 billion in 2050 and 11.2 billion in 2100 (World Population Prospects, 2015) this situation would therefore make an increasing demand for the decreasing forest resources. In Sri Lankan context, the forest resources accounted for 32.2 percent in 1992 of the total land area. However, in 2010, it decreased to 26.6% (Singh 2013). One of the major ramifications to the loss of forest resource is deforestation which has posed numerous threats to biodiversity, disruption in water supply, soil degradation, and climate change etc. (Silva and Dayawansa 2019).

Due to the lack of land use land cover change analysis, dearth of adequate research and localized and limited studies (Soto-Berelov et al. 2020), the loss of forest resources is neglected to be addressed. The satellite remote sensing is an excellent tool and widely used for geospatial mapping and to detect land use changes (Kennedy et al. 2015), through which we can trace the spatio-temporal changes (Reis 2008).

Substantial studies are vital to find out the spatio-temporal changes of the forest resources since they are under the severe stress due to the infrastructure activities. Geoinformatics application is a strong platform to detect the forest cover changes using the historical satellite imageries and the ground surveys, can produce high accuracy output and support to the protective and productive activities to conserve the forest resources. Therefore, this study also aims to find out the spatio-temporal changes in the forest resource within the Pottuvil and Thirukovil areas in the Ampara district for the period of 2007 and 2022 in order to make a significant contribution to conserve the forest resources in the study area.

2. Materials and Methods

Study Area

Thirukovil and Pottuvil Divisional Secretariat Divisions (DSD), located in the southeast Ampara district, have been selected for this research. The areas lie between 6°49'3.90"and 7°11'5.70" North Latitude, and 81°51'38.68, and 81°48'25.72 East Longitude. Pottuvil DSD covers an area of 29,401 hectares and includes 27 Grama Niladhari Divisions. There are 22 Grama Niladhari Divisions within Thirukkovil Divisional Secretariat limits which covers an area of 16,728 hectares. The undeclared (dispute area on the figure 01), which cannot be identified as Thirukovil or Pottuvil, is found to be 7,805 hectares. Generally, in Ampara district, farming and animal husbandry are considered as the major economic activities (Pavithra et al, 2017) particularly in the study area, agricultural activities can be observed in two seasons depending on the water accessibility and the existence of forest and pasture lands which greatly supports the cattle rearing. The study area is located in the tropical region of Sri Lanka.

Population of Pottuvil and Thirukkovil account for 41,864 and 30,344 respectively (Statistical Report (Pottuvil and Thirukkovil) -2021). These areas come under war-torn regions in Sri Lanka. Due to the fact that, the people, before 2007, lived reluctantly in areas close to forests. Pottuvil area is also popular for tourism in which the Arugam bay, being famous for international surfing, is located. In addition, the Kumana sanctuary which is one of the Ramsar wetlands, supporting biodiversity and sustaining ecological balance in the area, is also situated in the study area.

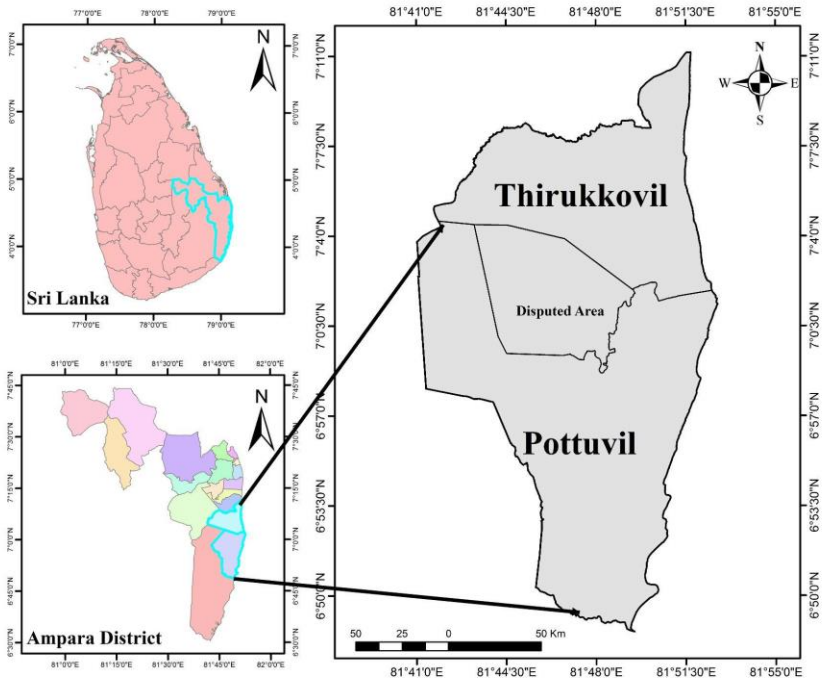

Figure 1- Study area
Source: - Source: Survey Department of Sri Lanka, 2018. https://it.survey.gov.lk/gn_updating/

3. Methods

Landsat 7 EMT+ and Landsat 9 OLI data were used for the analysis (path: 141 and Raw: 55) which were downloaded from earth explorer website. Supervised classification was done having collected the ground truth data (Kim 2016) 30 Ground Control Points (GCP) with the aid of GPS tool were collected from each land use feature in the study area. As such, 180 samples GCP points were collected and compared for the data validation. Land use features were identified through the supervised classification method and using the nearest neighbor resampling method.

In this study, a total of five land use classes such as Agriculture, Bare Land, Forest Land, Water bodies, and buildup land were identified and the spatio-temporal changes were detected which are shown in the maps. Accurate classifications are essential to ensure accurate change detection results (Reis 2008) and the accuracy was validated for both periods.

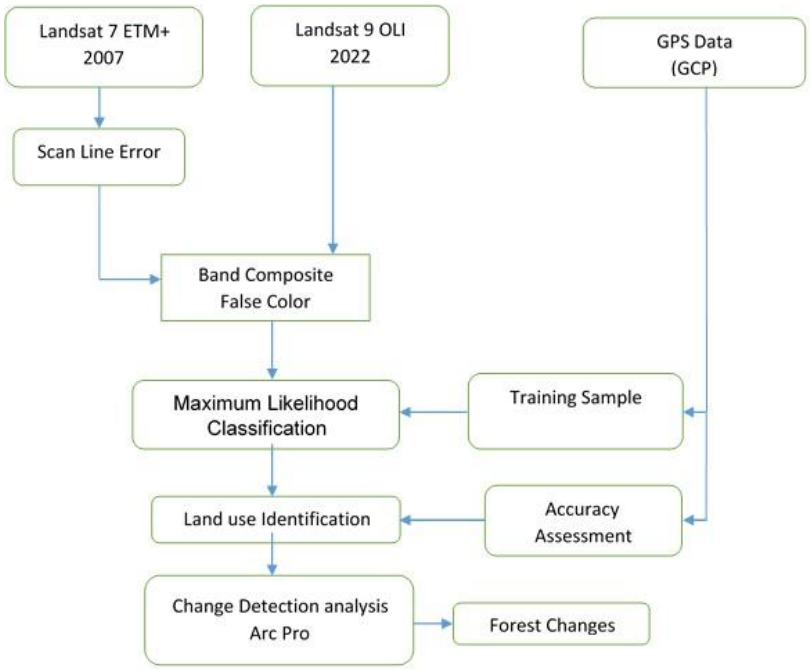

Figure 2: Methodology flowchart

Accuracy assessment

30 GPS points were acquired and analyzed for each land use feature to determine the accuracy of the satellite data. A total of 180 samples were obtained for this analysis and its accuracy was calculated.

Table 4: Accuracy assessment 2007 - 2022

Land Type	Barren	Developed	Forest	Planted / Cultivated	Water	Wetlands
Classification accuracy of 2007	89.6	93.3	90.4	88.1	92	80.1
Classification accuracy of 2022	90.9	92.3	92.3	85.7	93	83.8

Source: retrieved from Landsat Image, 2007 and 2022

The overall accuracy of this survey was found to be 88.9% in 2007 and 89.6% in 2022. User accuracy is 80.4% in 2007 and 82.5% in 2022. The producer accuracy for these two years is 90.1 and 91.0 respectively.

4. Results and Discussion

The study has found that the forest cover change occured in the study area between 2007 and 2022 according to figure 02.

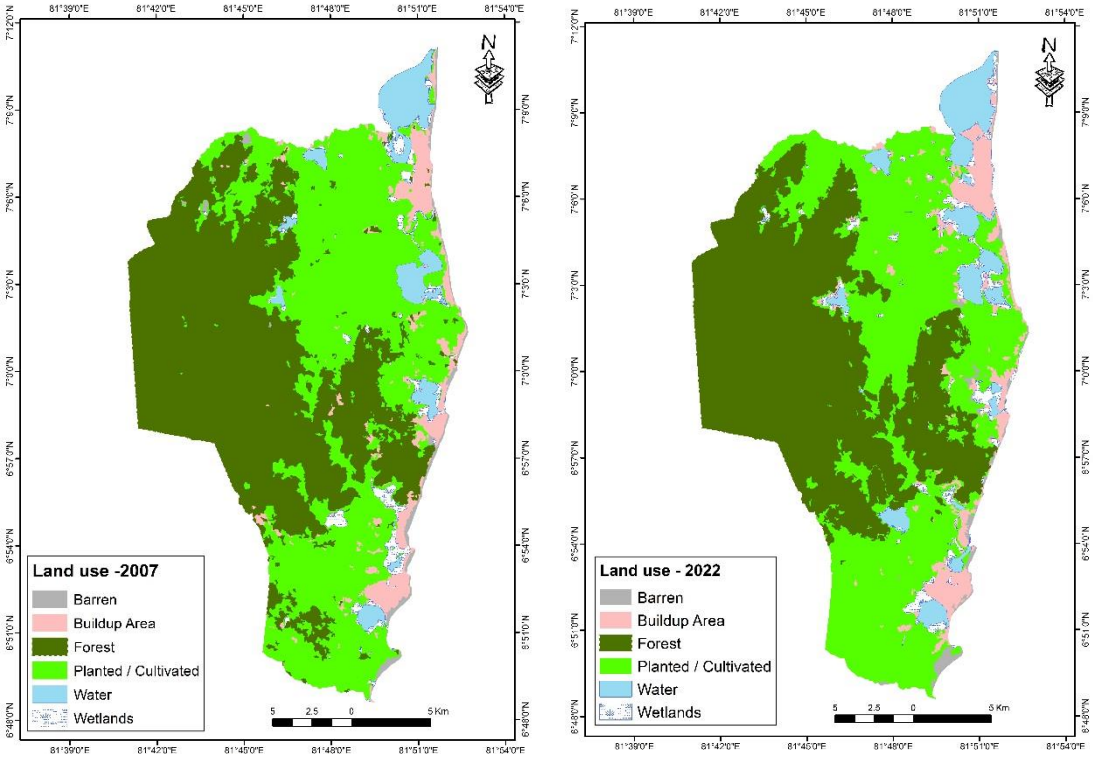

Figure 2: Land use changes of the years 2007 and 2022

Source: retrieved from Arc GIS

According to figure 02, the extent of Barren land was 664 ha in 2007 which has reduced to 591 ha in 2022. Conversely, the Buildup land shows an uptick to 3,075 ha which accounted for 2801 ha in 2007. This shows an increasing trend of settlements in the area during the post war period. It can be observed that in the study area, the loss of forest cover was recorded as 1,740 ha whereas the agricultural land has been increased by 1555 ha. Also, the water bodies which were at 2,520 ha in 2007 have decreased to 2427 ha in 2022 and the wetland has increased by 87 hectares from 2007 to 2022. It is evident that the forest cover has declined on which other land use has encroached in the study area.

Table 1: Land use Change 2007 - 2022

No.	Type of Land use	Extent(Ha)	
		2007	2022
1	Barren	664	591
2	Developed	2801	3075
3	Forest	23769	22020
4	Planted / Cultivated	21697	23252
5	Water	2520	2427
6	Wetlands	1313	1400
Total		52764	52764

Source: Created Based on Landsat Image, 2007 and 2022

In the last 15 years, forest cover in the study area has been showing reduction and the forestry lands have been turned into other land use. It can be noted that 18 hectares of forest cover have been cleared for

residential purposes. Also, 1,709 hectares of forests have been cleared for agricultural purposes including chena cultivation. Further, 07 and 16 hectares of forest land became wetland and barren land respectively in the study area.

Table 2: Forest Change in Pottuvil and Thirukovil Area 2007 - 2022

No.	Type	Extant(ha)
1	Forest ->Developed	18
2	Forest ->Planted /cultivated	1709
3	Forest->Wetland	7
4	Forest->Barren Land	16
5	No Change Forest	22020

Source: Analyzed from Landsat Image, 2007 and 2022

It can be cited that no change areas identified by TM based forest cover classification is not necessary for forest change monitoring according to Vijitharan et al, (2022). In the study area, around 22,020 hectares of forest cover have been identified as no change areas which means that there are no any changes within the particular forest cover from 2007 to date.

Forests are being converted into agricultural land as shown in the map (figure 3). It can be seen that the deforestation takes place in areas with clear boundaries. When deforestation occurs in conflicting areas, mutual complaints prevent deforestation in the study area. The figure 03 shows the conversion of forest cover into different land use patterns.

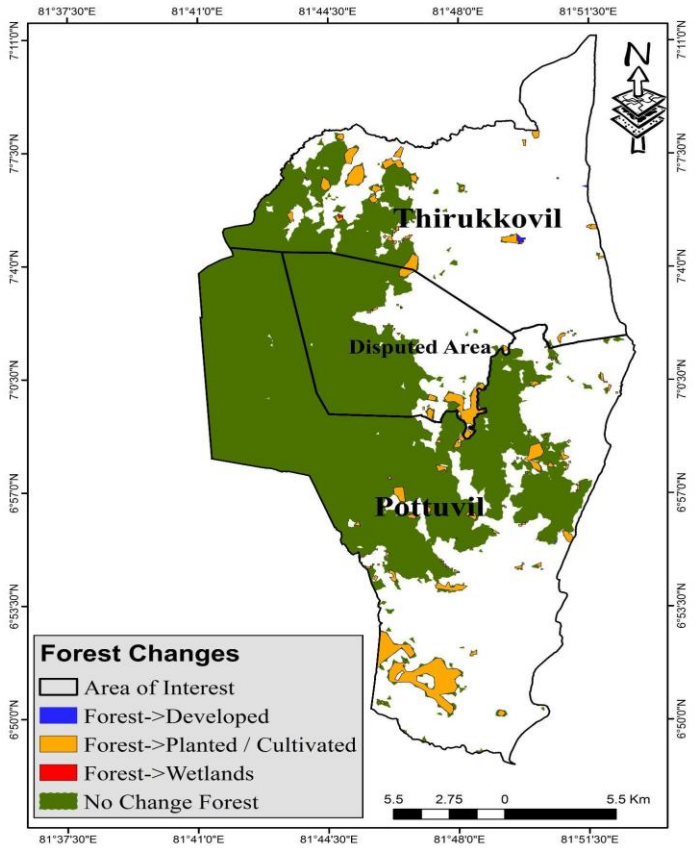

Figure 3: Forest cover changes
Source: Retrieved from Landsat Image, 2007 and 2022

Table 3: Forest cover Change in Pottuvil and Thirukovil Area 2007 - 2022

Changes	Thirukkovil	Pottuvil	Disputed area
Forest->Developed	6	12	
Forest->Planted / Cultivated	470	987	252
Forest->Wetlands	3	4	
Forest->Barren Land	7	8	1
No change	3146	12600	4474

Source: Created Based on Landsat Image, 2007 and 2022

The paper has found that 13% of forest cover in Thirukkovil and 7% of forest cover in Pottuvil have been destroyed due to deforestation.

Conclusion

Monitoring the forest cover change with geoinformatics technology provides efficient outcomes to develop strategies for forest resource management. Forests are an integral part of Sri Lanka which supports biodiversity and a dynamic entity that is constantly evolving under anthropogenic pressures. The study has found that in Pottuvil and Thirukkovil DSDs, the forest cover change occurred drastically in the period from 2007 to 2022. It can be suggested that sustainable measures are vital to protect the decaying forest resources in the study area with the stakeholder's integration and organizational and institutional collaborations.

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