# Assessing Long-Term Land Use and Land Cover Changes Around Raimona National Park, Assam, India

**Rachan Daimary<sup>1</sup>** \* and Hiranmoy Chetia<sup>2</sup>

<sup>1</sup>Manipal University Jaipur, India.

<sup>2</sup>Amity University Noida, India.

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Abstract: Raimona National Park was established in 2021 and is known for its rich biodiversity and unique ecosystems in Assam. Rapid human population growth, agricultural expansion, resource extraction, and climatic conditions have exerted significant pressure on the park and its surrounding landscape. Land use and land cover change (LULC) is the most significant observable environmental change and is a continuous process. Quantifying the magnitude and variety of the variability of these changes in the protected area provides a scientific understanding of past and present trends, as well as potential mitigation strategies for future park management. As a relatively new addition to India's protected area network, Raimona National Park offers an opportunity to study landscape transformations and changes in land use and land cover. This study examines public perceptions, LULC changes over the past half-century, and the ethnobiological relation to biodiversity, particularly how collection patterns have evolved. Satellite imagery from the Esri Sentinel-2 Land Cover Explorer was used to analyze LULC changes between 2017 and 2023. Additionally, decadal LULC changes were assessed using Google Earth maps from 1984, 1994, 2004, 2014, and 2024 to understand the historical landscape dynamics of Raimona National Park. Land use trends over 50 years were examined using questionnaire surveys, remote sensing, GIS, and historical data.

Keywords: Raimona National Park, LULC, Satellite Image, Remote Sensing, People Perception.

# **1.Introduction**

According to Government Notification No. FRW.02/2021/27, dated June 9, 2021, Raimona National Park (RNP) was officially established in 2021, covering a total area of 422 sq.km. in the Kokrajhar district of Assam. The park falls under the authority of Assam's Bodoland Territorial Region (BTR) and is geographically located between 26°37' and 26°50' N latitude and 89°51' and 90°14' E longitude. The Kokrajhar district was created on July 1, 1983, and was previously a part of the undivided Goalpara district. It spans 3296 sq. km. with approximately 1166.57 sq. km. covered by forests. The forested area consists of 358.38 sq. km. of moderately dense forest, 270.19 sq. km. of very dense forest, and 438 sq. km. of open forest accounting for 35.39% of the district's total geographical area (Mahanta et al., 2022). Raimona National Park is located in the

foothills of the Eastern Himalaya Biodiversity Hotspot and serves as the westernmost buffer zone of Manas Tiger Reserve. The park is home to a diverse range of wildlife, including spotted deer, wild buffalo, hornbills, Indian gaurs, clouded leopards, tigers, and golden langurs, among other species.

The RNP falls under Kachugaon Forest Division, the region that was formerly known as Ripu Reserve Forest (Government Notification No. 7606 dt. September 22, 1893), encompassing 605.27 sq. km. With the highest density of sal forest in Asia, the Ripu Reserve Forest was among the nation's oldest and best scientifically maintained forests in the late 19th century (Daimary & Basumatary, 2024). The name "Raimona" is derived from "Raymana," which was the capital name of the vassal state of Ripuduar located in the foothills of Bhutan (Hamilton & Bhuyan, 1940). The park is a treasure trove of biodiversity, boasting

an impressive array of flora and fauna. The park has a rich history dating back to the late 19th century when it was a dense Sal-Forest and part of the tributary state Ripuduar. However, by the end of the 1800s, the RNP region became enveloped by savannah forests (Mahanta *et al.*, 2022).

The RNP is renowned for its remarkable butterfly diversity, with over 150 species documented within the park. Its unique ecosystem supports a wide range of host plants, nectar sources, and mud puddling sites, creating an ideal breeding habitat for butterflies. Additionally, the park serves as a haven for avian species, with 227 bird species recorded, including globally threatened and migratory species. The park's conservation significance is further highlighted by the presence of notable avian species such as the Black-crested bulbul, Black drongo, and Golden-fronted leafbird.

A recent study highlighted the transition of Raimona National Park from savannah forest cover in the late 19th century to its current status as a national park. The study documented the plant wealth of this biodiversity-rich area, which had not been extensively explored before (Kumar, 2024; Kumar & Gorai, 2018; Kumar et al., 2022). The conservation significance of Raimona National Park cannot be overstated, as its unique ecosystem supports a wide range of biodiversity. Its protection is essential for maintaining ecosystem services. Various organizations have undertaken efforts to conserve and restore the park, recognizing its ecological value. Raimona National Park is a critical biodiversity hotspot that requires continued conservation efforts to protect its unique ecosystem. The park's butterfly, avian, and flowering plant diversity are a testament to its ecological importance. Further research and conservation initiatives are necessary to ensure the long-term preservation of this ecosystem and to promote ecotourism in the region.

However, the study's objective opted to analyze land use and land cover (LULC) changes in Raimona National Park over the past five decades using satellite imagery and historical land use data. Also, the second objective of the study is to investigate the ethnobiological relationship between local communities and biodiversity, particularly how resource collection patterns have evolved over time. This study utilized both quantitative and qualitative methods for data analysis. Data were collected from the fringe village of Raimona National Park, which comprises over 4000 households across four forest ranges. From these, the study selected 340 households from two forest ranges for de. The societal approach to conservation aims to understand the human

dimensions of conservation and natural resource management.

### 2.Study Area

Raimona National Park is situated in the trijunction interstate state and international border. It lies in the extreme western part of Assam, sharing its state border with West Bengal and its international border with Bhutan on the north. The park boundary starts from the Sonkosh River on the west to the Saralbhanga River on the east and touches the Indo-Bhutan international border on the north. The Buxa Tiger Reserve of West Bengal is located on the west and the Phipsoo Wildlife Sanctuary of Bhutan is located on the north which are contagious with the Raimona as transboundary. The park covers a total of 422 km2 under the Kachugaon Forest Division in the Kokrajhar district of BTR in Assam. Previously, it was known as Ripu Reserve Forest within the Kachugaon Forest Division, with a total area of 605.27 km2. The Ripu Reserve Forest once had the highest density of sal forest in Asia and was one of the country's oldest and most scientifically managed forests in the late 19th century (Daimary, 2011; Basumatary et al., 2022).



Figure 1: Location of Raimona National Park, India.

The term "Raimona" derives from "Raymana" a desolate area or the capital of the vassal state Ripudwar at the base of Bhutan (Hamilton & Bhuyan, 1940; Basumatary *et al.*, 2022; Daimary & Basumatary, 2024). A large area of the Raimona National Park was once covered by savannah forest at the turn of the 20th century (Perree, 1908; Basumatary *et al.*, 2022). The Bodoland Territorial Region (BTR) of Assam has authority over Raimona National Park, which is located between 26°37' and 26°50' N latitude and 89°51' to 90°14' E longitude. However, several government and non-government organizations have started collaborating on various conservation efforts for the park.

# **3.**Materials and Methods

#### 3.1 Data and methods

GIS-based mapping and analysis were employed to assess land cover dynamics within the Raimona Landscape. Satellite imagery from multiple periods was utilized to quantify changes in forest cover, agricultural land, settlements, water bodies, and other land use categories. Spatial analysis techniques, including change detection algorithms and landscape metrics, were applied to identify spatial patterns, trends, and hotspots of land use change.

### 3.2 Data Sources

Land Use/Land Cover (LULC) maps at a 10 m resolution from the ESRI Living Atlas (Karra *et al.*, 2021), categorized into waterbodies, tree cover, cropland, human-altered landscape, bare ground, and rangeland, covering the period from 2017 to 2023, along with Google Earth imagery from 1984 to 2024, served as primary datasets (Wibowo *et al.*, 2016). Information on the annual percent-wise change in LULC categories was derived solely from ESRI Living Atlas (Karra *et al.*, 2021).

GIS mapping data are collected in the form of satellite imagery from multiple periods to analyze land cover dynamics and quantify changes in forest cover, agricultural land, settlements, water bodies, and other land use categories. Spatial analysis techniques, including change detection algorithms and landscape metrics, identify spatial patterns, trends, and hotspots of land use change within the study area.



# Figure 2: Mapping strategies for addressing RNP LULC

To create precise maps essential for resource management, planning, and environmental monitoring. Figure 2 illustrates the procedures of spatial data collection strategies. These strategies make use of satellite imagery, field surveys, and remote sensing technologies. Geospatial mapping utilizes advanced GIS software to evaluate spatial data and identify significant patterns and trends essential for park management and environment improvement. The valuable qualitative insights gained from group discussions and interviews offer into social dynamics, policy implications, and community needs significantly enhance the understanding of both inside and outside of national park contexts.

# 4.Results

Earlier RNP was a part of Ripu Reserve Forest and Chirang Reserve Forest, located in the westernmost buffer to Manas National Park and Tiger Reserve. Historically, the area has been known for its elephant and golden langur habitat, which has a diversity of flora and fauna. The area was declared the Chirang-Ripu Elephant Reserve in 2003 covering an area of 2600 km2. In 1906, a 33.79 km meter gauge sleepers tramline was proposed to be built from Kokrajhar to the Saralbhanga River to facilitate the extraction of forest resources in the park area. However, the project was never completed. Later, the forest authorities constructed the Kachugaon Tramline to capitalize on the timber trade with Bengal. In 1924, a 30.57 km feeder forest tramline was completed, connecting Fokiragram and Kachugaon to the trunk line of the Eastern Bengal Railway. It passed via the locations of Kochugaon, Hel, Kujrabguri, Amlaiguri, Samtaibari, Raimana National Park, and the Dotma junction at Fokiragram. However, following these activities given earlier, the national park was less covered with vegetation compared to the present. The map indicates that forest patches were not dense, with new vegetation beginning to grow between 1984 and 1994. The period from 2004 to 2014 was a development of the forest cover to the maximum areas in the protected forest. Beyond 2014, the forest has continuously developed towards land cover.

#### 4.1 Three Decades of Google Earth Image

Figure. 3. shows the image of three decades of LULC with the help of Google Earth. As a result, the earlier image shows various activities in the landscape.

#### 4.2 Land Cover Changes of 1984-2024

Visual analysis of satellite imagery from 1984 to 2024 revealed a pronounced trajectory of deforestation within the Raimona Landscape (Figure 3). Initially characterized by extensive forest cover, the region underwent substantial transformation over the decades. Deforestation accelerated after 1994, leading to a significant reduction in forest area by 2014. The most drastic changes were observed in the 2024 imagery, highlighting the rapid pace of forest loss. These visual observations underscore the urgent need for comprehensive assessments of deforestation drivers and their ecological consequences in the study area.



# Figure 3: Google Earth images depict changes in the LULC of the area during April.

#### 4.3 Seven Years of LULC

The seven years (2017-2023) of LULC signifying the waterbodies, tree cover, cropland, human-altered landscape, bare ground, and rangeland have been examined to understand yearly trends, as shown in Figure 3. The analysis differentiates between areas within the protected area boundary and those outside it. Water bodies within the national park are significantly lower in percentage with notable fluctuations in 2019 and 2020 compared to other years. However, the main challenge of the national park is the scarcity of water bodies that retain water for short periods. Beyond the park boundary, streams flowing from north to south serve as water sources. The tree cover of the surrounding national park is showing approximately 80%, including the core area. However, the overall tree cover in the study area has decreased significantly from 2019 to 2023. Population growth has contributed to the expansion of cropland for human survival. Similarly, the data shows a consistent increase in cropland from 2017 to 2023 outside the park boundary. The human-altered landscape is showing a dramatic increase from 2017 to 2022 but dropped suddenly to 3% in 2023 across the whole study area. However, the bare ground and rangeland exhibited minimal changes during the study period. Additionally, analysis of LULC change trajectories revealed notable shifts in land cover composition

within the Raimona Landscape. Waterbodies exhibited relative stability, fluctuating marginally between 0.6% and 0.7%. Conversely, tree cover experienced a consistent decline from 80% to 76% between 2017 and 2023 (Figures 4 and 5). Cropland and bare ground percentages remained relatively constant, while human-altered landscapes and rangelands gradually increased. These findings indicate potential deforestation, shifts in land use practices, and their subsequent implications for ecological balance and resource management within the study area.



# Figure 4: LULC changes in the area over seven years (Source: ESRI Living Atlas)

Tree cover, farmland expansion, and human-altered landscapes are among the major environmental transformation trends shown by the analysis of land use and land cover (LULC) changes from 2017 to 2023. The percentage of forested regions decreased over time, with the tree cover reaching a peak of 80% in 2018 and 2019 before progressively dropping to 76% in 2022 and 2023. Growing human demands, such as the development of infrastructure and agricultural growth, could be the cause of this reduction. The intensification of agricultural operations was reflected in the farmland areas, which varied between 11% and 13% at the same time, with a substantial increase to 13% in 2022 and 2023.



Figure 5: Percentwise LULC changes in the area over seven years (Source: ESRI Living Atlas)

A gradual decrease to 3% in 2023 followed an upward trajectory for the human-altered landscape, which went from 2% in 2017 to 4% in 2022. The development of urbanization and land alterations suggested by this trend may have an effect on ecosystem services and biodiversity. Aside from little drops to 0.6% in 2019 and 2020, waterbodies stayed comparatively constant at 0.7%, suggesting slight variations in the amount of surface water available. Comparably, the amount of bare ground decreased from 3% in 2017 to a steady 2% starting in 2018, indicating a move toward vegetation regeneration or other land uses. Finally, in 2022 and 2023, the rangeland area rose marginally from 4% to 5%, which may be a sign of changes in ecological succession or pastoral land management.

#### 4.4 Local People's Opinion on the Park

A questionnaire-based survey on public opinion regarding the establishment of Raimona National Park

was conducted. Data analysis revealed that public opinion is somewhat negative. A study of segmented data on the probable benefits after becoming a National Park based on residential distance from the National Park of the individuals reveals this in detail. Most people in the distance range of 0-1800 meters have negative views of the National Park. However, there are also optimists within that population. In the 0-400 meters range, more than 20 % of the population is optimistic about the initiative. Most people living in this zone depend on the forest for their livelihood. Residents within the 400 to 1000-meter range appear less optimistic, possibly due to their lower dependency on the park's forest resources. Since the National Park was newly established, restrictions imposed by the government or conservation policies have reduced people's reliance on the forest.

**Opinion towards National Park** ۲....۱۸۰۰ 17............ Distance in meters 17...... **Opinion** Percentage Legend 1...... ٨...٦.. 1...... ۲.... 0 20 40 60 100 Positive Neutral Negative Population percentage

Figure 6: Local people's opinion towards the park

The analysis results depicted that the population residing near the National Park needs to be educated more about other opportunities. These opportunities may provide awareness programs that need to be conducted on a timely basis involving the local organizations and scientific community of the region. Additionally, there is a need to develop alternative livelihood sources for the community residing at the nearest distance from the national park. Therefore, livelihood awareness programs were conducted involving the local communities and increased entrepreneurs along with scientific organizations. Public opinion towards forest officials appears positive along with equal intensity of neutrals. This suggests an opportunity to further improve public perception of the National Park for its overall betterment.





#### 4.5 Behavioral Changes of Villagers on National Park Declaration

The fringe villagers are experiencing the changes for the first time as a forest reserve becomes a national park. They have mixed feelings-good, bad, and proud. The villagers are happy because the national park is close to their residences and are hoping for the best opportunities in the future. The main challenge for the villagers is the economic downfall due to significantly reducing their forest dependency and the threat of notational park boundary expansion in future management. Earlier visits to the Raimona were 94.7%, which has been reduced to 18.5% regularly to 74.1% people still visit per month to collect firewood and other day-to-day requirements. The dependence on the forests of Raimona that altered after it became a national park is 8.8%. Furthermore, 76.8% of the people are unaware of whether they have adopted some alternative income source or if they are being forced to generate income from other means instead of depending on the forest. Local communities residing around the park participate in biodiversity conservation and deal with the threats to the park. A total of 65.9% of the population wants to conserve biodiversity and is ready to protect it from various threats. These people want to keep their natural and environmental resources as they were in the past. They also do not support those who exploit the forest for commercial purposes. The villagers also have local committees to protect the forest and focus on the minimum use of forest access. These villagers mainly collect the dry branches of the trees instead of falling a green tree for the firewood. However, 33.5% of the population either have no interest in protecting the forest or are unaware of the importance of biodiversity and forests in their habitat. About 6.2% of families are directly involved in the biodiversity protection of Raimona, whereas 92.4% of families do not even know how to be involved in the process of biodiversity conservation for Raimona instead of local knowledge. In the end, it has been found that 80.6% of people are interested in protecting the Raimona National Part and in helping to reduce the threats to wildlife and biodiversity thriving in this protected area. The majority of people are in the fever of the national park and interested in helping the forest officials to act whenever they need to. People only expect financial benefits in the form of schemes, projects, and other development activities since the park is in their local area. The respondents to the survey highlighted key challenges and economic implications for their livelihood. Some of the key challenges and implications are given as follows:

The inhabitants of these areas are currently facing an economic crisis due to the stringent restrictions on accessing natural resources. This situation has been exacerbated by the prohibition of activities such as firewood collection and fishing, which were previously integral to their livelihoods. Given that a significant portion of the local population relies entirely on firewood for cooking, it is imperative that regulated firewood collection be permitted under the supervision of the relevant authorities.

Additionally, agricultural activities are increasingly threatened by wildlife, particularly elephants, due to the absence of adequate fencing or protective boundaries. Several respondents acknowledged the importance of conserving forests and wildlife, irrespective of whether the area is designated as a national park. However, they emphasized that wildlife should not pose a threat to local livelihoods.

Furthermore, the responsible authorities should consider the provision of designated grazing areas to support the rearing of livestock, a key economic activity for many local households. Since the establishment of Raimona National Park, local communities have consistently raised these concerns, expressing dissatisfaction with the park's designation due to its impact on their socioeconomic well-being. Many residents, particularly those from economically disadvantaged backgrounds, struggle to sustain their livelihoods in the absence of access to natural resources.

Despite these challenges, a segment of the population supports the conservation of wildlife and acknowledges the benefits of the park and the government's conservation initiatives. However, the overarching sentiment remains one of economic hardship and restricted livelihood opportunities, necessitating а more balanced approach to conservation and community welfare (Kumar & Daimary, 2024).

# **5.Discussion**

This study evaluates the ecological and socioeconomic effects of long-term land use and land cover (LULC) changes in and around Raimona National Park in Assam, India. The study would benefit from a clear discussion that links its findings to the Sustainable Development Goals (SDGs) of the UN, especially SDG 11 (Sustainable Cities and Communities), SDG 15 (Life on Land), and SDG 13 (Climate Action), in order to increase its worldwide significance.

Deforestation, intensified agriculture, and urbanization are three major environmental issues highlighted by the observed LULC trends, which may have long-term ecological repercussions. In order to minimize environmental degradation and balance developmental needs, sustainable land management methods are essential, as evidenced by the decline in tree cover and rise in human-altered landscapes. When developing plans for sustainable resource management and biodiversity conservation, legislators, conservationists, and land-use planners can benefit greatly from this research's insights. These findings align with broader regional trends of deforestation driven by factors such as agricultural expansion, infrastructure development, and population growth (Ahammad *et al.*, 2019; Siegel *et al.*, 2022; Ritchie & Roser, 2023; Daimary & Deka, 2025).

This study emphasizes the necessity for focused interventions to strike a balance between ecological preservation and community well-being, highlighting important policy implications for conservation and land-use planning. Implementing community-based resource management, including sustainable land-use practices, and fortifying conservation policies are some specific ideas. Support from NGOs and the government is crucial for reducing deforestation, fostering ecotourism and agroforestry as alternative forms of income, and resolving conflicts between people and animals by implementing protective measures and compensation plans. In places around protected areas like Raimona National Park, a collaborative governance approach that involves local communities in decision-making can ensure socioeconomic resilience while improving conservation outcomes.

The persistent decrease in tree cover has far-reaching implications for the ecosystem. A reduction in forest cover can lead to soil erosion, hydrological imbalances, loss of biodiversity, and increased vulnerability to climate change impacts (Cunningham et al., 2015; Muluneh, 2021). Moreover, the transition to non-forest land use categories may have significant consequences for local livelihoods and ecosystem services (Cunningham et al., 2015; Muluneh, 2021). It is crucial to acknowledge the limitations of this study, including the reliance on satellite imagery with varying resolutions and potential cloud cover issues. Additionally, while the analysis provides а comprehensive overview of LULC changes, a more indepth investigation into specific drivers of deforestation is needed.

By understanding the historical trajectory of land cover change and its potential consequences, policymakers and stakeholders can develop informed strategies to protect the region's valuable ecosystems and ensure the long-term sustainability of the Raimona Landscape. The trajectories of the land cover changed bringing a change to the local livelihoods. On the other hand, local people face the threat of not accessing the forest resources. However, forest resources are safe once local people stop accessing the forest resources. Additionally, there was also a suppression from the forest authority to the local community which impacted the LULC of Raimona National Park.

The questionnaire-based survey conducted on public opinion regarding the establishment of Raimona National Park provides valuable insights into the complex relationship between local communities and protected areas. While the overall sentiment tends to be negative, the analysis reveals nuanced perspectives influenced by factors such as residential proximity, livelihood dependence, and awareness levels. Additionally, interventions can be more effectively designed and implemented when the contexts of these perceptions and preferences are well understood (Nayak & Swain, 2023).

A key finding is the correlation between proximity to the park and public opinion. A major policy concern includes the low level of community involvement in park activities and the lack of collaboration and communication between management and residents (Moswete et al., 2012). Residents living within 1800 meters of the park are more likely to express negative views, likely due to increased reliance on forest resources for their livelihoods. This is particularly evident in the 0-400-meter range, where over 20% of respondents expressed optimism despite their dependence on the forest. The establishment of the national park has disrupted traditional livelihoods, leading to economic hardship for many local communities (Vedeld et al., 2012). The survey highlights the need for alternative income sources and livelihood training programs to mitigate these negative impacts. The study underscores the importance of public education and awareness campaigns. Many respondents, especially those living near the park, lack knowledge about the potential benefits of national parks and alternative livelihood opportunities. Implementing targeted education programs can help foster a more positive perception of the park and its conservation goals.

The survey identifies several key challenges faced by local communities, including economic hardship, wildlife conflicts, and limited access to natural resources. Addressing these issues through effective conservation strategies and community engagement is essential for ensuring the long-term success of the park (Moswete *et al.*, 2012; Kumar & Gorai, 2023a; 2023b; 2023c). Based on the findings of this research, the following recommendations can be made:

To effectively conserve Assam's national parks, such as Kaziranga, Manas, and Orang, it is necessary to inform the local population of the ecological and financial significance of protected places. The fact that Raimona National Park is still establishing its conservation framework makes community interaction even more important than in these more established parks. Active engagement can be increased by fortifying partnerships between native communities and park officials, as demonstrated in Manas through ecotourism projects. Raimona can reduce hazards by putting in place fences, warning systems, and compensation programs, just like Kaziranga, which frequently experiences conflicts between humans and wildlife. Reliance on forest resources can be decreased by promoting alternative livelihoods like sustainable agriculture and handicrafts, as demonstrated by Orang's conservation approach. Long-term conservation will be ensured by constant observation and flexible tactics, like Kaziranga's flood control. Raimona can create a sustainable conservation strategy that strikes a balance between community well-being and biodiversity preservation by implementing these tactics.

# **6.**Conclusion

Land use and land cover change in Raimona National Park have been closely tied to the involvement of the local communities. Historically, local people of the park have depended on the forest, which directly affected the forest cover over the years. Even today, many residents remain indirectly dependent on forest resources for their livelihoods. The enforcement of forest laws, such as the 1972 Wildlife Protection Act, brought significant social changes to the local population. Forest authority suddenly became very powerful over the local people in terms of protecting the forest from local people. This has harmed the park's authority. However, it is not such a single case that took place in India. Most of the tribal land was converted suddenly and notified as a national park in India which always encounters such uncertainties from resource extraction. It is also seen that the LULC of protected areas always changes for natural calamities. However, LULC of Raimona was once affected by the local people and now it is supported by the local people for its protection. The findings of this study positively indicate an increase in vegetation within the protected area. This vegetation is a good sign for the habitat in and around the national park for long-term protection. At the same time, population, cropland, and human-altered landscape have increased outside the protected area.

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