

**ASSESSING THE IMPACTS OF ROAD
NETWORK ON
WILDLIFE CORRIDORS AND MITIGATION
MEASURES IN ASSAM: Transportation against
animal corridor.**

A THESIS Submitted by

Roshme Borgohain

For the award of the Degree of

**MASTER OF SCIENCE
IN
HERITAGE CONSERVATION AND MANAGEMENT**

Under the guidance of

Dr. Bilal Habib (Scientist-E) and Dr. C. Ramesh (Scientist-C)



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DECLARATION

I **Roshme Borgohain**, hereby declare that the research work entitled “**Assessing the impact of road network on wildlife corridor and mitigation measures**”, carried out in partial fulfilment of M.Sc. (Heritage Conservation and Management) degree of Saurashtra University, Rajkot is an original work. This work was carried out under the supervision of Dr. Bilal Habib, Scientist-E and co-supervision of Dr. C. Ramesh, Scientist-C, at the Wildlife Institute of India from January to June. I hereby declare that this work has not been submitted in any form for any other degree or diploma at any university or other institutions.

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Date: 16th July' 2021

Place: Dehradun

CERTIFICATE

This is to certify that Mr. **Roshme Borgohain** has carried out an original piece of research in partial fulfilment of Master's degree in Wildlife Science of the Saurashtra University, Rajkot, Gujarat. The topic of his dissertation was "**Assessing the impact of road network on wildlife corridor and mitigation measures**". The study was carried out under our supervision from January to June. We hereby certify that this work has not been submitted for any degree to any university.



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Abstract

Protected Area Networks (PA) and Conservation Areas (CA) are very essential for ensuring the conservation of wildlife. However, the connectivity among these protected areas is much more important to ensure the viable population of species. Furthermore, the increase in infrastructural development and human encroachment leading to the fragmentation of forests and the natural habitat of wildlife species. The wildlife corridors are the essential structures to connect the fragmented areas, ensure the viability of the isolated population, restores the genetic variations, corridors also increases the habitat diversity in the two habitat patches that it connects, it provides a passage for migration and also acts as an escape route in cases of fire in one patch. Overall wildlife corridors are structures that are important for conservation. Although these protected areas were not well connected the corridor structures help to maintain the continuity of the area. The state falls under North-East India Biogeographic zones under the Province North-East-East-Brahmaputra Valley (9B), (Rodgers and Panwar 1998). In Assam, there are seven National Parks and twenty Wildlife Sanctuaries occupying the area of 3925+ sq. km, where two are designated as World Heritage site (WHS) which is the highest designation given to the protected area. Out of twenty-seven protected area in Assam, fifteen were bifurcated by road networks and there are total eleven corridors, connects the protected areas, eight corridors were cut at multiple places by roads. These connections of the corridors are essential to maintain the contiguous landscape, which is further essential for maintaining the integrity of the WHS. In this study, I have tried to look at the current status of the wildlife corridor portion bifurcated by the road networks in Assam. The objective of the study is 1) What is the extent of different types of road networks concerning PAs and corridors in the State of Assam? 2) What is the land use pattern near the corridor bifurcated by the road? 3) Characterize the current status of the corridor sites impacted by the road network. The limitation of my study is that I could not cover all the eleven corridors in Assam due to time constrain and the global pandemic. In this study, I have only covered four corridors namely the Amguri corridor, Kanchanjuri corridor, Haldibari corridor, and Panbari corridor, through which National Highway 715 (earlier called NH-37) passes by. These corridors connect the Kaziranga National Park and Karbi Anglong landscape. The results on the current status of the corridor are that there is a significant forest lost by the 59% from the year 2000-2021 with an increase in agricultural land and built-up increased by 80%, with the loss of forest there are few animal signs variation within 200 km range near the national highway, the most frequent and constant signs found near the road are of Elephants, One-horned Rhinoceros, Sambar Deer, and Wild Boar. Whereas, there is high traffic volume recorded about an average of 600

vehicles per hour with a speed of 120 km/hr. If the current status of the corridors will continue at the same pace it will degrade to a further extent in near future.

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CHAPTER 1

INTRODUCTION:

Since ancient times, routes, trails and roads played a pivotal role in connecting the different areas for easement of movement of the goods and the people around the world. Now in today's time road networks became essential for the social and economic growth of a nation. India being a developing economy and with increasing population, demands the good connectivity among the areas. However, construction of roads and railways comes with great ecological consequences especially the one which dissects the natural habitat of animals (Ree, Smith, Grilo 2015; Lurance 2009). Further, it leads to the direct consequences of forest loss and fragmentation, linear clearings, wildlife-vehicle collision and many more (Lurance 2009).

Fundamentally, the fragmentation leads to alter the arrangement of continuous landscape into small discontinuous patches of habitat (Andrews 1990), which becomes inconvenient for an individual animals to move from one habitat patch to another leading to a population isolation (Riley *et al.*, 2006). The linear infrastructures greatly affect the all sorts of wildlife, the biota and introduce invasive species (Spellerberg 1998). The busy roads with high traffic act as a barrier for some species which over the period of time shows avoidance response (Baker 2007) resulting to the population isolation which gives rise to problems such as decrease in species richness, genetic diversity (Beier *et al.*, 2002; Bailey *et al.*, 2010), adding to the risk of local species extinction (Clarke 1998).

However, with rapid road network expansion and other linear infrastructure development, the contiguous landscapes are becoming more and more fragmented and there are only few connecting passages left for dispersal from one habitat patch to another. Those linear patches facilitate the physical movement of wildlife and are called wildlife corridors (Srivastava 2016; WTI 2005). And, their role in wildlife conservation is well documented. However, there is a growing challenge to protect and conserve corridors due to increase urbanization and road networks (Beier 2008), especially those bisected by the roads. For further conservation and safeguard of wildlife, it is preferred not to build new roads near or through the protected areas and wildlife corridors (Beier 2008).

Therefore, India being one of the 17 'mega-diverse countries' hosts four biodiversity hotspots: the Himalayas, the Western Ghats, the Indo-Burma and the Sundaland and known for its high endemism (Mittermeier *et al.* 2004). Most of the endemic species are found in tropical and subtropical forested areas where India constitutes nearly 23% geological area. In the past few decades, India witnessed the fast growth of economy and development, especially in infrastructure sectors; road networks,

railway lines, power lines have greatly expanded and upgraded in the country. There is a 40% increase in the length of roads (National and State Highways Authority) between the year 2001 and 2015, whereas earlier it was 50% increase in the year 1980 and 2000 (Basic Road Statistics of India 2016-17), and shortly the increase in linear infrastructure is promising, there have been nearly 7000 linear project proposals submitted to the Government of India for forest clearance between July 2014 and September 2017 and primarily undertaken in the pristine forested habitats and leaving them fragmented (MoEFCC 2017).

To protect the remaining unique biodiversity, it is essential to establish more national parks, conservation reserves, sanctuaries and natural world heritage sites. However, there are 668 Protected Areas (PAs) in India extending over 1,61,221.57 sq. km, comprising 102 National Parks, 515 Wildlife Sanctuaries, 47 Conservation Reserves and 4 Community Reserves. Moreover, 7 Natural World Heritage Sites were designated by UNESCO. However, most of the protected areas are isolated due to linear infrastructure development. It is essential to maintain and protect the connecting links, which helps in dispersal and maintain the genetic flow of the species.

Natural World Heritage sites

UNESCO gives Natural World Heritage designation to the sites with a unique natural treasure unique and not found in any other part of the world. These sites are recognized based on their Outstanding Universal Value (OUV). Worldwide there are 213 natural sites, out of which seven are present in India, respectively. Amongst all the protected areas, these sites are under the highest level of recognition afforded globally for the protection and conservation across more than 95 countries (World Heritage Convention). These sites required the highest level of protection and maintenance to continue the site on the list of World Heritage. According to the IUCN, natural world heritage sites account for only 8% of total surface area covered by all 245,000+ terrestrial and marine protected areas worldwide, and these are under threat of climate change, invasive species, tourism, including poaching, planned infrastructure and oil gas projects.

The wildlife corridors in natural world heritage sites play a vital role in connecting the adjacent protected areas to facilitate animal movement and maintain the landscape's integrity. Sometimes these corridors are get disturbed by linear intrusions, which may alter the landscape in many ways.

Objectives:

1. Map the road networks with respect to the world heritage site, protected area and wildlife corridors in Assam.
2. Evaluate the present status of corridor portion bifurcated by the proposed and existing road networks.
3. Prioritizing roads for mitigation measures based on current and future road networks.

Research Questions:

1. What is the extent of different types of road networks with respect to PAs and corridors in the State of Assam?
2. What are the land use pattern near the corridor bifurcated by the road?
3. Characterize the current status of the corridor sites impacted by road network.

CHAPTER 2

LITERATURE REVIEW:

The rapid increase of infrastructural development all over the world results in the fragmentation of natural habitat and isolation of animal population. There has been a growing concern about the ecological effects of roads and traffic in countries like U.S.A, U.K, the Netherlands, Australia and New Zealand (Spellerberg 1998), there are plentiful reports and published paper on linear infrastructure effects on wildlife. Linear infrastructure development is an essential driver of forest fragmentation leading to loss of habitat and biodiversity to great extent. However, the tropical species are more vulnerable to such infrastructural development, especially roads and railway lines which leads to the cleaning of forested area exposing critical habitat, resulting in road-kill, predation or increase hunting and poaching of animals (Laurance 2009).

The Wildlife corridors are considered as essential tools for wildlife conservation (Sirvastava 2006) as corridors provide resources like shelter, food, nesting sites, and facilitate the movement of animals (Seiler 2001). Corridors are also responsible for connecting the two or more fragmented area and also allow species to respond more efficiently to long term climate change (A.McEuen 1993). However, the definition of wildlife corridors is ambiguous. However, W. corridors have yet to be formalized as a standard tool for ecological conservation in India.

The construction of new road brings new problems to the sensitive sites; it gives the socio-economic benefit which attracts the new human- settlements (Lennartz, Thomas 2013). Roads also provide the opportunities for hunting and extraction of other natural resources, waste disposal (Gucinski et al., 2001). Depending upon the road and heavy traffic, certain animals tend to avoid forest cleanings as narrow as 30 m (Laurance et al., 2009). Infrastructure act as a barrier to faunal movement and affect habitat use and migration paths (Bhattacharya et al. 2002; Develey and Stouffer 2001; Forman et al. 1997; Kociolek et al. 2002; Shepard et al. 2008; Strand 2004). The barrier effects due to linear structures may also reduce the gene flow (Riley et al. 2006) and affects population sizes and densities (Faring 2012). The patches resulting from linear gaps may be too small within limited resources and detrimental for the survival of some species, resulting in reduced diversity (Coffin 2007; Fahrig 2002).). A road exposes the natural area to the anthropogenic pressure (S.Nandy et al., 2015). The consequences of roads are endless, from direct mortality, behaviour alteration, pollution, habitat fragmentation, habitat degradation to spread of disease (Clarke 1998; Lurance 2009; Spellerberg 1998).

CHAPTER 3

STUDY AREA:

This study was conducted in the wildlife corridors of Kaziranga National Park (KNP) which is the Natural World Heritage Sites (NWHS) in Assam, India. The state shares the international boundary with Bhutan and Bangladesh and nationally with Arunachal Pradesh to the north, Meghalaya, Tripura, Mizoram to the south, Nagaland, and Manipur to the east and, West Bengal to the west. It falls under the North-East India Biogeographic zones under the Province North-East-East-Brahmaputra Valley (9B) (Rodgers and Panwar 1998).

The Kaziranga National Park is located in the central part of Assam and lies between 24°.07' N to 28°.00' N Latitude and 89°.42' E to 96°.02' E Longitude in Nagaon and Golaghat districts, the park is known to be contiguous with Karbi Anglong (KA) landscape, but now due to National Highway 715 (earlier NH 37), became partially disjoint (WWF, 2008). However, the wildlife corridors act as a dispersal route and connect both the areas (KNP and KA); nine corridors were identified based on the structure and functionality of the area connecting Kaziranga national park and Karbi Anglong landscape (Kaziranga corridor report 2019).

However, this study focuses on these four corridors as follows:

1. Panbari Corridor
2. Haldibari Corridor
3. Kanchanjuri Corridor
4. Amguri Corridor

The KNP is a Tiger Reserve with the highest density of tigers in India (Jhala et al., 2011) and is also essential breeding ground of Asian elephants, one-horned rhinoceros and for other large mammals, it also entitles as a Important Bird Area. Being a site of universal value it encompasses the ecological processes and different kinds of vegetation and provides a habitat for rare and threatened species. The vegetation type present is tropical semi-evergreen forest, tropical moist mixed deciduous forest and alluvial grassland (Champion and Seth, 1968). The Kaziranga- Karbi Anglong Landscape (KKL) have 8 Wildlife Sanctuaries (WLS), 2 Elephant Reserves (ER), Reserve Forest (RF), Proposed Reserve Forest (PRF), one National Park (NP) and District Council Reserve Forest (DCRF).

The climate of Assam is tropical monsoon type. There are three distinct seasons. The dry and windy summer runs from mid-February to May, with an average maximum temperature of 35 degrees Celsius. The rainy season extends from May to September with average annual rainfall ranging between 1500 to 2500 mm. the mild winter with an average maximum temperature of 25 degrees Celsius, and an average minimum temperature of 10 degrees Celsius extends from November to mid-February.

Flooding is an annual phenomenon in Assam. Every year the river Brahmaputra floods its banks and inundates extensive areas of Assam. Floods prove to be a necessary event for much agricultural land and mainly for the Kaziranga National Park because it brings in rich deposits of silt essential for the maintenance of grasslands. The receding floodwaters also flush out the invasive water hyacinth from the water bodies depending on the current in the water. Due to the long spells of inundation, the water table in KNP is high throughout the year, responsible for the heavy toll of animal mortality. Due to deforestation in the upper catchment areas, the intensity of the floods is on the rise and becomes one of the major problems that cause concern to the park management. However, the National Highway 715, which passes through the park's southern boundary, acts as a barrier for animals, especially during the monsoon season when they seek higher ground for refuge. The road also opens the way for poachers and vehicular collisions.

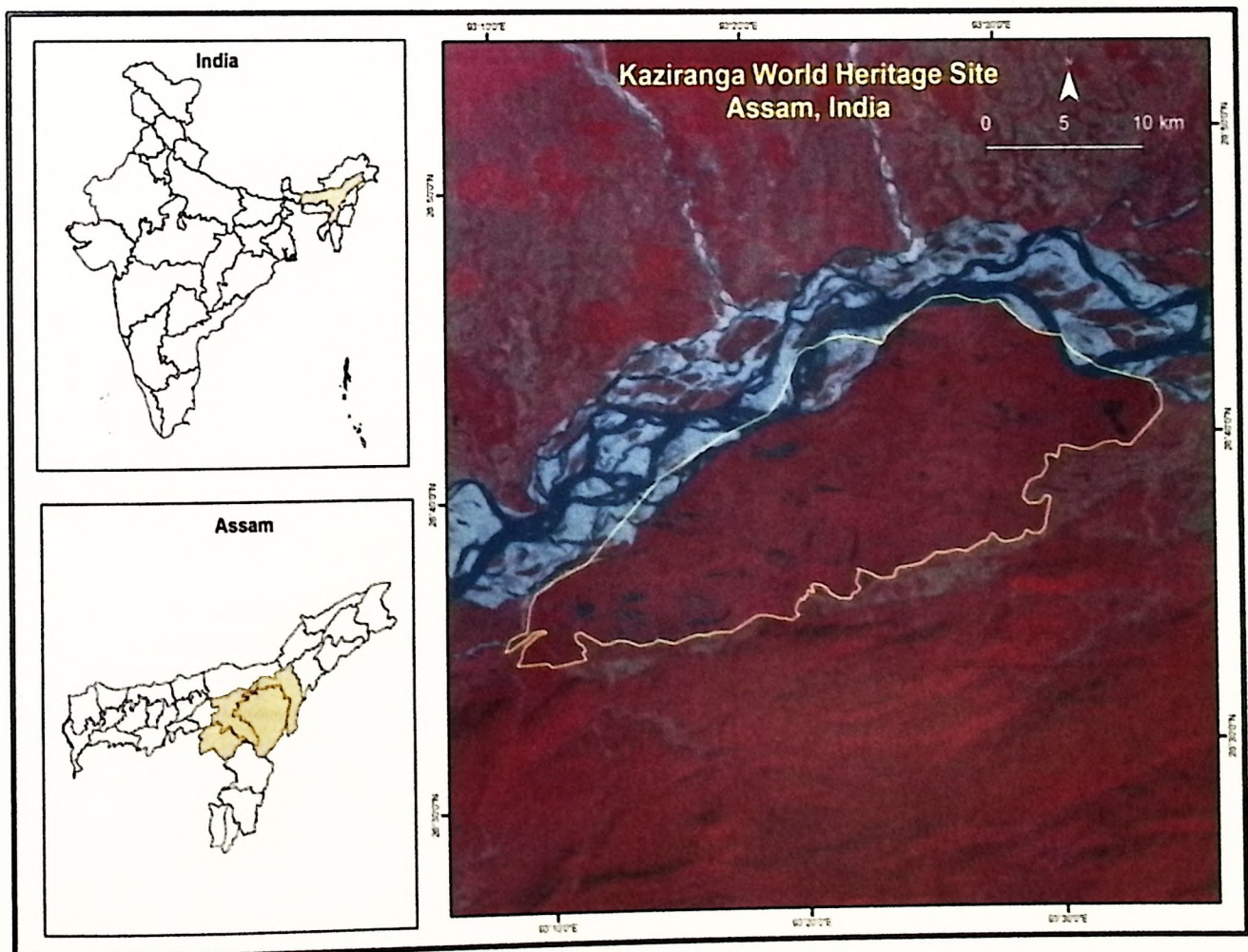


Figure 1: Location of the Kaziranga National Park/Tiger Reserve, Assam,

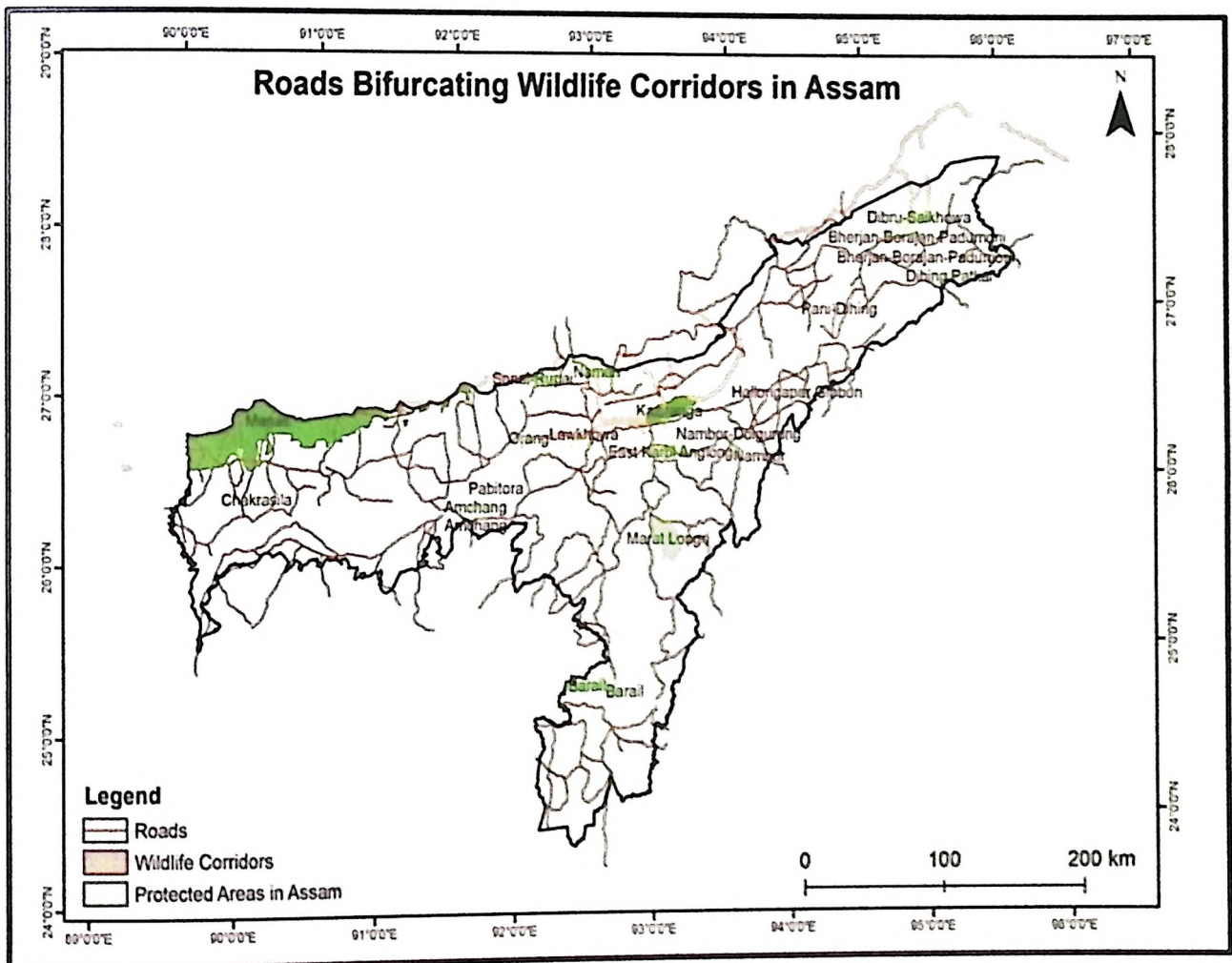


Figure 2: Roads bifurcating wildlife corridors in Assam.

CHAPTER 4

METHODOLOGY:

Field methods

To evaluate the present status of the wildlife corridor areas bifurcated by the road National Highway 715. Sign surveys were conducted by walking the random trails used by animals. GPS locations were collected with the help of Gramin Etrex X 20 for the direct and indirect sign's of wildlife such as footprints, pellets, pug marks, scratch marks, dung piles and other sign's of animals near the road within 500 meters to the 3-kilometre radius of the corridor were recorded, documentation of any anthropogenic disturbances inside the premises of protected area was recorded. However, GPS locations were also taken to see the trend in land use patterns near corridors in each selected corridor area. To determine the road traffic, the traffic counter device has been put on NH 715 for 24 Hrs for ten days. Similarly, repeating the process for the other corridors. This study was conducted in six months, starting from January 2021 till June 2021.

Dataset Used

The data used for this work is high resolution optical satellite data i.e., Sentinel-2 imagery and medium resolution Landsat series imagery. Sentinel 2 products provided by European Space Agency are freely available for the user at the higher spatial resolution of 10 meters. Landsat is a joint program of the USGS and NASA. They have been observing the Earth continuously from 1972 through the present day. Today the Landsat satellites image the entire Earth's surface at a 30-meter resolution about once every two weeks, including multispectral and thermal data. Though Sentinel 2 provides Top-of-Atmosphere reflectance data as well as Bottom-of-Atmosphere reflectance in cartographic geometry, we used radiometrically corrected Bottom-of-Atmosphere data also known as surface reflectance data in case of high-resolution imagery. Sentinel-2 Level-2 data with band composition of red(R), green (G), blue (B), near-infrared (NIR) and short-wave infrared (SWIR) is used for the year 2021 and 2020. While landsat data with band composition of red(R), green (G), blue (B), near-infrared (NIR), and short-wave infrared (SWIR) was used for the year 2000, 2005, 2010 and 2015.

The data for each year was stacked together to include the pixel value of the region for each season and then it was reduced to calculate mean for further processing. Only RGB, NIR and SWIR is used from the sentinel data as they have same spatial resolution i.e., 10 meters, and because normalized difference vegetation index (NDVI) and normalized difference water index (NDWI), which are the parameters to

detect vegetation area and water bodies respectively, can be computed using red and NIR band, and NIR and SWIR respectively.

Table 1: Satellite Sensors and their specifications

Satellite Sensors	Spatial Resolution	Spectral Resolution (Wavelength)	Year
Sentinel 2	10m	Band 2: 496.6nm (S2A) / 492.1nm (S2B) Band 3: 560nm (S2A) / 559nm (S2B) Band 4: 664.5nm (S2A) / 665nm (S2B) Band 8: 835.1nm (S2A) / 833nm (S2B) Band 11: 1613.7nm (S2A) / 1610.4nm (S2B) Band 12: 2202.4nm (S2A) / 2185.7nm (S2B)	2021 2020
Landsat 8	30m	Band 2: 0.45 - 0.51 μm Band 3: 0.525 - 0.600 μm Band 4: 0.630 - 0.680 μm Band 5: 0.845 - 0.885 μm Band 6: 1.57 - 1.65 μm Band 7: 2.11 - 2.29 μm	2015
Landsat 7	30m	Band 1: 0.45 - 0.52 μm Band 2: 0.52 - 0.60 μm Band 3: 0.63 - 0.69 μm Band 4: 0.76 - 0.90 μm Band 5: 1.55 - 1.75 μm Band 7: 2.08 - 2.35 μm	2010 2005 2000

Image classification

To identify the land use changes for the past decades in the study area, LULC classification was performed using multi-temporal remotely sensed images of Sentinel and Landsat. The analysis work has been done in Google Earth Engine (GEE). GEE is developed by Google as a free cloud computing platform that is used for big Earth observation data management and analysis. GEE is easily available to the research community for LULC change classification, image processing, town planning, and weather analysis by making use of various satellite datasets such as Landsat, Sentinel, and MODIS data.

An effective classification system and an adequate number of training samples are the basic requirements for a good classification. As open land, generally follow the

fellow land classification due to the absence of vegetation in and around its area, it could be easily identified at lower NDVI index, and can be distinguish from the forest cover area. And NDWI index is used to trace water bodies in our study area.

The first step of the classification method was to develop the classification algorithm based on our objective. The land cover classification method adopted for this work consist of 5 classes named Forest, built-up, water bodies, agricultural land, and open land classes. Next step was to decide the suitable indices that can distinctively classify the unique features in and around the road alignment for this time series classification.

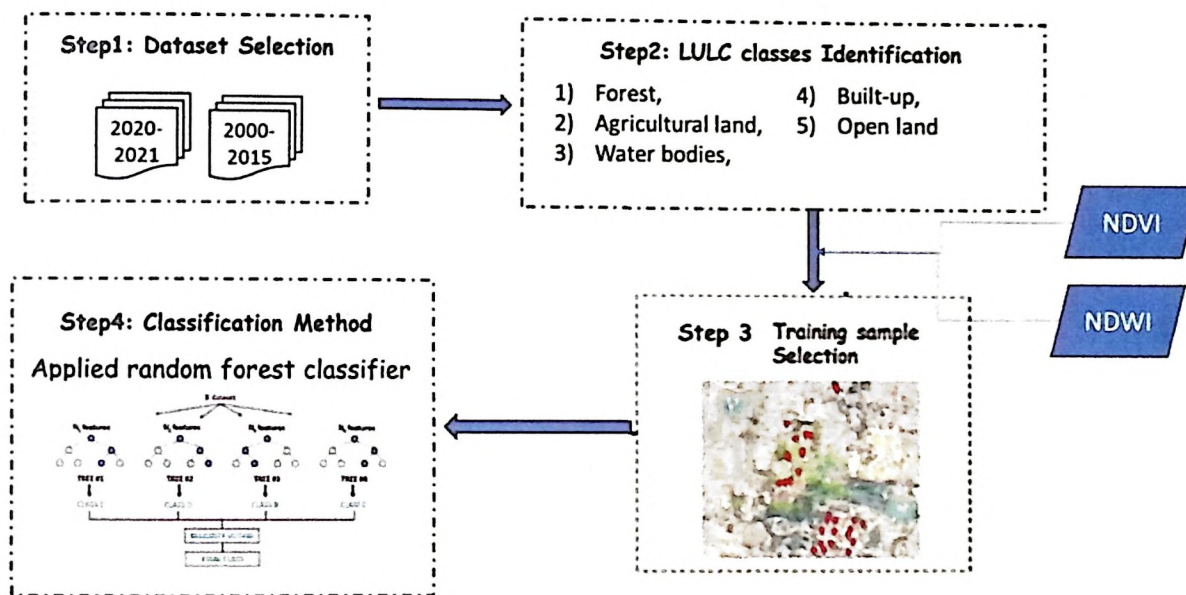


Figure 3: Work Flow for LULC Methodology

An NDVI threshold value of 0.4 is used in order to differentiate Forest, and agricultural land from rest of the classes, for Sentinel and Landsat 8 data, and for Landsat 7 NDVI of 0.2 is used as a threshold value. Similarly threshold value of 0.3 is used to extract water bodies' layer from the imagery. Reason for selecting these indices in order to demarcate the boundary, and also reason behind selection of visible NIR and SWIR for this analysis is shown in Table 2.

Table 2: Characteristics of thematic bands used

Band Name	Wavelength (μm)	Characteristics and Usage
Visible blue	0.45 – 0.52	Maximum Water Penetration
Visible Green	0.52 – 0.60	Good for measuring plant vigor
Visible Red	0.63 – 0.69	Vegetation Discrimination
Near InfraRed	0.76 – 0.90	Biomass and shoreline mapping
Short Wave InfraRed	1.57 – 1.65	Water and Soil Moisture mapping

Table 3: Representing Vegetation and Water Indices used

Indices	Landsat-7 Images	Landsat-8 Images	Sentinel-2 Images
NDVI	Band 4 (NIR) – Band 3 (Red)	Band 5 (NIR) – Band 4 (Red)	Band 8 (NIR) – Band 4 (Red)
	Band 4 (NIR) + Band 3 (Red)	Band 5 (NIR) + Band 4 (Red)	Band 8 (NIR) + Band 4 (Red)
NDWI	Band 4 (NIR) – Band 5 (SWIR)	Band 5 (NIR) – Band 6 (SWIR)	Band 8 (NIR) – Band 11 (SWIR)
	Band 4 (NIR) + Band 5 (SWIR)	Band 5 (NIR) + Band 6 (SWIR)	Band 8 (NIR) + Band 11 (SWIR)

Here, NIR is Near Infrared band found in multispectral image, and Red is red band image, while SWIR is short wave infrared band in multispectral imagery.

Classification Method

Data science provides a plethora of classification algorithms such as logistic regression, support vector machine, naive Bayes classifier, and decision trees. But near the top of the classifier hierarchy is the random forest classifier. Thus, for this study random forest classifier is used. Random forest, like its name implies, consists of a large number of individual decision trees that operate as an ensemble. Each individual tree in the random forest spits out a class prediction and the class with the most votes become our model's prediction. These large number of relatively uncorrelated models (also represented as trees in the classifier) operating as a group will outdo any of the individual constituent models.

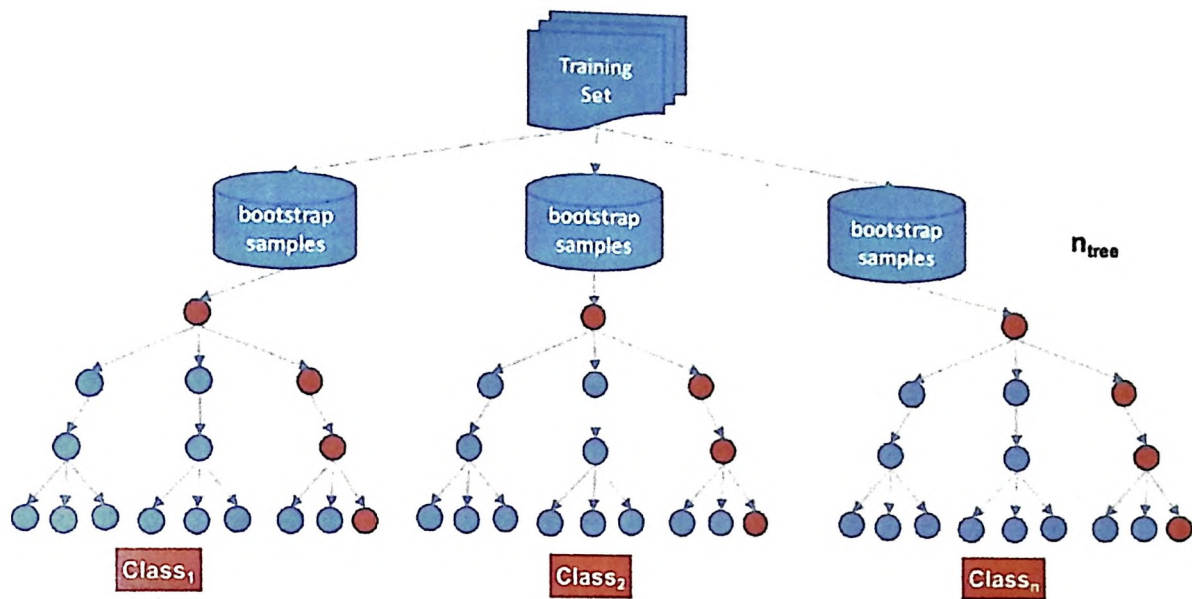


Figure 4: Representation of Random Forest Classifier

CHAPTER 5

RESULT AND DISCUSSION:

Present status of the Corridors:

1. Panbari Corridor:

The Panbari corridor is one of the nine corridors identified. WWF has identified a part of Kaziranga-Karbi Anglong Landscape (KKL)- India under the AREAS programme to develop the strategic conservation plan for the endangered species and their habitats (WWF corridor report). This corridor has been cut through by the NH 715 in the 4 km stretch. The corridor area is surrounded by Panbari RF, Dolamara PRF, Jaitha Pahar DCRF and community-owned forest. Moreover, it mainly falls in the district of Karbi Anglong and Golaghat. This corridor facilitates the movement of animals from KNP to other adjoining forest areas or vice versa. The corridor is extending up to the foothills of KA to the south, and evidence of using it by wildlife (WWF report). Moreover, the tropical moist deciduous forest harbours a variety of flora and fauna. It is a vital connection between the KNP and KA hills thus, holds a major significant role in maintaining the integrity of the Natural World Heritage Site.

Animal Sign:

The most frequent indirect sighting in this corridor is of Elephant, the fresh dung indicates the frequent usage of corridor by elephants, they are active from late night to early morning or sometimes could be seen in daytime, and the second frequently seen animal is Sambar Deer which were mostly seen during the early morning and evening hours. However, other animals like Hog Deer, Wild Boar, few indirect sightings of Rhino (Table 2). The nearest sighting of an animal in this corridor is within 20 Meters, indirect sign of elephant. The direct sighting of Sambar Deer is within 250 Meters from the NH715 (Fig 2)

Table 4: Animal Species sight in the Panbari Corridor

S.no.	Animal Species sighted
1.	Elephant
2.	Sambar Deer
3.	Rhino
4.	Wild Boar

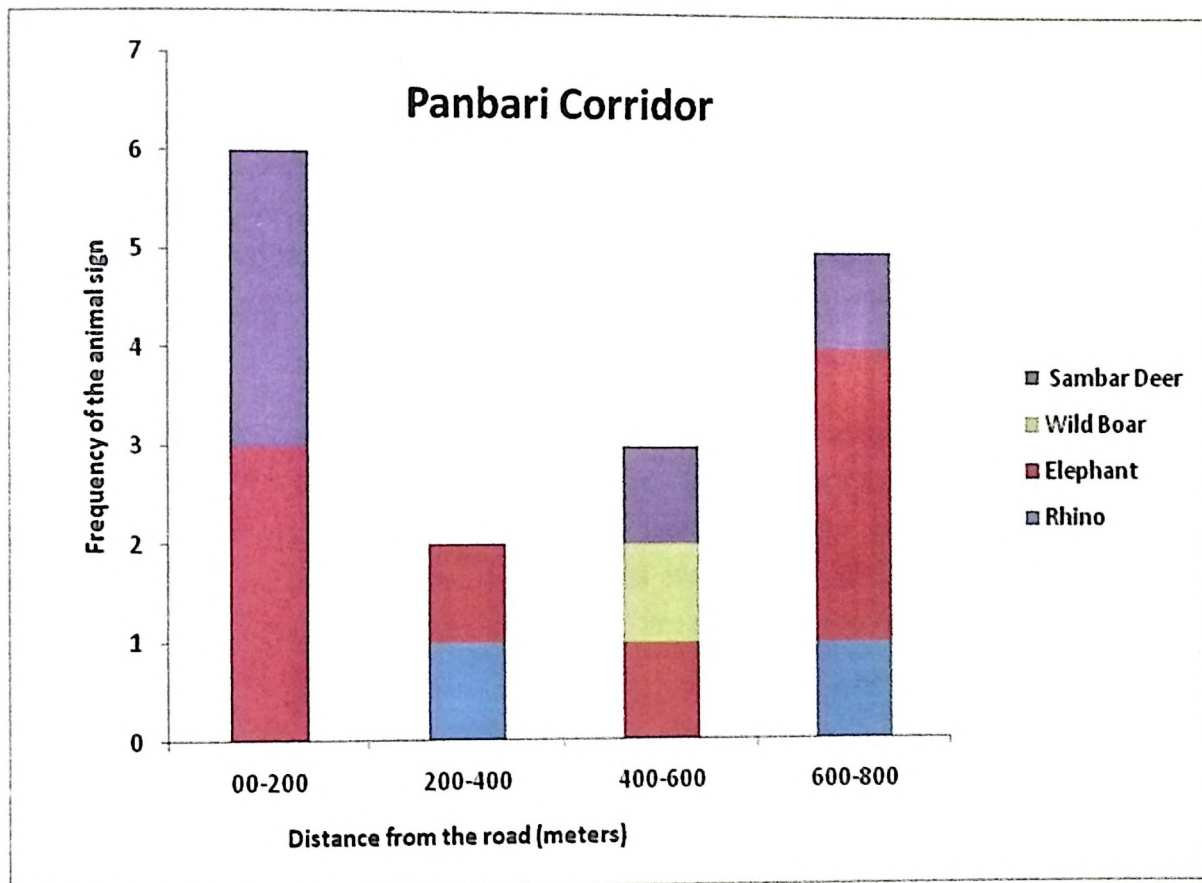


Fig 5: Sighting of animals from NH 715 in Panbari Corridor

Disturbances in the Area:

The major disturbances in the corridor area are the tea gardens such as Methoni, Diffolu and Naharajan tea gardens, these gardens spreads in a large area. Moreover, there is a mix of ownership, some gardens are small scale and privately owned whereas, some are large scale and cooperative. The second, most prominent problem is the agricultural development and small business along the NH 715.

2. Haldibari Corridor:

Haldibari corridor falls under the district of Golaghat, adjoining the Karbi Anglong Hills. This corridor is considered as the important corridor area on NH 715. A 2 Km corridor stretch is bisected by NH 715 which located between Bagori range office and Kohora range office of KNP. This corridor is vital corridor, adjoining the KNP to North KAWLS and also connects the community forest of Karbi Anglong hill.

Animal Sign:

Presently from the sign survey, the frequently encountered animal species in this corridor are elephants, wild buffalo's, Rhino, Hog deer and rhesus macaques. Elephants were seen to use this corridor area in regular intervals, as shown in the Fig 3.

The usage of the corridor by the elephants within the distance 200 meters from the NH is less. However, the sightings increases with distance, they are mostly active during the late night and early morning. Whereas, the hog deer's and Rhesus macaques were active throughout the day as compare to other species. However, the direct sightings of rhino during the daytime are very far from the road.

Table 5: Species of animals sighted in the Haldibari Corridor

S.no.	Animal species sighted
1.	One-horned Rhinoceros
2.	Hog Deer
3.	Elephant
4.	Wild Buffalo
5.	Rhesus macaque

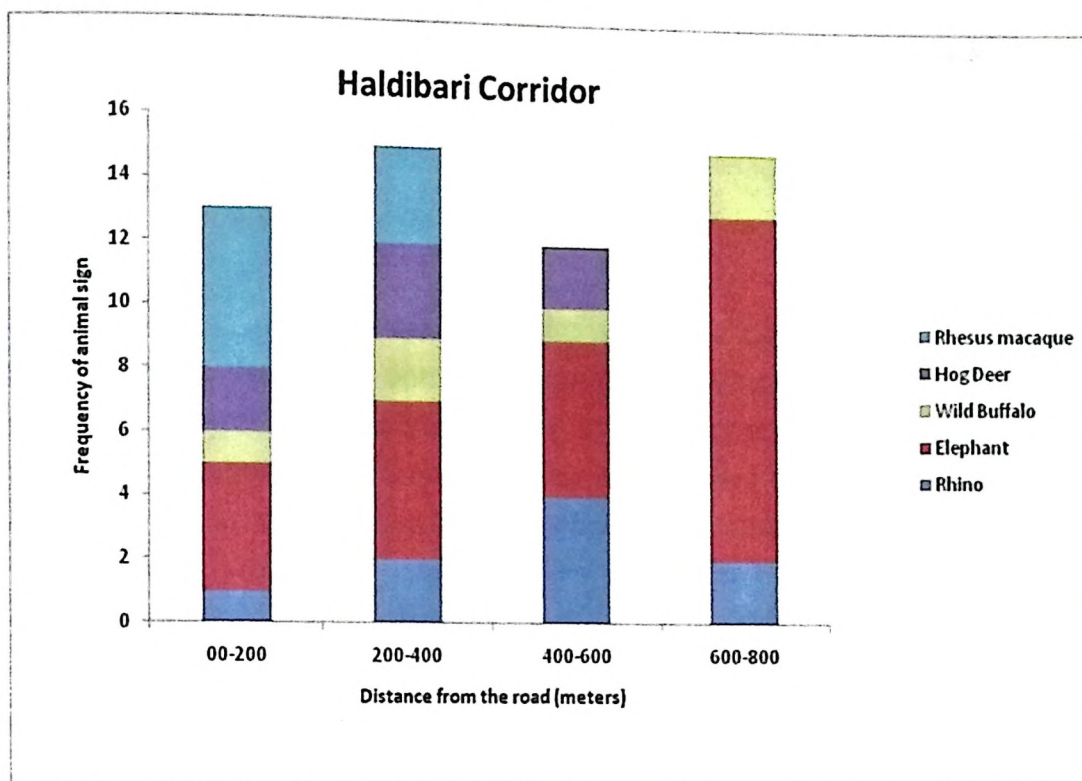


Fig 6: Sighting of animals from NH 715 in Haldibari Corridor

Disturbances in the Area:

The increasing anthropogenic pressures such as small shops along the road near the Burhi Mai Mandir, which also leads to vehicular traffic on NH 715. Natural resource extraction such as Non Timber Forest Product (NTFP) collection in the corridor area very prominent, cattle grazing, illegal fishing by the communities residing near the corridor could be seen in the corridor area.

3. Kanchanjuri Corridor:

Kachanjuri corridor is located between the Burapahar and Kanchanjuri view point. This corridor connects the KNP to the KA hills the Ruther Paharin the south and Bagser RF, a 6 Km stretch of the corridor is cut by a NH 715. The vegetation is characterization of a typical tropical semi-evergreen forest (Champion and Seth 1968). The corridor is the most vital corridor area, the recent study found the functionality of the Kanchanjuri Corridor, over 39 species were identified out of which 12 species belonging to Schedule I (Wildlife Protection Act 1972), 11 under Vulnerable category and apart from this the study recorded new animal species which were never documented before in the corridor area such as; Clouded

Leopard, Kalij Pheasant, Golden Cat, Hoary bellied Squirrel so on (Chakraborty, 2021). Thus the study indicates the functionality of the corridor.

Animal Sign:

In the kanchanjuri corridor there are comparatively more sightings of animals than the other corridors. It also shows comparatively higher number of sightings near the NH 715 shown in Fig 5. the nearest sighting in this corridor is 5 meters from the NH, the large mammals were found near the road. Other than these, hog deer's, wild boar, barking deer, capped langur, Rhesus macaques were present. The sign's of elephant followed by the rhino and hog deer and wild buffalo were consistent throughout the corridors, the fresh dung piles of rhino and elephant signifies the regular use of corridor by these animals. However, compare to other corridors the direct sighting of the animals were higher in kanchanjuri.

Table 6: Species of animals sighted in the Kanchanjuri Corridor

S.no.	Animal Species sighted
1.	Tiger
2.	Barking Deer
3.	Capped Langur
4.	Wild Buffalo
5.	Rhesus macaque
6.	Hog Deer
7.	Wild Boar
8.	Elephant
9.	Rhino

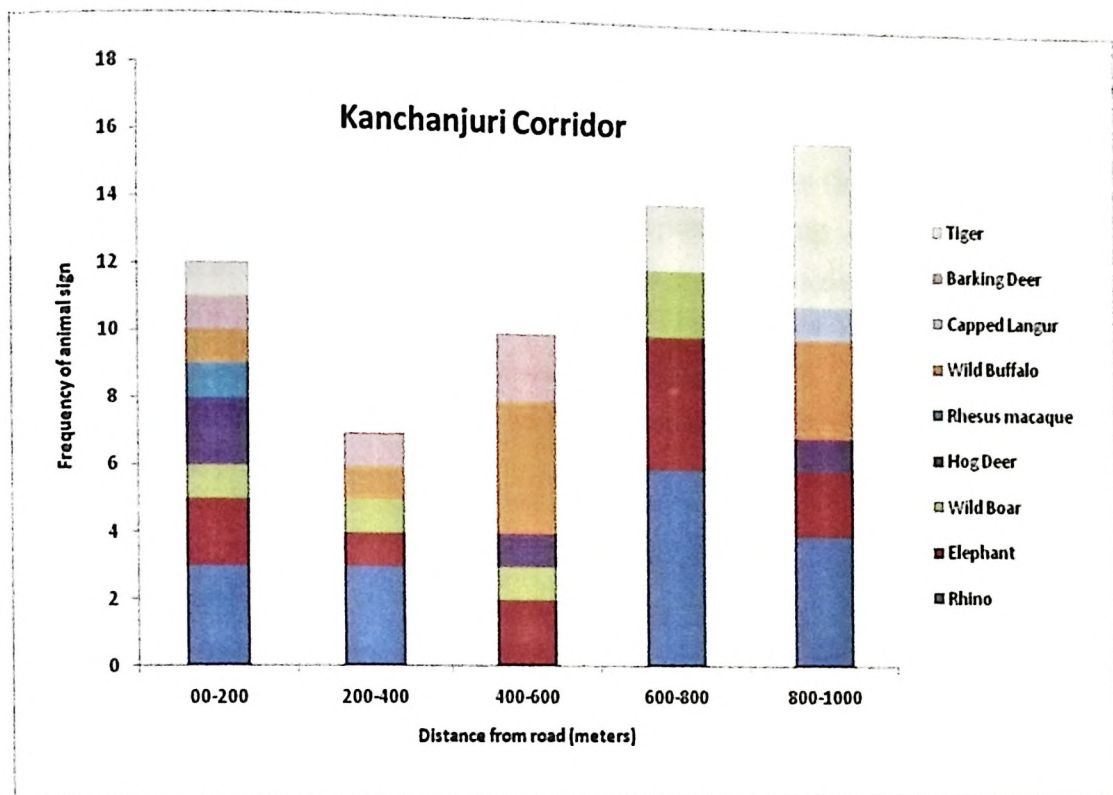


Fig 7: Sighting of animals from NH 715 in Kanchanjuri Corridor

Disturbances:

The prominent disturbance is the agriculture, monoculture practice such as tea plantation, rubber plantation near the corridor; secondly the budding problem along the NH715 is the commercial businesses such as hotels, resorts, parks, small shops for the livelihood are the upcoming threat to the corridor.

5. Amguri Corridor:

Amguri corridor area falls under Kaliabor sub-division of Nagaon District. The corridor begins from Baneshwar in the west which falls under the Nagaon Forest Division continues till the end of Burapahar in the east. This corridor connects the Kaziranga National Park with the Bagser RF and adjoins the Karbi Anglong in the south. However, this corridor is not currently managed in anyway (WWF report).

Animal Sign:

The animal species recorded during the field survey were; rhino, elephant, swamp deer, wild buffalo, wild boar and tiger. Evidences found near the road within 200 meters were mostly of the large mammals. However, swamp deer were sighted comparatively far from the road between 400 to 600 meters inside the buffer area of KNP. Apart from the monsoon months when low lying area of KNP submerged in water, ungulate species and all other animal approach the NH 715 seeking higher ground for refuge, otherwise species like swamp deer avoids the road.

Table 7: Species of animals sighted in the Amguri Corridor

S.no.	Animals Species Sighted
1.	Wild Water Buffalo
2.	Swamp Deer
3.	Tiger
4.	Wild Boar
5.	Elephant
6.	One-Horned Rhinoceros

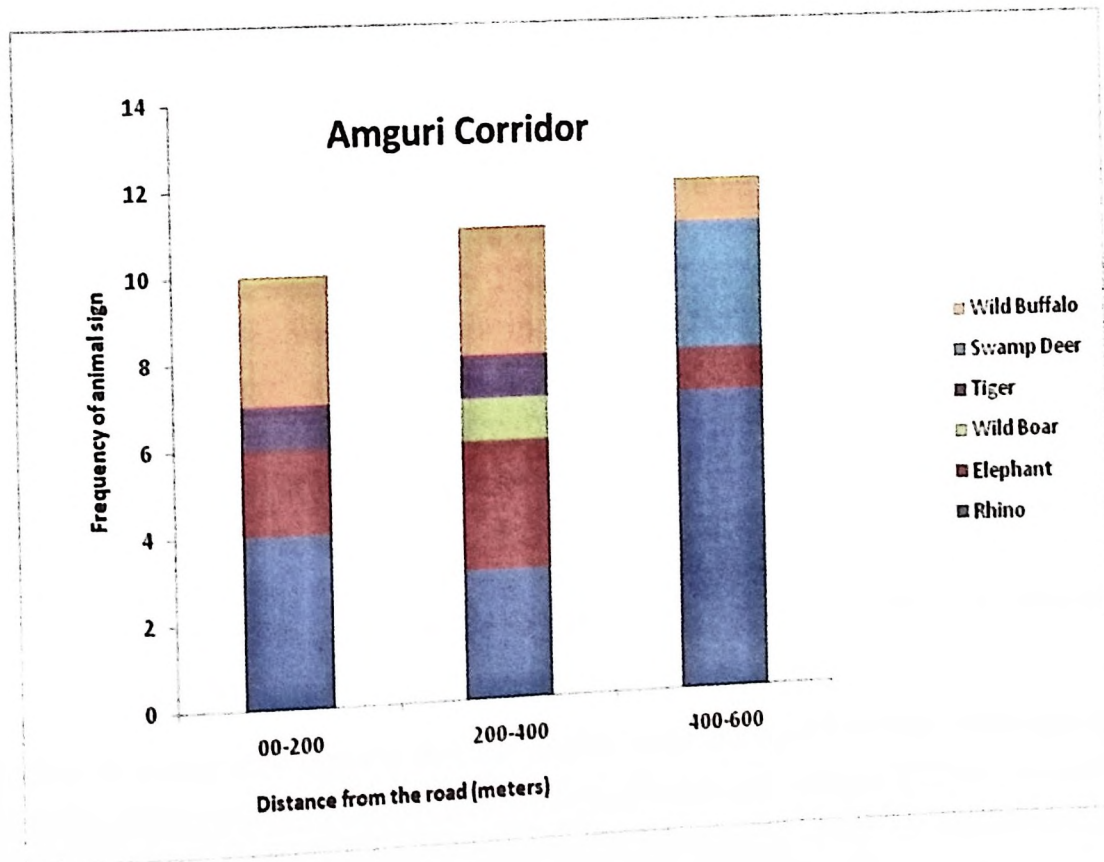


Fig 8: Sighting of animals from NH 715 in Amguri Corridor

Disturbances:

The major disturbance to this corridor is agriculture practices, tea plantation, upcoming commercial businesses which potentially threatens the structure of the corridor and becomes the barrier in animal movement.

Land Use change in the corridors of KNP

The Land Use and Land Cover mapping along the NH 715 on both sides was carried out for the year 2000, 2005, 2010, 2015, 2020 and 2021. The land use land cover map prepared for the years were classified into 5 classes, namely; forest, agricultural land, water bodies, built-up and open land. Fig 9 and Table 8 shows that the area covered by agriculture increased in the area from 60 sq.km in 2000 to 204 sq. Km in 2021, and there is drastic increase in agricultural land from 60 sq. Km in the year 2010 to 135 sq. Km in 2015 to 188 sq. Km in 2020 and within one year it goes to 204 sq. km till recently. There is also a positive trend in built-up, where in 2000 it was 0.72 sq. Km and 0.53 sq. Km in 2005. However there is a sudden hike of 1 sq. Km in 2010 and from there it increased to 4 sq. Km in 2015 and, in the year 2020 it comparatively came down to 4 sq. Km and the following decrease by 2 sq. Km in 2021. The open land area has increased in past two decades, 19 sq. Km in 2000 to 0.005357 sq. Km in 2005 and there is a decline to 18 sq. Km in 2010 followed by 22 sq. Km in 2015 and in 2020 the land cover was 21 sq. Km and 25 sq. Km in 2021. There is trend of slight increase and decline in land cover of open land area. Whereas, there is significant decline in forest cover in past two decades, in the year 2000 the area covered by the forest was 420 sq. Km which became 417 sq. Km within a decade, but after 2010 the land cover changed rapidly to 4.266539 sq. Km in 2005 (within 5 years of time), in 2020 it reduces to 282 sq. Km and till recent date it reduces to 267 sq. Km, therefore the average 59% decline in the forest cover along the National Highway within two decade of period with increase in average 70% of agricultural land.

The decline of forest area depicts that the habitat near the road has been undergoing significant decline and degradation due to the influence of various human induced activities, mainly; the agricultural development near the road is significantly responsible for the decline of forest cover.

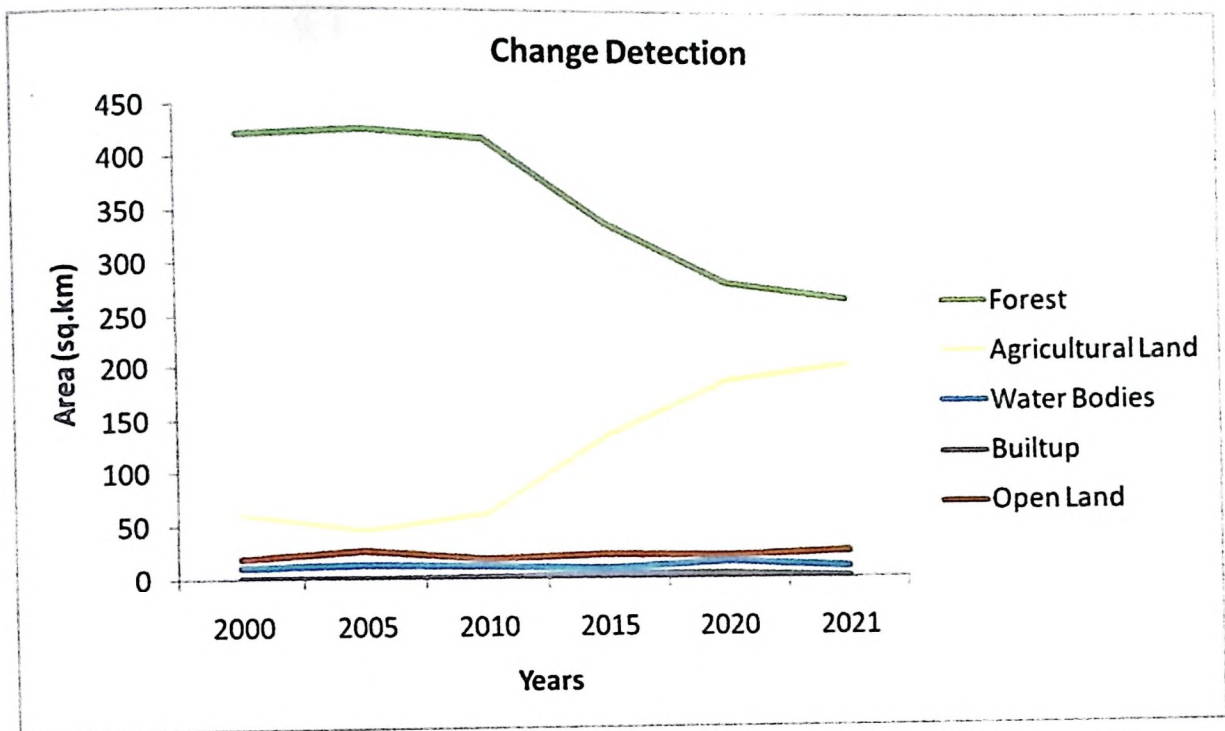


Fig 9: Change Detection from the year 2000 to 2021

Table 8: Land Use Land Cover Change from the year 2000 to 2021

LULC class	2000	2005	2010	2015	2020	2021
Forest	420	426	417	339	282	267
Agricultural land	60	45	60	135	188	204
Water bodies	11	12	11	9	15	11
Built-up	0.72	0.53	1	4	4	2
Open land	19	26	18	22	21	25

Table 9: Percentage change in five years interval

LULC class	2000-2005	2005-2010	2010-2015	2015-2020	2020-2021	2000-2021
Forest	14	-20	-23	-20	-5	-59
Agricultural land	-33	25	95	27	8	70
Water bodies	16	-8	-23	38	-37	2
Built-up	7	71	58	-12	-60	80
Open land	27	-39	15	-5	15	23

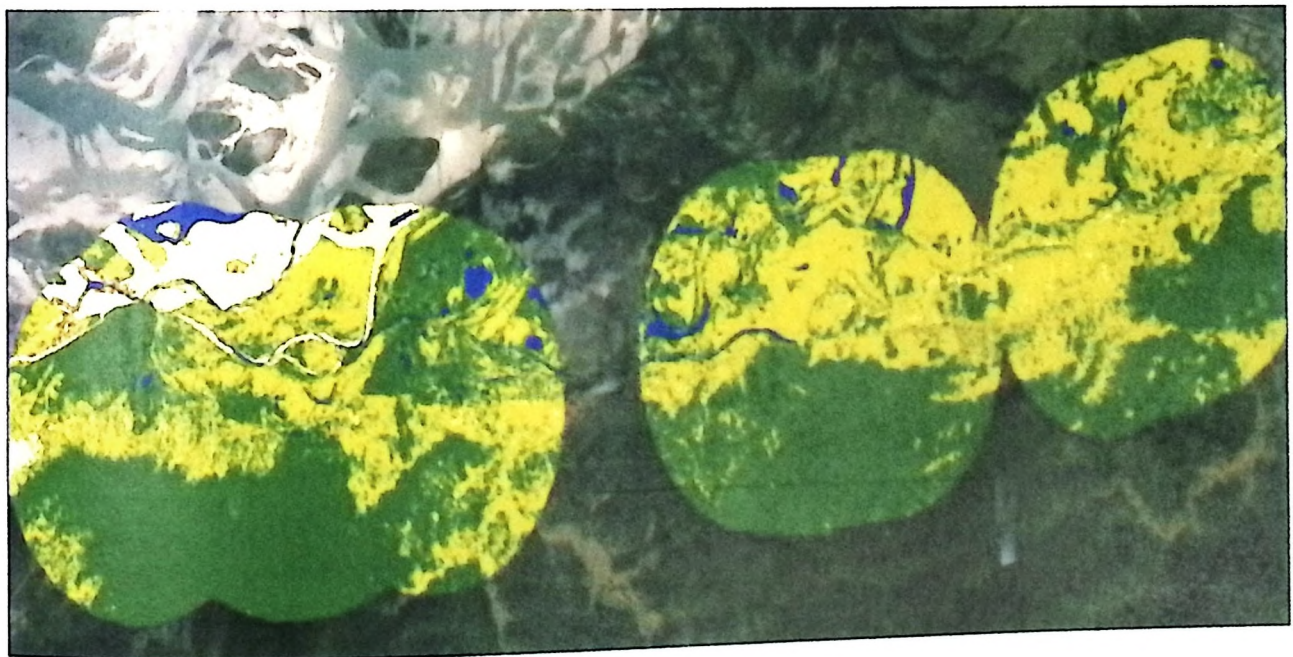
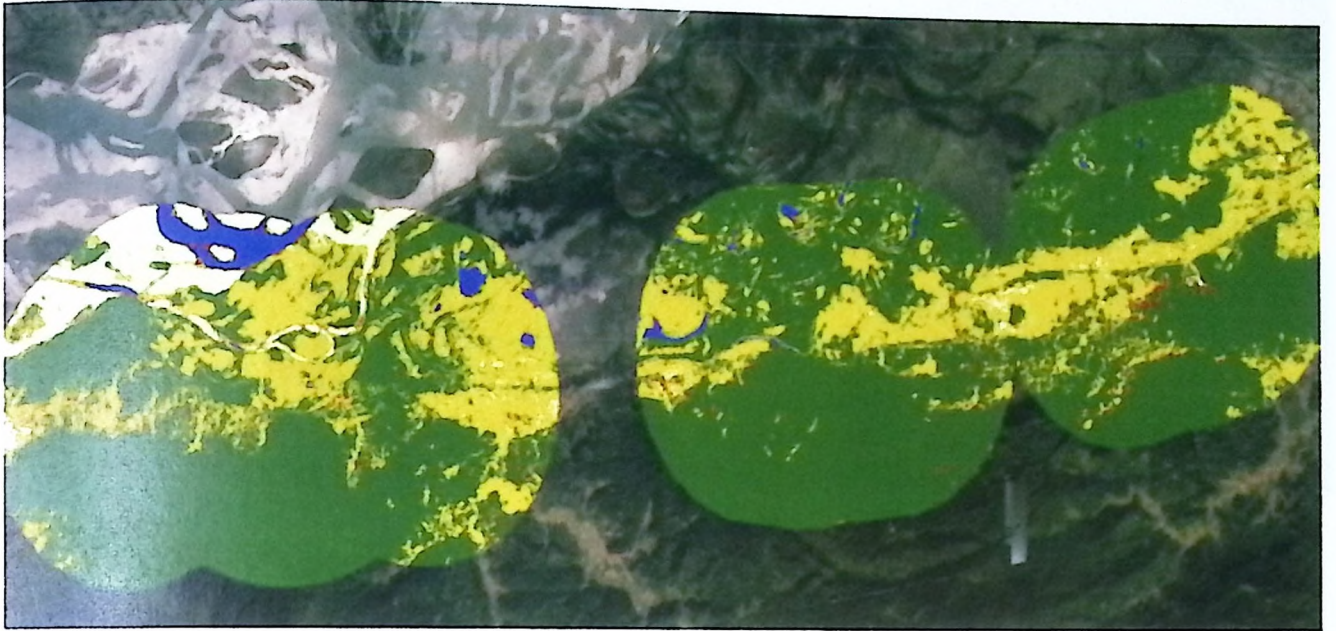
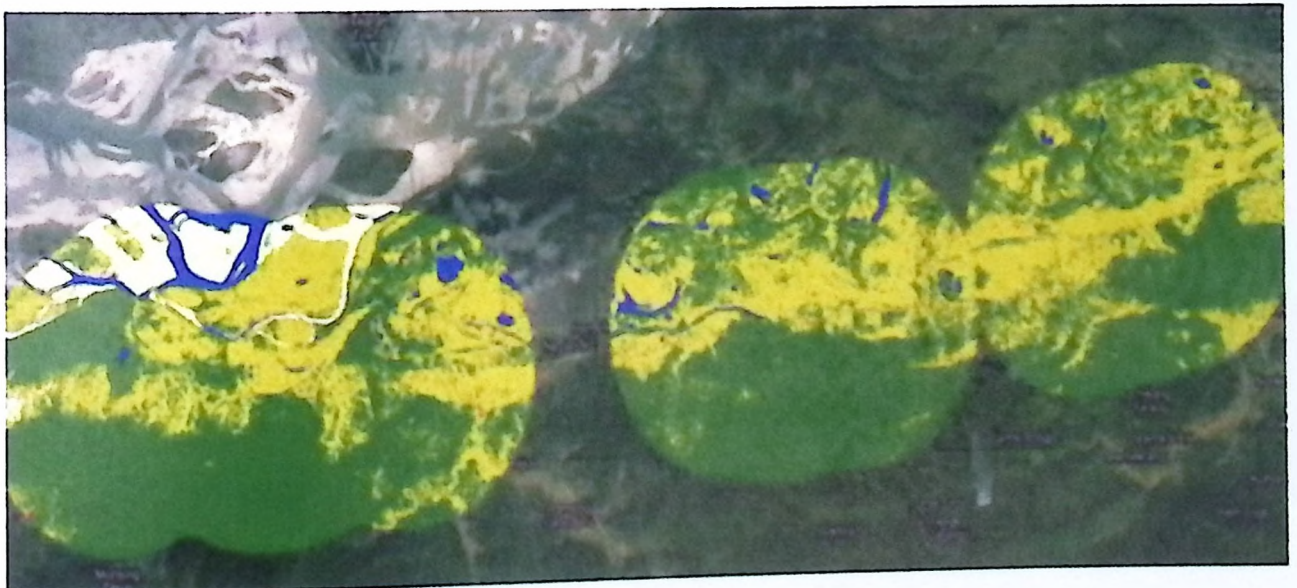


Fig 10: LULC at 5km buffer from the alignment (Jan2021-June2021)



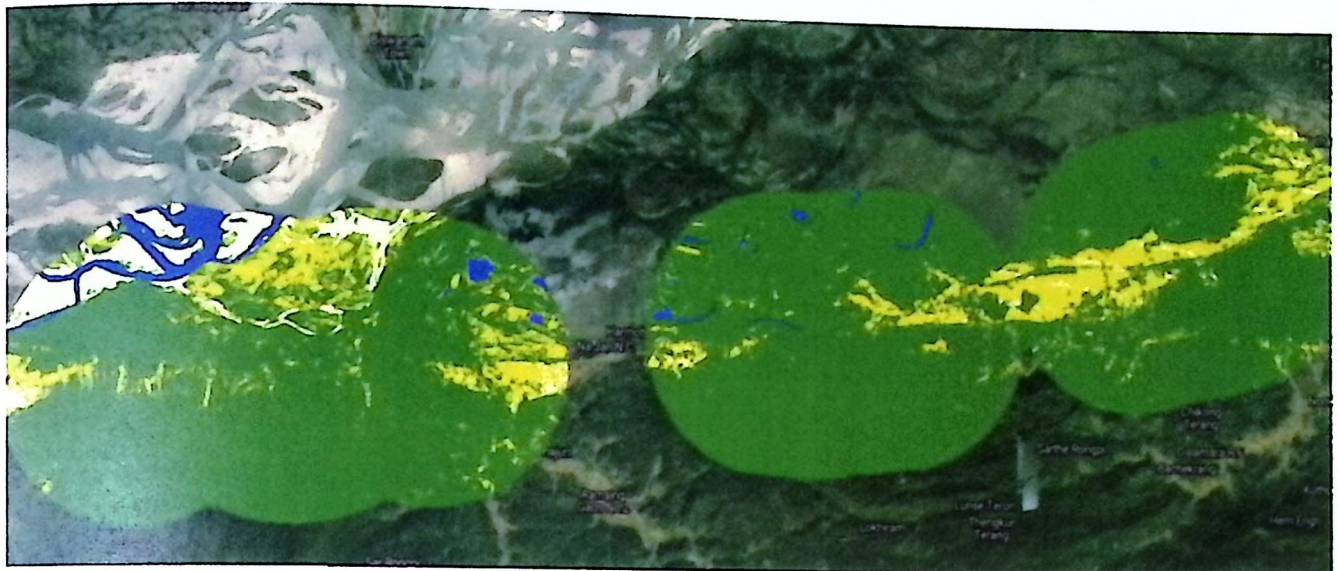
- Forest
- Agricultural Land
- Water Bodies
- Builtup
- Open Land

Fig 11: at 5km buffer from the alignment (Jan2020-June2020)



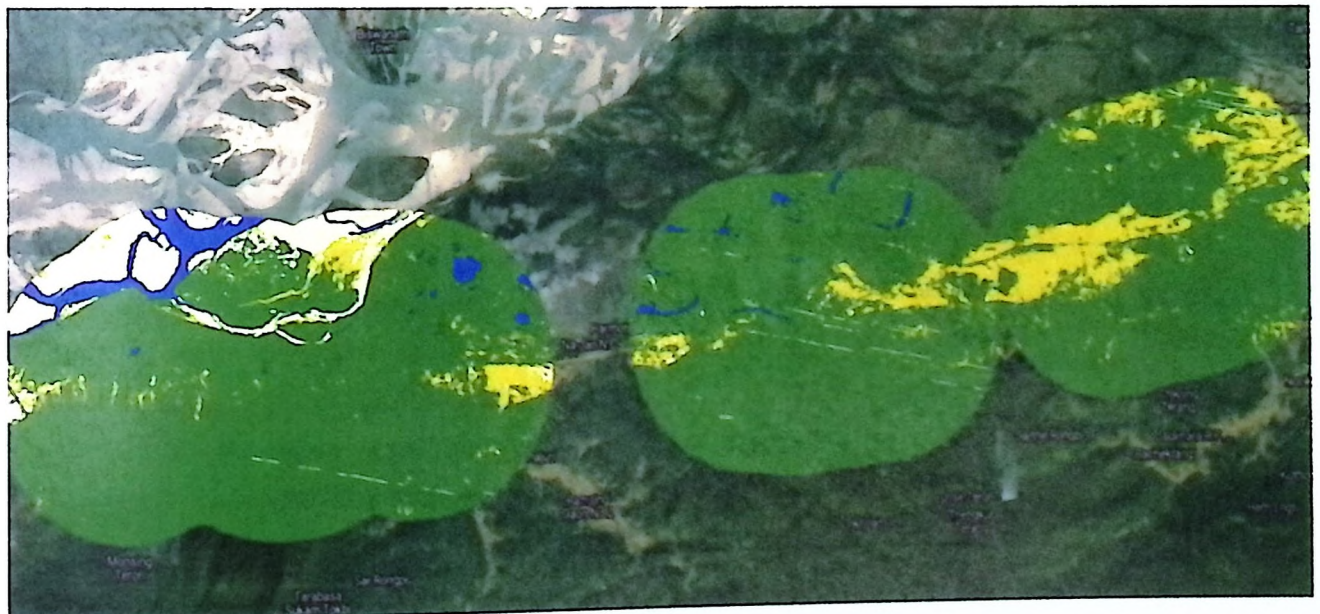
- Forest
- Agricultural Land
- Water Bodies
- Builtup
- Open Land

Fig 12: at 5km buffer from the alignment (Jan2015-June2015)



- Forest
- Agricultural Land
- Water Bodies
- Builtup
- Open Land

Fig13: at 5km buffer from the alignment (Jan2010-June2010)



- Forest
- Agricultural Land
- Water Bodies
- Builtup
- Open Land

Fig 14: at 5km buffer from the alignment (Jan2005-June2005)

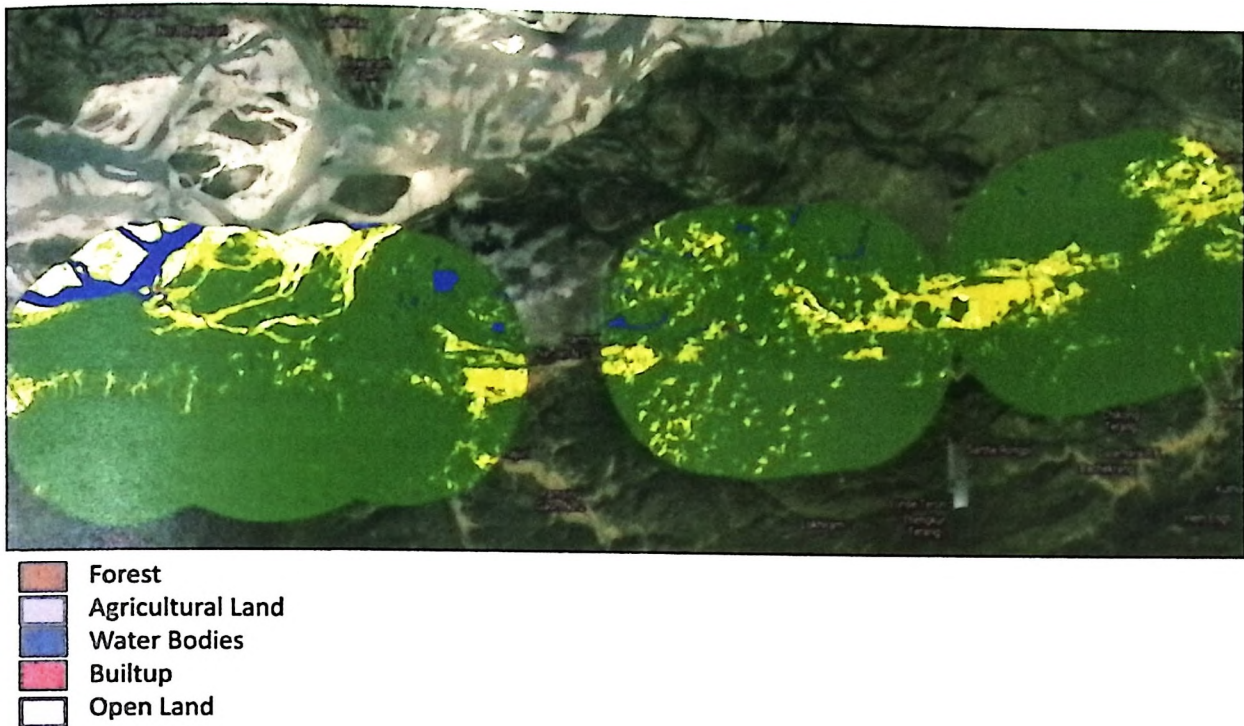


Fig 15: at 5km buffer from the alignment (Jan2000-June200)

Road Traffic in National Highway 715

The National Highway 715, which is earlier called NH 37, connects Assam to other neighboring states like Nagaland and Manipur and, brings good opportunities for commerce and development. However, it also brings loss to the environment and wildlife, as the 54 Km stretch of the highway passes through the southern boundary of the natural heritage the Kaziranga National Park, which has brought challenges for the conservation of wildlife which is heritage of Assam. The Panbari corridor is one of the nine corridors identified. WWF has identified a part of Kaziranga-Karbi Anglong Landscape (KKL)- India under the AREAS programme to develop the strategic conservation plan for the endangered species and their habitats (WWF, 2008). This corridor has been cut through by the NH 715 in the 4 Km stretch. The corridor area is surrounded by Panbari RF, Dolamara PRF, Jaitha Pahar DCRF and community-owned forest.

Moreover, it mainly falls in the district of Karbi Anglong and Golaghat. This corridor facilitates the movement of animals from KNP to other adjoining forest areas or vice versa. The corridor is extending up to the foothills of KA to the south, and evidence of using it by wildlife (WWF, 2008). Moreover, the tropical moist deciduous forest harbors a variety of flora and fauna. It is a vital connection between the KNP and KA hills thus, holds a major significant role in maintaining the integrity of the Natural World Heritage Site. The challenges like vehicular

collision, change in land use, traffic (MoEF, 2003) are prominent along the national highway.

However all the corridors disturbed by the same road (NH-715), the traffic counter device PicoCount 4500 has put in a same place for 10 day and 24 hours data has been collected. Therefore, it has seen that there is a hike in traffic volume as well as traffic speed which could negatively affect the wildlife in the area. In the year 1998-2001 the average vehicular speed was 40 km per hour and traffic plying rate 60 vehicles per hour when the road condition is not good and with potholes. In the year 2003 where the average speed of a vehicle was 70 km per hour and traffic plying rate was 96 vehicle per hour with good and smooth road conditions. Therefore in the recent time it increases to increase to 120 km per hour and traffic plying rate is 600 vehicles her hour

The traffic is mainly high around the evening time form 1:00 PM to 8:00 PM, whereas the early morning and late night the traffic is much lesser.

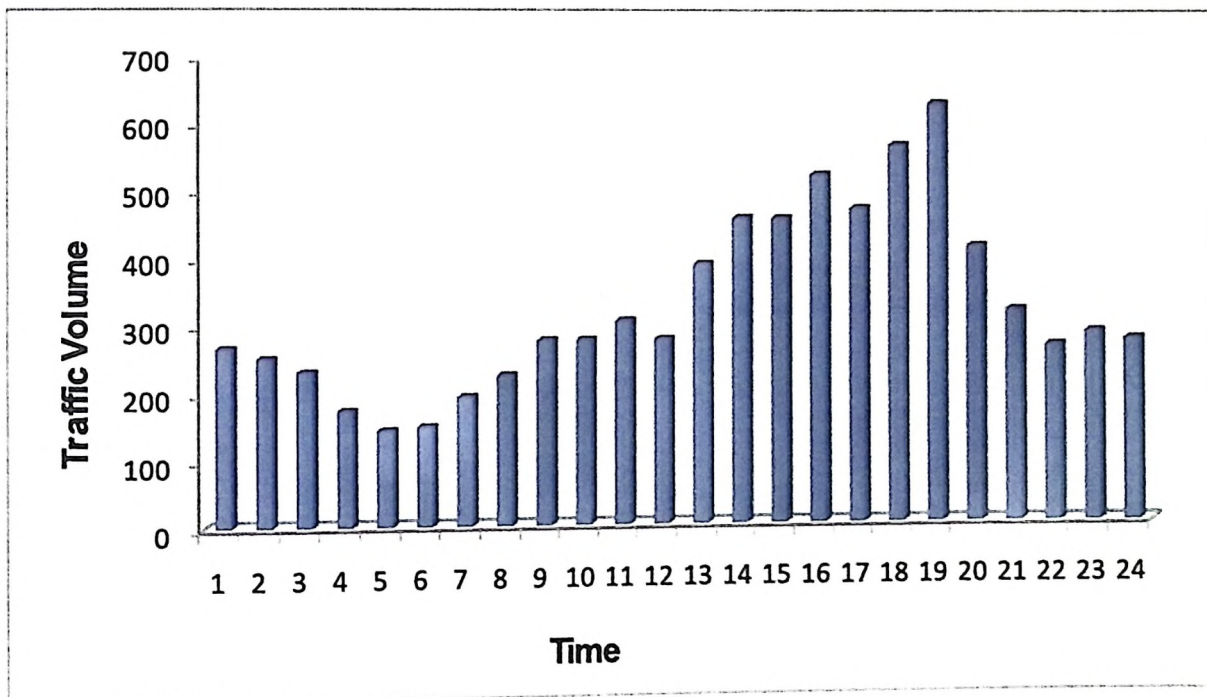


Fig 16: Representation of peak traffic volume

DISCUSSION:

The extent of different types of road networks with respect to PAs and corridors in the State of Assam

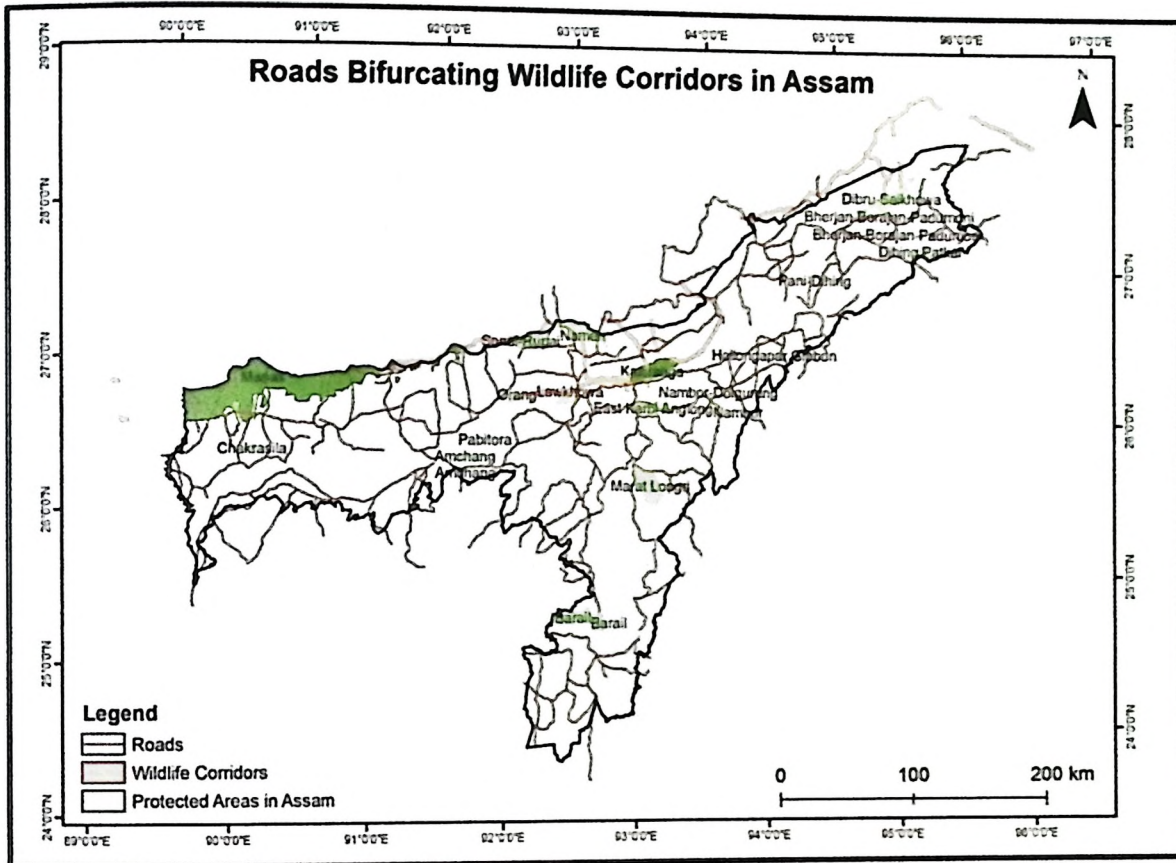


Fig17: Map representing the corridors of Assam cut by the road networks

The linear infrastructural development is increasing rapidly in the north-eastern state of India, especially in Assam, where there are 39 existing National Highways, 15 proposed National Highway with State Highways and local roads walking through several forested areas and animal corridors. Whereas, roads were known for bringing problems to the wildlife and its habitat.

In the state of Assam, there are 39 no. of national highways in Assam 3900.44 km in length, following 26 no. of state highways 7547.39 km in length. There is an up-gradation of roads from state highways to national highways or from regional to state highways. However, from 2014 to 2018, there is primarily the construction of 2 lane and four-lane roads, and a total length of 187.104 Km constructed in 4 years. In the year 2014 to 2015, 12.011 Km length of the road was awarded followed by The year 2015 to 2016, 14.818 subsequently in the year 2016 to 2017 there is a 257.895 Km constructed, and the year 2017 to 2018 the road constructed were 79.10

Km. Thus, it is evident that roads awarded during 2014 in Assam have increased and their ecological consequences.

There is total seven National Parks, out of which two are recently declared as a national park in the 2021 and twenty Wildlife Sanctuaries, three proposed and occupies 3925 sq. Km area. However, as the infrastructural development is taking heights, it also adds to further fragmentation of the forested area and contiguous landscapes. Therefore, out of total PA's in Assam, the road is passing through 11 of the protected areas.

The National Highway 715, which is a two-lane road that runs parallel to Kaziranga National Park's southern boundary, acts as a barrier to animals moving from the park to Karbi Anglong hills, and it has opened new challenges for wildlife conservation. Due to the NH 715, the park's southern side became exposed and attracts human settlements, tea planters, new businesses, and agriculture. Thus, the change in land use pattern significantly diminished the forest cover and caused the fragmentation of wildlife habitat.

There are twelve identified corridors in Assam, out of which eight corridors are bifurcated by roads in more than one place. Kaziranga- Itanagar WLS is a vital corridor for tiger movement, which connects Kaziranga tiger reserve and Itanagar Wildlife Sanctuary and maintains the genetic diversity of the species; apart from tigers it also allows the movement of other animals. Apart from Kaziranga- Itanagar WSL, other corridors such as Kaziranga-Karbianglong, Kaziranga- Nameri, Kaziranga-Orang, Kaziranga-Papumpare, Pakke-Nameri-Sonai Rupi near Kaziranga National Park and corridors such as Manas-Buxa near Manas Wildlife Sanctuary and Dibru-ering 1 connecting Dibrusaikhowa NP and D'Ering.

Through Kaziranga- Itanagar WSL state highway-43 is passing by in one spot wherein.

Kaziranga-Karbianglong 1&2 corridor national highway-37 passes through south to Kaziranga NP, Kaziranga- Nameri 1 corridor bisected by NH-52 SH-45 where Kaziranga-nameri 2 bisected by NH-37 Kaziranga-Orang and Kaziranga-Papumpare are bifurcated by NH-37 and 52.

The land use pattern near the corridor bifurcated by the road

The land use pattern has significantly changed over the period in the corridor complexes in Kaziranga National Park along the National Highway 715. However, a series of satellite imagery has taken from the year 2000 with five years of Intervals in between till today. There is an increase in the decline in forest land with the increase in agricultural land. Moreover the percentage loss of forest covers in the year 2005 is 14% which becomes 20% in the year 2010, but there was a drastic decline in forest cover from the year 2010 to the year 2015 by 23% and further the percentage change in the year 2021 by 5%. Whereas, the trend of agricultural land drastic increase from the year 2005 to 2010, where in the year 2005 the percentage change is 25% and in the year 2010, the agricultural land changes by 95%. Furthermore the increasing trend continues till date. Thus, with the increasing agricultural land the forest covers especially along the NH 715 is rapidly changing and more pronounced.

However, there might be a plethora of reasons for the degradation of forest land in KNP along the NH 715, but the prominent and growing problem is due to the conversion of forest land into the agricultural land, which is mainly owned by the local communities residing near the park, primarily depends on agriculture and small businesses for livelihood (WWF, 2008a). Also, cattle grazing in the buffer area, NTFP collection and illegal fishing could potentially disturb the buffer area near national highway. Therefore, the trend of increase in the agricultural land is likely continue with passage of time if, there is no change in livelihood of the fringe communities.

The rapid conversion of forest land annually, consequently increase the events of human-wildlife in the area (Das et.al., 2012). The intense human- elephant conflict is the prominent issue in the Golaghat district of Assam (Das et.al., 2012). The encroachment of the forest land for tea plantation and monoculture has significantly degraded the forest cover, leading to the conflict with wildlife especially with elephants (Das et.al., 2012).

Moreover, there is significant increase in built-up near the national highway, mostly the commercial businesses such as hotels, resorts, parks, small continuous chains of shops, local markets just beside the NH715 adds to the problem and builds the anthropogenic pressure on the ecosystem and act as a barrier for wild animals moving from KNP to KA hills.

Another major obstacle in maintaining the corridor functionality is the speeding NH715, as it cuts through the animal corridors. Though, there were many steps already taken to minimize the traffic by the forest department. The incidences of vehicular collision are more prominent in the monsoon seasons, when animals seek refuge in the Highway. Otherwise, the road casualties were comparatively low in the month when the study is done. This also brings in the question why there are less casualties compare to monsoon season when the maximum vehicles speed is between 40 t 70 Km per hour? Is there are less animals crossing the road or totally avoiding it? In some corridor the number of species sighted was more and in some

The signs of particular species are high and some species were sighted in all the corridors where others were not.

However, in Kanchanjuri corridor the sighting of animal species is more compare to other corridors and the direct and indirect sightings at very near distance to the NH. Whereas, compare to Haldibari corridors where the traffic is high throughout the day due to Bhuri Mai Mandir, when most of the vehicles stop by and large vehicles like trucks are parked near the temple, many small shops have also came up recently and the small business are continue to grow near the mandir. Moreover, the Panbari

corridor is an important area for elephant movement but the rapid conversion of privately owned and forest land into the tea estates in both small and large scale.

To attain the peaceful co-existence with wildlife it is essential to involve local communities in decision making process, finding alternative livelihood for the communities is very essential to avoid natural resource extraction.

CHAPTER 6:

CONCLUSION

This study mainly deals with the status of the corridors namely; Panbari Corridor, Haldibari Corridor, Kanchajuri Corridor, and Amguri Corridor in Kaziranga National Park. From the finding, it is evident that there is a major forest loss especially in the corridor portions bifurcated by the road. The change detection from the year 2000 to 2021 has indicated a major forest loss, the reason for the forest is mainly human-induced, pollution near the road is also a reason for the habitat degradation, natural timber collection, and expansion of agriculture, monoculture. There is also a huge increase in built-up which are mainly close to the road which also acts as a barrier to animal movement. As a result of the sign surveys in each corridor and the land use pattern along the National Highway 715, due to the loss of habitat, there are very few animal signs recorded near the road (within 200km), away from the road the sign was more frequent and varied, the direct sightings of animals are farther from the roads which indicate the avoidance during the peak traffic hour. However, the signs near the road or the direct sightings of animals were mainly during the late night or early morning when the traffic and human activity is low. Though, there was significant indirect evidence of animals near the national highway. However, throughout the corridors, the animal's signs present were the same, and mostly the large mammals such as elephants, rhino, and wild buffalo, hog deer's and where wild boar were active throughout the day and direct sightings of it.

However, there is a high anthropogenic pressure along the NH715. The wild animals especially elephants were seen to use the human-dominated area while moving towards Karbi Anglong hills.

As in the World Heritage sites, it is essential to maintain the integrity of the site. However, the Kaziranga National Park is inscribed for its unique ecosystems and its threatened and endangered species. It becomes important for the site to maintain all the universal values and the continuity of the landscape. Moreover, the animal corridors connect the adjoining protected area and facilitate the movement of wildlife.

Therefore, the current status of the corridors gives the idea of the area, which helps in the monitoring of the landscape as a whole and also tells about a new possible threat to wildlife.

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