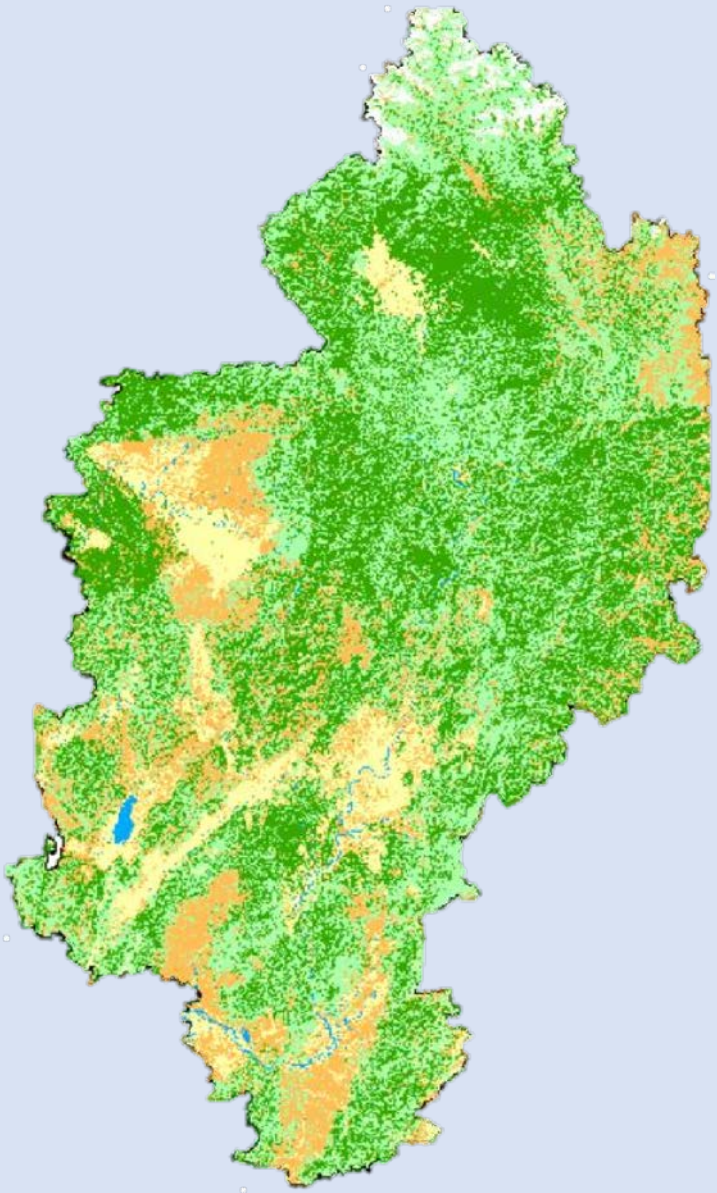

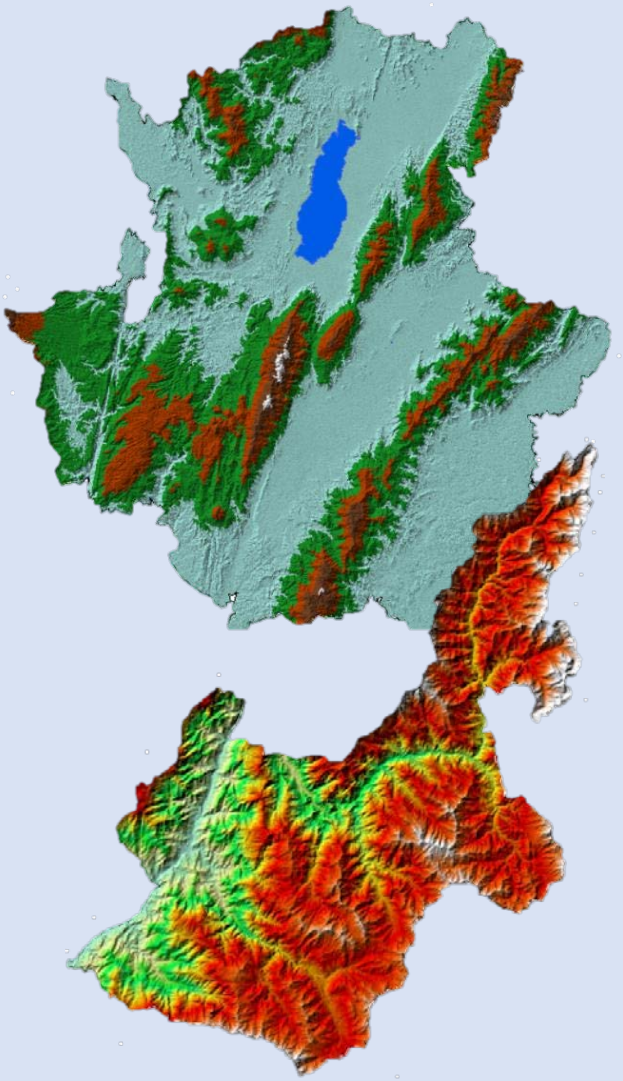

GIS and RS Study Report on Assessing Land Use Land Cover Status and Land Use Mapping in the Hotspot Regions of Kachin State: Chipwi Township and Mohnyin Township

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Abbreviation

ASEAN	-	Association of South East Asia Nations
CSR	-	Cooperate Social Responsible
DEM	-	Digital Elevation Model
DFMP	-	District Forest Management Plan
EVI	-	Enhanced Vegetation Index
FRA	-	Forest Resource Assessment
GEE	-	Google Earth Engine
GIS	-	Geographic Information System
ha	-	Hectare
IBA	-	Important Bird and Biodiversity Area
IK	-	Indigenous Knowledge
KBA	-	Key Biodiversity Areas
LULCC	-	Land Use Land Cover Change
m	-	Meter
MAB	-	Man and Biosphere Reserve
MIMU	-	Myanmar Information Management Unit
MLC	-	Maximum Likelihood Classifier
MONREC	-	Ministry of Natural Resources and Environmental Conservation
MSI	-	Multi Spectral Instrument
Mt.	-	Mountain
NTFPs	-	Non-Timber Forest Products
Ntree	-	Number of Trees
NYNG	-	Nam Mun Youth Network Group
OSM	-	Open Street Map
PAS	-	Protected Area System
PPF	-	Protected Public Forest
REM	-	Rare Earth Mining
RF	-	Reserved Forest
RNH	-	Re-Establishing Natural Habitats
RS	-	Remote Sensing
SEZ	-	Special Economic Zones
SRTM	-	Shuttle Radar Topography Mission
SVM	-	Support Vector Machine
TIN	-	Triangulated Irregular Network
TK	-	Traditional Knowledge

UNESCO	-	United Nations Educational, Scientific and Cultural Organization
UTM	-	Universal Transverse Mecrator

Abstract

This pilot study delves into the intricate dynamics of land use and land cover changes in the hotspot regions of Kachin State; Chipwi Township and Mohnyin Township, spanning the period from 2019 to 2024. Employing a comprehensive classification scheme comprising (7) distinct land classes - Degraded Forest, Forest, Cropland, Built-up, Bare Land, Water, and Mining - the study offers valuable insights into the evolving landscape of these two townships. The overall accuracy and Kappa coefficient for LULCC classification on Chipwi Township for 2019 and 2024 were 96.20%, 0.9268 and 91.00%, 0.8503 respectively. For Mohnyin Township, the overall accuracy and Kappa coefficient for LULCC classification for 2019 and 2024 were 96.20%, 0.9290 and 94.80%, 0.9139 respectively. The analysis reveals notable shifts in land cover patterns, with Degraded Forest areas witnessing an increase, while Forest cover experiences a decline during the study period. In Mohnyin Township, the prevalence of Degraded Forest rises from 15.24% in 2019 to 20.99% in 2024, while Forest cover decreases from 70.54% to 61.75% over the same timeframe. Similarly, in Chipwi Township, the proportion of Degraded Forest expands from 13.97% to 17.33%, accompanied by a decrease in Forest cover from 73.72% to 63.32%. Notably, the escalation of mining activities emerges as a significant driver of land use change, particularly evident in the vicinity of Indawgyi Lake and Pang War Town. The prevalence of gold mining near Indawgyi Lake and Rare Earth Mining around Pang War Town underscores the urgent need for sustainable land management practices and regulatory interventions to mitigate the adverse environmental impacts of mining activities. Furthermore, the study underscores the critical importance of watershed conservation in Kachin State, given its status as the headwater region of Myanmar. Recognizing the interconnectedness of land use changes with broader socio-political, economic, and environmental dynamics, this study advocates for collaborative, multi-stakeholder approaches to address the complex challenges facing Kachin State. By prioritizing conservation efforts, promoting sustainable livelihoods, and integrating traditional knowledge with scientific expertise, stakeholders can pave the way for a more resilient and sustainable future for Kachin State and its inhabitants.

Keywords: Land Use Land Cover Change, Degraded Forest, Forest, Kappa Coefficient

1. Introduction

Kachin State is located in the northernmost part of the country, one of the seven states in Myanmar. Being bordered by China to the north and the east, Shan State to the south, and Sagaing Region and India to the west, it lies between North Latitude 23° 27' and 28° 25', East Longitude 96° 0' and 98° 0', composing of 18 townships with covering an area of 89,041.771 square kilometers (34,379.22 sq. miles) (Naw, 2007). According to the 2014 Population Census Data of Myanmar, the population of Kachin State is known to be about 1.6 million comprising with 48.4% of male and 51.6% of Female, including largely Kachin, Shan, and other Ethnic Groups who are coexisting together. The main livelihood sector of the state is known to be land-based economy such as agriculture, farming and mining. The topography of the Kachin State is mountainous, filled with steep and long mountain ranges with distinct flat plains such as Puta-O Plain and Hopin Plain. At the most northern extremities of Myanmar is a sparsely populated, little-explored region that is generally referred to the 'Icy Mountains', containing Himalayan Peaks, such as Mt. Hkakabo Razi, an estimated 5889 m high (Khaing, 2008). Moreover, Kachin State possesses Indawgyi Lake, the largest inland lake in Southeast Asia.

Kachin State is also known as a "hotspot for biological diversity" and the conservation of its natural resources, which cannot be valued in monetary terms, is of international and cultural importance. It is also rich in vast varieties of forest resources and the forest cover is about 71.52% of the total area of the state and the mean annual deforestation rate between 2015 and 2020 is like to be 0.5% it means to 46,543.48 ha of the state area are deforested annually (FRA, Forest Resource Assessment, 2020).

Besides, it has a lot of minerals including jade, ruby, sapphire, diamond, decorative stones, amber, copper, metal, iron ore, rare earth, zinc, tungsten, gold, and platinum. Mainly, because of having varieties of natural resources richness, since the past decades, the Kachin State had a lot of issues and challenges on peace processes and resource extraction upon the unstable political situations.

Kachin is a landlocked state in Myanmar and thus, mostly depending upon China's products, encourage unregulated trade at the border regions. This trade mainly includes timber, NTFPs, mining, wildlife parts, energy, construction materials, special economic zones (SEZ), labor markets, agri-business, livestock, etc. Demanding on the substantial commodities and higher inflation rates due to blocking domestics trades in certain regions lead to inviting unregulated foreign investments which may turns into unstainable development infrastructures such as unregulated mining, land grabbing, uncontrolled large scale tissue banana plantations across the state.

In Kachin State, there have diversities tribes of ethnicities on which their habit, beliefs, and practices are forming various customary practices. Most of the significant practices are fundamental to livelihoods, custom design symbols, food systems, forest products, herbals medicinal and traditional ceremonials, all events of the indigenous knowledge (IK) and traditional knowledge (TK). Therefore, their bio-cultural and bio-physical environments rely on land and forest governance and management system. *Taungya* or Shifting cultivation, slash and burn, upland cultivation is a common, customary land use system with no ownership right.

Most of rural people are depending on natural resources and it becomes a major livelihood for those who are living in rural areas. For the grass-root levels, forests are major sources to generate basic needs and necessary income (FAO, 2009). Thus, this study is a pilot study to explore and to map

the areas affected by land degradation and deforestation in the biodiversity hotspot regions of Kachin State due to unsustainable development manners. In this study, Chipwi Township and Mohnyin Township were selected to accounting land use land cover change, and surface analysis for the formulation of better land use practices intend to sustainable Kachin landscape management in the future scenarios. These two regions are famous for different approaches of mining activities i.e. open-pit gold mining and in-situ leaching rare earth mining (REM). The study intends to aware the Kachin Communities on land use land cover change especially dramatic changes in forest cover on which to prepare people participated sustainable afforestation and reforestation programs in the future settings to encounter climate change crisis.

2. Scoping Study Areas

2.1. Chipwi Township

Chipwi Township is situated in the northeast part of Kachin State and it includes in Myitkyina District. Chipwi Township is located between North Latitude 25˚ 25' and 26˚ 35' and East Longitude 97˚ 55' and 98˚ 45'. The extent of the township area is 342,940.08 ha and is comprised with (2) towns; Chipwi Town and Pang War Town. The boundary shared with the People's Republic of China in the East and Injangyang Township in the West, Waimaw Township in the South and Tsawlaw Township in the North.

The population of the township are (21,450) in which (10,648) are male and (10,802) are female (GAD, Regional Facts and Figures of Chipwi Township, September, 2019). Based on the information of local literature and cultural associations, (6000) of Lisu tribe, (5000) of Lachik tribe and Lhaovo tribe are inhabited in the region.

No.	Land Entitlement	Extent (ha)
1	**Net Agricultural Land**	**3,354.05**
	(a) Low Land (Paddy Land)	423.71
	(b) Up Land (Ya)	823.13
	(c) Orchard	1617.94
	(d) Hillside Cultivation Land (Taungya)	489.27
2	**Fallow Land**	**602.98**
No.	**Land Entitlement**	**Extent (ha)**
	(a) Low Land (Paddy Land)	302.30
	(b) Up Land (Ya)	300.68
3	**Urban Area**	**171.59**
4	**Village Land**	**110.48**

The economic conditions of the township are growing with slow pace and the main livelihood is agriculture. However, the township cannot produce main agricultural products in sufficient amount and rely on the imports of other regions.

5	**Other Land**	**330,461.14**
6	**Virgin Land**	**963.97**
7	**Non-Arable Land**	**7,275.87**
	Grand Total	**342,940.08**

Chipwi Township is well known for its pristine forests and crystal-clear water. During the past decade, accompanying with the mineral mining, the rare earth mining backing from the China Companies are being initialized in the region. Adding limited law enforcement in the region, unregulated and lack of transparency in resource mining leads to environmental deterioration, unsustainable development in economic viability, and alter in social norms in the region. China's outsourcing of rare earth mining to Myanmar has prompted a rapid expansion of the industry there, fueling human rights abuses, damaging the environment and propping up pro-junta militias.

Chipwi Township is abundant with hills, mountains, ravines, water courses and possesses few flat lands. The soil depth is shallow, and the underlying layers are combined with gravel layer, igneous rock layer and mature metamorphic rock layer.

The land use of the Chipwi Township was recorded as follows;

Table – 1. Extent of Land Use in Chipwi Township (GAD, Regional Facts and Figures of Chipwi Township, September, 2019)

Although the main livelihood of the region is agriculture, the rice and edible oil security in 2019 were 26.24% and 8.06% respectively (GAD, Regional Facts and Figures of Chipwi Township, September, 2019). Relying on imports of basic food from other region, incentives of the investors and forces of relevant authorities on exploiting natural resources drive unregulated and unresponsible mining in the region. Local people reported that some of the local people were relocated by force through compensating extremely amount of money to allow rare earth mining on their ancestral land.

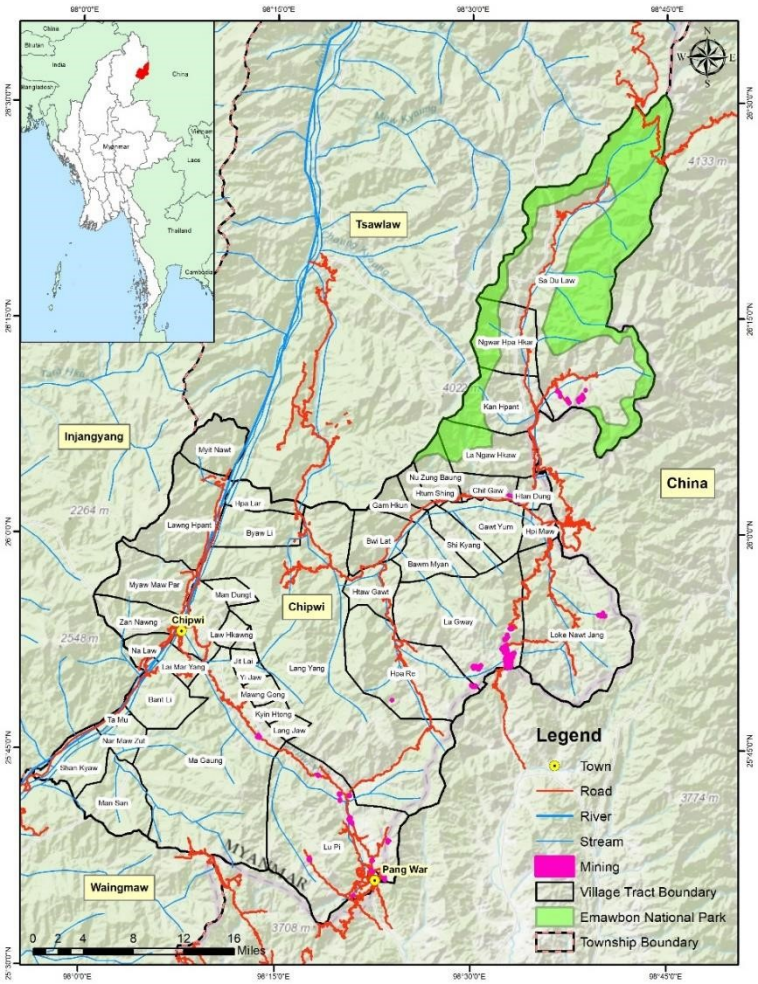


Fig. 1. Location Map of Chipwi Township

In accordance with FRA (2020), the forest cover of the township is 81.71% (277,141.50 ha) and the mean annual deforestation rate between 2015 and 2020 is likely -0.34% which means 1,150.01 ha of the forest areas are increased annually. The comparison of land use land cover changes in Chipwi township between 2010 and 2020, 5 year periodically are shown in the below map (FRA, Forest Resource Assessment, 2020).[1]

1

Closed Forest	Closed Forest means under forestry or no land use, spanning more than 0.5 hectares, with trees higher than 5 meters and a canopy cover of more than 40 percent.
Open Forest	Open Forest means under forestry or no land use, spanning more than 0.5 hectares, with trees higher than 5 meters and a canopy cover of between 10 and 40 percent.
Other Wooded Land	Land not defined as 'Forest', spanning more than 0.5 hectares; with trees higher 5-10 percent, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use.
Others	All land that is not classified as "Forest" or "Other wooded land" including agricultural land, meadows and pastures, built-up areas, barren land, etc.
Water	Generally include major rivers, lakes and water reservoirs.
Snow	Snow (or) Land under permanent ice (or) Cloudy Area

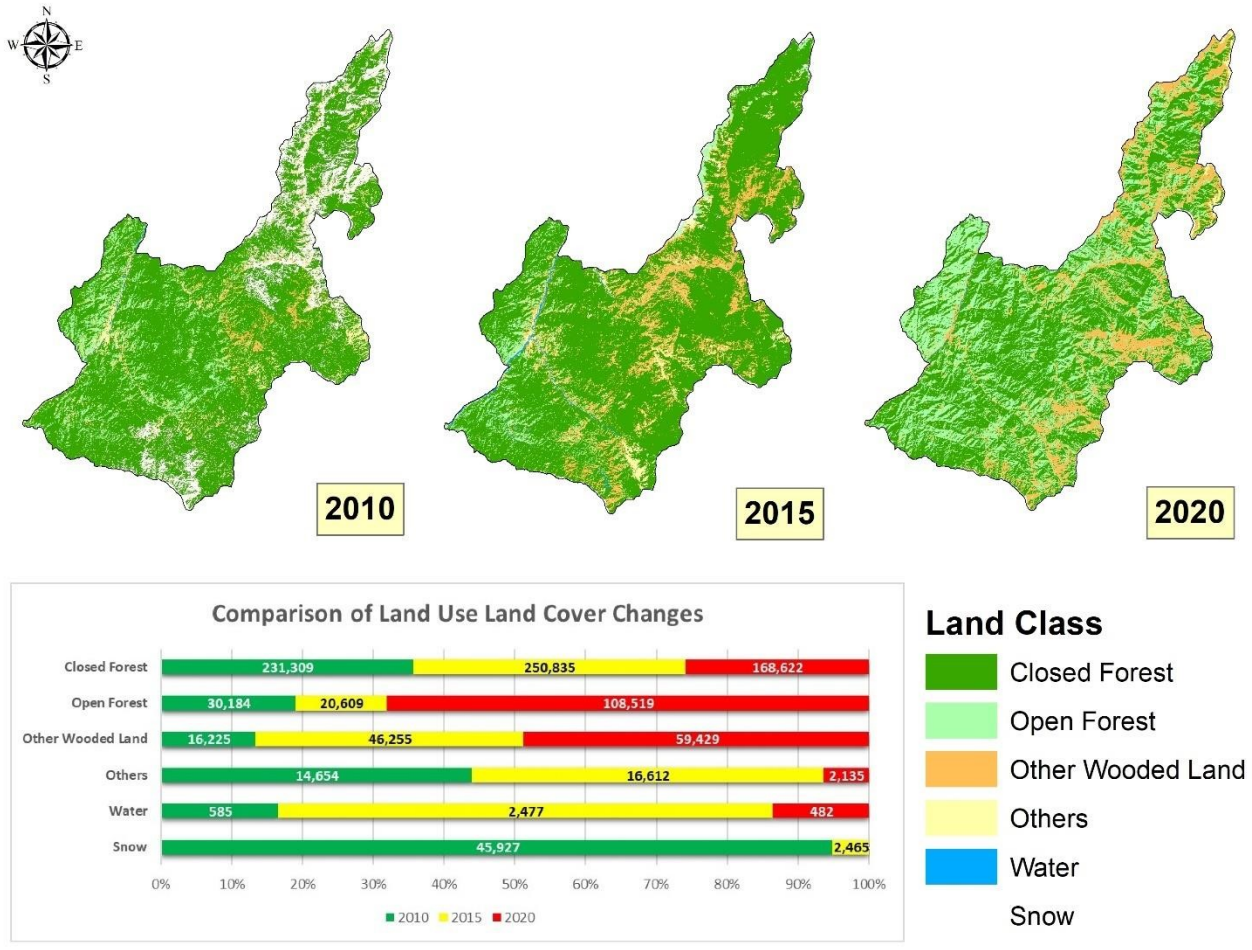


Fig. 2. Comparison of Land Use Land Cover Change in Chipwi Township (FRA, Forest Resource Assessment, 2020)

Being included in one of the biological hotspot areas, Chipwi Township possesses Emawbon National Park in the northern parts of the region. Emawbon National Park was notified as a protected

area in 2016 and the distinct ecosystem is evergreen forest, mixed evergreen forest and bamboo forest. The key species are Primates species, Red Panda, Musk Deer, Bear, Clouded Leopard, Sambar, Takin, Red Goral, Jungle Cats, and Birds species (NWCD, 2019).

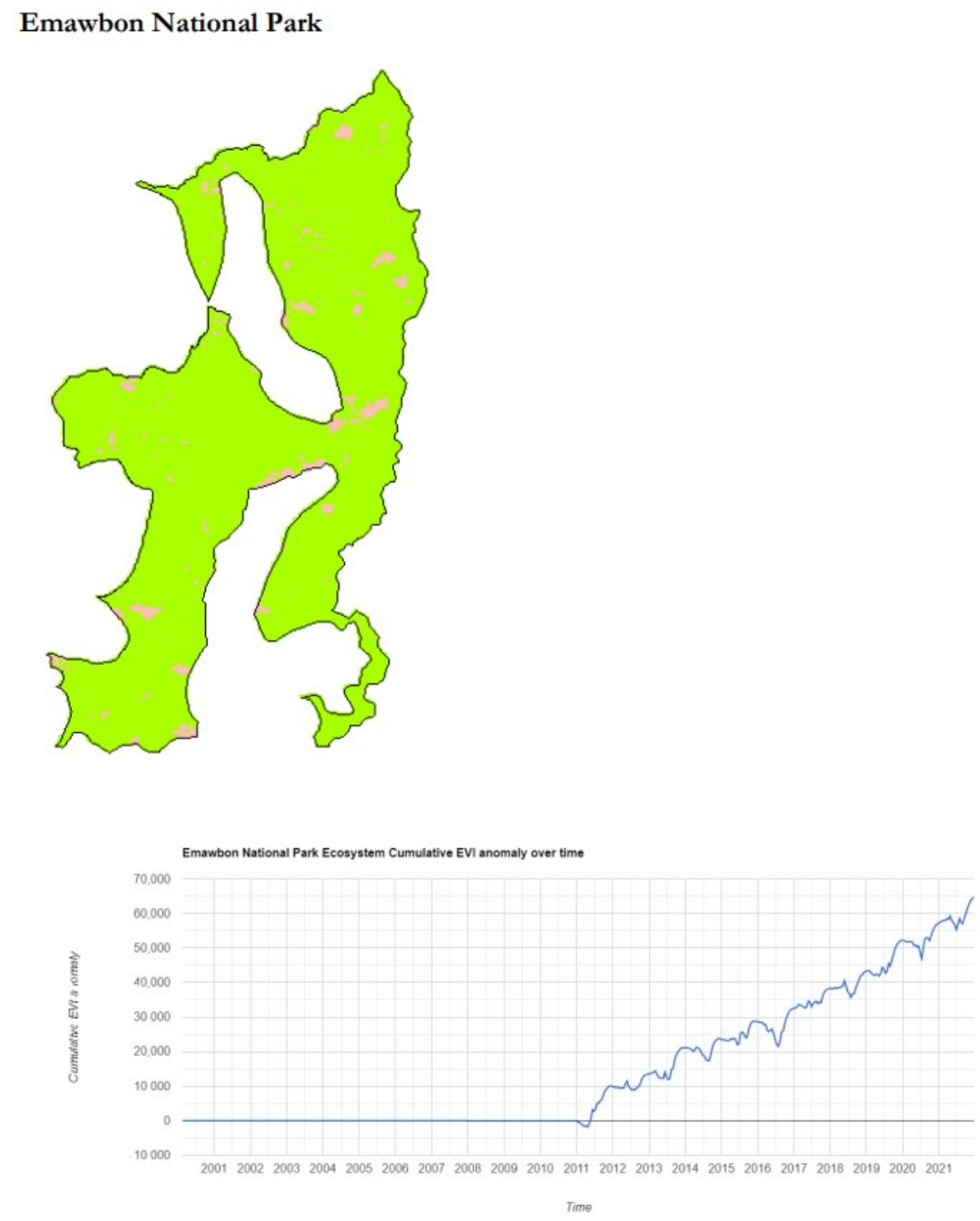


Fig. 3. Ecosystem Stress Report on Emawbon National Park (Dr. Moe Myint, 2022)

Emawbon National Park does not show the ecosystem stress significantly. Only 4% of the park is detected as ecological stress areas. Pink areas on the map should be focused on restoration activities and conservation planning (Dr. Moe Myint, 2022).

2.2. Mohnyin Township

Mohnyin Township is situated in the southern part of Kachin State and it includes in Mohnyin District. The township is located between North Latitude 24˚ 30' and 25˚ 27' and East Longitude 96˚ 02' and 96˚ 48'. The extent of the township area is 667,831.02 ha and is comprised with (4) towns; Mohnyin, Hopin, Inn Taw Gyi and Nam Mun. The boundary shared with Mogaung Township, Shwegu Township and Myitkyina Township in the East and Homalin Township, Banmauk Township in the West, Indaw Township in the South and Hpakant Township in the North.

The population of the township are (211,676) in which (101,662) are male and (110,014) are female (GAD, Regional Facts and Figures of Mohnyin Township, September, 2019)

Being located on the Union Highway (Shwebo-Myitkyina Highway) and on Mandalay-Myitkyina Railway, the township becomes economically central and develop moderately in the State because of good transportation infrastructures. The main livelihood of the region depends on agriculture and also jade and gold mining are implemented economically.

Mohnyin Township is well known for Indawgyi Lake (Nau Mae Mai), the largest freshwater lake in Myanmar, swamp land, seasonally flooded grassland, and a substantial portion of the surrounding forested watershed. Due to the richness of biodiversity, the habitat of endangered species, and the presence of healthy vegetation in watershed areas, the lake area was recognized as an ASEANHeritage Park in 2004, an Asian – Australasian Flyway Partnership Site in 2014, a Ramsar Site in 2016 and a UNESCO Biosphere Reserve as well as Key Biodiversity Areas (KBA) and Important Bird and Biodiversity Area (IBA) in 2017. Unique and diverse cultures and traditional practices adopted by Kachin Tribes and Shanni Tribes dwelled in Indawgyi Man and Biosphere Reserve (MAB) and the dwellers practice fishing, agricultural and grazing as their livelihood.

Mohnyin Township is mountainous areas with remarkable flat plains; Hopin Plains and Indawgyi Plains. The land use of the Mohnyin Township was recorded as follows;

No.	Land Entitlement	Extent (ha)
1	**Net Agricultural Land**	**40,123.12**
	(a) Low Land (Paddy Land)	34,609.66
	(b) Up Land (Ya)	1,169.95
	(c) Silty Land (Kaing Kyun)	424.52
	(d) Orchard	3,918.99
2	**Fallow Land**	**2,814.20**
	(a) Low Land (Paddy Land)	2,444.31
	(b) Up Land (Ya)	371.91
3	**Urban Area**	**636.98**
4	**Village Land**	**1,215.28**

5	Other Land	1,407.50
6	Forest Land (RF/ PPF)	163,371.03
7	Wild Forest Land	234,064.23
8	Virgin Land	121,986.90
No.	Land Entitlement	Extent (ha)
9	Non-Arable Land	38,007.42
	Grand Total	603,626.66

Table – 2. Extent of Land Use in Mohnyin Township (GAD, Regional Facts and Figures of Mohnyin Township, September, 2019)

The main agricultural product is rice and mainly exported across the regions of Kachin State and others commodities are mainly imported through Mandalay Region. In Mohnyin Township, the rice security in 2019 was 262.44% and the edible oil security in 2019 was 76.80% (GAD, Regional Facts and Figures of Mohnyin Township, September, 2019).

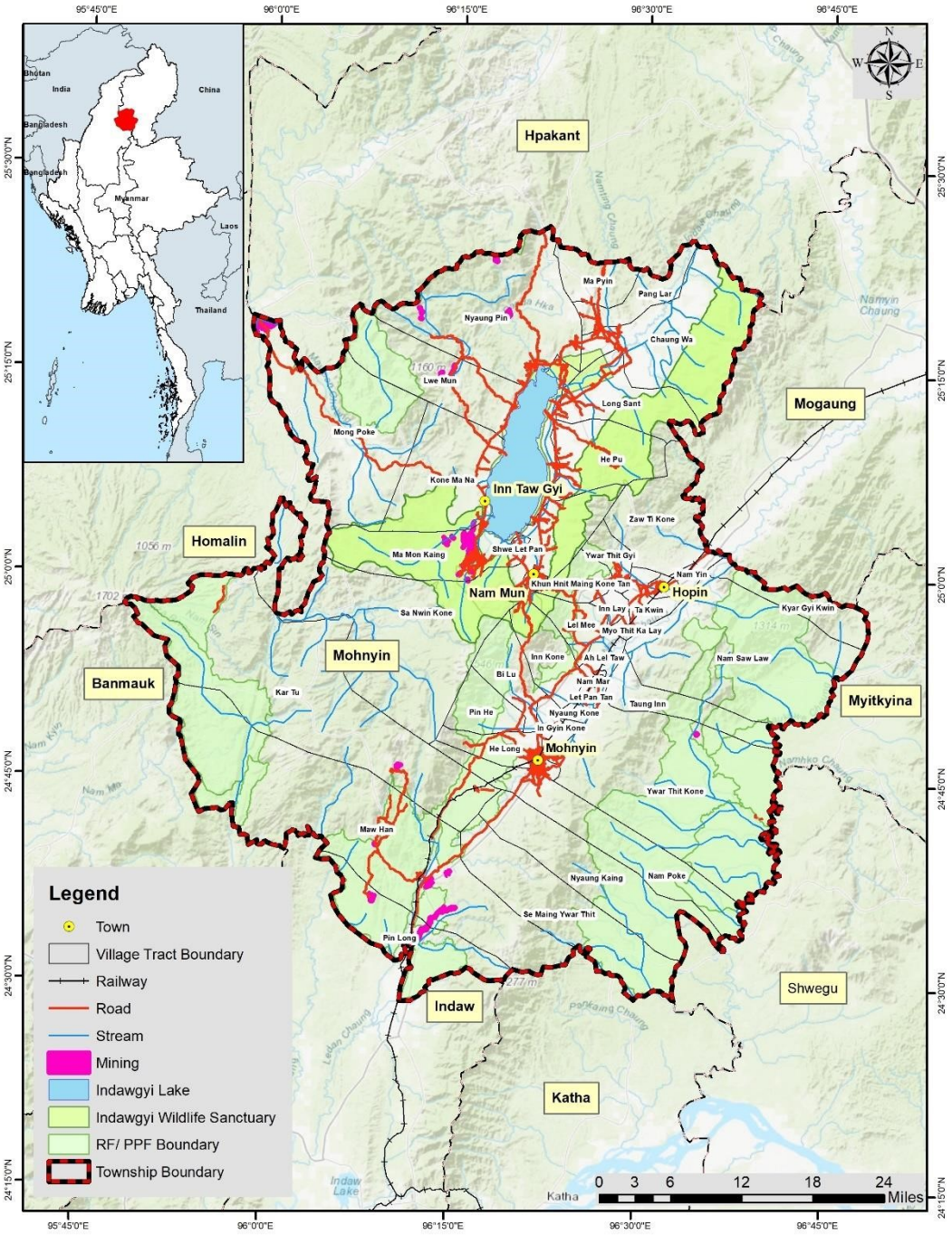


Fig. 4. Location Map of Mohnyin Township

In accordance with FRA (2020), the forest cover of the township is 55.26% (350,090 ha) and the mean annual deforestation rate between 2015 and 2020 is likely 0.27% which means 1697.32 ha are deforested annually. The comparison of land use land cover changes in Mohnyin township between 2010 and 2020, 5 year periodically are shown in the below map (FRA, Forest Resource Assessment, 2020).[2]

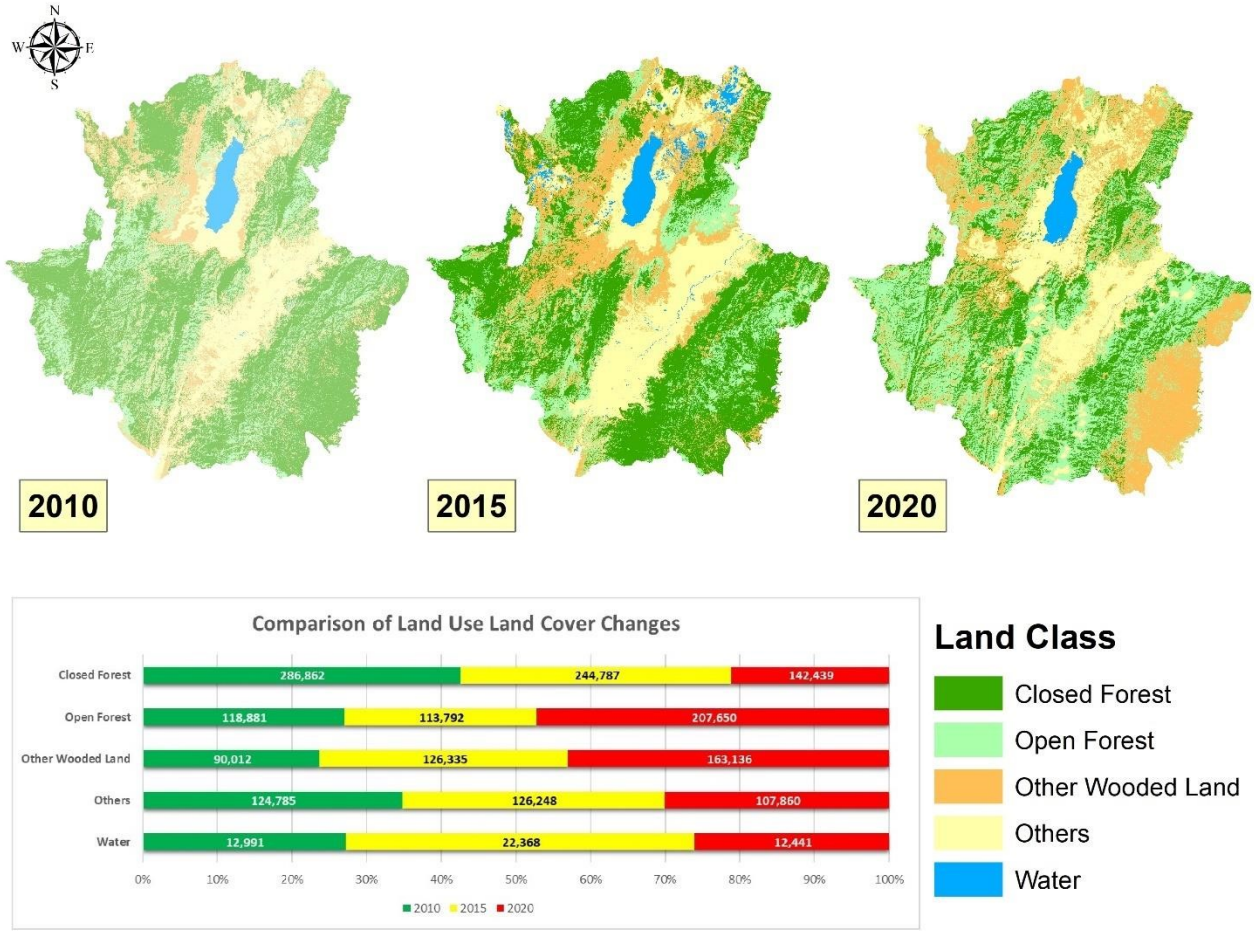


Fig. 5. Comparison of Land Use Land Cover Change in Mohnyin Township (FRA, Forest Resource Assessment, 2020)

Mohnyin Township possesses Indawgyi MAB contained Indawgyi Lake, the largest inland lake in Southeast Asia. The area was constituted as Wildlife Sanctuary in 1999 by the Forest Department

[2]

Closed Forest	Closed Forest means under forestry or no land use, spanning more than 0.5 hectares, with trees higher than 5 meters and a canopy cover of more than 40 percent.
Open Forest	Open Forest means under forestry or no land use, spanning more than 0.5 hectares, with trees higher than 5 meters and a canopy cover of between 10 and 40 percent.
Others	All land that is not classified as “Forest” or “Other wooded land” including agricultural land, meadows and pastures, built-up areas, barren land, etc.
Water	Generally include major rivers, lakes and water reservoirs.
Snow	Snow (or) Land under permanent ice (or) Cloudy Area

covering 81,499.16 ha (NWCD, 2019) and ranges in elevation from 169 m at lake surface to over 1,400 m. Generally, almost all of the water courses drain to the north and the lake includes 12,000

ha of open water, along with the mash, floating vegetation, and submerged macrophytes. The paddy fields are surrounding the lake in some low-elevation areas, meanwhile mixed deciduous forest, riverine evergreen forest and hill evergreen forest dominate the uplands in the watershed area (Forest Department, 2016) The key species are Elephant, Sambar deer, Leopard, Bear, Serow, Gaur, Migratory and Residence birds (NWCD, 2019).

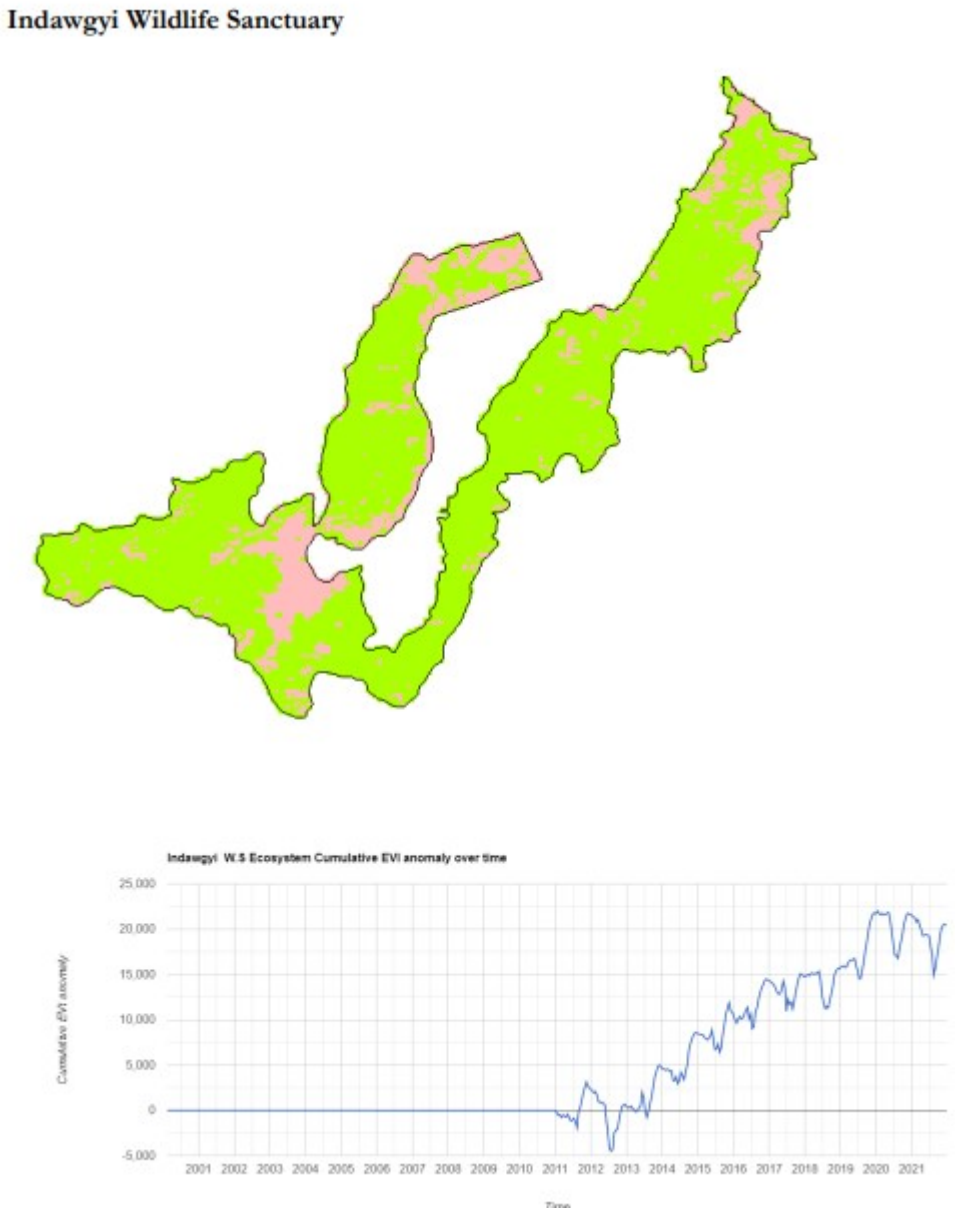


Fig. 6. Ecosystem Stress Report on Indawgyi Wildlife Sanctuary (Dr. Moe Myint, 2022)

Indawgyi Wildlife Sanctuary Ecosystem was stressed until 2013 and recovering. 18% of the park is ecologically stressed. Pink areas on the map should be focused on restoration activities and conservation planning (Dr. Moe Myint, 2022).

3. Objectives

The main objectives of the study are as follows:

- To explore land use land cover change conditions in Chipwi Township and Mohnyin Township and its extent including change detection analysis between 2019 and 2024 to the present time.
- To predict the land use land cover changes in coming 5-year period in the regions based on the land use land cover change analysis on the period of 2019 and 2024.
- To highlight land use land cover change between different approach of mining activities between the targeted regions.
- To formulate site suitability analysis for the land use in the study areas in broad sense.

4. Methodology, Materials and Methods

The main methodology applied in the study were integrated use of Remote Sensing (RS) and Geographic Information System (GIS) technology with the combination of literature review on different approaches to image classification. The secondary data such as news, articles, reports relating to the regional contexts were also applied in analyzing the data. For accuracy assessment and validating the image classification results, the geo-tagged photos taken from the targeted regions were compiled and high-resolution google earth satellite images (2019 and 2024) were applied because of limited access to implement ground-truth checking.

4.1. Data Compiling Process

The basic information and the features of the two regions such as population, township boundaries, roads, railways, village tract boundaries, etc. were obtained through MIMU and OSM, and the RF/PPF and PAS data were obtained through DFMP and RNH of the Forest Department Website (https://www.forest department.gov.mm). FRA data were obtained from GIS and RS Section, Policy and Planning Division of the Forest Department. SRTM DEM data for surface analysis and Sentinel-2 Satellite Images for LULCC classification were obtained through GEE platform. The high-resolution google earth satellite image were downloaded with the aid of SAS Planet Platform and the geo-tagged photos from NYNG and High Land Alliance Youth Network were collected for verification and accuracy assessment for LULCC classification. All the geospatial data were projected to UTM Zone 47N because the two regions are completely located in that zone.

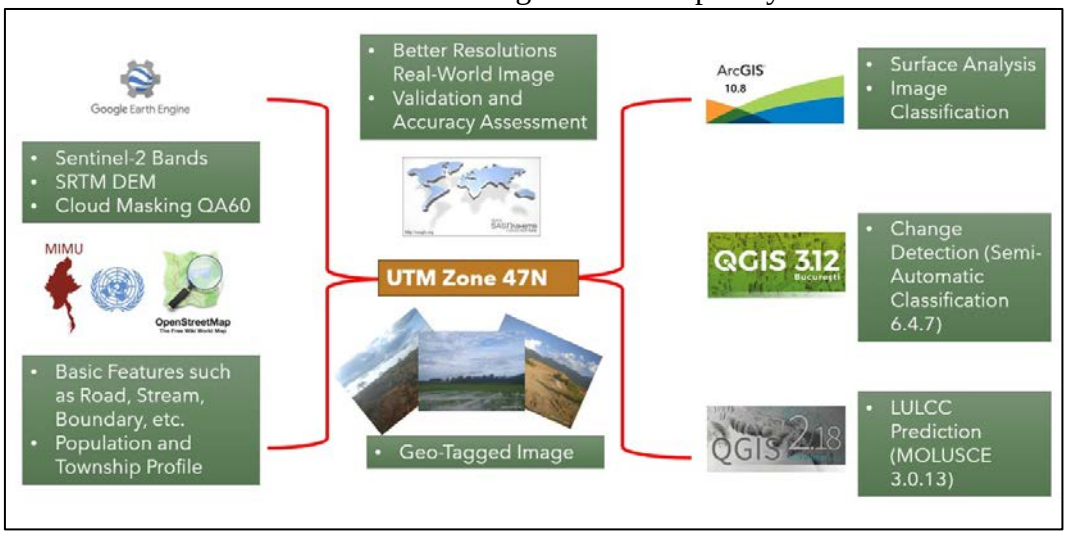


Fig. 7. Basic Workflow for Data Compiling and Processing

4.2. Data Processing and Analyzing Process

4.2.1. Surface Analysis Process

SRTM DEM data were solely applied for the surface analysis for the targeted areas with the aid of Spatial Analyst Tools of ArcGIS10.8 Software. Contour lines of 50m intervals, slope degree, aspects and elevation TIN were calculated for site suitability analysis and to support training inputs for LULCC classification process. Stream order and stream lines were calculated through hydrology tools. The basic workflow and process of surface analysis were shown in the following diagram.

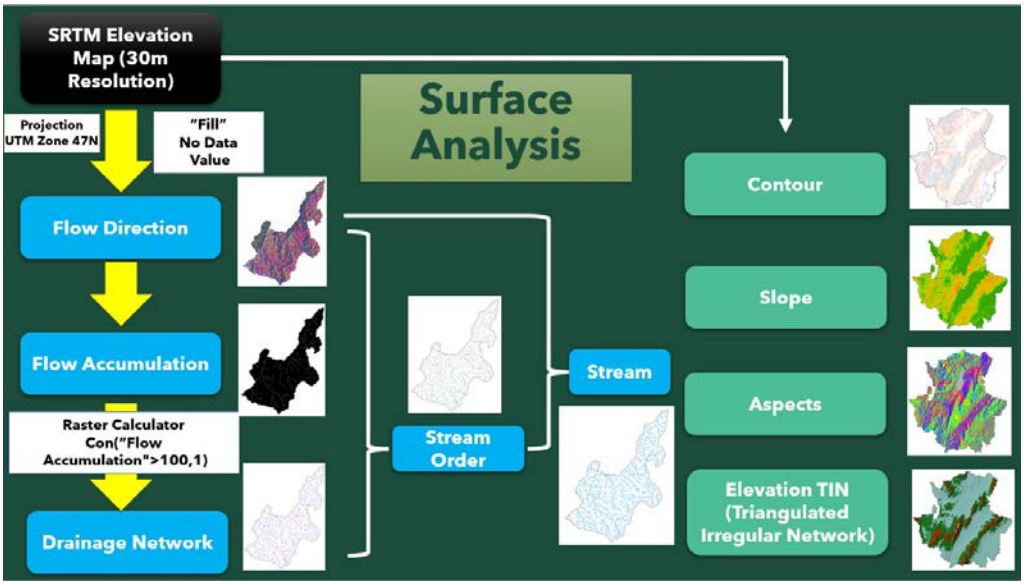


Fig. 8. Basic Workflow and Process for Surface Analysis

4.2.2. Image Classification Process

A consistent image acquisition time is vital for LULCC classification, particularly for the vegetation dominant areas considering the tree phenology changes in different seasons. Sentinel-2 MSI images were selected for the assessment due to its open-source availability, high spatial, temporal, and spectral resolution. Moreover, it has a global 5-day revisit frequency, which provides a sufficient number of images for the target study period. The characteristics of the Sentinel-2 bands are mentioned in the following image.

Sentinel-2 bands	Central wavelength (µm)	Resolution (m)
Band 1 – Coastal aerosol	0.443	60
Band 2 – Blue	0.490	10
Band 3 – Green	0.560	10
Band 4 – Red	0.665	10
Band 5 – Vegetation red edge	0.705	20
Band 6 – Vegetation red edge	0.740	20
Band 7 – Vegetation red edge	0.783	20
Band 8 – NIR	0.842	10
Band 8A – Vegetation red edge	0.865	20
Band 9 – Water vapour	0.945	60
Band 10 – SWIR – Cirrius	1.375	60
Band 11 – SWIR	1.610	20
Band 12 – SWIR	2.190	20

Fig. 9. Characteristics Sentinel-2 Bands

Sentinel-2 images within January and March of 2019 and 2024 were selected because of less cloudy conditions and tree canopies of most species are still present (the conditions were decided based on the local knowledge). For the cloud masking, QA60 band was applied. Finally, the median seasonal composite method was applied to achieve a representative image for each year (Zhu, 2014). Not only the satellite information but topographic information (elevation, slope) was also added because this information effectively contributes in identifying the topography-based land utilization.

A total of (7) land classes were applied in LULCC classification and were shown in the following table.

Land Classes	Description
Degraded Forest	Secondary forest which has lost due to natural and anthropogenic activities, combined with small trees and a few large trees, scattered forest trees
Forest	Mixed forest land, open forest and closed forest with areas where tree dominate and associate with bamboo, densely growth
Cropland (or) Crop	Agriculture crops fields with fallow land, shifting cultivation, pasture land
Built-up	Settlements, residential, commercial, transportation, roads, anthropogenic infrastructure
Bare Land	Empty land without any trees, building or any other land cover, sedimentation
Water (or) Waterbody	Streams, rivers, open water and lake
Mining	Land area of dedicated for mining purpose

Table – 3. Description of Land Cover Classes

Training input samples were collected by focusing on the above-mentioned land classes. For Chipwi Township, a total of (480) and (492) training data were collected for 2019 and 2024 respectively. For Mohnyin Township, there were (381) and (450) training data for 2019 and 2024 respectively.

Based on the classes identified prior to the classification process, LULCC classification for the years 2019 and 2024 was performed using the Random Forest Classifier algorithm. Among the machine learning approaches, Random Forest is preferable for various reasons: better capability of handling outliers and data noises, better performance with multidimensional datasets from different sources, relatively better accuracy than other commonly used classifiers, such as Support Vector Machine (SVM), Maximum Likelihood Classifier (MLC), and optimized processing speed due to selection of effective variables. According to a large number of trees can provide a sound result for variables. For the better results, the number of trees (Ntree) was assigned as 500 (Dibaba, Demissie, & Miegel, 2020).

4.2.3. Accuracy Assessment Process

Once the images were classified through Random Forest Classification Algorithm, the next step employed was image classification accuracy assessment. Accuracy assessment is considered as a

component of the image classification method that enables the researcher to check whether the classification result has a strong, medium, or poor agreement with the ground truth (Liping, YuJun, & Saeed, 2018). It helps assess the classification methodology and is crucial for identifying any potential errors. The accuracy evaluation of each classification generated by the random forestbased classification was performed in the present study utilizing random points extracted using the classification and segmentation toolsets in the Spatial Analyst tools of ArcGIS and verified using historical Google Earth images through SAS Planet. In this study, a total (500) validation points for all image classifications were generated with stratified random sampling method.

The accuracy for LULCC classification was assessed using the statistical tool known as the Kappa coefficient. A classification has low agreement if the kappa coefficient value is less than 0.4, medium agreement if it is between 0.4 and 0.8, and good agreement if it is over 0.8 (Pandey, Kumari, & Al Nawajish, 2023).

4.2.4. Change Detection and Evaluation Process

After validating the LULCC classification, change detection analyses were performed through land cover change tools of semi-automatic classification plugin (Version: 6.4.7) on QGIS Software (Version: 3.12). Based on the pre-defined land classes (Table – 3), a total of (49) combinations of land use land cover change were obtained.

4.2.5. Land Use Land Cover Change Prediction Process

For land use land cover change prediction process, MOLUSCE plugin (Version:3.0.13) on QGIS Software (Version: 2.18) was applied. The spatial variables selected for the current study were elevation, slope gradient, Euclidean distance from the main roads, and Euclidean distance from the streams. After relevant spatial variables were selected and factor maps were created, geometry matching was conducted, which included the cell size of the raster data, NoData value, data extent, dimension, and coordinate reference system. The cell size, NoData value, and coordinate reference system are 30m, 0, and WGS1984 UTM Zone 47N, respectively, for all spatial variables.

In this study, Pearson's correlation was used to measure the correlation between variables. Pearson correlation was chosen because the variables used in this study are not categorical (Paulos Lukas, 2023).

5. Results

5.1. Chipwi Township

5.1.1. Surface Analysis

The elevation map of Chipwi Township was prepared by creating TIN layer through SRTM DEM data. The elevation range of the region is between 178 m and 4029 m (Fig.10).

The slope degree of Chipwi Township was also evaluated through SRTM DEM Data. The slope degrees were classified into 8 classes with 5 degrees interval because of steep slope and higher elevation in the region (Fig.11). Generally, the range of slope degree between 0 and 5 is suitable for settlement area, between 5 and 15 degree is compatible for agricultural purpose, between 15 and 30 degree is suitable for forest plantation and above 30 degree is better untouched due to the

comparable shallow soil depths and prone to erosion. Therefore, the gradual loss of vegetation cover in the area above 30 degrees slope must be conserved and restored.

Based on these two surface analyses and adding aspects of the Chipwi Township, the slope degree of the most areas of the region were observed as higher degree. Therefore, the sensitivity of the land use land cover changes in the region can be assumed as higher degree of difficulty to attain its original state naturally. Dwindling of forest resources, biodiversity and wildlife resources in the region due to dramatic expanding of unregulated mining activities in the region would affect on the natural resilience of the ecosystem because of higher slope degree.

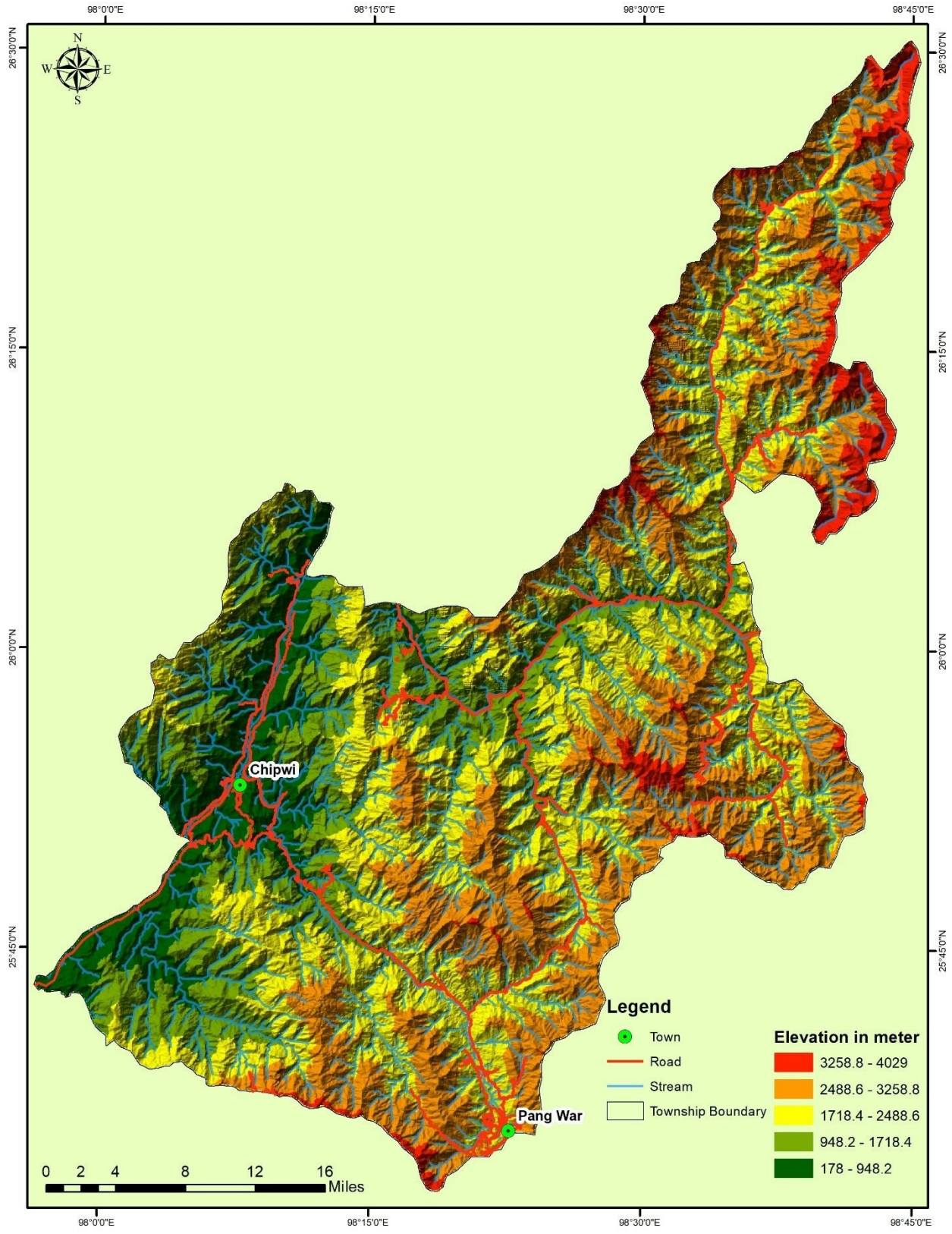


Fig. 10. Elevation Map of Chipwi Township

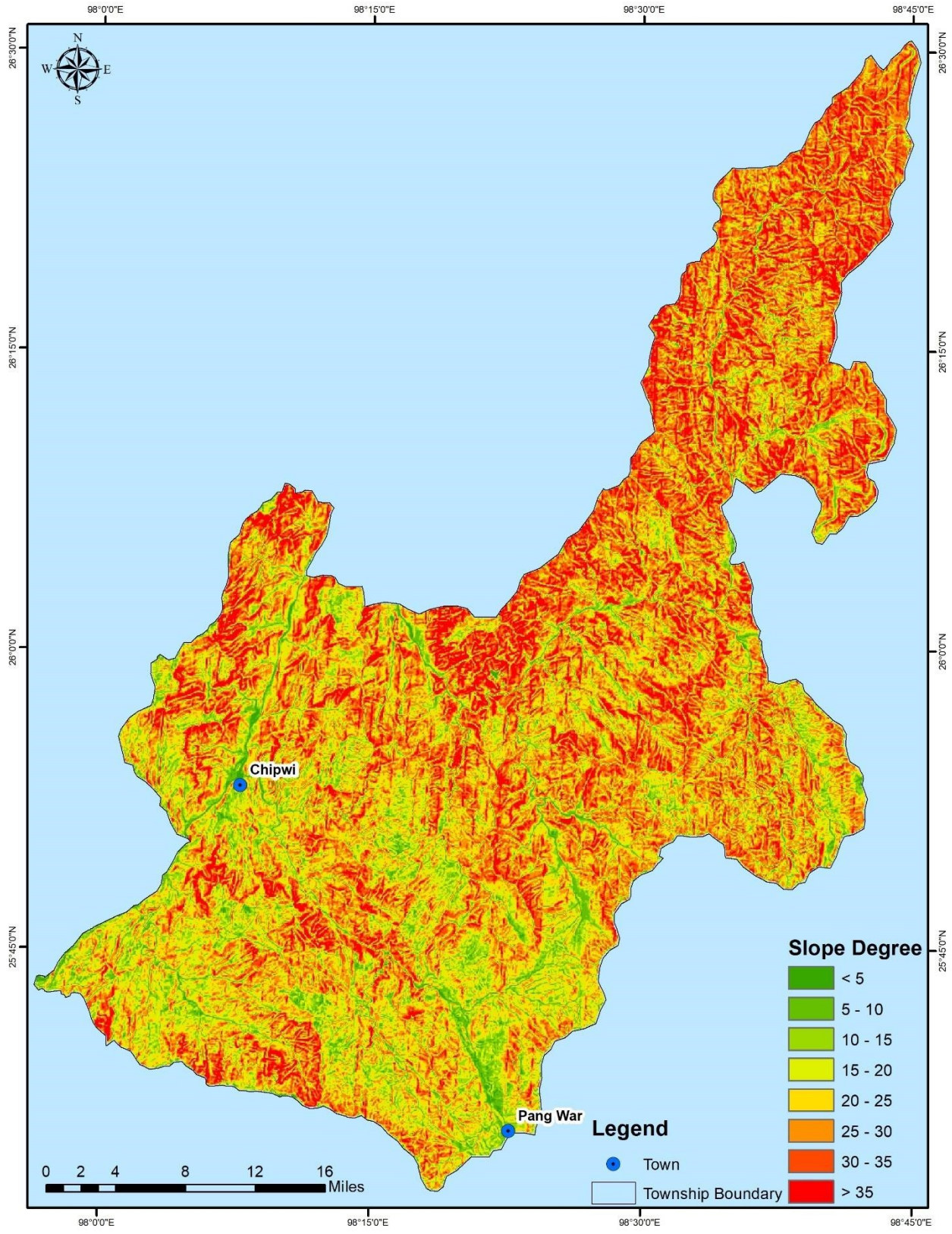
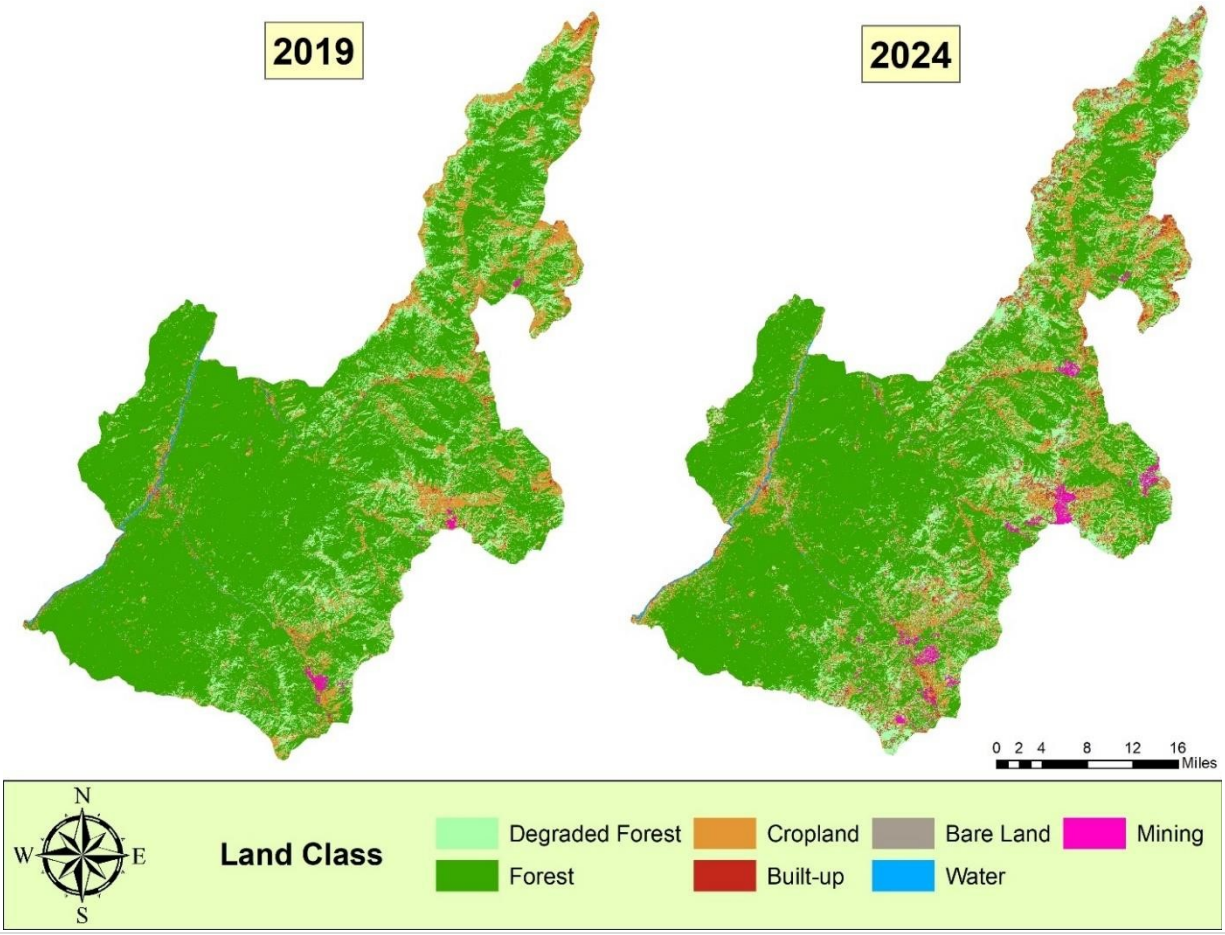
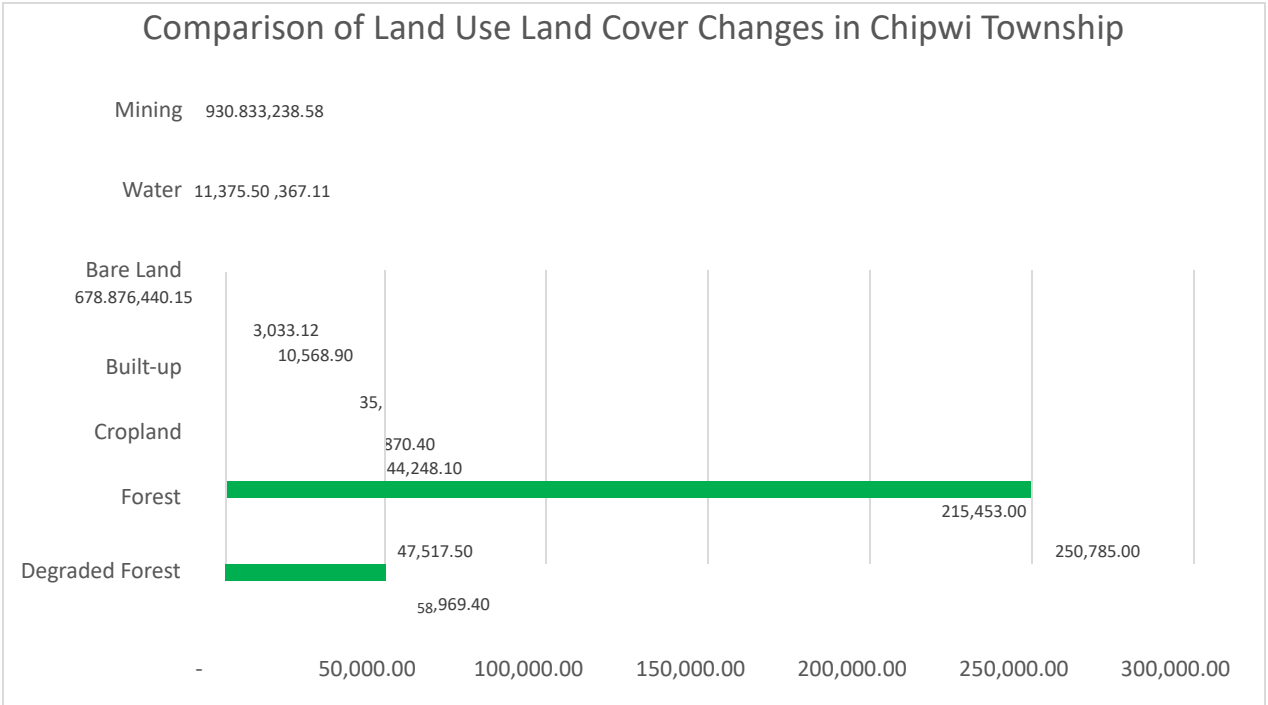


Fig. 11. Slope Degree Map of Chipwi Township

5.1.2. Land Use Land Cover Change Status

In accordance with the image classification results, the forest cover of Chipwi Township in 2019 and 2024 were 87.69% and 80.64% respectively. The mean annual deforestation rate in the region is like to be 1.41% which means 4791.18 ha of the forest cover were lost annually.





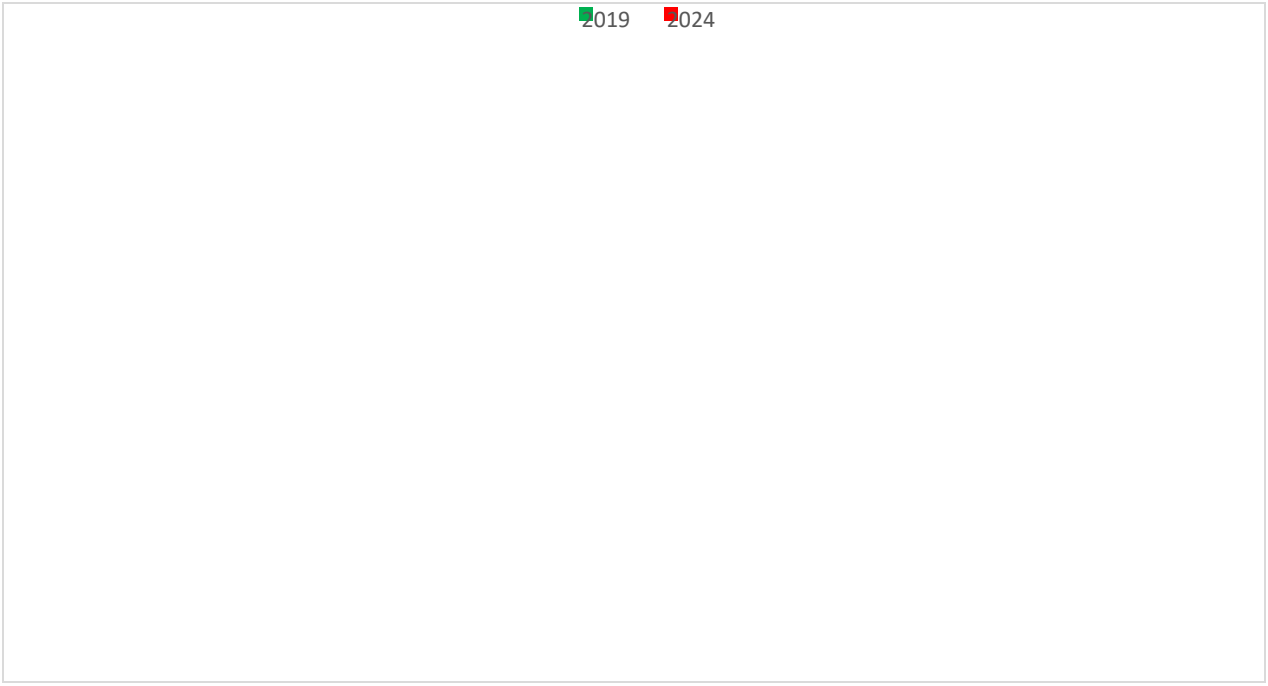


Fig. 12. Land Use Land Cover Change Map of Chipwi Township (2019-2024)

The land use land cover changes for each land class are shown in the following table.

Land Class	2019		2024		Net Changes (2019 - 2024)	
	Area (ha)	Percentage	Area (ha)	Percentage	Area (ha)	Percentage
Degraded Forest	47,517.50	13.97%	58,969.40	17.33%	11,451.90	3.36%
Forest	250,785.00	73.72%	215,453.00	63.32%	(35,332.00)	-10.40%
Cropland	35,870.40	10.54%	44,248.10	13.00%	8,377.70	2.46%
Built-up	3,033.12	0.89%	10,568.90	3.11%	7,535.78	2.21%
Bare Land	678.87	0.20%	6,440.15	1.89%	5,761.28	1.69%
Water	1,375.50	0.40%	1,367.11	0.40%	(8.39)	0.00%
Mining	930.83	0.27%	3,238.58	0.95%	2,307.75	0.68%

Table – 4. Land Use Land Cover Status of Chipwi Township between 2019 and 2024

Based on the above-mentioned table, the rate of change in land classes between 2019 and 2024 were bare land, built-up, mining and cropland in descending order; 9.49, 3.48, 3.48 and 1.23 times respectively.

5.1.3. Classification Accuracy Assessment

For accuracy assessment classification, 500 validation points were generated through stratified random sampling method. The overall accuracy and Kappa coefficient for LULCC classification on Chipwi Township for 2019 and 2024 were 96.20%, 0.9268 and 91.00%, 0.8503 respectively. The results for the accuracy assessment for LULCC classification of Chipwi Township for 2019 and 2024 were shown in the following tables.

Land Class	Reference							Total	U_Accuracy	Kappa
	Degraded Forest	Forest	Cropland	Built-up	Bare Land	Water	Mining			
Degraded Forest	67	3	0	0	0	0	0	70	95.71%	0.0000
Forest	8	328	1	0	0	0	0	337	97.33%	0.0000
Cropland	2	0	48	2	1	0	0	53	90.57%	0.0000
Built-up	0	0	0	10	0	0	0	10	100.00%	0.0000
Bare Land	0	0	0	1	9	0	0	10	90.00%	0.0000

Water	0	1	0	0	0	9	0	10	90.00%	0.0000
Mining	0	0	0	0	0	0	10	10	100.00%	0.0000
Total	77	332	49	13	10	9	10	**500**	0.00%	0.0000
P_Accuracy	87.01%	98.80%	97.96%	76.92%	90.00%	100.00%	100.00%	0.00%	**96.20%**	0.0000
Kappa	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.9268**

Table – 5. Confusion Matrix for LULCC Classification of Chipwi Township (2019)

Land Class	**Reference**							**Total**	**U_Accuracy**	**Kappa**
	Degraded Forest	**Forest**	**Cropland**	**Built-up**	**Bare Land**	**Water**	**Mining**			
Degraded Forest	82	2	1	1	1	0	0	87	94.25%	0.0000
Forest	20	275	7	0	0	0	0	302	91.06%	0.0000
Cropland	3	5	57	0	0	0	0	65	87.69%	0.0000
Built-up	1	0	1	14	0	0	0	16	87.50%	0.0000
Bare Land	1	0	0	0	9	0	0	10	90.00%	0.0000
Water	0	1	0	0	0	9	0	10	90.00%	0.0000
Mining	1	0	0	0	0	0	9	10	90.00%	0.0000
Total	108	283	66	15	10	9	9	**500**	0.00%	0.0000
P_Accuracy	0.7593	0.9717	0.8636	0.9333	0.9000	1.0000	1.0000	0.0000	**91.00%**	0.0000
Kappa	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.8503**

Table – 6. Confusion Matrix for LULCC Classification of Chipwi Township (2024)

5.1.4. Change Detection Analysis

Change detection analysis was performed based on the differences of LULCC between 2019 and 2024 in Chipwi Township.

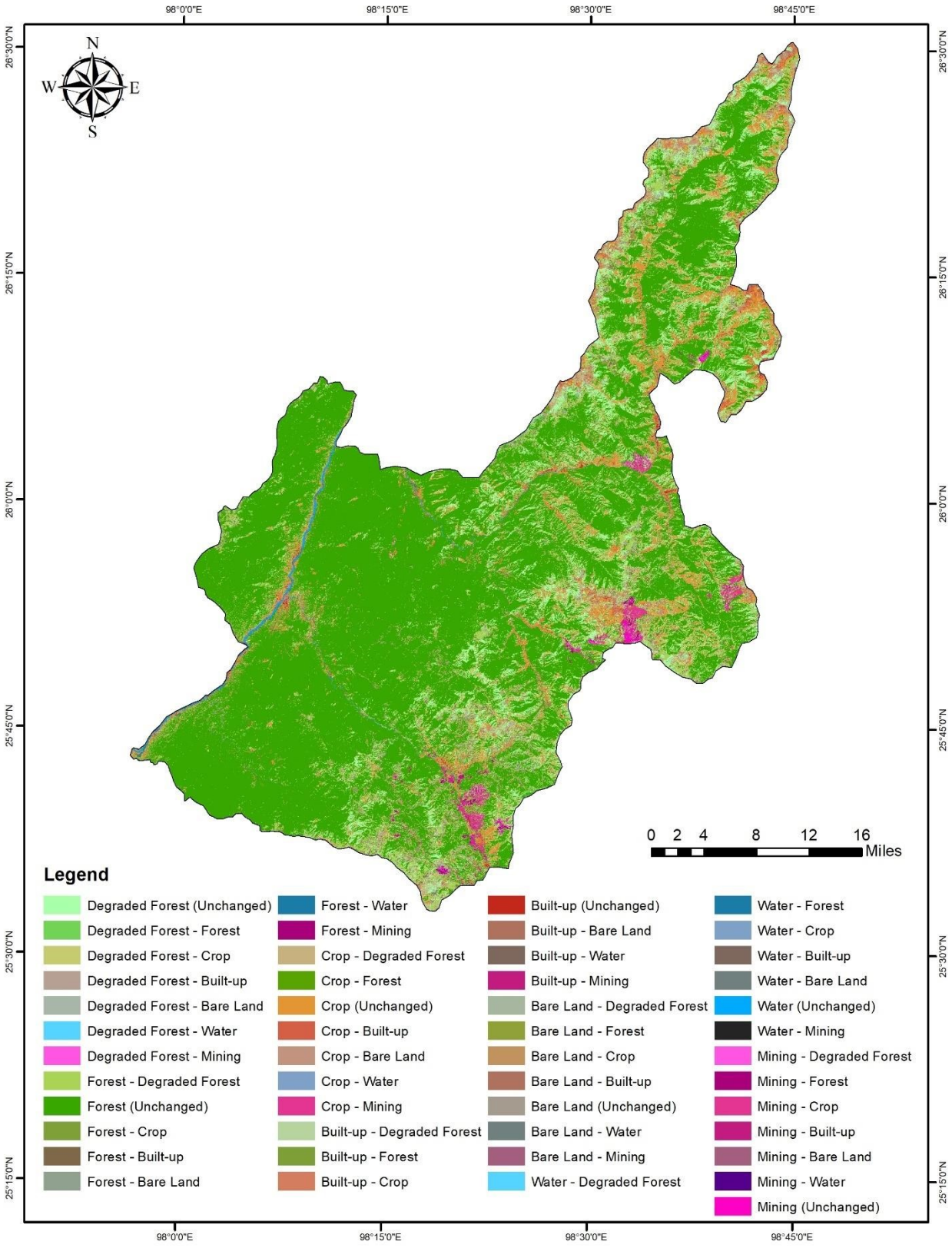


Fig. 13. Change Detection Analysis Map of Chipwi Township (2019-2024)

The percentage changes of each land class between 2019 and 2024 were shown in the following table.

Land Class		2024						
		Degraded Forest	Forest	Cropland	Builtup	Bare Land	Water	Mining
2019	Degraded Forest	**7.26%**	2.25%	3.25%	0.55%	0.49%	0.01%	0.16%
	Forest	7.60%	**60.43%**	3.88%	1.10%	0.45%	0.05%	0.20%
	Cropland	2.25%	0.58%	**5.49%**	1.12%	0.67%	0.02%	0.42%
	Built-up	0.13%	0.04%	0.24%	**0.26%**	0.16%	0.02%	0.05%
	Bare Land	0.03%	0.00%	0.03%	0.03%	**0.09%**	0.01%	0.02%
	Water	0.03%	0.02%	0.02%	0.02%	0.01%	**0.29%**	0.00%
	Mining	0.03%	0.01%	0.09%	0.03%	0.02%	0.00%	**0.10%**

Table – 7. Percentage of Land Class Changes in Chipwi Township between 2019 and 2024

In accordance with the change detection analysis on land use land cover changes of Chipwi Township between 2019 and 2024, the changes of forest cover into other land uses in descending order were as follows; cropland, built-up, bare land and mining.

5.1.5. Future Land Use Land Cover Change Prediction

LULCC prediction for 2029 was simulated based on independent variables as LULCC 2019 and LULCC 2024 and dependent variables or spatial variables as elevation, slope degree, Euclidean distance from the main roads, and Euclidean distance from the streams. The result of Kappa Validation was 0.78 and it can be assumed as medium acceptable (Pandey, Kumari, & Al Nawajish, 2023). (Fig.14.)

The trend of LULCC in Chipwi Township through 2019-2029 are shown in the following table.

Land Class	2019		2024		Simulation 2029	
	Area (ha)	Percentage	Area (ha)	Percentage	Area (ha)	Percentage
Degraded Forest	47517.5000	13.97%	58969.4000	17.33%	61185.2400	17.98%
Forest	250785.0000	73.72%	215453.0000	63.32%	213384.7800	62.69%
Cropland	35870.4000	10.54%	44248.1000	13.00%	42115.2300	12.37%
Built-up	3033.1200	0.89%	10568.9000	3.11%	16575.8400	4.87%
Bare Land	678.8680	0.20%	6440.1500	1.89%	5144.3100	1.51%
Water	1375.5000	0.40%	1367.1100	0.40%	539.3700	0.16%
Mining	930.8290	0.27%	3238.5800	0.95%	1435.7700	0.42%

Table – 8. LULCC in Chipwi Township through 2019-2029

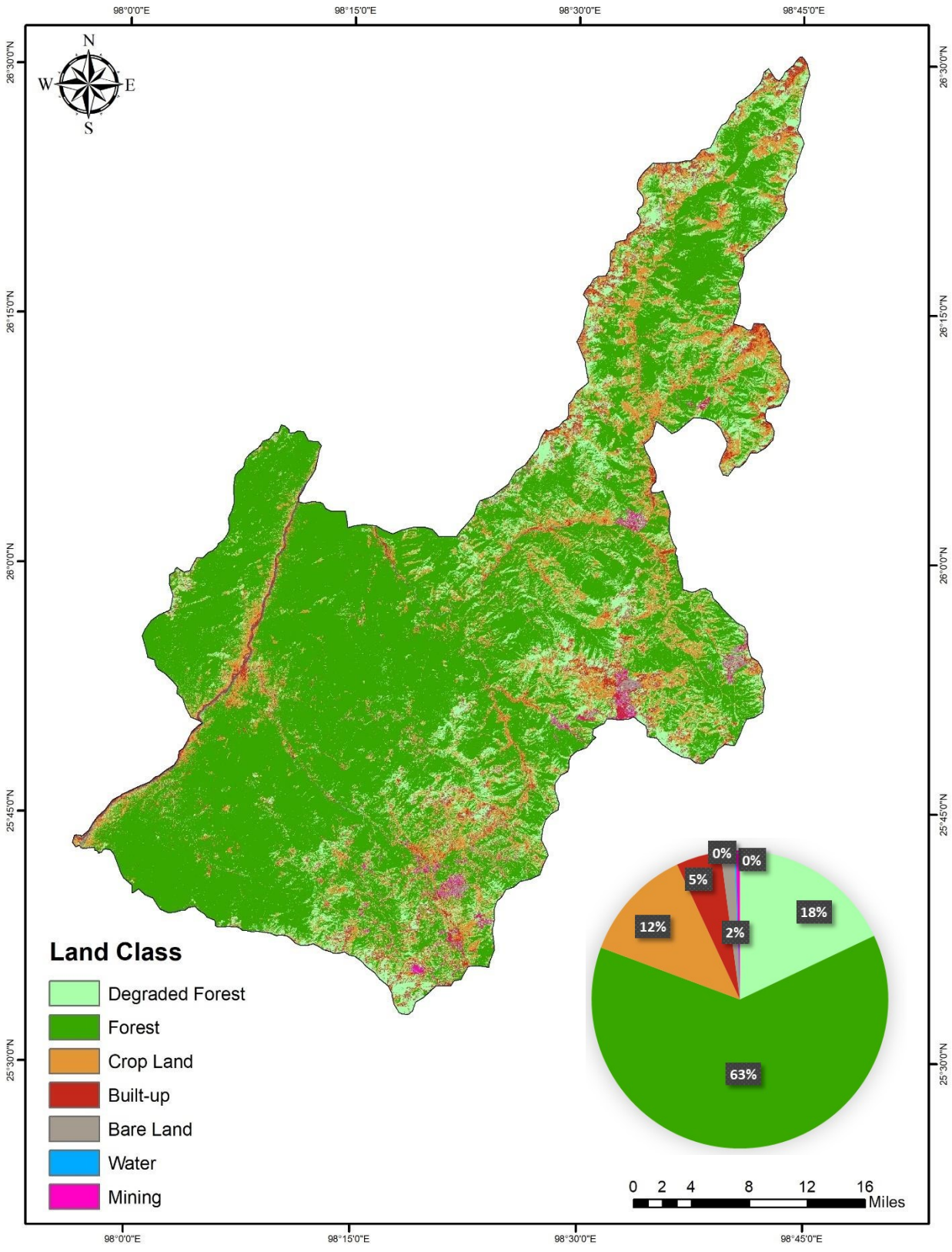


Fig. 14. Simulation Land Use Land Cover Change Prediction Map of Chipwi Township (2029)

In accordance with the simulation results, the forest cover of Chipwi Township in 2029 would be 80.67% which means 0.03% of forest area would be recovered comparing to 2024. However, the

simulated mean annual deforestation rate in the region would like to be 0.70% referring to 2019 baseline forest cover in the region which means 2388.52 ha of the forest cover were lost annually.

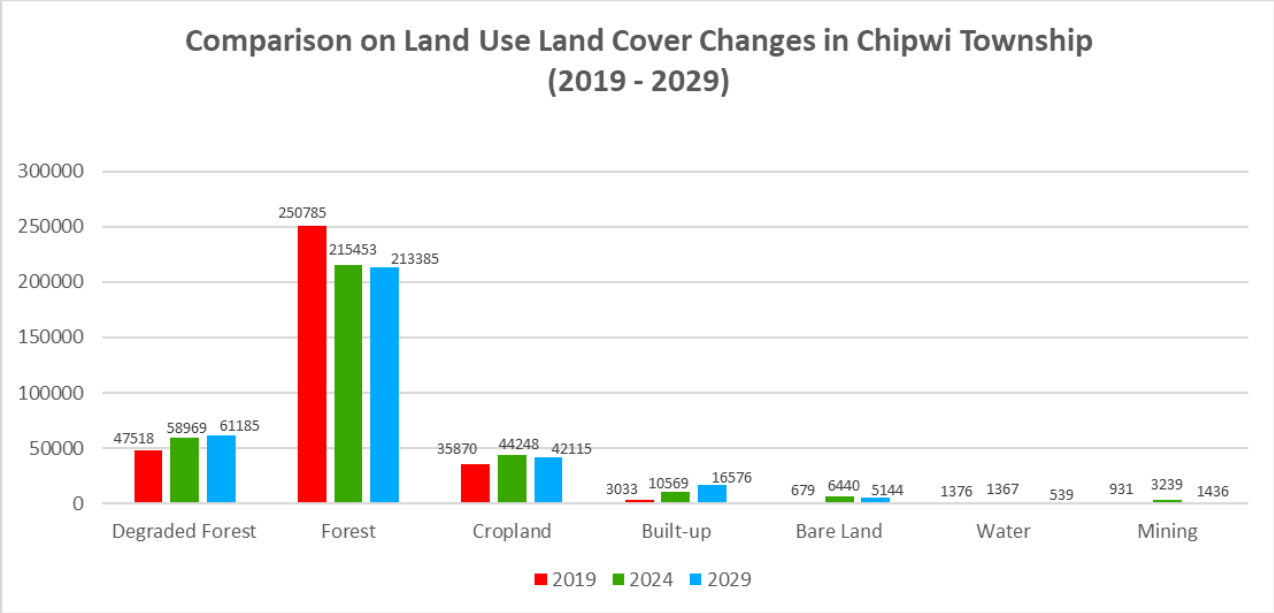


Fig. 15. Comparison of LULCC in Chipwi Township through 2019-2029

5.2. Mohnyin Township

5.2.1. Surface Analysis

The elevation map of Mohnyin Township was prepared by creating TIN layer through SRTM DEM data. The elevation range of the region is between 96 m and 1608 m.

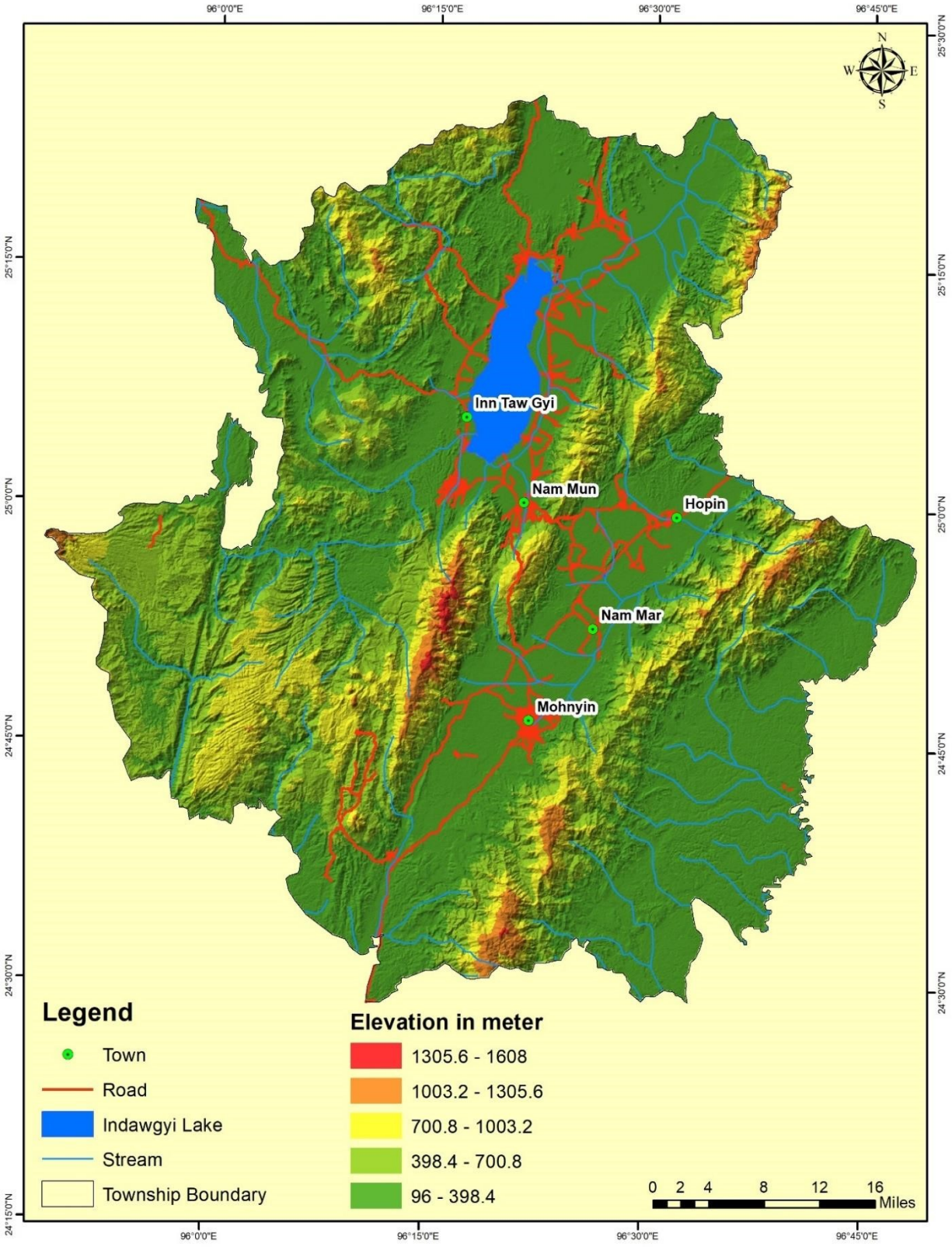


Fig. 16. Elevation Map of Mohnyin Township

The slope degree of Mohnyin Township was also evaluated through SRTM DEM Data. The slope degrees were classified into 4 classes based on the compatible land use practices. Generally, the range of slope degree between 0 and 5 is suitable for settlement area, between 5 and 15 degree is compatible for agricultural purpose, between 15 and 30 degree is suitable for forest plantation and above 30 degree is better untouched due to the comparable shallow soil depths and prone to erosion. Therefore, the gradual loss of vegetation cover in the area above 30 degrees slope must be conserved and restored. The slope degree of the most areas of the region were observed as relatively moderate degree due to the existence of Hopin and Indawgyi plains.

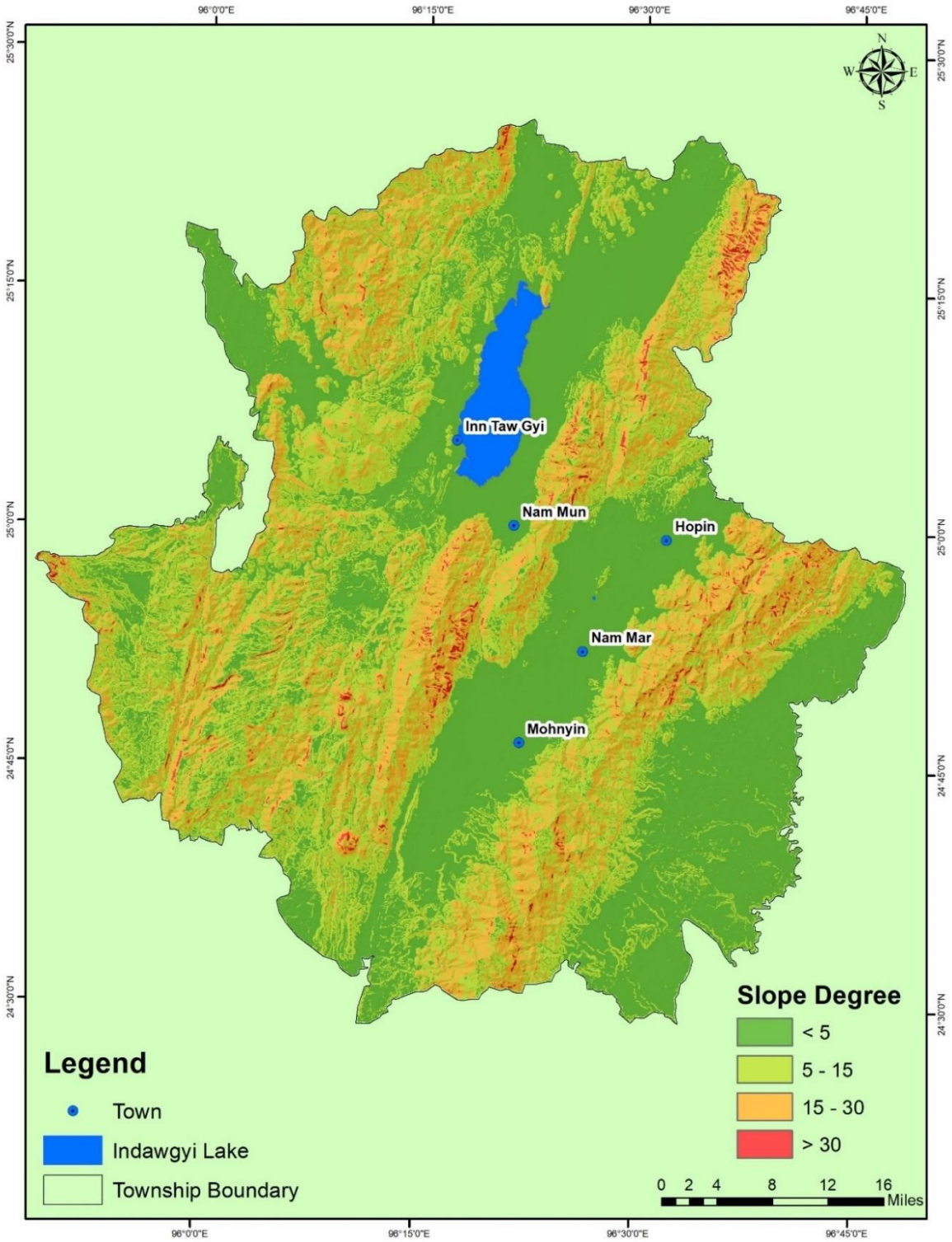


Fig. 17. Slope Degree Map of Mohnyin Township

5.2.2. Land Use Land Cover Change Status

In accordance with the image classification results, the forest cover of Mohnyin Township in 2019 and 2024 were 85.78% and 82.74% respectively. The mean annual deforestation rate in the region is like to be 0.61% which means 3852.65 ha of the forest cover were lost annually.

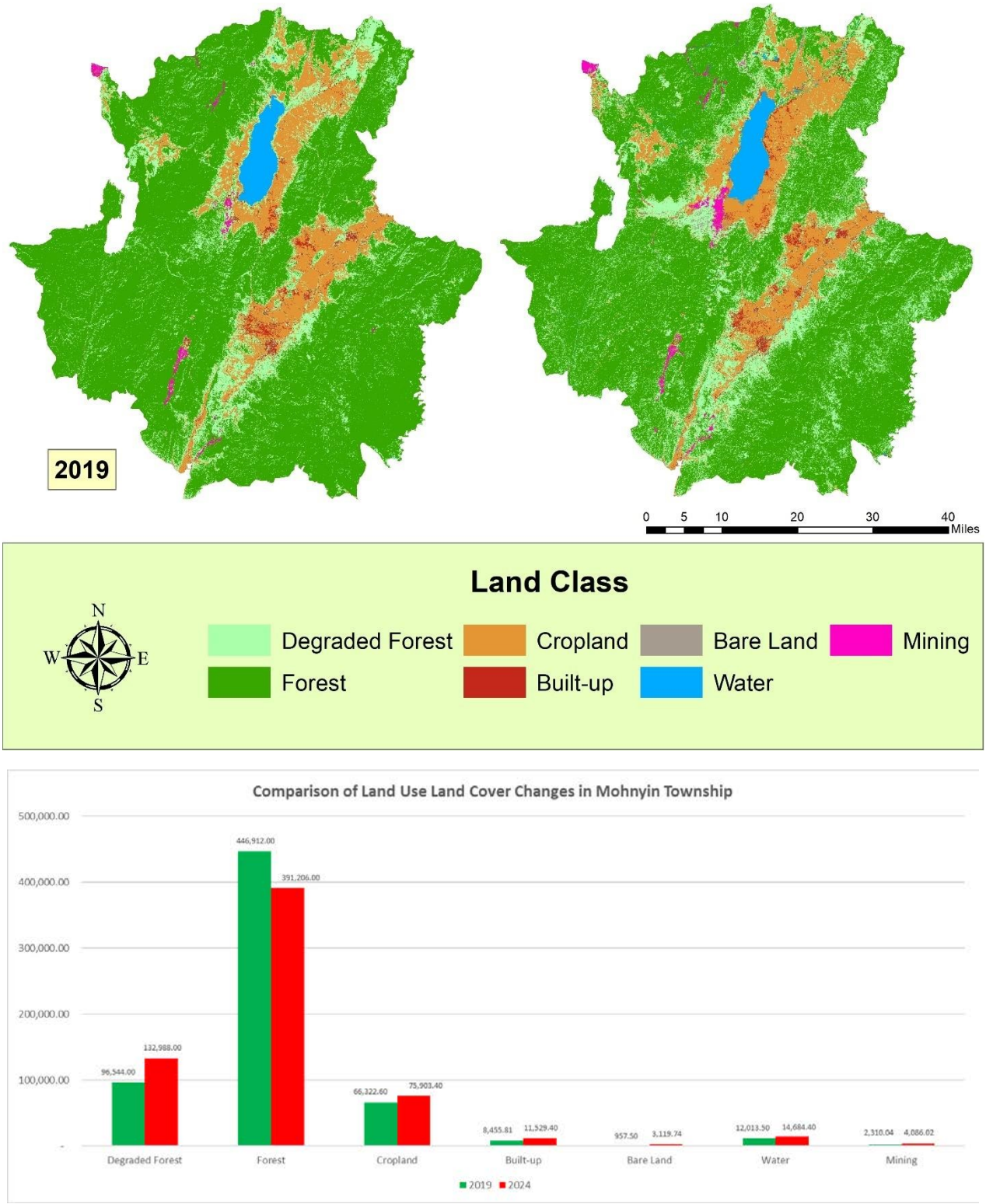


Fig. 18. Land Use Land Cover Change Map of Mohnyin Township (2019-2024)

The land use land cover changes for each land class are shown in the following table.

Land Class	2019		2024		Net Changes (2019 - 2024)	
	Area (ha)	Percentage	Area (ha)	Percentage	Area (ha)	Percentage
Degraded Forest	96,544.00	15.24%	132,988.00	20.99%	36,444.00	5.75%

Forest	446,912.00	70.54%	391,206.00	61.75%	(55,706.00)	-8.79%
Cropland	66,322.60	10.47%	75,903.40	11.98%	9,580.80	1.51%
Built-up	8,455.81	1.33%	11,529.40	1.82%	3,073.59	0.49%
Bare Land	957.50	0.15%	3,119.74	0.49%	2,162.24	0.34%
Water	12,013.50	1.90%	14,684.40	2.32%	2,670.90	0.42%
Mining	2,310.04	0.36%	4,086.02	0.64%	1,775.98	0.28%

Table – 9. Land Use Land Cover Status of Mohnyin Township between 2019 and 2024

Based on the above-mentioned table, the rate of change in land classes between 2019 and 2024 were bare land, mining, built-up, water and cropland in descending order; 3.26, 1.77, 1.36, 1.22 and 1.14 times respectively.

5.2.3. Classification Accuracy Assessment

For accuracy assessment classification, 500 validation points were generated through stratified random sampling method. The overall accuracy and Kappa coefficient for LULCC classification on Mohnyin Township for 2019 and 2024 were 96.20%, 0.9290 and 94.80%, 0.9139 respectively. The results for the accuracy assessment for LULCC classification of Mohnyin Township for 2019 and 2024 were shown in the following tables.

Land Class	Reference							Total	U_Accuracy	Kappa
	Degraded Forest	Forest	Cropland	Built-up	Bare Land	Water	Mining			
Degraded Forest	74	1	1	0	0	0	0	76	97%	0.0000
Forest	10	320	0	2	0	0	0	332	96%	0.0000
Cropland	1	0	50	0	0	0	1	52	96%	0.0000
Built-up	1	0	0	9	0	0	0	10	90%	0.0000
Bare Land	0	0	2	0	8	0	0	10	80%	0.0000
Water	0	0	0	0	0	10	0	10	100%	0.0000
Mining	0	0	0	0	0	0	10	10	100%	0.0000
Total	86	321	53	11	8	10	11	**500**	0.0000	0.0000
P_Accuracy	86%	100%	94%	82%	100%	100%	91%	0.0000	**96.20%**	0.0000
Kappa	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.9290**

Table – 10. Confusion Matrix for LULCC Classification of Mohnyin Township (2019)

Land Class	Reference							Total	U_Accuracy	Kappa
	Degraded Forest	Forest	Cropland	Built-up	Bare Land	Water	Mining			
Degraded Forest	100	4	1	0	0	0	0	105	95.24%	0.0000
Forest	12	278	3	0	0	0	0	293	94.88%	0.0000
Cropland	1	0	58	1	0	0	0	60	96.67%	0.0000
Built-up	0	0	2	7	0	0	1	10	70.00%	0.0000
Bare Land	0	1	0	0	9	0	0	10	90.00%	0.0000
Water	0	0	0	0	0	12	0	12	100.00%	0.0000
Mining	0	0	0	0	0	0	10	10	100.00%	0.0000
Total	113.0000	283.0000	64.0000	8.0000	9.0000	12.0000	11.0000	**500**	0.00%	0.0000
P_Accuracy	0.8850	0.9823	0.9063	0.8750	1.0000	1.0000	0.9091	0.0000	**94.80%**	0.0000
Kappa	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00%	**0.9139**

Table – 11. Confusion Matrix for LULCC Classification of Mohnyin Township (2024)

5.2.4. Change Detection Analysis

Change detection analysis was performed based on the differences of LULCC between 2019 and 2024 in Mohnyin Township.

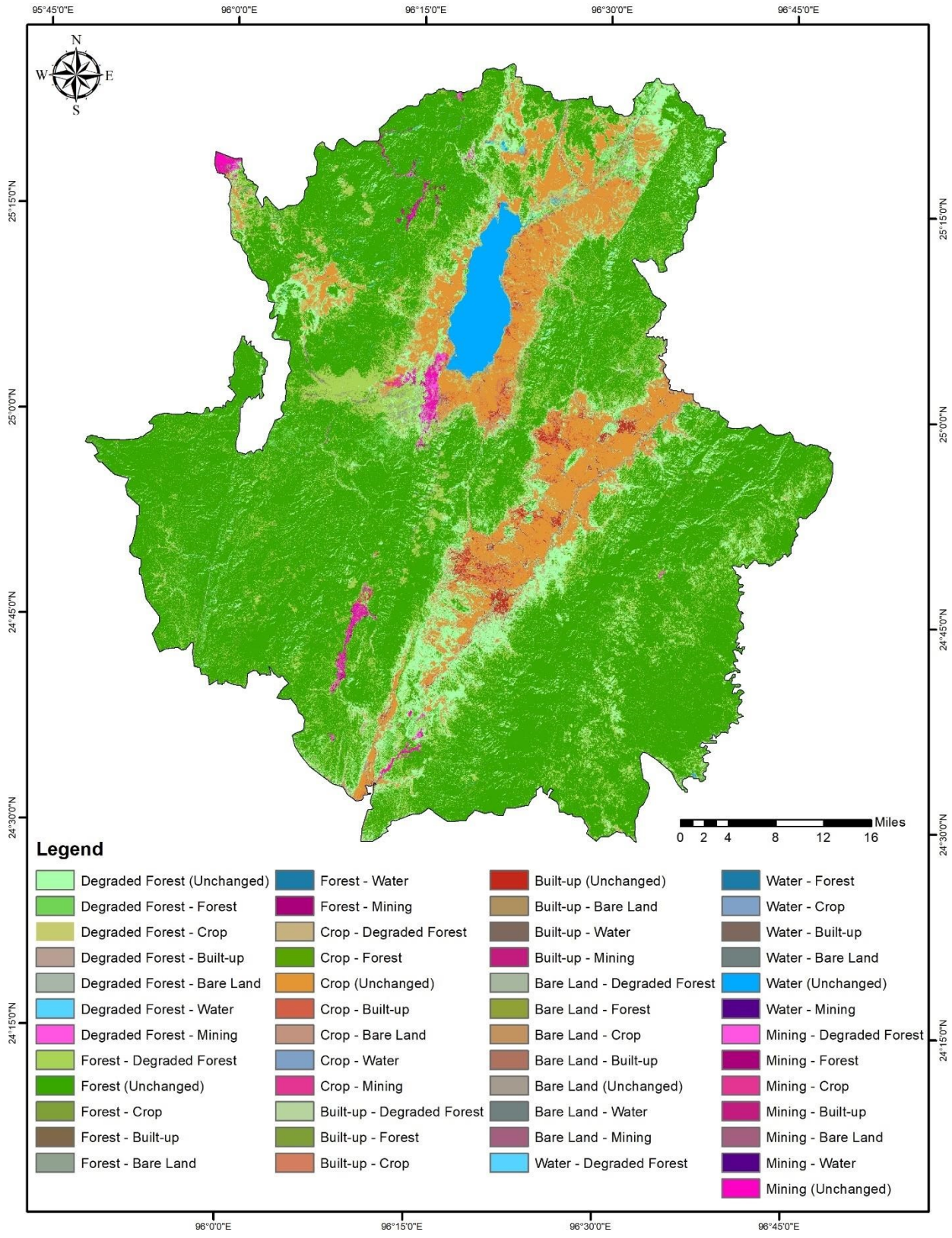


Fig. 19. Change Detection Analysis Map of Mohnyin Township (2019-2024)

The percentage changes of each land class between 2019 and 2024 were shown in the following table.

Land Class	2024

		Degraded Forest	Forest	Cropland	Builtup	Bare Land	Water	Mining
2019	Degraded Forest	9.11%	2.94%	2.16%	0.47%	0.11%	0.24%	0.20%
	Forest	10.79%	58.69%	0.56%	0.15%	0.16%	0.09%	0.08%
	Cropland	0.86%	0.07%	8.61%	0.65%	0.12%	0.08%	0.08%
	Built-up	0.15%	0.02%	0.52%	0.52%	0.05%	0.04%	0.04%
	Bare Land	0.01%	0.00%	0.09%	0.01%	0.02%	0.00%	0.02%
	Water	0.02%	0.00%	0.01%	0.00%	0.00%	1.86%	0.00%
	Mining	0.05%	0.02%	0.03%	0.02%	0.02%	0.01%	0.22%

Table – 12. Percentage of Land Class Changes in Mohnyin Township between 2019 and 2024

In accordance with the change detection analysis on land use land cover changes of Mohnyin Township between 2019 and 2024, the changes of forest cover into other land uses in descending order were as follows; cropland, built-up, bare land and mining.

5.2.5. Future Land Use Land Cover Change Prediction

LULCC prediction for 2029 was simulated based on independent variables as LULCC 2019 and LULCC 2024 and dependent variables or spatial variables as elevation, slope degree, Euclidean distance from the main roads, and Euclidean distance from the streams. The result of Kappa Validation was 0.83 and it can be assumed as good agreement to accept (Pandey, Kumari, & Al Nawajish, 2023). (Fig.19)

The trend of LULCC in Mohnyin Township through 2019-2029 are shown in the following table.

Land Class	2019		2024		Simulation 2029	
	Area (ha)	Percentage	Area (ha)	Percentage	Area (ha)	Percentage
Degraded Forest	96544.0000	15.24%	132988.0000	20.99%	119309.4000	18.83%
Forest	446912.0000	70.54%	391206.0000	61.75%	405042.7500	63.92%
Cropland	66322.6000	10.47%	75903.4000	11.98%	79949.0700	12.62%
Built-up	8455.8100	1.33%	11529.4000	1.82%	9335.3400	1.47%
Bare Land	957.5040	0.15%	3119.7400	0.49%	2248.3800	0.35%
Water	12013.5000	1.90%	14684.4000	2.32%	14601.6900	2.30%
Mining	2310.0400	0.36%	4086.0200	0.64%	3220.6500	0.51%

Table – 8. LULCC in Mohnyin Township through 2019-2029

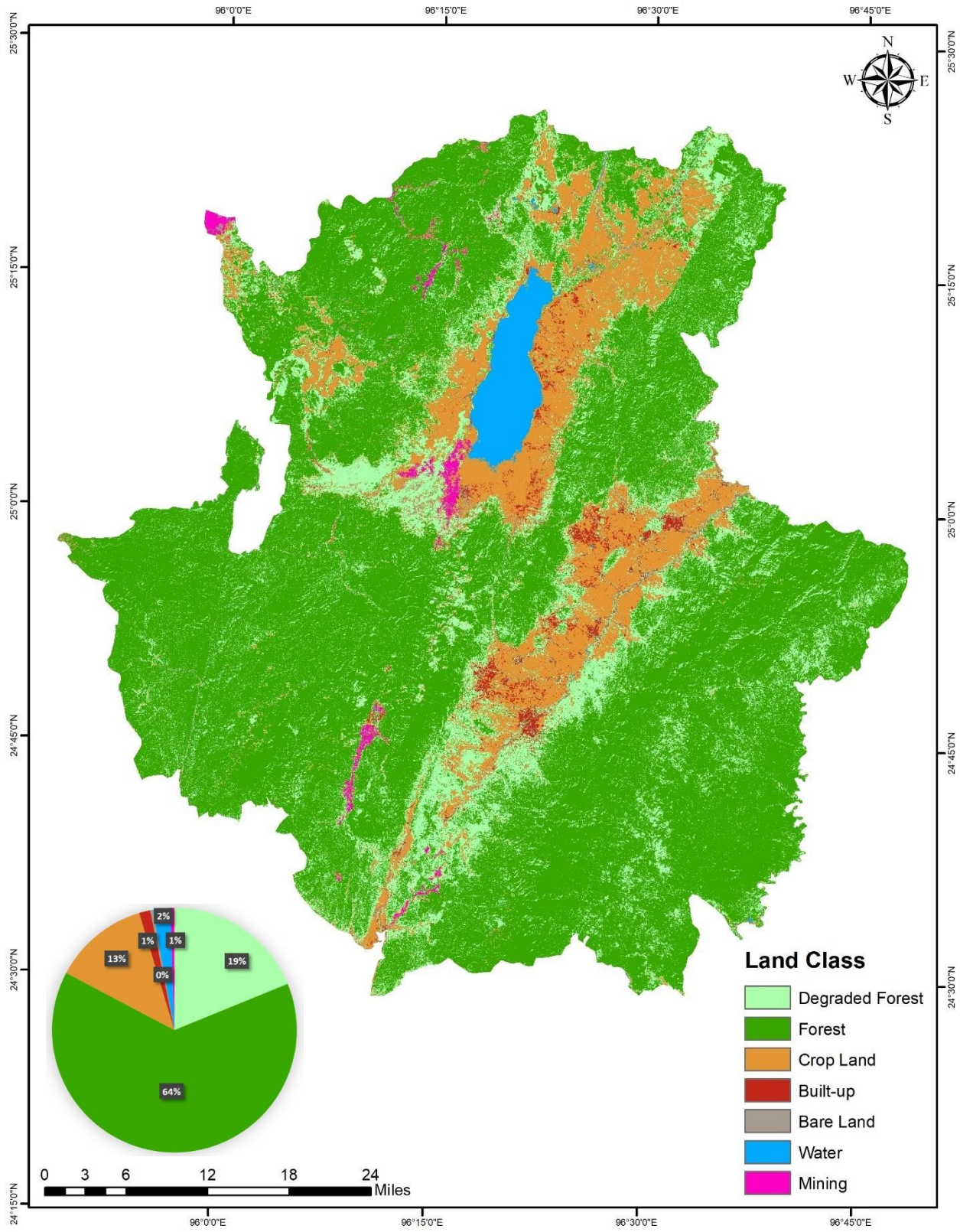


Fig. 20. Simulation Land Use Land Cover Change Prediction Map of Mohnyin Township (2029)

In accordance with the simulation results, suprisingly, the forest cover of Mohnyin Township in 2029 would be 82.74% which means the forest cover would remain unchanged comparing to 2024. However, the simulated mean annual deforestation rate in the region would like to be 0.30%

referring to 2019 baseline forest cover in the region which means 1926.84 ha of the forest cover were lost annually.

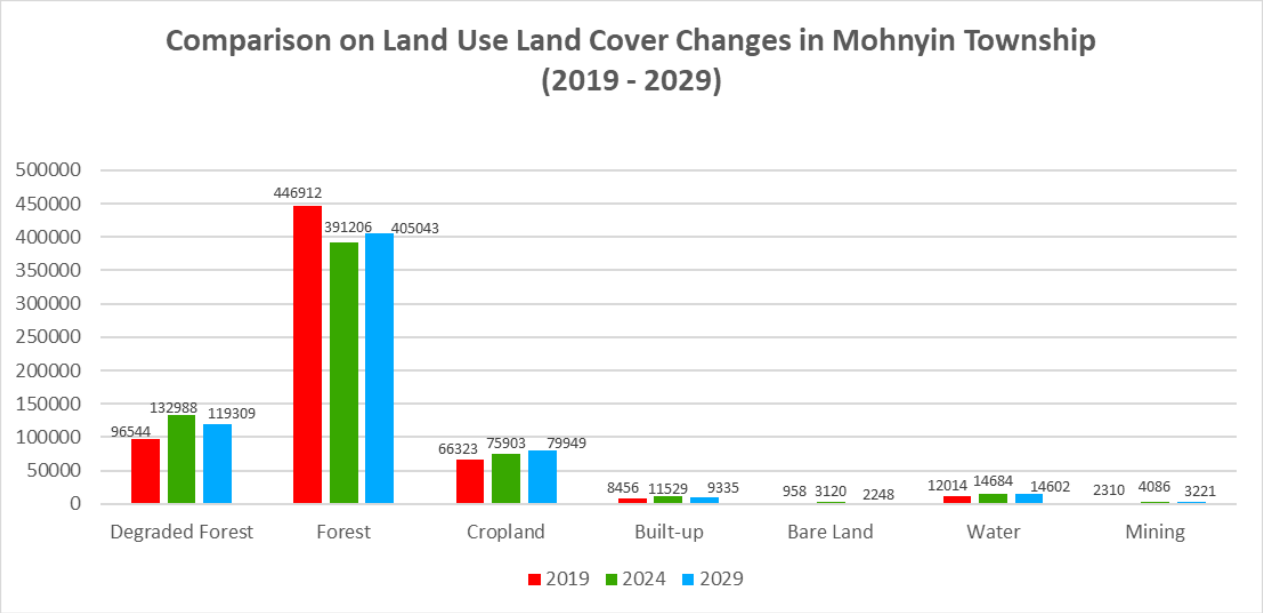


Fig. 21. Comparison of LULCC in Mohnyin Township through 2019-2029

6. Discussion and Suggestion

During 2019 and 2024, the forest cover of Mohnyin Township was lost to 3.04% and 0.28% increase in mining area. Meanwhile, in Chipwi Township, the forest cover was dropped down to 7.04% and ballooned up the mining area to 0.68%. Comparing to the different approaches of mining activities between these two regions, the study revealed that the mining activities in Chipwi Township are ballooned up during 2019 and 2024.

Due to the limitation on accessibility to ground-truth information and time availability, there is still need to perform further study focusing on the hotspots areas of the State starting with small scale to emphasize on more specific information likely watershed delineation analysis. Given its significance as the headwater region of Myanmar, watershed conservation should be a top priority. Mining activities, particularly near water bodies like Indawgyi Lake, pose a threat to water quality and ecosystem health. It is imperative to conduct further studies to assess the environmental impacts of mining and implement stringent regulations to mitigate these effects. Additionally, promoting sustainable land management practices and community engagement initiatives can help preserve the ecological integrity of the region.

The observed land use changes highlight the need for comprehensive conservation efforts in Kachin State.

Implementing Sustainable Land Management Techniques: Promote sustainable land management techniques, such as reforestation, soil conservation, and watershed restoration, to improve soil fertility, prevent erosion, and enhance water retention capacity. Working with local communities to implement these techniques can help restore degraded landscapes and mitigate the impacts of land use change. Combining with the findings of surface analysis of the regions, the sustainable land use pattern could be formulated.

Education and Awareness Campaigns: Conduct education and awareness campaigns to raise public awareness about the importance of environmental conservation and the consequences of unsustainable land use practices. These campaigns can target school children, community leaders, and the general public, emphasizing the interconnectedness of ecosystems and the need for collective action to protect them.

In addition to the observed land use changes and their implications, several key factors need to be considered in addressing the challenges facing Kachin State:

Indigenous Rights and Land Tenure: Recognizing and protecting the land rights of indigenous communities is crucial for sustainable land management and conservation efforts. Indigenous peoples in Kachin State have historically relied on traditional land use practices that are often more ecologically sustainable than modern land management approaches. Ensuring secure land tenure for indigenous communities can help preserve traditional knowledge, promote community-based conservation initiatives, and enhance resilience to environmental change.

Cross-border Impacts and Transboundary Cooperation: Kachin State shares borders with China and India, making it vulnerable to cross-border impacts from transboundary activities such as deforestation, illegal logging, and wildlife trafficking. Strengthening cooperation and coordination with neighboring countries is essential to address these transboundary challenges effectively. Bilateral and regional agreements can facilitate information sharing, joint monitoring, and collaborative management of shared ecosystems and resources.

Climate Change Adaptation and Resilience Building: Climate change is exacerbating environmental pressures in Kachin State, including changes in rainfall patterns, increased frequency of extreme weather events, and heightened risks of natural disasters such as flash floods and landslides. Building community resilience and adaptive capacity is essential for coping with these climate-related challenges. This may involve implementing climate-smart agriculture practices, enhancing early warning systems, and integrating climate change considerations into land use planning and disaster risk reduction strategies including risk or disaster risk assessment in the regions.

Promotion of Sustainable Livelihoods: Addressing the root causes of environmental degradation in Kachin State requires addressing underlying socio-economic drivers, including poverty, inequality, and lack of alternative livelihood options. Promoting sustainable livelihoods that are compatible with environmental conservation goals can help alleviate pressure on natural resources and reduce dependence on extractive industries. This may involve supporting small-scale agriculture, eco-tourism, renewable energy development, and other green economy initiatives that generate income while safeguarding the environment.

Investment in Environmental Education and Capacity Building: Enhancing environmental literacy and building local capacity for natural resource management are essential for fostering informed decision-making and empowering communities to participate in conservation efforts. Investing in environmental education programs, training workshops, and knowledge exchange platforms can empower local stakeholders, mainly civil society organizations, and indigenous leaders, to take proactive measures to protect and sustainably manage Kachin State's natural heritage.

Integration of Traditional Knowledge and Science: Recognizing the value of traditional ecological knowledge alongside scientific expertise can enrich conservation efforts and promote holistic approaches to land management. Indigenous peoples in Kachin State possess valuable insights into local ecosystems, biodiversity, and sustainable resource management practices that can complement scientific research and inform evidence-based decision-making. Creating platforms for dialogue and collaboration between traditional knowledge holders and scientific experts can foster mutual learning and contribute to more inclusive and effective conservation strategies.

Organizing Land and Forest Resource Watch Task Force: Organizing community-based land and forest resource watch task force by implementing the need assessment program such as providing technical training, workshop. Based on the watch activities of the task force, the driven factors of changing forest cover and land use shift model could be documented.

Mapping of Land Entitlement: Exploring the type of land including ownership, type of management, type of land registration and documenting current land use practices through participatory approach method. Through these results, the suitable land use pattern can be formulated by combining with the surface analysis of the region and the suitable soil conservation and rehabilitation could be formed.

By addressing these key issues and implementing the suggested recommendations, stakeholders in Kachin State can work towards building a more resilient, equitable, and sustainable future for the region and its inhabitants. Collaboration, innovation, and a commitment to social and environmental justice are essential for overcoming the complex challenges facing Kachin State and safeguarding its natural heritage for generations to come.

7. Conclusion

Kachin State is endowed with natural resources. Moreover, Kachin State is the headwater of the Ayeyarwaddy River which is vital to the whole nation. The study reveals significant land use and land cover changes in Chipwi Township and Mohnyin Township of Kachin State between 2019 and 2024. Degraded Forest areas have expanded, while Forest cover has declined, primarily due to mining activities. Against the backdrop of ongoing political transitions, social transformations, and economic developments, the observed shifts in land cover underscore the complex challenges facing the region.

Politically, Kachin State has been at the center of Myanmar's long-standing ethnic conflicts, with armed conflicts between ethnic armed groups and the Myanmar military contributing to displacement, human rights violations, and environmental degradation. The presence of natural resources, including forests and minerals, has exacerbated these conflicts, leading to land grabs, resource exploitation, and environmental degradation in conflict-affected areas.

Socially, the diverse ethnic composition of Kachin State, home to various indigenous communities, adds another layer of complexity to land use dynamics. The impacts of land use changes are unevenly distributed among different ethnic groups, with marginalized communities often bearing the brunt of environmental degradation and resource extraction. Access to land, natural resources, and decision-making processes remains a contentious issue, highlighting the need for inclusive and participatory approaches to land management and conservation.

Economically, Kachin State's natural resources, including timber, minerals, and hydropower potential, have attracted investments and driven economic growth. However, the exploitation of these resources has been largely unsustainable, leading to deforestation, habitat loss, and water pollution. Moreover, the benefits of resource extraction have not always trickled down to local communities, exacerbating socio-economic inequalities and undermining long-term livelihood security.

Environmentally, Kachin State's ecological significance cannot be overstated, serving as the headwater region of Myanmar and supporting rich biodiversity and ecosystem services. However, unchecked land use changes, including deforestation, mining, and infrastructure development, threaten the region's environmental integrity and resilience. The degradation of forests, wetlands, and water bodies not only undermines local ecosystems but also exacerbates climate change impacts and undermines the long-term sustainability of the region.

Moreover, watershed conservation emerges as a crucial concern, considering Kachin State's role as the headwater region of Myanmar. To ensure the long-term sustainability of the region's ecosystems, it is essential to prioritize conservation efforts, regulate mining activities, and engage local communities in sustainable land management practices.

In light of these interconnected challenges, concerted efforts are needed to promote sustainable land use practices, protect critical ecosystems, and address the underlying drivers of environmental degradation in Kachin State. This requires a holistic approach that integrates environmental conservation with peacebuilding, social justice, and economic development initiatives. Strengthening governance mechanisms, promoting indigenous rights, and fostering multistakeholder partnerships are essential steps towards realizing a more equitable and sustainable future for Kachin State and its people.

By recognizing the intricate linkages between land use changes and broader socio-political, economic, and environmental dynamics, policymakers, civil society organizations, and local communities can work together to chart a path towards inclusive and sustainable development in Kachin State and beyond.

8. Case Studies

Case Study – 1: Jar Kha Creek (or) Gold Creek

Jar Kha creek is originated from the Law Kum Bum and flows into the Nam Mun Creek. Once, the stream water was a crystal clear and can see the natural movement of fish, crab and shrimps.

Nowadays, the creek is dying and there has no aquatic life form due to anthropogenic activities such as quarrying and gold mining in recent years. The water is no longer clean and it is impossible to drink and use.

Due to the mining activities, the water way is collapsed and bank erosion are severally occurred.

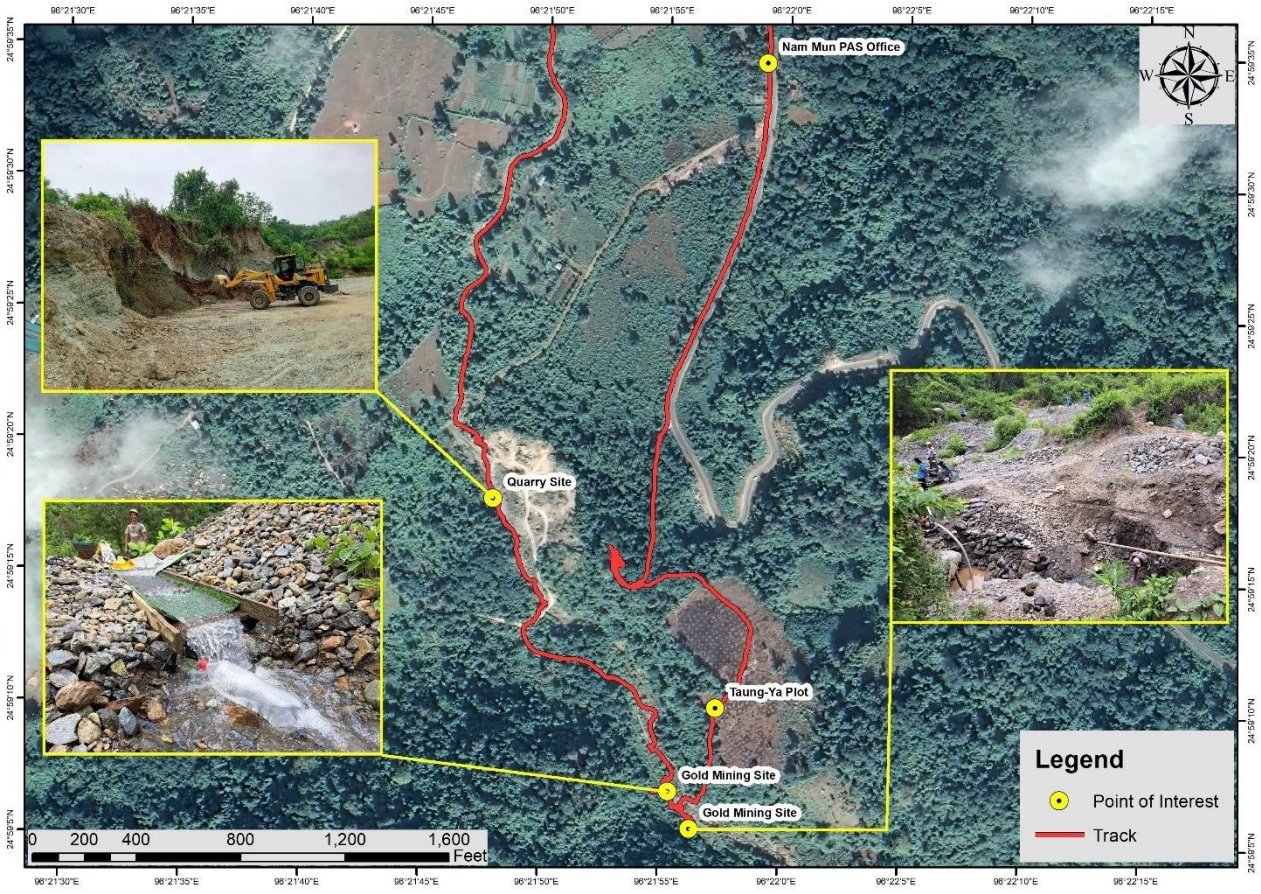


Fig. 22. Transect Walk Recorded Track along the Jar Kha Creek

Case Study –

2: Unprecedented Flooding in Nam Mun Region

Starting from the mid-night on 8th July, 2022, the heavy rain precipitated in the Indawgyi Region. During 3-hour precipitation time, the heavy water flooded the Nam Mun region through mountain torrents and the residents could not relocate their commodity in time. Therefore, a lot of valuable commodities were lost and some buildings were damaged.

It can be concluded that there had not enough vegetation cover in the upland areas to control flow rate to some extent. Moreover, the blockage of waterways due to improper waste disposal and the shallowed channel due to deposition of silt and sand through mineral mining encourage that unprecedented flooding in Nam Mun Region.

Fig. 23. Flooding in Nam Mun Town

Case Study –

3: Deposition of Sand in the Agricultural Land

In parallel to the unprecedented flooding in Nam Mun Town, mass deposition of sand in the paddy field was also happened in He Pa Village. With the heavy flow of water due to lack vegetation cover conveys sand to the lowland paddy fields and become no more longer arable land.

Fig. 24. Heavy Deposition of Sand in He Pa Village

4: Field Inspection and Monitoring on Myanmar Myo Ko Ko Company Limited by Department of Mines under MONREC

Myanmar Myo Ko Ko Company applied to change their license of iron mining to REM in 2017. Based on the field inspection on their application, the Department of Mines observed that the corner (C) of the plot (1) is only 200 feet far from the Chipwi Creek, the corner (A) of plot (4) is in the Zauk Lam Creek and the corner (D) of that plot is included in the corn yard and the corner (D) of plot (5) is inserted (150) feet into the Chipwi-Pang War road. And also, the inspection team observed that (15) Chinese Technician and (10) Chinese Workers stayed at the site illegally. The inspection team also instructed the company to get the approval from the relevant government bodies for site location and also entering Chinese people at the site. Moreover, the company was ordered to prepare Layout Plan, Mine Drainage System, Waste Management Plan, Emergency Response Plan, Mine

Case Study –

Closure Plan and CSR Program. However, the relevant government took no action on them and they granted the permit to the Company in 2018 accordingly the company applied.

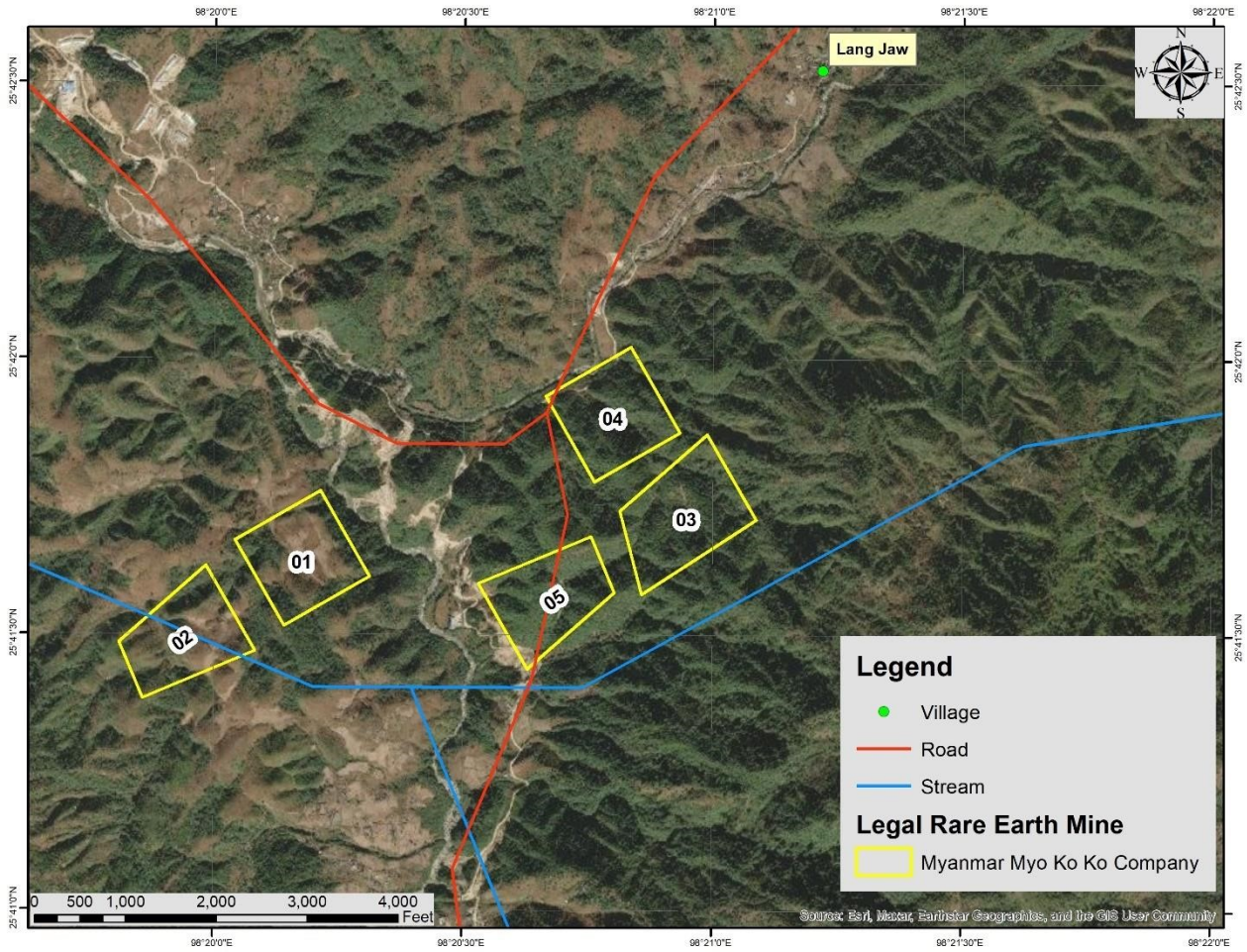


Fig. 25. Location Map of Rare Earth Mining Plots of Myanmar Myo Ko Ko Company

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