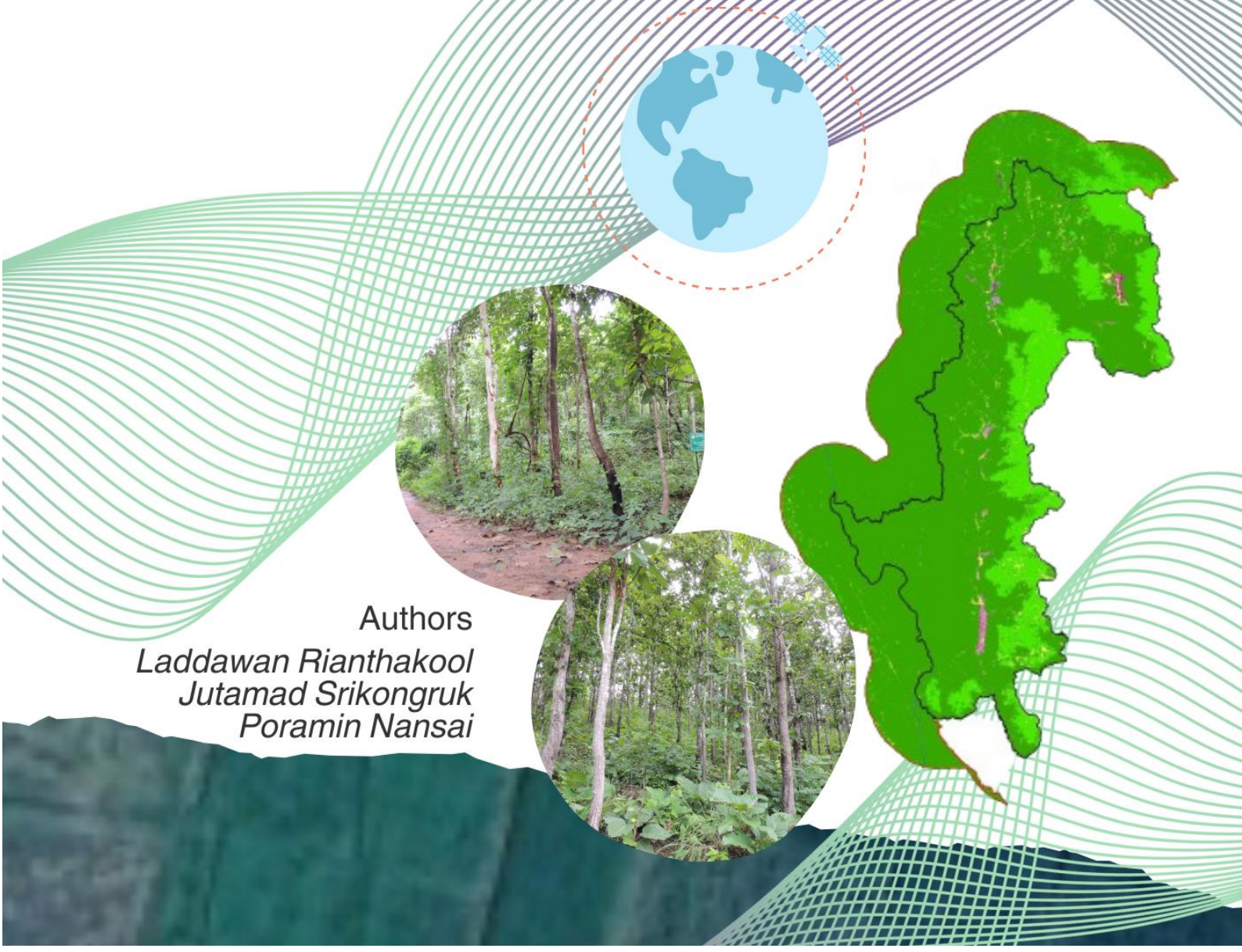
ITTO Project: PP-A/60-369

"Strengthening Surveillance and Monitoring to Tackle the Surge in Forest Loss and Land Degradation, Induced by Intensifying Conflict in Thailand's Border Areas"

Project technical report

Image Interpretation



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Project Technical Report

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Project Name

Strengthening Surveillance and Monitoring to Tackle the Surge in Forest Loss and Land Degradation, Induced by Intensifying Conflict in Thailand's Border Areas

Project Number: PP-A/60-369

Host Government: The Government of Japan

Name of the Executing Agency: International Tropical Timber Organization

Project Coordinator: Asst. Prof. Chakrit Na Takuathung

Start: 7 June 2024

Duration of the Project: 9 months

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Introduction

The aftermath of the Myanmar coup has triggered a major influx of refugees into Thailand's border areas, especially in Tak and Mae Hong Son Provinces, worsening an already fragile situation. This migration has led to widespread deforestation and environmental degradation, increasing illicit activities like wildlife poaching and collection of non-timber forest products (NTFPs), while threatening the livelihoods and food security of 25 vulnerable communities residing in the region.

The situation is especially severe in four sub-districts of Mae Hong Son Province, where refugee camps are located. Escalating border conflict, particularly in late March and April 2023, has intensified the humanitarian crisis. Additionally, climate change impacts - such as more frequent forest fires during dry season and flash floods- have further worsened the already precarious conditions.

In response to the growing crisis, there is an urgent need to address livelihoods losses and rising illegal activities driven by the ongoing political conflict and natural disasters. The proposed emergency project aims to reduce deforestation and forest degradation while promoting sustainable livelihoods in community forests and remaining forests outside protected areas along the Thailand-Myanmar border.

The ITTO project: PP-A/60-369, titled "*Strengthening Surveillance and Monitoring to Tackle the Surge in Forest Loss and Land Degradation, Induced by Intensifying Conflict in Thailand's Border Areas*", was approved by the Government of Japan in April 2024 under the Emergency Fund of ITTO. This project aims to tackle deforestation, forest degradation, and the vulnerability of communities along the Thailand- Myanmar border areas through advanced forest monitoring technology and capacity-building for local authorities, community groups, and youth in community forest protection and sustainable livelihoods

As part of the broader initiative, this study focuses on image interpretation of land use and forest cover maps for 1990 and 2023 to assess forest cover changes over the 33-years. By analyzing satellite imagery, it will generate essential data to support forest conservation efforts and sustainable land management strategies. This detailed assessment will enhance better understanding of deforestation impacts and guide future conservation and restoration efforts.

This study aims to analyze land use status in Mae Hong Son province and a 20 km buffer area into Myanmar for 1990 and 2023 using satellite imagery, and to assess changes over the 33-year period.

Study area

Mae Hong Son is a border province located in the upper northern part of Thailand, situated to the northwest of the country. It covers an area of approximately 12,780.49 square kilometers (or about 7,987,808.27 rai), making it the third-largest province in Northern Thailand (Figure 1). To the north and west, it shares borders with three states of Myanmar: Shan State, Kayah State, and Karen State, with natural boundaries formed by the Thungchai West Mountain Range, the Salween River, and the Moei River. To the south, it borders the Tha Song Yang District in Tak Province, with the Ngao River serving as the boundary. To the east, it borders the eight Districts comprising Wiang Haeng, Chiang Dao, Mae Taeng, Samoeng, Kalayaniwattana, Mae Jam, Hot, and Omkoi of Chiang Mai Province, with the Thungchai Central and Eastern Mountain Ranges forming the natural boundary. This study will extend the buffer zone 20 kilometers beyond the border of Thailand, resulting in a total study area of approximately 21,405.8 square kilometers (or about 13,378,609.190 rai).

Figure 1. Landscape of Mae Hong Son Province, showing the transition between agricultural land and forest areas, part of the study area for the land use and forest cover analysis.

Data

1. **Landsat 5 Satellite Image Data**: Thematic Mapper (TM) data with Level 1 Precision Terrain corrected (L1TP) product, 30-meter resolution for land use classification in 1990. This includes 5 image scenes: Path 131 Row 046, Path 131 Row 047, Path 131 Row 048, Path 132 Row 046, and Path 132 Row 047. The satellite image data was collected between December and March 1990.
2. **Landsat 8-9 Satellite Image Data**: Operational Land Imager (OLI) and Operational Land Imager-2 (OLI-2) data with L1TP product, 30-meter resolution for land use classification in 2023. This includes 6 image scenes: Path 131 Row 046, Path 131 Row 047, Path 131 Row 048, Path 132 Row 046, Path 132 Row 047, and Path 132 Row 048. The satellite imagery data was collected between December and March 2023.
3. **Administrative boundary data**: The administrative boundary data of Mae Hong Son province was created by the Local Administration Bureau, Department of Provincial Administration, Ministry of Interior, in 2020. The data is stored in a Geographic Information System (GIS) in the form of a vector polygon.
4. **Land Use Data for 2020**: The land use boundary data of Mae Hong Son province for the year 2020 is stored in a GIS in the form of a vector polygon, obtained from the Land Development Department's website (https://dinonline.ldd.go.th/).
5. **Land Use Data (Forests) for 2023**: The forest area boundary data of Mae Hong Son province is stored in a GIS in the form of a vector polygon, obtained from the 2023 forest area mapping project by the Forest Land Management Bureau, Royal Forest Department.

Software and applications

1. **QGIS Software**: QGIS is a Geographic Information System (GIS) Free and Open-Source Software. It is continuously developed and has additional functionality through plug-ins to support specific use cases. It is suitable for spatial analysis and map creation.
2. **Ling Map**: Ling Map is a mobile application for simple map creation that is suitable for portability. In this case, it is used to collect coordinates and verify the accuracy of satellite image interpretation (Figure 2).

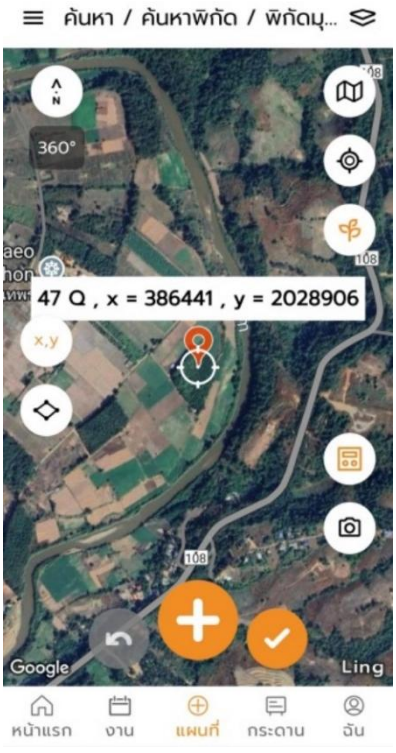

Figure 2.
Screenshot of Ling Maps mobile application used for collecting coordinates to verify the accuracy of satellite image interpretation in the field.

Methodology

This task analyzes forest changes in Mae Hong Son province and a 20 km buffer area along the Thailand-Myanmar border using Landsat satellite imagery from 1990 and 2023. By integrating level 2* land use data from the Land Development Department (and the Royal Forest Department, the study will identify land use and forest cover changes over the past three decades. It will distinguish between deciduous and evergreen forests and include a comprehensive change detection analysis to understand the forest change patterns and drivers in the transboundary region. Ground truth data will be collected to validate and ensure classification accuracy. The workflow of this study is shown in Figure 3:

1) Satellite image data collection:

- Acquire satellite images for Mae Hong Son province and the 20 km buffer area along the Thailand-Myanmar border for 1990 (Figure 4) and 2023 (Figure 5).

- Gather existing land use classification data from relevant agencies to use as a basemap for interpretation.

2) Image pre-processing:

- Digital number (DN) values were converted to top-of-atmosphere (TOA) reflectance, an essential parameter for satellite image analysis, to mitigate atmospheric effects at the time of image capture. This process was done manually by converting DN values band-by-band using the Raster Calculator. Once each year's images were corrected, the bands were combined to create a single composite image for further analysis.

* Level 2 land use classification provides a more detailed breakdown of the categories defined in Level 1. For example, "Urban and Built-up Land" (U) is divided into subcategories such as "City, Commercial and Service" (U1), "Village" (U2), and "Institution" (U3). "Agricultural Land" (A) is subdivided into "Paddy Field Crop" (A1), "Field Crop" (A2), "Perennial" (A3), "Orchard" (A4), and more. "Forest Land" (F) is further divided into "Evergreen Forest" (F1), "Deciduous Forest" (F2), and "Forest Plantation" (F3). The classification also includes detailed subcategories for water bodies and miscellaneous areas, such as "Natural Water Bodies" (W1), "Reservoirs" (W2), "Rangeland" (M1), and "Wetland" (M2). This system enables a comprehensive and detailed analysis of land use in the region.

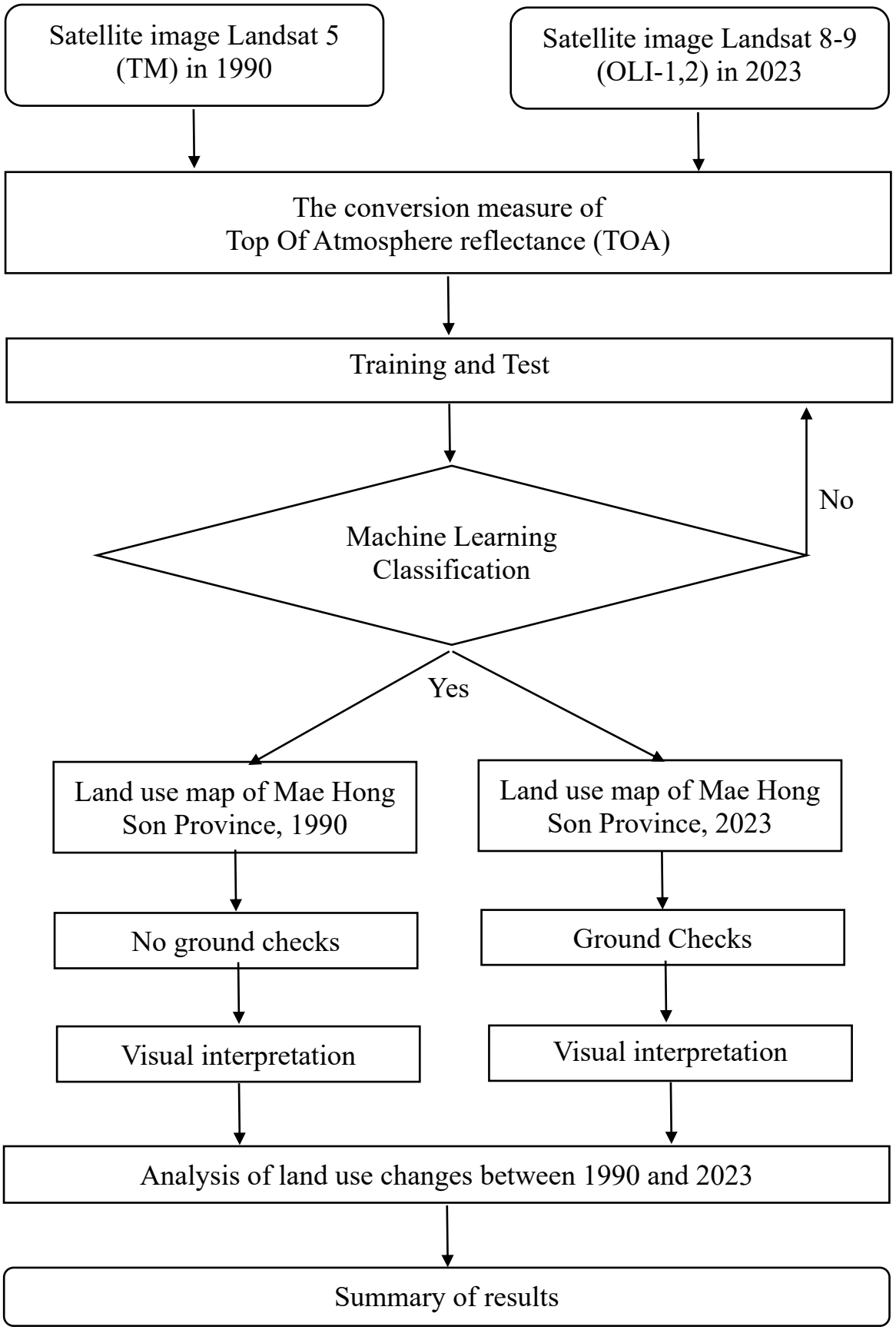

Figure 3. Image Interpretation Workflow for Forest Change Analysis in Mae Hong Son Province and Adjacent Border Areas (1990-2023)

3) Basemap integration and interpretation using machine learning classification:

- Representative training areas were established for land use classification using a machine learning technique known as Support Vector Machine (SVM), a form of supervised learning. Sample areas were designated for each land use type at level 2, including evergreen forest, deciduous forest, natural water bodies (rivers), artificial water bodies (reservoirs), paddy fields, field crops, perennial crops, swidden cultivation, city areas, villages, bare land, and wetlands or beach areas. For each land use type, at least 30 sample areas were selected.

- Land use data was analyzed and classified using machine learning techniques, with additional manual corrections performed through visual inspection.

- The field verification survey classified and allocated checkpoint locations proportionally based on each land use type across Mae Hong Son province (Figure 6), totaling 301 points distributed across each district.

4) Generate land use maps and land use changes between 1990 and 2023

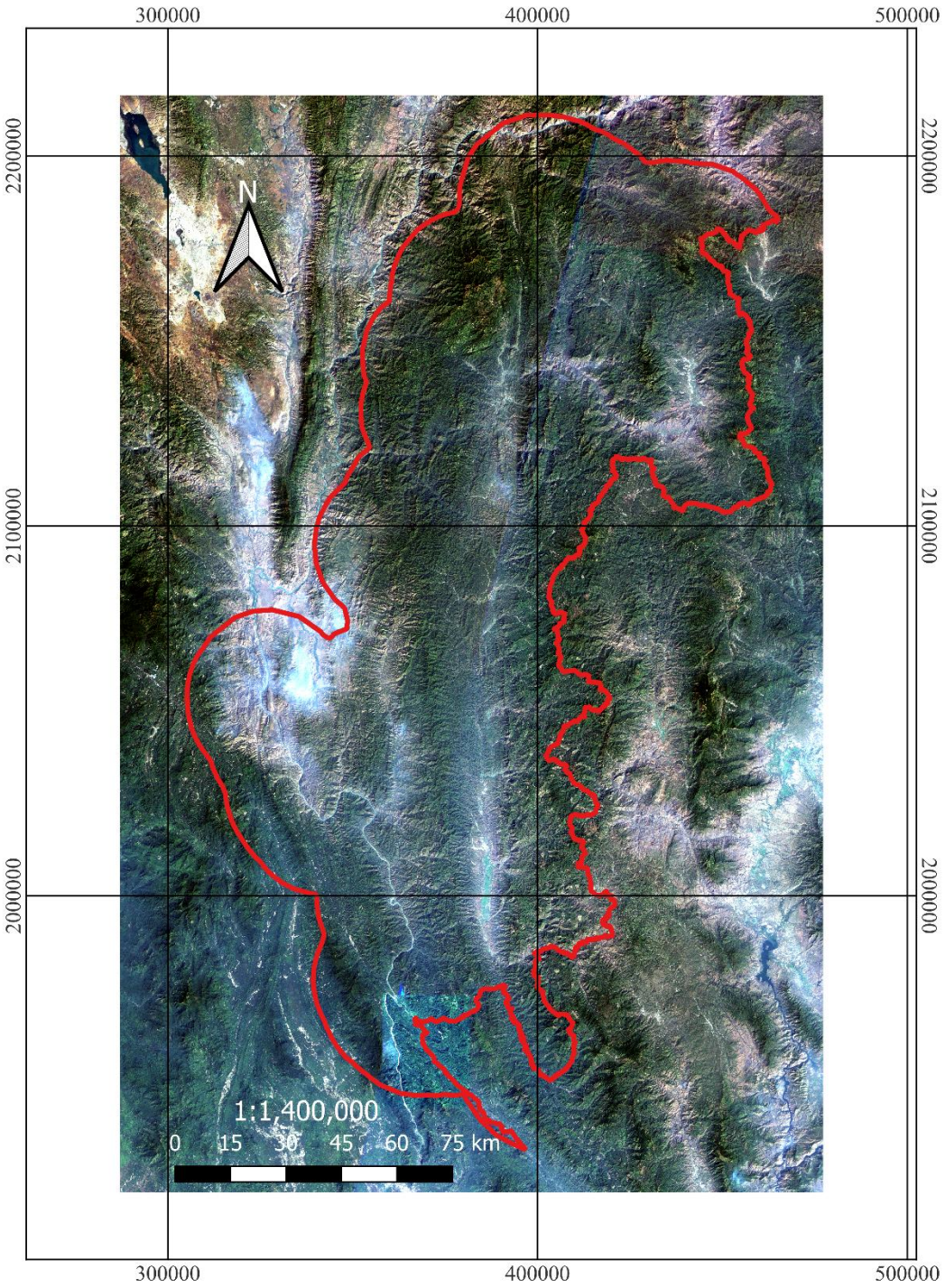

Figure 4. Landsat 5 satellite image of Mae Hong Son province and an additional 20 km buffer along the Thailand-Myanmar border in 1990 map.

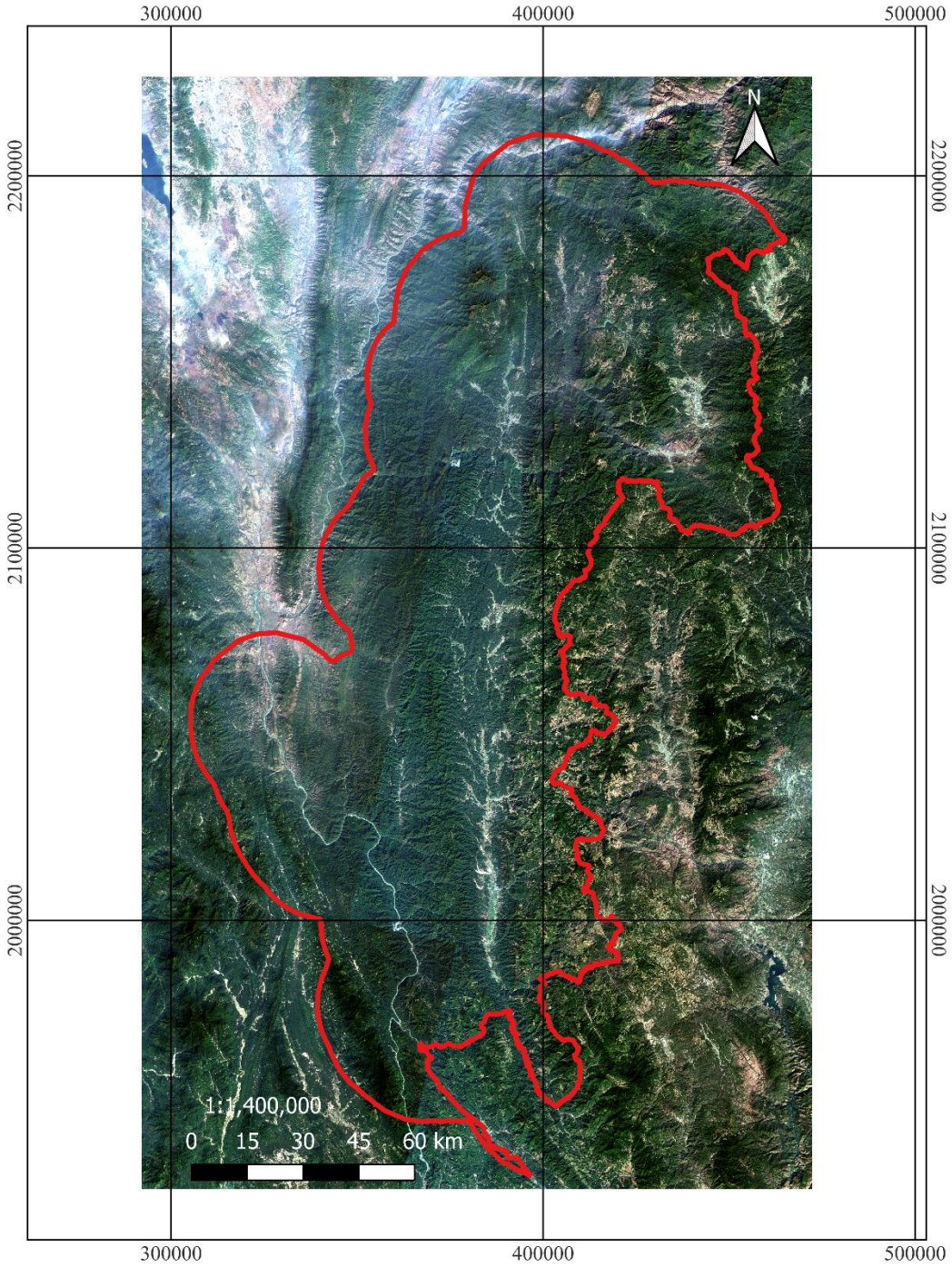

Figure 5. Landsat 8-9 satellite image of Mae Hong Son province and an additional 20 km buffer along the Thailand-Myanmar border in the 2023 map.

A1 Paddy field crop

A2 Field crop

A3 Perennial

U1 City, Commercial and Service

U2 Village

U3 Institution

U4 Transportation

F1 Evergreen Forest

F2 Deciduous Forest

W1 Natural Water Bodies

W2 Reservoirs

M2 Wetland

B1 Bare land

Figure 6. Land use Type

Results

The study presents land use maps and classifications for 1990 and 2023. Table 1 and Figure 7 show the 1990 land use distribution by forest type, revealing that the majority of the area was forested, primarily with evergreen and deciduous forests. Evergreen forest covered an area of 2,059,787.37 rai (15.396%), while deciduous forest occupied 10,999,330.79 rai (82.216%) of the total area. Combined, these two forest types made up 97.612% of the total land use, highlighting the region's forest dominance in 1990.

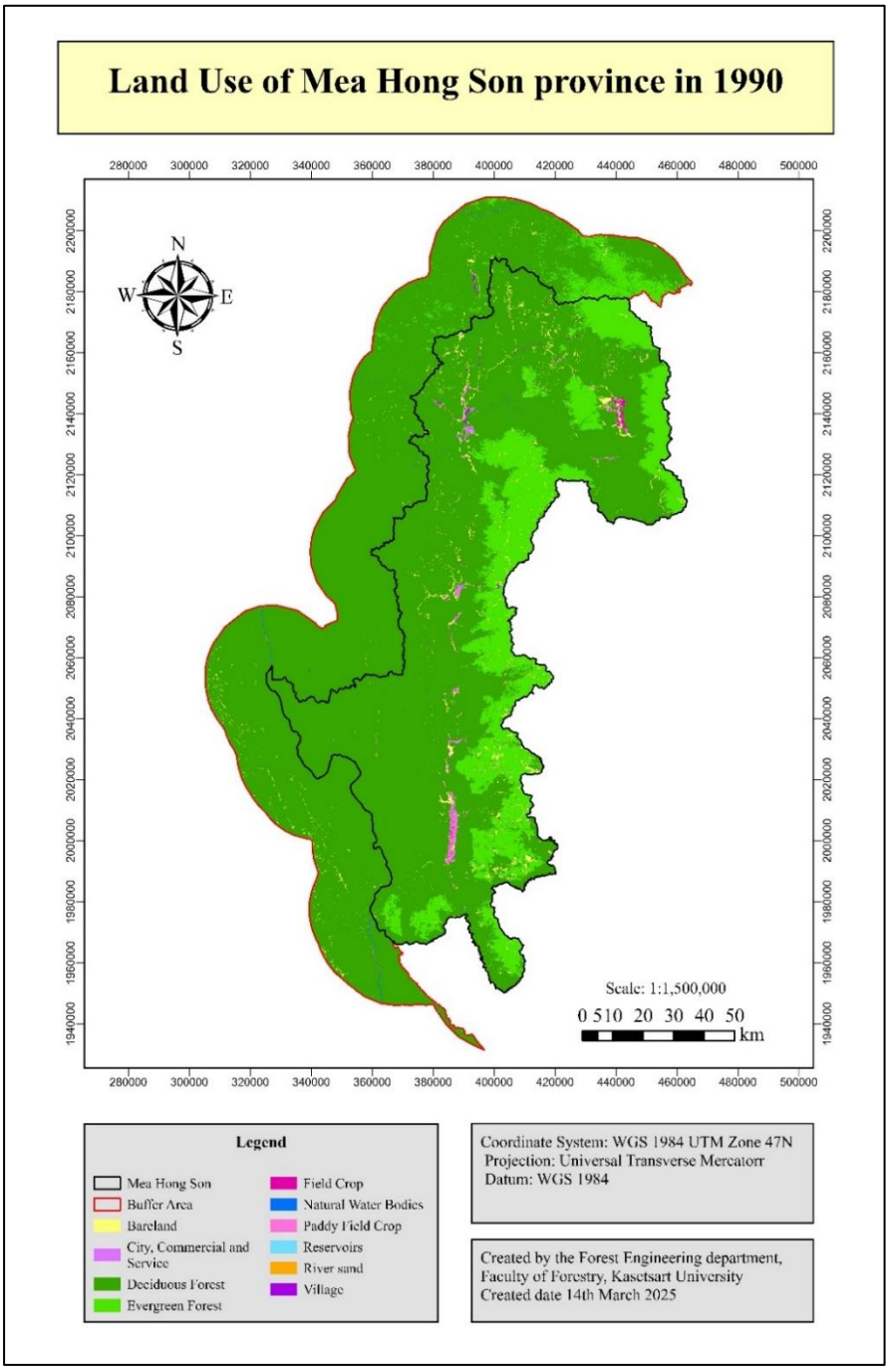

Figure 7. Map of land use distribution for 1990, categorized by forest type

Table 1. Land use distribution for 1990, categorized by forest type

Code No	Code ID	Land use	Area (m^2)	Area (rai*)	%
11	F1	Evergreen Forest	3,295,659,795.00	2,059,787.37	15.396
12	F2	Deciduous Forest	17,598,929,265.00	10,999,330.79	82.216
21	W1	Natural Water Bodies	48,930,014.02	30,581.26	0.229
22	W2	Reservoirs	274,123.19	171.33	0.001
31	A1	Paddy Field Crop	62,087,617.15	38,804.76	0.290
32	A2	Field Crop	21,696,249.03	13,560.16	0.101
41	U1	City, Commercial, and Service	23,380,978.78	14,613.11	0.109
42	U2	Village	28,043,649.90	17,527.28	0.131
51	B1	Bare land	312,741,154.80	195,463.22	1.461
82	M2	River sand	14,031,856.76	8,769.91	0.066
		Total	**21,405,774,703.63**	**13,378,609.19**	**100.000**

* 1 ha = 6.25 rai

The land use distribution for 2023 by forest type is shown in Figure 8 and Table 2. The land use distribution for 2023 shows a significant portion of the area still covered by forests. Evergreen forest covered 1,995,587.67 rai (14.916%) of the total area. Deciduous forest accounted for 10,810,748.88 rai (80.806 %) of the total area. Combined, these two forest types made up 95.722% of the total land use, indicating that the majority of the land in 2023 was still forested, though the proportion of evergreen forest had decreased compared to 1990.

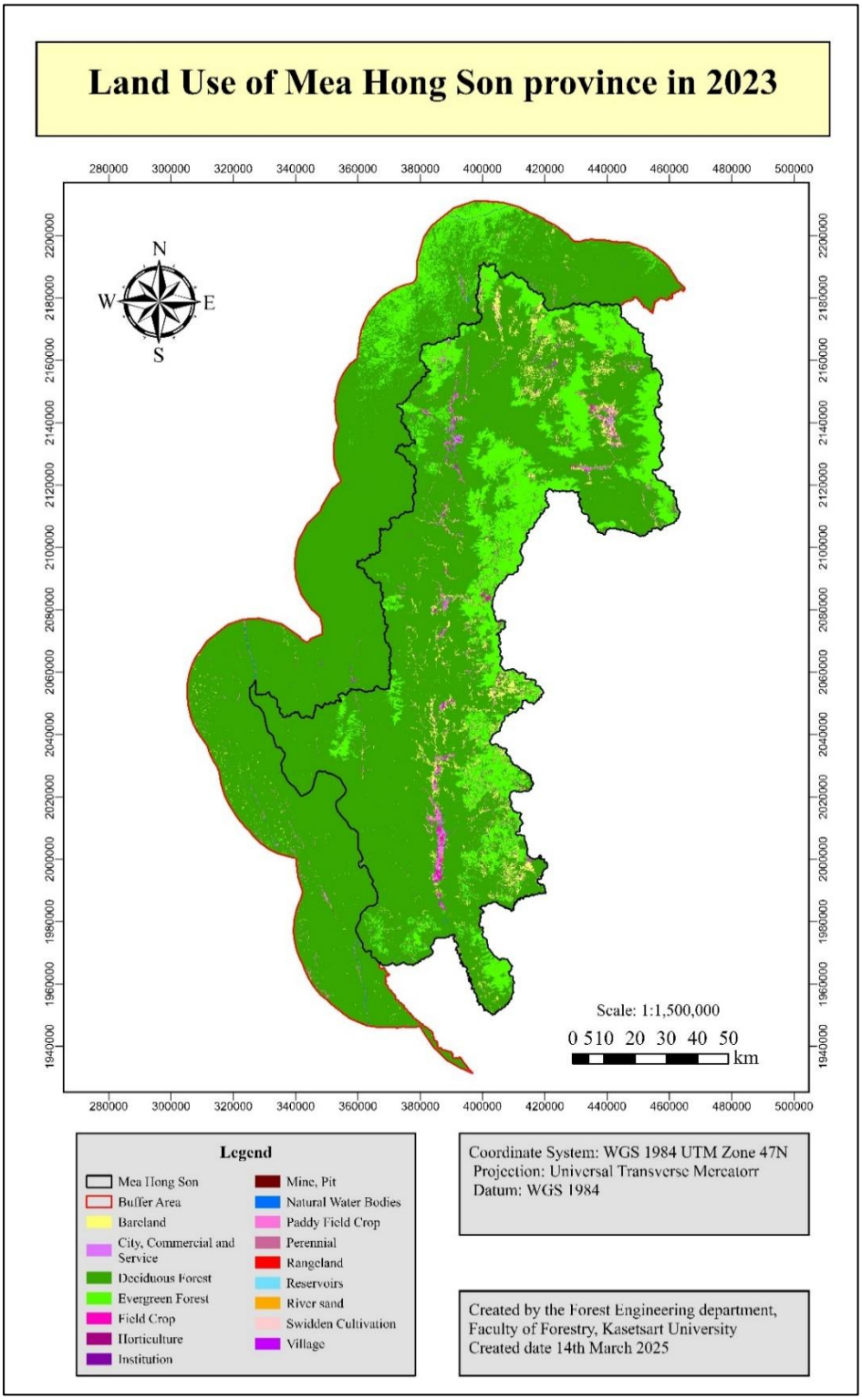

Figure 8. Map of land use distribution for 2023, categorized by forest type

Table 2 Land use distribution for 2023, categorized by forest type

Code No	Code ID	Land use	Area (m^2)	Area (rai*)	%
11	F1	Evergreen Forest	3,192,940,269.00	1,995,587.67	14.916
12	F2	Deciduous Forest	17,297,198,214.00	10,810,748.88	80.806
21	W1	Natural Water Bodies	47,022,269.40	29,388.92	0.220
22	W2	Reservoirs	2,024,569.85	1,265.36	0.009
31	A1	Paddy Field Crop	146,460,498.00	91,537.81	0.684
32	A2	Field Crop	52,398,238.32	32,748.90	0.245
33	A3	Perennial	5,105,959.69	3,191.23	0.024
35	A5	Horticulture	2,672,393.02	1,670.25	0.012
36	A6	Swidden Cultivation	99,000.00	61.88	0.000
41	U1	City, Commercial, and Service	19,918,425.32	12,449.02	0.093
42	U2	Village	78,707,571.37	49,192.23	0.368
43	U3	Institution	4,051,800.00	2,532.38	0.019
51	B1	Bare land	532,525,539.90	332,828.46	2.488
81	M1	Rangeland	2,277,000.00	1,423.13	0.011
82	M2	River sand	22,095,467.59	13,809.67	0.103
83	M3	Mine, Pit	277,487.34	173.43	0.001
		Total	**21,405,774,702.80**	**13,378,609.19**	**100.000**

* 1 ha = 6.25 rai

The 1990 and 2023 maps show significant land use and forest cover changes in Mae Hong Son province and the 20 km buffer area into Myanmar. In 1990, Mae Hong Son province had extensive evergreen and deciduous forests. By 2023, evergreen forest areas had increased in some regions, but there were notable reductions in bare land and agricultural zones (such as paddy fields and field crops), indicating conversion of previously forested areas to other land uses (Table 3).

The Thailand - Myanmar border areas experienced significant changes, with deforestation and land use conversion (Figure 9) evident in the southern and northern parts of the study area, where bare land expanded significantly, likely due to agriculture, logging, and infrastructure development. The central region of Mae Hong Son province also saw forest loss, as agriculture replaced forested areas, particularly with increased field crops and paddy crops, especially in flat, accessible regions.

Over the past 33 years, forested areas have declined, mainly in border and agricultural zones. The dominant trend has been the conversion of forest to bare land and agriculture, reflecting human-driven land use changes in the region.

Figure 9. Deforestation and land use conversion in the study area, showing the expansion of bare land and agricultural use.

Table 3. Land use change between 1990 and 2023 in Mae Hong Son province, showing the area (in rai) for each land use type

Land Use Change		2023																
		F1	**F2**	**W1**	**W2**	**A1**	**A2**	**A3**	**A5**	**A6**	**U1**	**U2**	**U3**	**B1**	**M1**	**M2**	**M3**	**Total Area (rai*)**
1990	**F1**	1,144,297.89	842,157.55	45.69	9.08	5,401.48	3,494.78	80.16	406.06		2.25	3,128.94	49.92	60,486.32	147.76	79.49		**2,059,787.37**
	F2	833,411.41	9,854,692.10	4,547.50	549.94	36,764.40	11,640.25	1,423.23	589.18	47.06	2,337.86	21,691.54	916.38	225,919.16	759.12	3,872.74	168.93	**10,999,330.79**
	W1	145.68	4,550.55	22,490.71	164.02	163.99	87.07	27.82			2.34	50.12	1.13	181.88	14.76	2,701.20		**30,581.26**
	W2	2.43	64.50	2.25	86.40		3.38				0.56		1.69	10.13				**171.33**
	A1	33.19	5,338.28	1,032.13	102.38	16,044.04	8,252.76	469.85	5.06	6.94	1,335.74	1,397.54	57.94	3,452.01	296.97	979.95		**38,804.76**
	A2		2,123.55	43.88	12.94	1,408.62	2,862.41	157.16		2.81	497.55	1,494.60	102.96	4,760.19	19.87	72.50	1.13	**13,560.16**
	A3																	**N**
	A5																	**N**
	A6																	**N**
	U1		3,367.38	67.55	17.44	562.80	223.51	493.16			6,828.58	2,203.78	510.93	311.95	3.38	22.10	0.56	**14,613.11**
	U2	494.95	5,346.79	46.60	16.82	1,660.38	518.02	96.35			295.35	7,822.02	309.28	898.85	6.40	15.47		**17,527.28**
	U3																	**N**
	B1	17,125.88	91,038.43	430.95	302.97	29,482.61	5,651.15	443.49	669.94	5.06	1,147.66	11,350.82	581.58	36,800.67	174.87	254.32	2.81	**195,463.22**
	M1																	**N**
	M2	76.25	2,069.76	681.67	3.38	49.50	15.58				1.13	52.87	0.56	7.31		5,811.91		**8,769.91**
	M3																	**N**
	Total Area (rai)	**1,995,587.67**	**10,810,748.89**	**29,388.92**	**1,265.36**	**91,537.81**	**32,748.90**	**3,191.22**	**1,670.25**	**61.88**	**12,449.02**	**49,192.23**	**2,532.38**	**332,828.46**	**1,423.13**	**13,809.67**	**173.43**	**13,378,609.20**

* 1 ha = 6.25 rai

Remark:

F1	Evergreen Forest	U1	City, Commercial, and Service
F2	Deciduous Forest	U2	Village
W1	Natural Water Bodies	U3	Institution
W2	Reservoirs	B1	Bare land
A1	Paddy Field Crop	M1	Rangeland
A2	Field Crop	M2	River sand
A3	Perennial	M3	Mine, Pit
A5	Horticulture		
A6	Swidden Cultivation		

Conclusions

This supports sustainable land management in the Thailand - Myanmar border areas by providing key insights into land use and forest cover changes over the past three decades. Analysis of land use in Mae Hong Son province and its 20 km buffer zone reveals ongoing landscape transformation, marked by reduction in forest cover and expansion of agricultural and urban areas. By identifying patterns and drivers of land degradation, this study aids in managing natural resources sustainably amid human and environmental pressures. The findings of this study are valuable for policymakers, local authorities, and conservationists in developing strategies to reduce forest loss, restore land, and promote sustainable land use practices, helping maintain ecological, economic, and social benefits for future generations. They also contribute to broader efforts to combat land degradation and preserve ecosystem services in conflict-affected regions for, rapid development.

Recommendations

1. Recommendations for the study

Future studies should expand the spatial and temporal coverage of satellite images to include additional years, allowing for a more comprehensive trend analysis. Incorporating high-resolution imagery and data from alternative sources, such as drones or high-resolution satellites, can enhance the accuracy of land use and forest cover classifications. Implementing advanced machine learning or deep learning techniques can enhance the accuracy and precision of land use change detection, particularly in areas with mixed land uses. Increased field validation and ground truthing are also essential to verify satellite-based classifications and ensure they reflect real-world conditions.

2. Recommendations for applying the results

Based on the findings, a real-time monitoring system using satellite data and ground tracking should be established to detect forest cover changes and illegal activities in border areas. The results should guide sustainable livelihood development through agriculture, agroforestry, and eco-tourism, easing pressure on forests and boosting local economies. Cross-border cooperation between Thailand and Myanmar is essential to address issues like illegal logging and poaching. The findings should also inform policy decisions on land management, including regulation on land conversion, reforestation support, and promoting sustainable practices.

Implications for practice

The study provide key insights to guide sustainable forest and land management in the Thailand - Myanmar border areas. Establishing a real-time forest monitoring system using advanced satellite and ground-level tracking, will help local authorities and communities manage and protect forest resources more effectively. This should be supported by capacity-building programs to promote sustainable land use practices and livelihoods, encouraging sustainable agriculture, agroforestry, and eco-tourism can alleviate pressure on forest ecosystems and boost local economies. The findings also stress the need for cross-border collaboration to address shared challenges like illegal logging and poaching. Additionally, the results highlight the importance of updating policies and regulations to prevent land degradation, incentivize reforestation, and promote sustainable land management. These actions are vital for preserving the region's biodiversity, strengthening community resilience, and addressing climate change impacts and natural disasters.

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