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USE OF SPATIAL TECHNOLOGY FOR LAND COVER CHANGE ASSESSMENT IN PROTECTED AREA MANAGEMENT

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Abstract

Land cover assessment and monitoring of land cover dynamics are important to understand social and ecological processes in protected areas and it is helpful in monitoring, modelling and detection of environmental changes. Land cover is the characteristics of the physical material on the ground surface. Change in land cover is among the most important human alteration affecting the surface of earth that directly impacts on biological diversity. Such changes affect and increase the vulnerability of population, environment and ecosystem to global phenomena of climate change. This study has assessed the changes in land cover in Shivapuri Nagarjun National Park (SNNP) along with its Buffer Zone during twenty-seven years. The main objective of this study is to identify the changed scenario on land cover condition of the study area based on available topographic maps (1994), Google Earth images (2021) and Key Informant Interview (KII). The study has adopted Remote Sensing (RS), Geographic Information System (GIS) and Global Positioning System (GPS) approach supported by secondary data and focus group discussion for classification and mapping of land cover. Among the different land cover classes, forest land, sandy area, water bodies and others land particularly built up area have been increased whereas, the bush/shrub land, cultivated land and grass land have been found decreased in the park area. On the other hand, the cultivated land, grass land and water bodies have been found decreased, while the bush/shrub land, forest land, sandy area and others land particularly built up areas have been found significantly increased during 1994 to 2021 in the BZ area. It will provide a baseline for planners and policy makers to make proper plans to sustainably manage the protected area's land cover.

Keywords: Conservation, environment, google earth images, natural resources, protected area

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Introduction

Geographical Information System (GIS) enhances geographical knowledge, improves geographical enquiry, spatial analysis ability and develops mapping skills (Ofstet, 2004). Protected areas throughout the world are the key for conserving biodiversity and maintaining ecosystem services essential for human sustenance (Defries et al., 2007). Land cover change is a global multi-scale process affecting ecosystems, with potential implications for ecological processes and for the biological communities that support them (Small & Sousa, 2016). Land cover changes are especially relevant for protected areas where long-term ecosystem stability is a critical aspect of protecting and maintaining high levels of biodiversity and ecosystem functions (Guerra et al., 2019). Understanding of land cover change is essential to understand landscape patterns and their changes, which is useful for the assessment of human induced drivers and their impacts on the ecosystem (Bajracharya et al., 2010). Peoples' participation, management objectives and type of Protected areas governance provides opportunities for information and education, recreation, scientific research and contributes to regional and local development (Getzner et al. 2010).

Protected area management system has been established in Nepal since 1973 with the establishment of Chitwan National Park as the first National Park. In addition to protected areas establishment, Government of Nepal has also strengthened the protection measures of wildlife and their habitat (DNPWC, 2011 cited in Paudyal, 2016). Nepal has established a network of protected areas consisting of twelve National Parks, six Conservation Areas, one Wildlife Reserve, one Hunting Reserve, with thirteen Buffer Zones in and around National Parks and Reserves covering 23.39 percent (34,419.75 sq km) of the total geographical area of Nepal (DNPWC, 2020).

Remote Sensing (RS), Geographical Information System (GIS) and Global Positioning System (GPS) are the most capable tool to identify land cover change and detect analysis in both temporal and spatial dimensions (Wijesinghe & Withanage, 2021). These technologies have emerged as important tools for monitoring and management of natural resources including protected areas.

Information on land cover and land management practices is essential for the sustainable management and economic development of natural resources (FAO, 2017). Information regarding the current state of resources and how they are being managed is required to predict future states. For better management of protected areas, conservationists, decision makers and manager are required to have informed knowledge on biophysical as well as socio-economic information and human use patterns of natural resources

in addition to their proper accounting system. This information will enable them to solve problems of resource protection and sustainable use, environmental degradation, land cover assessment, natural resource management. With this background, RS, GIS and GPS based spatial database and mapping of existing land cover types and their classification according to national categories will provide basic set of information in terms of digital spatial coverage and tabular form which will enable sustainable management and protection of the PAs. However, there is a long gap in generating spatial database and quantitative geographic outputs for taking appropriate management decisions. In this regards, this study aims to identify the changed scenario on land cover condition of the study area in spatial form of database and maps based on available topographic maps (1994) and Google Earth (2021).

Methods and Materials

Data source and methods

Primary and Secondary sources of data has been compiled for this study. Digital data layers on land cover (1994) based on topographic map has been collected from the Department of Survey, Government of Nepal and present land cover map (2021) has been prepared using the Google Earth image downloaded from Google Earth Pro for the study area. The Google earth image has been converted into vector ESRI shape file by the application of Arc GIS 10.5 software through digitization procedure which has given the land cover map of the study area for 2021. Further, ground truthing has been carried out through the help of hand held GPS (Garmin 64 CS), printed form of Google image and topographic maps with the interaction and sharing to park staffs, local communities and key informants for more realistic and efficient way.

Land cover classification has been categorized into major six classes (Bush/shrub land, cultivated land, forest area, grass land, sandy area and water bodies) then remaining land classes (like barren land, built up area, landslides/cliffs) have been included under others land to detect change analysis during the temporal expansion of twenty seven years. After the categorization of different classes and defining the code, overlay analysis has been applied through Arc GIS 10.5 software. Tabulation and summarization for fact figure calculation has been developed in MS excel software through pivot table generation.

Study Area

Geographically Shivapuri Part of SNNP is located within 27°45' to 27°52' N latitude and 85°16' to 85°45' E longitude and Nagarjun part is located within 27°43' to 27°46' N latitude and 85°13' to 85°18' E longitude. It covers parts of Kathmandu, Nuwakot,

Sindhupalchowk and Dhading districts of central Nepal and has extended in the surface area of total 159 sq km in Park (it is according to the Nepal Gazettes, however it is actually 112.055 sq km in the field using the GIS application) and an area of 118.61 sq km in Buffer zone (116.346 sq km in the field using GIS application) (Figure 1).Elevation of the park ranges from 960 to 2732 meters above the sea level. However, most of the park lies between 1,600 m and 2,500 m. Shivapuri is the origin of some important river systems including Bagmati, Bishnumati, Nagmati, Syalmati, Rudramati, and Ikshumati. Shivapuri Nagarjun National Park has one of the richest biodiversity owing to topographical and climatic diversity ranging from mid-hill, high-hill to the mountainous topography and is a Great Mid-Himalayan ecosystem (Sharma et al., 2012). It has subtropical to warm temperate climate. There is a high variation in annual temperature and precipitation. The weather station at Kakani (altitude 2066 m), has record of average maximum temperature of 22.7^0 C in mid - May/June and of average minimum temperature of 0.3^0 C in December/January. The mean annual precipitation is 2700 mm mostly occurring during monsoon period. The time during autumn is perfect to visit the national park.

The SNNP comprises four types of forests, which supports rich floral and faunal diversity. The SNNP is estimated to possess 1402 species of plants and 30 species of mammals, including nine threatened species, such as Pangolin, Leopard cat, Clouded leopard, Common leopard, Goral, Himalayan black bear, Assamese monkey (SNNP/ DNPWC, 2018).

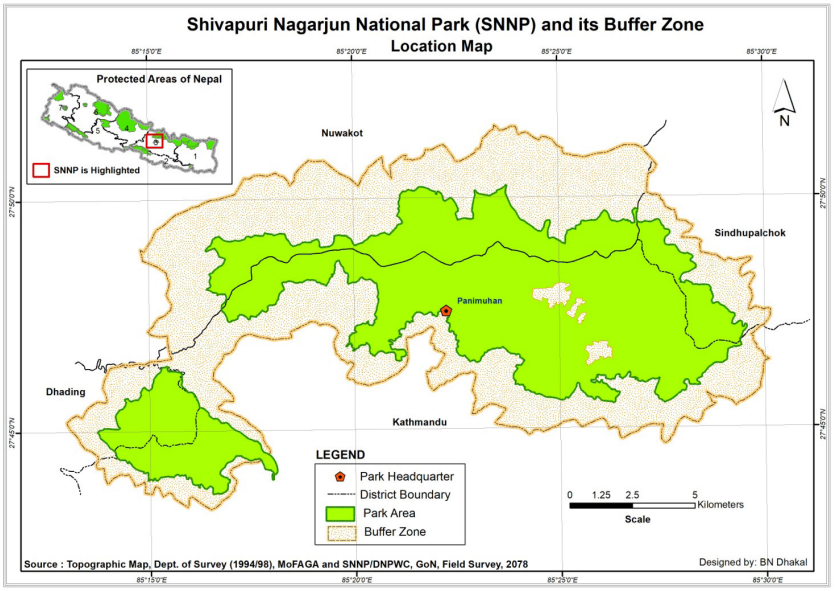

Figure 1: Location map of study area

Results and discussions

Existing Land Cover of SNNP

Land Cover Classes (1994 to 2021)

Land cover classes have been categorized into major six classes (Bush/shrub land, cultivated land, forest area, grass land, sandy area and water bodies) then remaining land classes (like barren land, built up area, landslides/cliffs) have been included under others land. According to the land cover classification based on topographic maps and Google earth images, forest, bush/shrubs and cultivated land have been found the major land cover classes in the SNNP area. The total land occupied by the SNNP is found as 112.055 sq km. Forest land has the major dominating land cover type in the park covering 74.35 percent of the total area of the park and followed by bush/shrub land with 20.10 percent of total area. Similarly, cultivated land has occupied 5.0 percent of the total area of the park based on topographic map (1994) (Table 1). Likewise, forest land has occupied 86.26 percent of the total area of the park and followed by bush/shrub land with 10.56 percent of total area. Similarly, cultivated land has occupied only 2.0 percent of the total area of the park based on Google Earth Image (2021) (Table 1).

Table 1: Land cover in park area of SNNP (1994 and 2021)

Land Cover Classes	**1994**		**2021**	
	Area (Sq. km)	**Percent**	**Area (Sq. km)**	**Percent**
Bush/shrub area	22.519	20.10	11.838	10.56
Cultivated land	5.599	5.00	2.236	2.00
Forest area	83.315	74.35	96.662	86.26
Grass land	0.567	0.51	0.455	0.41
Sandy area	0.000	0.00	0.001	0.00
Water bodies	0.005	0.00	0.036	0.03
Others land	0.051	0.05	0.827	0.74
Grand Total	**112.055**	100.00	**112.055**	100.00

Source: Topographic Map, Department of Survey, GoN (1994) and Google Earth Images (2021)

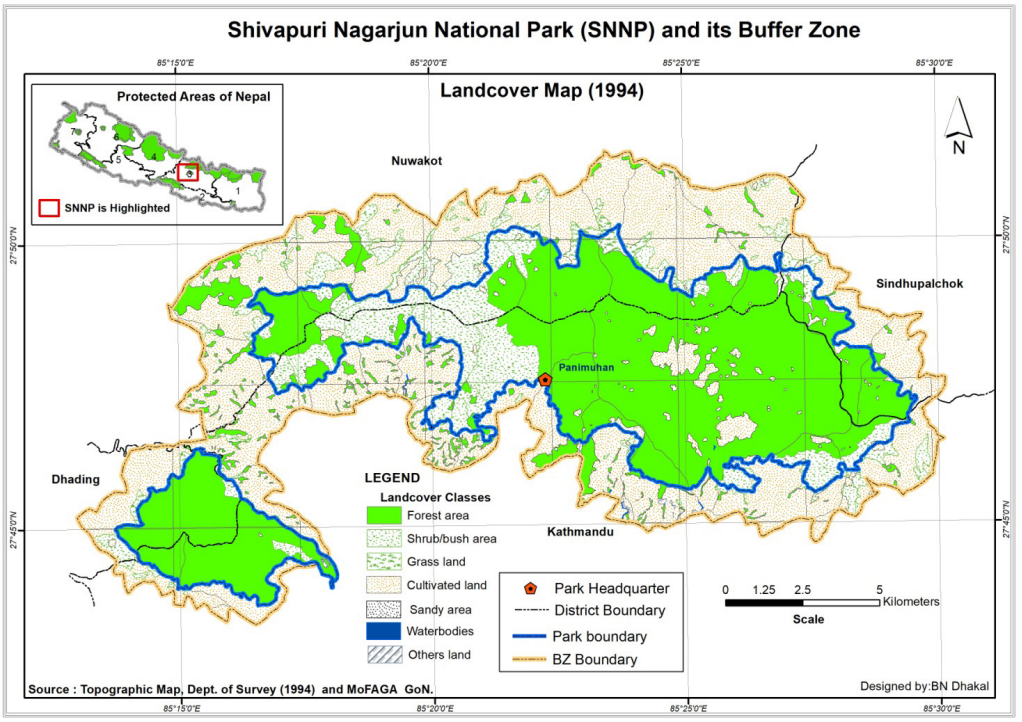

Figure 2: Land cover map (1994)

Land cover changes between 1994-2021 in park area of SNNP

According to the existing land cover classes based on the topographic data of the year 1994 and Google Earth Image 2021, the forest land has increased by 11.91 percent during the study period in the park area. Whereas, the bush/shrub land and cultivated land have plummeted de significantly by 9.53 percent and 3.0 percent respectively within the same period of time (Table 2). In the same way, grass land has also found decreasing by 0.1 percent. However, sandy area, water bodies and others land particularly built up area has been found increased during the study period in the park area (Figure 3). Similar type of study conducted in the Chitwan Annapurna Landscape area during 2000 to 2020 noticed an overall increase in Sal dominated forest, built up area, mixed forest and decreased in riverine forest, barren area, croplands and grasslands (Adhikari et al., 2022).

Table 2: Land cover changes during 1994-2021 in park area

Land cover classes	Bush/ Shrub area	Cultivated land	Forest area	Grassland	Others land	Sandy area	Water Bodies	Grand Total
Bush/shrub area	0.917	0.140	21.288	0.015	0.159	0.000	0.000	22.519
Cultivated land	1.454	1.798	1.549	0.356	0.423	0.000	0.018	5.599
Forest area	9.437	0.298	73.239	0.083	0.242	0.000	0.015	83.315
Grass land	0.029	0.000	0.537	0.000	0.000	0.000	0.000	0.567
Others land	0.000	0.000	0.047	0.000	0.004	0.000	0.000	0.051
Water bodies	0.000	0.000	0.001	0.000	0.000	0.000	0.004	0.005
Grand Total	**11.838**	**2.236**	**96.662**	**0.455**	**0.827**	**0.001**	**0.036**	**112.055**

Source: Compiled by author.

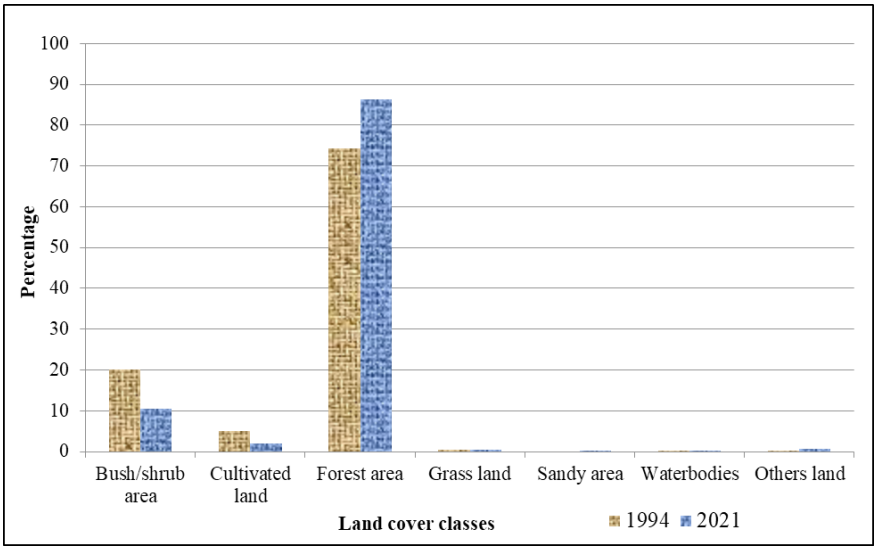

Figure 3: Land cover change in park area of SNNP

Existing Land Cover in Buffer Zone of Shivapuri Nagarjun National Park

According to the land cover classification based on topographic maps and Google earth images; cultivated land, bush/shrubs, forest land, grass land, sandy area and water bodies have been found the major land cover classes in the BZ of SNNP. The total land occupied by the BZ of SNNP is 116.346 sq km., cultivated land has been found the major dominating land cover type in the BZ area covering 80.43 percent of the total area of the BZ followed by bush/shrub land with 8.69 percent of total area. Similarly, forest

land has occupied 8.04 percent of the total area of the BZ based on topographic map (1994) (Table 3). Likewise, cultivated land has occupied only 42.99 percent of the total area of the BZ followed by bush/shrub land with 25.82 percent of total area. Similarly, forest land has occupied more area i.e. 18.06 percent of the total area of the BZ based on Google Earth Image (2021) (Table 3).

Table 3: Land cover in buffer zone (1994 and 2021)

Land Cover Classes	1994		2021	
	Area (Sq km)	Percent	Area (Sq km)	Percent
Bush/shrub area	11.274	9.69	30.041	25.82
Cultivated land	93.577	80.43	50.017	42.99
Forest area	9.359	8.04	21.013	18.06
Grass land	1.743	1.50	1.586	1.36
Sandy area	0.178	0.15	0.270	0.23
Water bodies	0.086	0.07	0.063	0.05
Others land	0.128	0.11	13.356	11.48
Grand Total	**116.346**	100.00	**116.346**	**100.00**

Source: Topographic Map, Department of Survey, GoN (1994) and Google Earth images (2021)

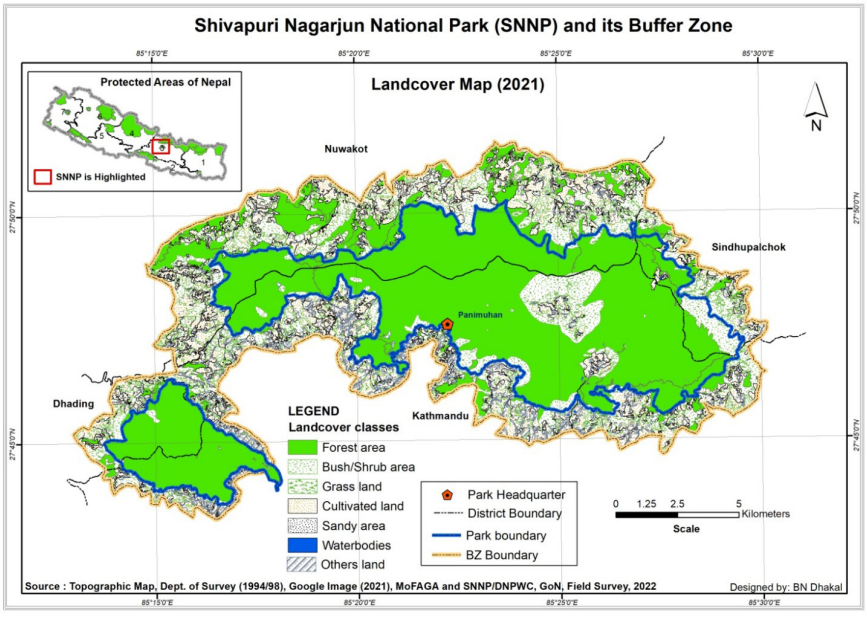

Figure 4: Land cover map (2021)

Land Cover Change in Buffer Zone Area of SNNP during 1994 to 2021

According to the existing land cover classes based on the topographic data of the year 1994 and Google Earth Image 2021, the cultivated land has been found decreased significantly by 37.44 percent during the study period in the BZ area. Whereas, the bush/shrub land and forest land has been found skyrocketed significantly by 16.13 percent and 10.02 percent respectively within the same period of time (Table 4). In the other way, grass land and water bodies have observed decreasing by 0.14 and 0.02 percent respectively. However, sandy area and others land particularly built up area has been found increased during the study period in the BZ area (Figure 5). Same type of another study conducted in Bagmati River Basin (BRB) of Nepal during 1988-2018 and found that there have been an increase in urban/built-up, barren land, shrub land, and a decline in forest cover, cultivated land, water bodies, sandy area, and grass cover during the study period (Rijal et al., 2021).

Table 4: Land cover change in buffer zone area during 1994 to 2021

Land cover classes	**Bush/ Shrub area**	**Cultivated land**	**Forest area**	**Grassland**	**Others land**	**Sandy area**	**Water bodies**	**Grand Total**
Bush/ shrub area	3.433	0.654	6.573	0.346	0.263	0.003	0.002	11.274
Cultivated land	22.524	47.880	9.051	1.197	12.612	0.258	0.056	93.577
Forest area	3.066	1.118	4.688	0.036	0.441	0.009	0.001	9.359
Grass land	0.902	0.192	0.633	0.007	0.009	0.000	0.000	1.743
Others land	0.067	0.037	0.000	0.000	0.023	0.000	0.000	0.128
Sandy area	0.034	0.077	0.063	0.000	0.002	0.000	0.002	0.178
Water bodies	0.015	0.059	0.005	0.000	0.006	0.000	0.002	0.086
Grand Total	**30.041**	**50.017**	**21.013**	**1.586**	**13.356**	**0.270**	**0.063**	**116.346**

Source: Compiled by author.

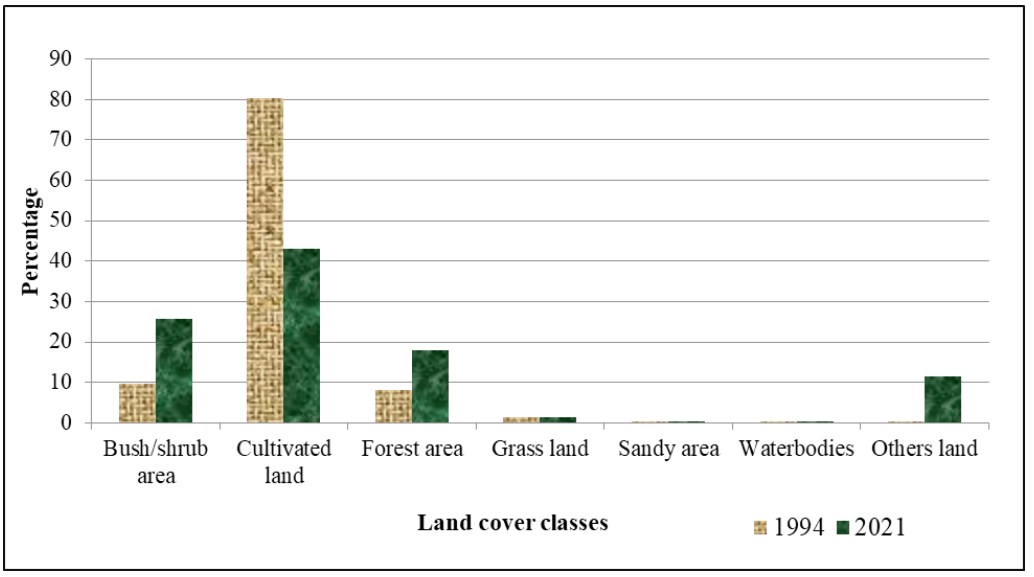

Figure 5: Land cover change in buffer zone area of SNNP

Conclusions

Land is the most important natural resource on which all bio-physical and socio-economic activities are based and it is dynamic and indeed changing. This study presents land cover changes within and outside of protected area using Remote Sensing (RS), GIS and GPS technology during 1994 to 2021.Use of spatial technology is an effective way to monitor and analyze the land cover change. The study of land cover dynamics is essential to identify past and current trends of change and stability to understand how these vary over space and time.

Forest, bush/shrubs, grass, cultivated land, sandy area and water bodies have been identified as the major land cover categories in the Shivapuri Nagarjun National Park (SNNP) and its buffer zone. Among the different land cover classes, this study has found that forest land, sandy area, water bodies and others land particularly built up area have been increased whereas, the bush/shrub land, cultivated land and grass land have been found decreased significantly during the study period in the park area. On the other hand, the cultivated land, grass land and water bodies have plummeted significantly during the study period in the BZ area. Whereas, the bush/shrub land, forest land, sandy area and others land particularly built up area have been found escalated significantly within the same period of time during 1994 to 2021. It is concluded that forest resource

area is in increasing trend in both park and BZ areas. It indicates that there has been positive implication on conservation of forest resources in SNNP and its buffer zone which has also enhanced wildlife protection and biodiversity conservation along with the formation of effective periodic and long term plans. **U**nmanaged infrastructure development like community institutions (schools, temples, gumba, church etc.) and new road constructions have been reported for the reasons behind the decreasing of the cultivated and others land in the study area. Where, the government should take an action in order to control unmanaged land use plans. This study provides a baseline for planners and policy makers to make proper plans to sustainably manage the protected area's land cover.

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