Executive Summary Report

Assessment of Suitable Indicators and Measures for Land Degradation Management Based on the Concept of Land Degradation Neutrality (LDN) Using Geoinformatics in Thailand

Land Development Department

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Preface

This Executive Summary Report presents the details of assessing the suitability of indicators and measures for land degradation management based on the concept of land degradation neutrality (LDN) in a summarized form. It includes important details comprise: a review of international land degradation assessment data using the concept of LDN, the alignment of land degradation management measures with the context of Thailand, an assessment of land degradation trends to identify areas at risk of land degradation, the assessment of degradation from soil moisture indicators in a pilot project on soil and water management both on and beneath the surface in drought-prone areas to enhance farmers' productivity, prioritization analysis using economic models for policy planning and decision-making, and the proposal of ways to develop the capacity for land degradation management projects based on the concept of LDN to achieve the Sustainable Development Goals (SDGs) and the strategic goals of the United Nations Convention to Combat Desertification (UNCCD) Strategic Framework. All of these aspects are presented in 16 items according to the content of this report.

The Land Development Department sincerely hopes that this report on assessing the suitability of indicators and measures for managing land degradation through the concept of LDN will help create a deeper and broader understanding and be used as a tool to support the implementation of LDN. It aims to support the operations for LDN Transformative Projects and Programmes of all relevant parties to achieve Thailand's LDN goal by 2030, as well as the related Sustainable Development Goals (SDGs) and the strategic objectives of the UNCCD Strategic Framework.

Executive Summary

Land Development Department is Thailand's focal point in implementing the United Nations Convention to Combat Desertification (UNCCD). The 15th Conference of the Parties (COP 15) decided that parties should drive the concept of Land Degradation Neutrality (LDN), integrating it with the Sustainable Development Goals (SDGs), specifically SDG Target 15.3, Indicator 15.3.1, which proportion of land that is degraded over total land area, using indicators such as Land Cover Change (LUC), Land Productivity (LP), and Soil Organic Carbon Stock (SOC). The Land Development Department (LDD) has continuously worked on developing databases since 2021 across 42 provinces. By 2024, it will have assessed land degradation using the LDN concept at the international level and evaluated the alignment of LDN-based land degradation management measures in Thailand. The objectives of this effort are:

1. To review the goals, indicators, and criteria for assessing land degradation using the LDN concept at the international level and assess the consistency of LDN-based land degradation management measures in Thailand.
2. To assess land degradation trends using remote sensing technology covering all provinces in Thailand.
3. To assess degradation based on soil moisture indicators through a pilot project on integrated land and water management (surface and underground) in drought-prone areas to enhance agricultural productivity, supporting LDN assessments.
4. To conduct prioritization analysis using economic models for policy planning and decision-making.
5. To propose strategies for capacity development in managing land degradation projects using the concept of LDN in Thailand to achieving the SDGs and the strategic objectives of the United Nations Convention to Combat Desertification.

The data review on SDG Indicator 15.1.3 or LDN indicators confirms that the project adheres to the minimum indicators recommended by the UNCCD. However, it was found that the data available for LDN indicators is limited to coarse-to-medium resolution. Higher-resolution datasets calibrated for specific areas are expected to be more readily available in the future. As such, the project integrates data from Tier 1–2–3 indicators and applies methods from both the UNCCD and the Land Development Department. Development of Tier 2 datasets will ensure that the existing and future datasets are suitable and meet data quality standards.

The assessment of the status of land degradation across Thailand from 2009 to 2023 using the Geographic Information System (GIS) and the One-out, All-out (1OAO) principle categorized the degradation into three levels:

- Low level: 1 indicator showed negative results or a change to a degraded status in 2023.
- Medium level: 2 indicators showed negative results or changes to degraded status in 2023.
- Severe level: All 3 indicators showed negative results or changes to degraded status in 2023.

The assessment of land degradation status in Thailand from 2009 to 2023 revealed that approximately 9,569,578.73 hectares, or 18.49% of the country's total land area, were classified as degraded. Of this total, 8,716,011.43 hectares (16.84%) in low-level degradation, 831,701.80 hectares (1.61%) in moderate degradation, and 21,865.50 hectares (0.04%) in high-level degradation. In contrast, 3,815,419.15 hectares (7.37%) showed improvement, while 25,588,928.39 hectares (49.43%) with no change in status. Areas designated for conservation or those with insufficient data for assessment amounted to 12,792,124.74 hectares (24.71%). At the regional level, the Northern region had the most negative change in land degradation status, covering 3,342,735.25 hectares (6.46% of the country's total area). Followed by the Northeastern region with 2,359,757.63 hectares (4.56%), the Southern region with 1,800,790.80 hectares (3.48%), the Central region with 1,082,023.02 hectares (2.09%), and the Eastern region with 984,272.03 hectares (1.90%).

The analysis also classified the areas of land degradation and improvement status by land type.

Status of Land Degradation			Status of Land Improvement		
Land Type	**Area (hectares)**	**%**	**Land Type**	**Area (hectares)**	**%**
1. Forest lands	6,077,689.95	11.74	1. Croplands	2,047,001.71	3.95
2. Croplands	2,746,587.18	5.31	2. Grasslands	1,085,700.59	2.10
3. Grasslands	419,443.57	0.81	3. Forest lands	448,008.59	0.87
4. Wetlands	164,700.85	0.32	4. Water bodies	104,286.27	0.20
5. Artificial areas/ Settlements	62,241.94	0.12	5. Other lands	100,765.82	0.19
6. Other lands	49,990.87	0.10	6. Wetlands	21,880.08	0.04
7. Water bodies	48,924.37	0.09	7. Artificial areas/ Settlements	7,776.09	0.02
Total	**9,569,578.73**	**18.49**	**Total**	**3,815,419.15**	**7.37**

Assessment of the Focal Areas at Risk of Drought

The project uses annual Drought Risk Index (DRI) data from 2017 to 2024 to assess the spatial distribution of drought conditions across Thailand. The analysis was categorized based on the severity and recurrence frequency divided into two categories: 1) Areas affected by recurring drought within 1-3 years and 2) Areas affected by recurring drought within 4-8 years. Category 2, which includes areas with high and very high drought severity, is classified as drought-risk areas. It was found that Thailand has 14,709,093.60 hectares, or 28.41% of Thailand's total land area, which falls within drought-risk areas. Among the regions, the Northeastern region accounted for the largest share, with 6,871,428.48 hectares or 13.27%, followed by the Northern region with 4,438,377.53 hectares (8.57%), the Central region with 1,678,635.58 hectares (3.24%), the Eastern region with 1,277,894.02 hectares (2.47%), and the Southern region with 442,757.99 hectares (0.86%), respectively. These identified drought-risk areas are the focal drought-risk areas for the planning and implementation of land and water conservation management systems, particularly in developing adaptive management practices and support measures for farmers.

Analysis of Prioritization Using an Economic Model for Policy Planning and Decision-Making.

The project used the Data Envelopment Analysis (DEA) model to measure technical efficiency (TE), assess efficiency, and rank the implementation of land development policies in Thailand. The output variable was GPP (Gross Primary Productivity). It was found that the region with the lowest efficiency, or the region that needs immediate action, was the Eastern region (TE Score = 0.221), followed by the Central region (TE Score = 0.388), Southern region (TE Score = 0.509), Northeastern region (TE Score = 0.548), and Northern region (TE Score = 0.570). However, when the output variable was GPP specific to the agricultural sector, the region with the lowest efficiency was the Central region, followed by the Northeastern region, Northern region, Eastern region, and Southern region. These results highlight the need for sustainable economic development policies to prioritize regions with the lowest efficiency scores.

LDN Framework in the Context of Thailand

The review of existing policies and plans at various levels found that such measures have already been integrated into existing operational plans of various related agencies. The LDN goal at the area level of Thailand focuses on two main land types: forest land and cropland. Proposed development guidelines are as follows:

- Land Degradation Assessment Techniques: Development of Tier 2 datasets to improve the resolution and quality of existing and future indicators, such as LP and SOC.

- Counterbalancing Land Degradation Neutrality: The land management approach to achieve LDN will focus on two main land types: forest land and cropland (including grasslands and wetlands). For forest land, the emphasis is on expanding green areas through the restoration of natural forests, developing economic forests, and creating of green spaces in both urban and rural areas. For cropland, the focus is on sustainable land management (SLM) practices, reducing the use of unsuitable land based on its potential and soil capability and increasing the proportion of land that has been restored or developed for productive purposes. The LDN response hierarchy should be applied in managing and planning LDN, using Avoid > Reduce > Reverse land degradation, in line with the UNFCCC and CBD conventions. Restoration of areas that have already degraded lands should follow a sequence based on the severity of land degradation, from high, medium, to low severity.

- Economic Dimension: The result of efficiency measurement and prioritization in land development policy provides an overall land use priority. The detailed policy on developing specific areas suggests further provincial studies, gathering field data, and identifying additional factors or variables. The results of economic prioritization should be used together with soil potential data to guide policy decisions for land development in areas that have not yet experienced land degradation.

- Water Management for Agricultural Areas: Water conservation and restoration of soil and land resources in agricultural areas are essential. This includes improving water management efficiency, conserving headwater areas, and developing agricultural water resources to improve land productivity, ensure food security, and increase income. Water management during crises should consider the drought-risk area data to prioritize areas for land degradation management along with drought-risk areas.

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1. Principles and Rationale

The resolution of the 12th session of the Conference of the Parties to the United Nations Convention to Combat Desertification (UNCCD) designated the concept of Land Degradation Neutrality (LDN) as the operational principle of the UNCCD, aligning with Sustainable Development Goal (SDG) Target 15.3, Indicator 15.3.1: the proportion of land that is degraded over total land area. The objective is to counterbalance the losses from land degradation with the gains from restoration or sustainable land management measures. This approach emphasizes a combination of measures, including avoiding, reducing, and reversing degraded land. Furthermore, LDN relates to various SDGs, such as poverty reduction, food security, environmental quality conservation, and sustainable use of natural resources.

The Land Development Department is the focal point office for implementing the UNCCD in Thailand. The resolution of the 15th session of the Conference of the Parties (COP 15) mandates member countries to promote the concept of LDN, integrating it with the SDGs, particularly Target 15.3, Indicator 15.3.1: the proportion of degraded land over total land area. This is to achieve the goal of LDN. The indicators associated with land degradation are utilized to establish baseline data and continuously monitor changes from 2015 to 2030. These include Land Use Change (LUC), Land Productivity (LP), and Soil Organic Carbon Stock (SOC). The Land Development Department has been developing a database system since 2021, covering 42 provinces. In 2024, the department began implementing LDN projects, with measures derived from analyzing causal factors using LUC, LP, and SOC indicators. These measures include preventing and rehabilitating degraded land through soil and water conservation systems and soil quality improvement via participatory processes involving farmers and communities.

2. Objectives

2.1 To review goals, indicators, and criteria for assessing land degradation using the LDN concept at the international level and assess the consistency of LDN-based land degradation management measures in Thailand.

2.2 To assess land degradation trends using remote sensing technology covering all provinces of Thailand.

2.3 To assess land degradation based on soil moisture indicators through a pilot project on integrated land and water management (surface and underground) in drought-prone areas to enhance agricultural productivity, supporting LDN assessment.

2.4 To conduct prioritization analysis using economic modeling for policy planning and decision-making.

2.5 To propose strategies for capacity development in managing land degradation projects using the concept of LDN in Thailand to achieve the SDGs and the strategic objectives of the United Nations Convention to Combat Desertification (UNCCD Strategic Framework).

3. Output Goals

3.1 Report on evaluating appropriate indicators and measures for managing land degradation using the concept of LDN in Thailand 2024, in both English and Thai.

3.2 A national database on land degradation trends using the concept of LDN.

4. Approaches and Methodology

The study methodology consists of reviewing international assessment data on land degradation using the concept of LDN and assessing the consistency of LDN-based management measures in the Thai context. The next step is to assess land degradation trends to identify areas at risk of land degradation and to evaluate degradation using soil moisture indicators in a pilot project on integrated land and water management in drought-prone areas to enhance agricultural productivity. The following step involves prioritization analysis using economic modeling to support planning and policy decisions. The final step is to present strategies for enhancing project management capacity in land degradation using the concept of LDN to achieve the SDGs and the strategic objectives of the UNCCD Strategic Framework, as illustrated in **Figure 1**.

5. Review of LDN Information at the International Level

Land Degradation Neutrality (LDN) is a no net loss approach (**Figure 2**) that aims to ensure that land degradation areas are under control and that land improvement is maximized as much as possible. The UNCCD Strategic Framework 2018–2030 focuses on improving the quality of life of more than 1.3 billion people and reducing the impact of drought on vulnerable populations, supporting the achievement of the LDN target by 2030.

The LDN response hierarchy of Avoid > Reduce > Reverse land degradation is an overarching principle for implementing LDN. This hierarchy serves as a guide for decision-makers to plan interventions to achieve LDN. Sustainable Land Management (SLM) is a pathway toward achieving (or exceeding) LDN targets by avoiding degradation in undegraded areas, reducing degradation risks in managed lands, and reversing degradation in areas where it is still occurring or has occurred in the past.

It is noted that, when considering the cost of implementation, avoiding land degradation while it is still in healthy condition is less costly than reducing degradation. Restoration of degraded land is the most expensive and time-consuming.

Land degradation assessment includes the identification of land-based indicators for implementing LDN: changes in land cover/land use, changes in land productivity, and changes in soil organic carbon. These are used as indicators to monitor and evaluate performance over the Sustainable Development Goals (SDG) target period.

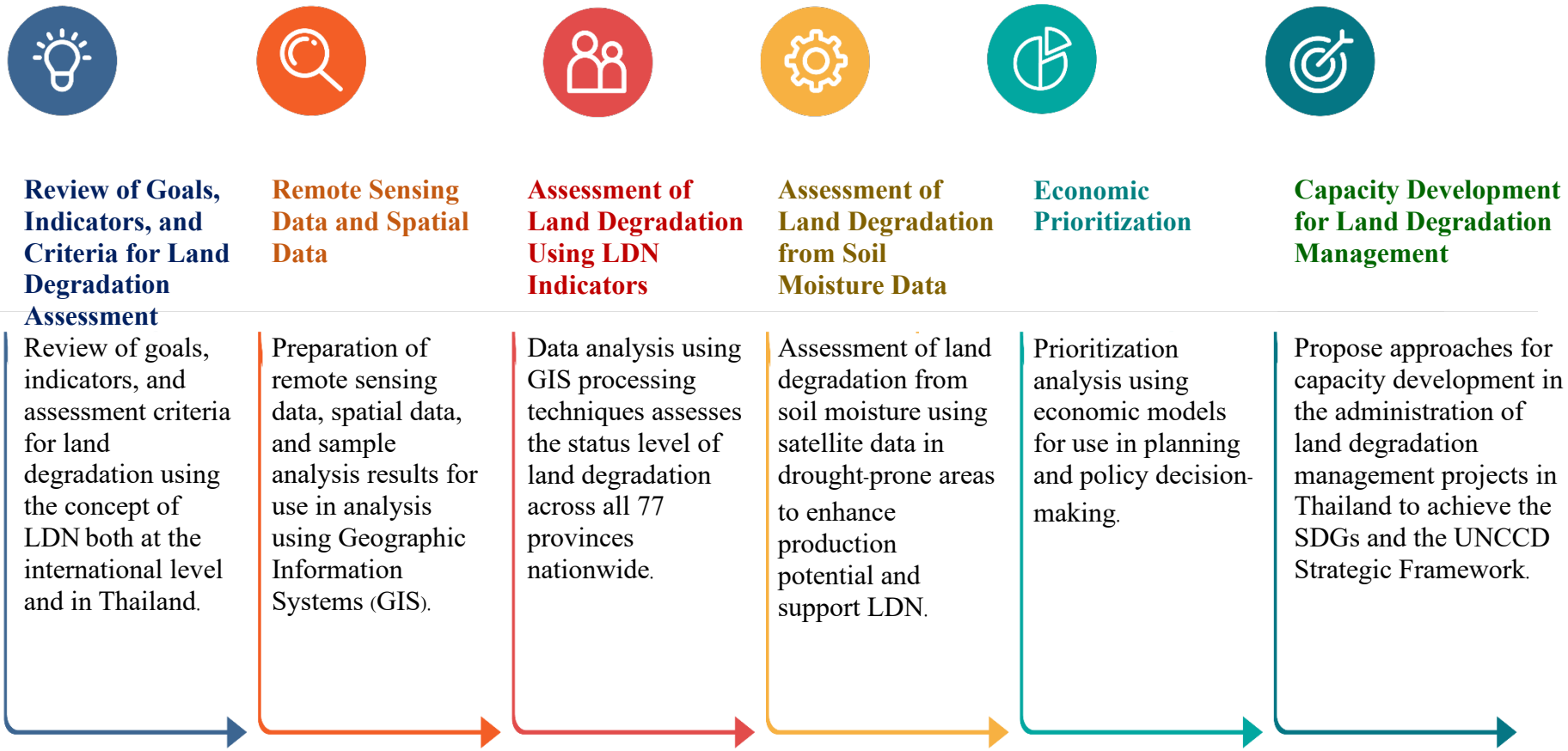
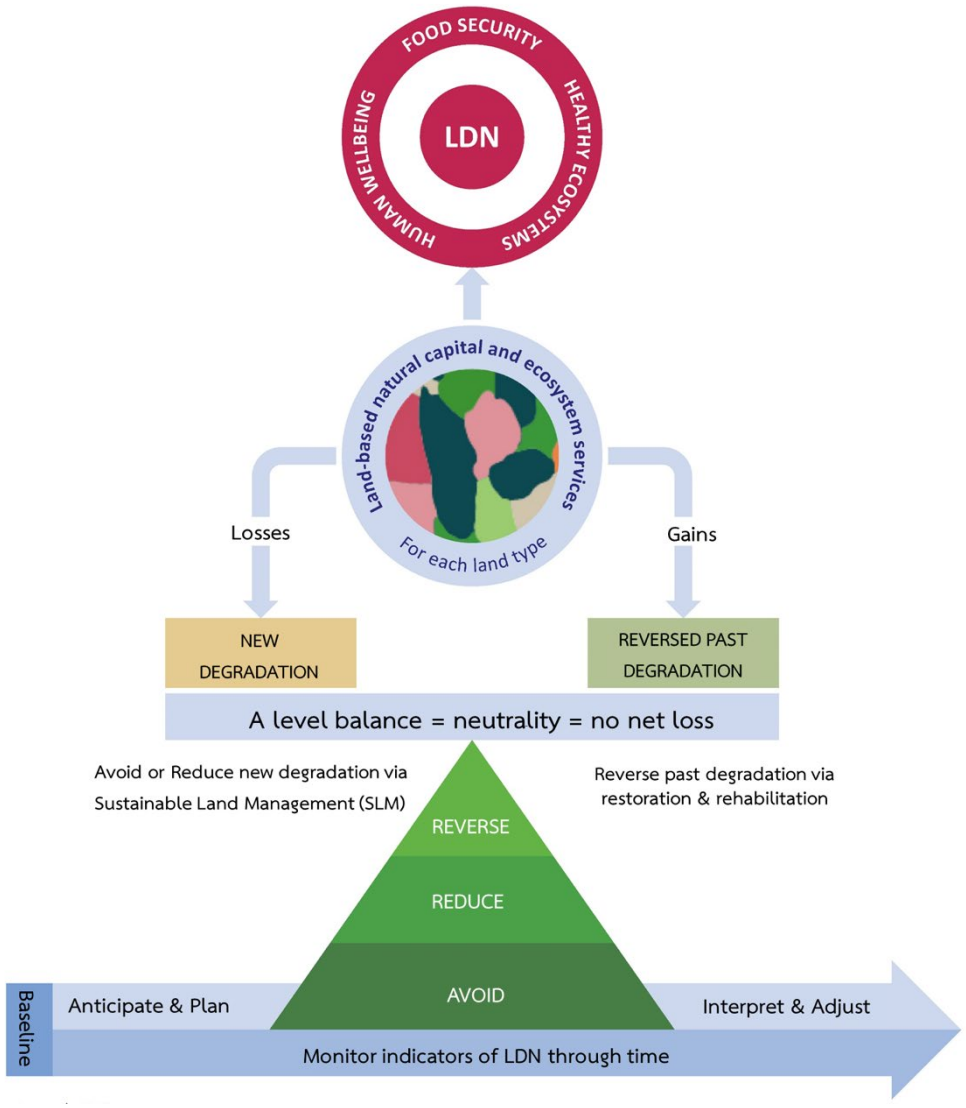


Figure 1. Project implementation sequence



Source: Orr et al. (2017)

Figure 2. Key elements of the scientific conceptual framework for LDN and their interrelationships

The approach to reducing land degradation involves two main principles: reducing the rate of land degradation and increasing the restoration rate of degraded land. In addition to the three global indicators (SOC, NPP, and land cover change), countries may adopt national-level indicators that are relevant to local ecosystem services not captured by SOC, NPP, or land cover change. One or more such indicators may be selected using the one-out, all-out approach.

Alternatively, supplementary indicators may be used to provide complementary information to better understand land degradation trends and interpret the results of the three global indicators to inform responses. It is noted that the one-out, all-out approach becomes increasingly conservative as the number of indicators applied under this method increases.

In the monitoring of LDN, the indicators will be remeasured (using the same method as in the baseline period) at the time of final monitoring (e.g., in 2030), with at least two intermediate monitoring points during implementation to determine significant positive change (gains), significant negative change (losses), and areas with no significant change (stable). Finally, the ambition to achieve LDN is no net loss of healthy and productive land for each land type, compared with the baseline (t0) and the final evaluation year (t1).

6. Review of LDN Data in the Key Context of Thailand

The Land Development Department, under the Ministry of Agriculture and Cooperatives, is the focal point agency for Thailand's implementation of the United Nations Convention to Combat Desertification (UNCCD). The implementation of LDN in Thailand is under the responsibility of the National Committee on UNCCD and the Subcommittee on UNCCD on Technical Affairs, which are responsible for setting targets based on the concept of land degradation neutrality (LDN), monitoring the status of land degradation, and providing technical recommendations for the implementation of the Convention. It consists of four main activities:

1. Preparation of baseline data to assess land degradation trends
2. Assessment of the surrounding environment that triggers land degradation, monitoring of land degradation status, setting targets and appropriate land management measures for conservation, mitigation of impacts, and land restoration
3. Providing technical recommendations on the formulation of policies, guidelines, criteria, and operational mechanisms under the Convention, including dissemination of the concept to stakeholders
4. Monitoring the implementation results and continuous tracking of operational changes from 2015 to 2030

Indicators related to land degradation are used to prepare baseline data and consist of three indicators: 1) land use change, 2) land productivity, and 3) soil organic carbon. The analysis of land degradation areas must integrate all three indicators under the One-out, All-out principle. In 2019, it was found that Thailand had land degradation accounting for 21 percent of the total area. Therefore, to prevent, restore, and halt land degradation, LDN targets were set by developing the LDN Baseline database from 2021 to 2027 to cover all 77 provinces nationwide.

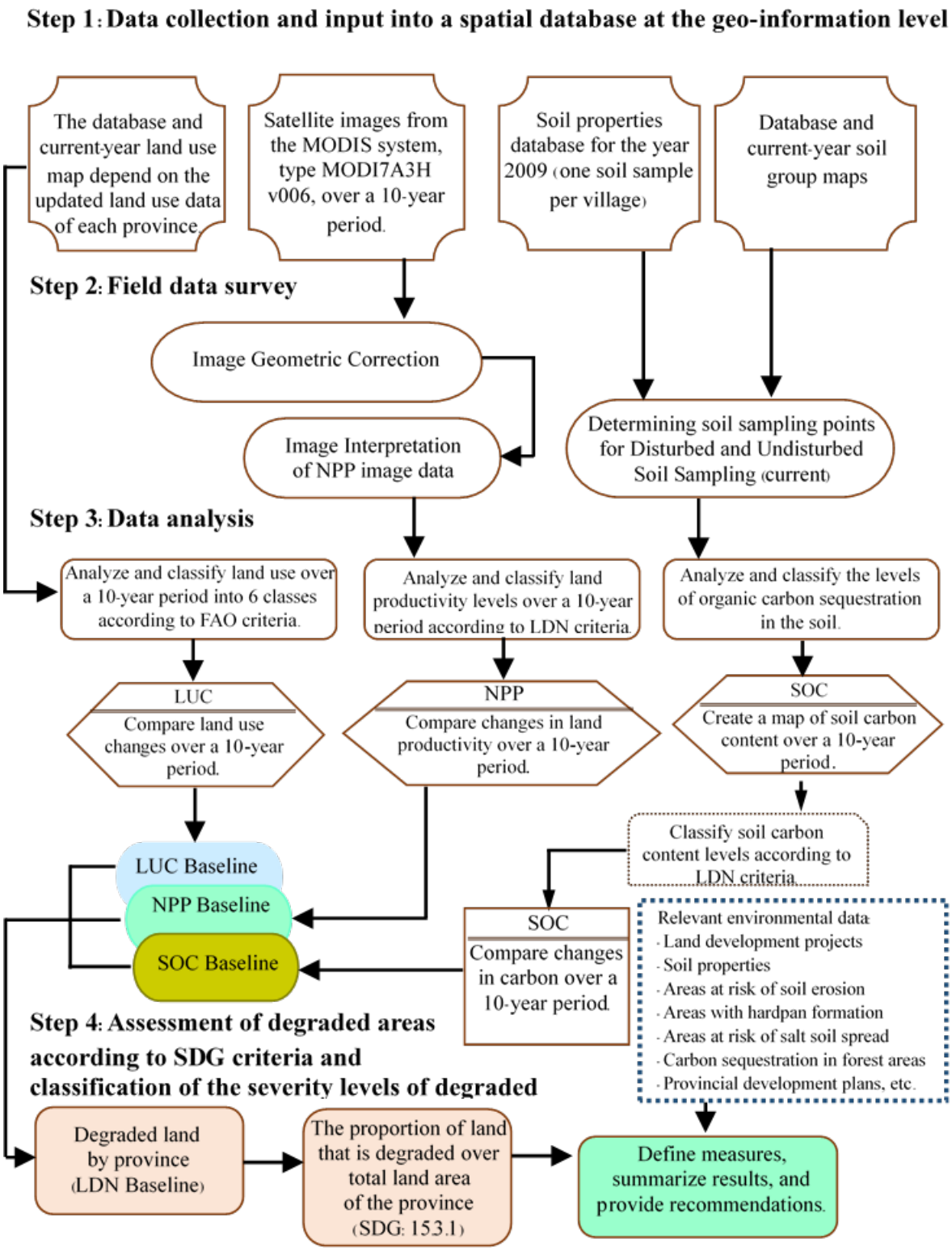
Assessing LDN indicators at the local level will be one approach to improving the accuracy of LDN indicators at the Tier 2 level. The Land Development Department (LDD) has initiated a project to establish localized LDN targets and indicators to guide land degradation management measures across Thailand. This initiative spans 2021 to 2027 and aims to cover all 77 provinces nationwide. Between 2021 and 2023, target-setting activities were conducted in 42 provinces, covering 34,834,693.60 hectares. Of this area, 8,030,785.92 hectares, or 23.05%, were classified as degraded land. When the degraded land areas were classified by severity in order to prioritize the areas for setting targets for prevention and restoration of degraded land using appropriate measures, it was found that the area classified as severely degraded was 59,988 hectares, moderately degraded was 1,049,320.64 hectares, and slightly degraded was 6,854,950.4 hectares, respectively (**Figure 3** and **Table 1**).

In addition, in the fiscal year 2024, the LDD has implemented a project on land degradation management based on the concept of LDN or LDN Implementation in 13 sites. The project has been implemented in degraded areas to determine land degradation management measures, establish soil and water conservation systems, and support production inputs to improve soil quality, with a total area of 3,952 hectares.

7. Summary of Data Review and Its Application in Project Implementation

The review of the LDN indicators in both the global context, following the UNCCD guidelines, and in the context of Thailand, according to the Land Development Department and relevant agencies' operational guidelines, from the past until the present, revealed that there are limitations in the LDN indicator data, such as data quality characteristics and data resolution levels. Currently, only coarse to medium-resolution data are available. The availability of high-resolution datasets that have been calibrated at the local level is expected to increase in the future. At present, all related parties are continuously developing data, and it is anticipated that datasets will evolve over time with the launch of new sensors. The data from these sensors will be calibrated, and updated datasets will be prepared for use in LDN analysis and assessment, making the datasets suitable for calculating indicators to expand the benefits of the SDG indicator 15.3.1 and LDN indicators for environmental analysis and decision support at the global, regional, and national levels.

Therefore, the datasets for the LDN indicators (LCC, LP, and SOC) that are available for assessing the land degradation status at the national level in the project are a combination of datasets from Tier 1, Tier 2, and Tier 3, applying both UNCCD and the Land Development Department's methods. However, considering the project's objectives to use them for planning, decision-making at the policy level, and proposing guidelines for enhancing the management capacity of land degradation in Thailand, the selected datasets and methods are those that can be used to assess changes in land status and can address both spatial aspects and prioritization for planning further action at the local level.



Source: Land Development Department (2024a)

Figure 3. Steps and methods for assessing land degradation according to the LDN approach in Thailand

Table 1. Assessment results of land degradation neutrality (LDN) at the local level for 2021–2024

SFG	Target Area	Area (hectares)	Severity level						Total degraded land area as assessed by LDN indicators	
	Province		Severely degraded		Moderately degraded		Slightly degraded			
			Hectares	%	Hectares	%	Hectares	%	Hectares	%
1	Nakhon Nayok	212,200.00	958.08	1.04	13,448.16	14.55	78,048.96	84.42	92,455.20	43.57
	Suphan Buri	535,800.80	7.20	0.01	1,857.76	3.59	49,833.60	96.39	51,698.56	9.65
	Saraburi	357,648.64	347.52	0.24	15,101.60	10.41	129,621.44	89.35	145,070.56	40.56
	Lopburi	619,975.36	4.96	0.01	1,207.20	1.35	88,254.08	98.65	89,466.24	14.43
	Pathum Thani	152,585.60	13.12	0.04	2,302.24	6.26	34,455.04	93.70	36,770.40	24.10
	Sing Buri	82,247.84	0.00	0.00	0.00	0.00	21,880.64	100.00	21,880.64	26.60
2	Chanthaburi	633,800.00	887.52	0.39	31,301.92	13.67	196,819.36	85.94	229,008.80	36.13
	Chonburi	436,300.00	1,053.44	0.74	22,430.56	15.73	119,101.92	83.53	142,585.92	32.68
	Rayong	355,200.00	689.28	0.51	20,906.56	15.58	116,839.04	87.09	134,154.40	37.77
	Chachoengsao	535,100.00	0.00	0.00	115,832.96	97.82	2,580.96	2.18	118,413.92	22.13
3	Nakhon Ratchasima	2,049,396.48	77.76	0.04	6,721.92	3.26	199,168.32	96.70	205,968.00	10.05
	Buri Ram	1,032,188.48	1,345.92	0.92	9,458.88	6.46	135,588.48	92.62	146,393.28	14.18
	Chaiyaphum	1,277,828.48	2,179.04	0.61	24,580.64	6.89	330,037.12	92.50	356,796.80	27.92
	Surin	812,405.60	416.32	0.55	1,648.16	2.17	73,802.40	97.28	75,866.88	9.34
4	Roi Et	829,944.96	275.68	0.14	15,285.28	8.00	175,498.56	91.86	191,059.52	23.02
	Ubon Ratchathani	1,574,484.96	10.72	0.01	4,580.80	4.28	102,554.40	95.71	107,145.92	6.81
	Si Sa Ket	883,997.44	0.00	0.00	28.64	0.14	19,980.64	99.86	20,009.28	2.26
5	Maha Sarakham	529,168.32	678.08	0.25	32,198.56	12.10	231,121.76	86.82	266,203.04	50.31
	Khon Kaen	1,063,867.04	87.36	0.03	14,473.28	5.59	244,511.52	94.38	259,072.16	24.35
	Sakonnakhon	952,182.08	242.08	0.08	18,355.04	6.15	279,667.36	93.76	298,264.48	31.32

Table 1. Assessment results of land degradation neutrality (LDN) at the local level for 2021–2024 (continued)

SFG	Target Area	Area (hectares)	Severity level						Total degraded land area as assessed by LDN indicators	
	Province		Severely degraded		Moderately degraded		Slightly degraded			
			Hectares	%	Hectares	%	Hectares	%	Hectares	%
6	Lampang	1,253,396.16	1,880.64	0.47	40,263.84	9.96	362,291.04	89.58	404,435.36	32.27
	Chiang Mai	2,010,705.76	23.84	0.03	3,901.76	5.03	73,619.04	94.94	77,544.64	3.86
	Lamphun	450,588.00	38.40	0.08	950.40	2.02	45,945.12	97.89	46,933.92	10.42
7	Nan	1,147,207.20	5,489.28	1.18	83,733.28	17.96	376,982.08	80.86	466,204.80	40.64
	Phayao	633,505.92	2,414.88	1.61	28,558.88	19.05	118,954.72	79.34	149,928.48	23.67
	Chiang Rai	1,167,836.96	7,017.76	1.10	129,696.16	20.40	498,906.72	78.49	635,620.64	54.43
8	Phitsanulok	1,081,585.44	4,035.04	0.99	41,335.36	10.18	360,609.44	88.82	405,979.84	37.54
	Phetchabun	1,266,841.60	8,457.92	1.08	74,330.88	9.53	697,083.84	89.38	779,872.64	61.56
	Loei	1,142,461.12	0.00	0.00	5,909.60	5.67	98,277.60	94.33	104,187.20	9.12
9	Tak	1,640,664.96	1,251.52	1.33	20,801.12	22.10	72,060.32	76.57	94,112.96	5.74
	Sukhothai	659,609.12	481.12	0.33	19,413.12	13.38	125,219.84	86.29	145,114.08	22.00
	Nakhon	959,767.68	144.80	0.19	2,215.52	2.95	72,686.40	96.85	75,046.72	7.82
10	Kanchanaburi	1,948,314.88	13,848.80	11.11	8,250.56	6.62	102,561.44	82.27	124,660.80	6.40
	Phetchaburi	622,513.76	335.20	0.45	7,244.16	9.83	66,092.64	89.71	73,672.00	11.83
	Ratchaburi	519,646.24	12.64	0.04	852.16	2.83	29,245.28	97.13	30,110.08	5.79
11	Surat Thani	1,289,146.88	1,018.40	0.29	36,028.00	10.28	313,464.00	89.43	350,510.40	27.19
	Phang Nga	417,089.44	973.12	0.60	23,035.52	14.30	137,039.36	85.09	161,048.00	38.61
	Krabi	470,851.20	348.16	0.20	85,196.96	49.22	87,555.52	50.58	173,100.64	36.76
12	Phatthalung	342,447.36	1,394.72	0.79	28,476.80	16.05	147,505.60	83.16	177,377.12	51.80
	Satun	247,897.76	177.92	0.10	13,849.76	7.81	94,746.88	53.42	177,377.28	71.55
	Pattani	157,137.44	713.92	0.49	16,374.24	11.16	129,570.40	88.35	146,658.56	93.33
	Trang	479,156.64	655.84	0.27	27,182.40	11.19	215,167.52	88.54	243,005.76	50.72
Total		**34,834,693.60**	**59,988.00**	**0.75**	**1,049,320.64**	**13.07**	**6,854,950.40**	**85.36**	**8,030,785.92**	**23.05**

Source: Land Development Department (2025)

Thailand currently lacks national-level data assessment for the baseline period for Tier 2 datasets during the years 2000–2015. Consequently, baseline degradation status is derived from Tier 1 data in global databases and the default global datasets from Trends.Earth, which indicates a relatively positive trend. Thus, the results of the data review to adapt it to the Thai context are being implemented in parallel, where sustainable management and land restoration are being carried out, including forest and agricultural areas, focusing on areas with high, medium, and low levels of land degradation severity, respectively. At the same time, Tier 2 datasets are being developed to make the existing datasets or those to be developed in the future suitable and of high-quality standards to calculate indicator 15.3.1 with greater precision.

Thailand's land and soil resource management policies have established agencies as institutional mechanisms to drive implementation across all related sectors. This ensures that operations under the LDN concept continue in line with the drive for other SDG indicators. According to the UNCCD guidelines (a report of the Science-Policy Interface), the current step involves a counterbalancing mechanism to achieve neutrality and monitor progress to assess the achievement of LDN. Therefore, the operation in planning and implementing land management measures under the project still adheres to the UNCCD principles, which recommend integrating these principles into existing plans and aligning them with various national and the Land Development Department's ongoing plans.

8. Consideration for the Use of Remote Sensing and Spatial Data

The project selected a 14-year period, from 2009 to 2023, to compare with the reporting periods and reduce the impact of seasonal and inter-annual weather variability. For NPP and SOC values, the data should represent the average over a period of 10-15 years (Orr et al., 2017). Below are the considerations for the data sources of each LDN indicator used in the project, including soil moisture:

1. **Land Cover Change (LCC) Indicator**

   The satellite data from the baseline year (t0) 2009 and the reporting year (tn) 2023 were chosen from the Regional Land Cover Monitoring System (RLCMS) of the SERVIR Southeast Asia project, which classifies satellite data from LANDSAT and Sentinel satellites with a 30-meter pixel resolution.

2. **Land Productivity (LP) Indicator**

   Net Primary Productivity (NPP) data, which represent the amount of carbon remaining after respiration and photosynthesis of plants, were chosen for this indicator. The unit is tons of carbon per hectare per year. The data for the baseline year (t0) 2009 and the reporting year (tn) 2023 were selected from the MOD17A3HGF product version 6.1 (MOD17A3HGF v061), which is an improvement on the MOD17 product from the Terra MODIS satellite, with a 500-meter pixel resolution. The productivity state is more sensitive to the recent magnitude and direction of change in NPP than long-term productivity trends. The project thus considered using the average annual NPP data for the last 3 years, along with the annual rainfall data for Thailand, applying the same average annual NPP data for both the baseline (2007 – 2009) and reporting (2021 – 2023) years.

3. **Soil Organic Carbon Stock (SOC Stock) Indicator**

   For this indicator, the baseline year (t0) 2009 and reporting year (tn) 2023 data were selected from the soil organic carbon data at sampling points stored in the Geographic Information System (GIS) of the Land Development Department, which collected soil samples nationwide under the "One Village One Soil Sample" project in 2009 to create spatial data for estimating soil organic carbon in areas without point surveys. For the 2023 soil organic carbon data, the project considered using a method to assess the change in SOC based on land cover changes, following the Trend Earth principles, to derive the soil organic carbon status for 2023.

However, to develop SOC datasets for Thailand, the project piloted the analysis and assessment of soil organic carbon in the northeastern region. The analysis used 23,069 soil sample points (from 20 provinces) collected in 2009, and 968 soil sample points (from 11 provinces) from the Land Development Department's 2021–2023 soil sampling project to create an equation for estimating SOC using spatial estimation combined with Landsat satellite data. The results of developing the SOC dataset for Thailand and testing the soil organic carbon stock prediction model (SOC Prediction Model) in the northeastern region showed that the Forest-based model and multiple regression equations using variables derived from Landsat satellite data (Red, NIR, SWIR1, SWIR2) combined with spatial interpolation using the Empirical Bayesian Kriging (EBK) method yielded the highest accuracy.

4. **Soil Moisture Indicator**

   The Drought Risk Index (DRI), an improved and developed drought risk map system based on moderate-resolution Suomi NPP satellite imagery with daily frequency and a 1-kilometer resolution, was selected. The DRI system classifies drought risk into five levels: no risk, low risk, moderate risk, high risk, and very high risk. The project used the annual DRI data from 2017 to 2024 (8 years) to evaluate focal areas of drought risk. The identified drought-risk areas were integrated with land degradation data based on LDN indicators to propose targeted areas and land and water development strategies in drought-prone regions.

9. Land Degradation Assessment Using LDN Indicators with Geographic Information System

The national land degradation assessment for the project was carried out using LDN indicators for the baseline year 2009 and the reporting year 2023. The assessment results from the three indicators — Land Cover Change (LCC), Net Primary Productivity (NPP), and Soil Organic Carbon Stock (SOC Stock) — were analyzed together by overlaying the data from all three indicators. The national land degradation status was then assessed using the One-out, All-out principle (as shown in **Figure 4**). The trend analysis of land degradation or the land degradation status as of 2023 covered all 77 provinces of Thailand (using the administrative boundaries of provinces from the Ministry of Interior, 2012, as the operational area). The assessment followed the LDN indicator evaluation method as outlined in the Land Development Department's updated January 2024 guidelines for formulating land degradation management measures at the local level (Land Development Department, 2024a), in conjunction with the Good Practice Guidance for SDG Indicator 15.3.1 from the UNCCD (Sims et al., 2021). The methodology was adjusted to better suit Thailand's context, including

modifications to the assessment of land productivity and soil organic carbon stock indicators. The steps for assessing land degradation using the LDN indicators are as follows:

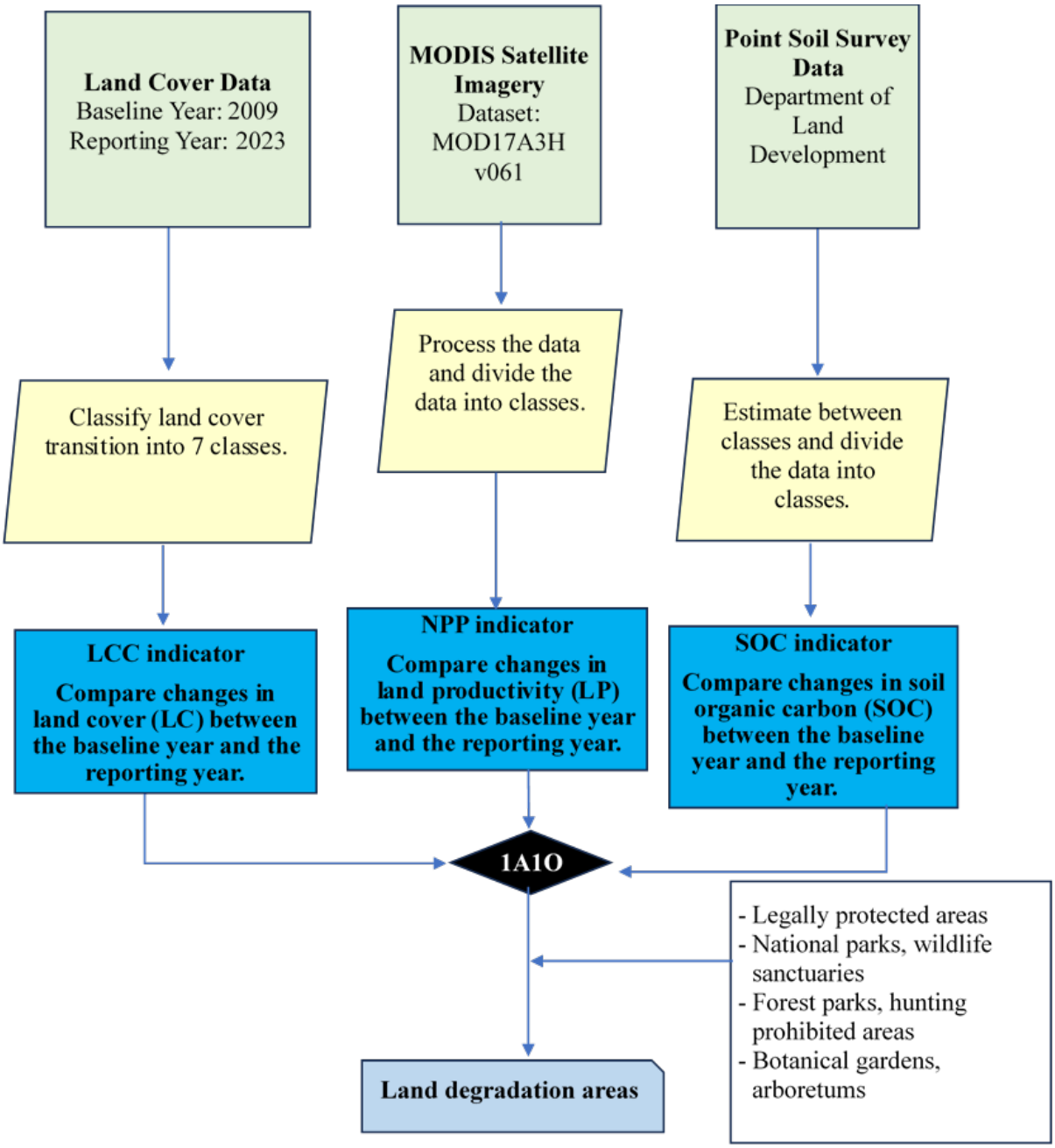


Figure 4. Steps for assessing land degradation

1) Assessment of Land Cover Change (LCC) Indicator: The land cover classification was grouped into seven (7) classes based on the guidelines for land degradation indicator analysis and land-use change, as outlined in the updated January 2024 manual from the Land Development Department's Land Use Planning Division (Land Development Department, 2024b), and the Good Practice Guidance SDG Indicator 15.3.1 from the UNCCD

(1) Forest Land (all types of forests, including forest plantations)
(2) Grasslands and Scrublands
(3) Cropland
(4) Wetlands (wetlands, peat swamp forests, mangrove forests, and coastal wetlands)
(5) Artificial areas/Settlements
(6) Other Areas (open land of various types such as rocky land, landslides, and old mining sites, old excavation pits)
(7) Water bodies (natural water sources, human-made water sources, seas, aquaculture areas, salt fields)

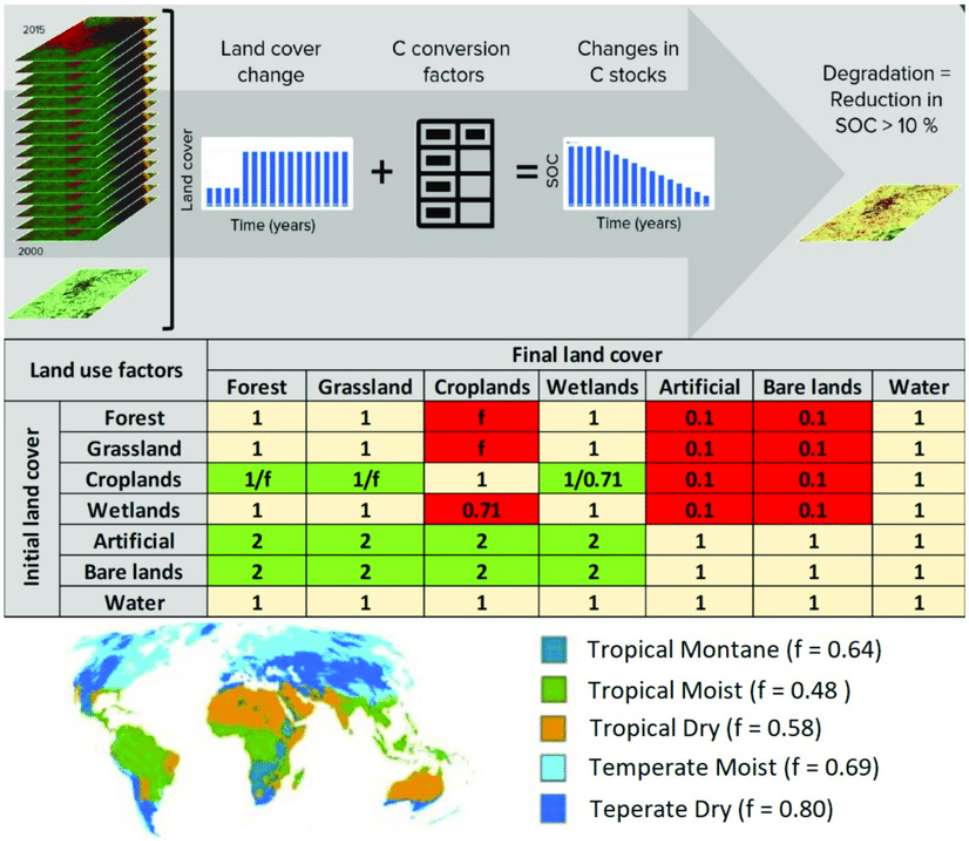
2) Assessment of Land Productivity (LP) Indicator: This indicator studies land productivity indirectly by using annual Net Primary Production (NPP) data. The NPP average for the baseline year (2009) is calculated by using the average NPP from 2007 to 2009, and the NPP for the reporting year (2023) is calculated using the average NPP from 2021 to 2023. This approach ensures that the NPP values are suitable, taking into account the annual rainfall and the effect of El Niño and La Niña phenomena. The data is then geometrically corrected, transformed into a geographic coordinate system, and divided into seven (7) classes to compare NPP values across two periods using GIS overlap techniques.

3) Assessment of Soil Organic Carbon Stock (SOC Stock) Indicator: This indicator assesses the amount of soil organic carbon stock using baseline data from 2009 gathered from the Land Development Department's soil survey. It also evaluates soil organic carbon stock indirectly by applying the Trend Earth method to study changes in soil organic carbon in relation to land cover change. The data for soil organic carbon stock in 2009 was collected through point-based surveys. These data are spatially analyzed to estimate areas without data, with 72, 603 points surveyed. The carbon stock values ranged from 0.03 to 27.14 tons of carbon per Rai. The data is classified into 7 categories, and the carbon stock status is assessed indirectly for the years 2009 to 2023 using Trends Earth plugins in QGIS, as shown in **Figure 5.**

(4) Land Degradation Assessment: Land degradation is assessed using the LDN indicator based on the One-out, All-out principle as follows:

(1) If at least one indicator shows a decrease (-), it is categorized as degraded land.
(2) If all three indicators show no change, it is categorized as stable land.
(3) If there is no decrease in any indicator but at least one indicator shows an increase (+) [not falling under categories (1) or (2)], it is categorized as improved land.

The three indicators are analyzed using GIS tools. Protected forest areas, such as national parks, wildlife sanctuaries, forest parks, and non-hunting areas, according to the laws of the Department of National Parks, Wildlife and Plant Conservation, and the Department of Forestry, are excluded from the data. These areas will not undergo land degradation assessment.



Land use factors		Final land cover						
		Forest	Grassland	Croplands	Wetlands	Artificial	Bare lands	Water
Initial land cover	Forest	1	1	f	1	0.1	0.1	1
	Grassland	1	1	f	1	0.1	0.1	1
	Croplands	1/f	1/f	1	1/0.71	0.1	0.1	1
	Wetlands	1	1	0.71	1	0.1	0.1	1
	Artificial	2	2	2	2	1	1	1
	Bare lands	2	2	2	2	1	1	1
	Water	1	1	1	1	1	1	1

Note: Thailand uses f=0.48
Source: Alamanos, A., & Linnane, S. (2021)

Figure 5. The principle of assessment and determination of the change in soil organic carbon stock in the Trends.Earth plugin of the QGIS program

In addition, the SOC dataset from the pilot development of the analysis and assessment of soil organic carbon data in the Northeastern region using the Forest-based model and multiple regression equation, or from the SOC Prediction Model, will be used for further assessment in the Northeastern region to evaluate the change in land status level using the soil organic carbon stock indicator in the years 2009 and 2023. It will also assess land degradation status using the LDN indicators (LCC, LP, and SOC) in the Northeastern region (19 provinces excluding Loei). Furthermore, it aims to compare the results of land degradation status assessment using the LDN indicators in the Northeastern region during 2009–2023 between using the SOC indicator data from the SOC Prediction Model and from the Trends.Earth plugin in the QGIS program.

10. Results of the assessment of the change in land status levels for each LDN indicator during 2009–2023 using Geographic Information System (GIS)

10.1 Land Cover Change (LCC)

The assessment results of land status change based on the land cover indicator during the years 2009 and 2023 classify land use into seven (7) classes, as shown in **Figure 6**. It was found that in 2023, Thailand had 6,443,119.91 hectares of land with a degraded status, which accounted for 12.45% of the country's total area. There were 1,426,293.79 hectares of land with an improved status, or 2.75%, 33,247,954.08 hectares with a stable status, or 64.23%, and 10,648,683.23 hectares of conserved land, or 20.57%. When classified by region, it was found that the Northeastern region had the highest negative or degraded land status change, with a total area of 2,109,862.50 hectares, or 4.08% of the country's total area. The following regions are: Northern region (1,757,211 hectares, or 3.39%), Southern region (1,059,947.36 hectares, or 2.05%), Eastern region (797,361.94 hectares, or 1.54%) and the Central region (718,737.11 hectares, or 1.39%), respectively.

10.2 Land Productivity Change (LP)

The results of the assessment of land status changes using the land productivity indicator during 2009 and 2023 are shown in **Figure 7**. It was found that in 2023, 3,985,376.73 hectares of land, or 7.70% of the country's total area, had degraded status. There were 2,958,866.63 hectares of land, or 5.72%, with an improved status; 32,203,639.91 hectares, or 62.21%, with a stable status; and 1,969,484.51 hectares, or 3.80%, with no data (N/A), as well as 10,648,683.23 hectares of conserved land, or 20.57%. When classified by region, it was found that the Northern region had the most negative or degraded land productivity status change, with a total area of 1,803,358.25 hectares, or 3.48% of the country's total area. The following regions are: Southern region (1,131,445.53 hectares, or 2.19%), Central region (415,169.02 hectares, or 0.80%), Northeastern region (350,944.1 hectares, or 0.68%), and Eastern region (284,459.83 hectares, or 0.55%).

10.3 Soil Organic Carbon (SOC) Stock Change

The results of the assessment of land status changes using the soil organic carbon stock indicator during 2009 and 2023 are shown in **Figure 8**. It was found that in 2023, 517,465.47 hectares of land, or 1.00%, had a degraded status. There were 282,571.45 hectares of land, or 0.55%, with an improved status, 39,706,331.88 hectares, or 76.70%, with a stable status, 610,998.98 hectares, or 1.18%, with no data (N/A), and 10,648,683.23 hectares of conserved land, or 20.57%. When classified by region, it was found that the Central region had the most negative or degraded soil organic carbon stock change, with a total area of 181,453.18 hectares, or 0.35% of the country's total area. The following regions are: Northern region (136,112.97 hectares, or 0.26%), Northeastern region (96,864.87 hectares, or 0.19%), Eastern region (55,315.18 hectares, or 0.11%), and Southern region (47,719.27 hectares, or 0.09%), respectively.

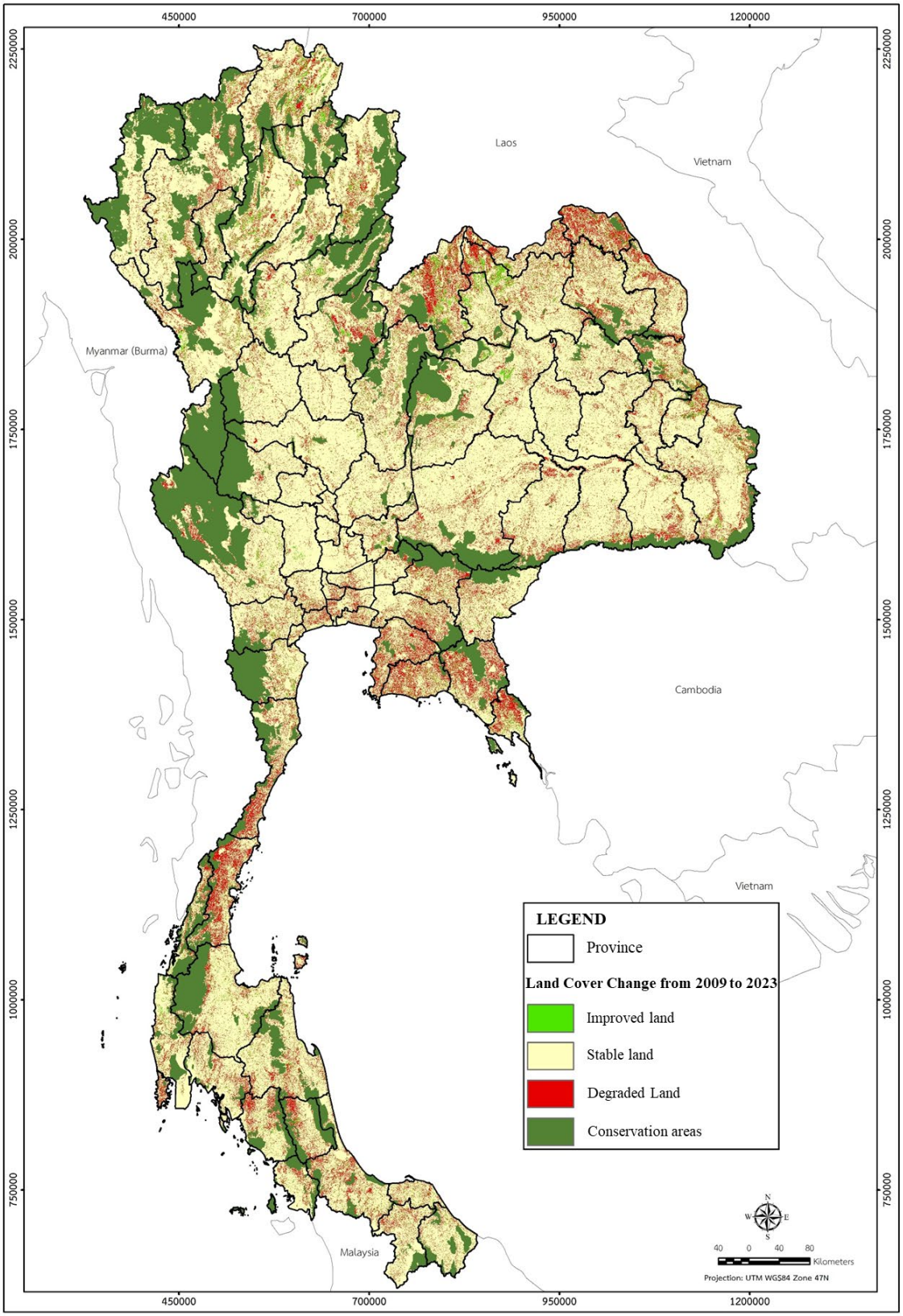


Figure 6. Map of land status changes based on land cover indicator from 2009 to 2023

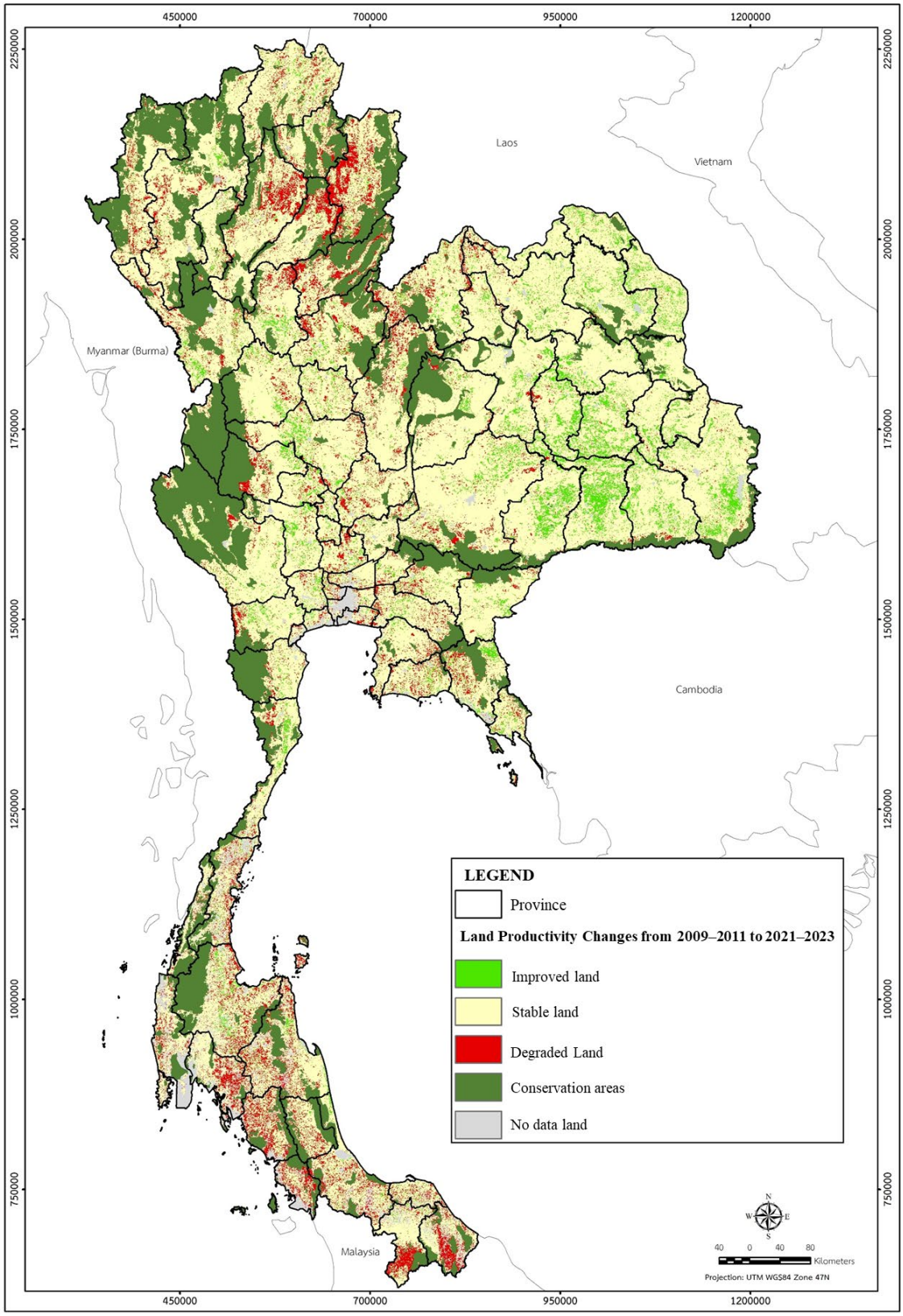


Figure 7. Map of land status changes based on land productivity indicator from 2009 to 2023

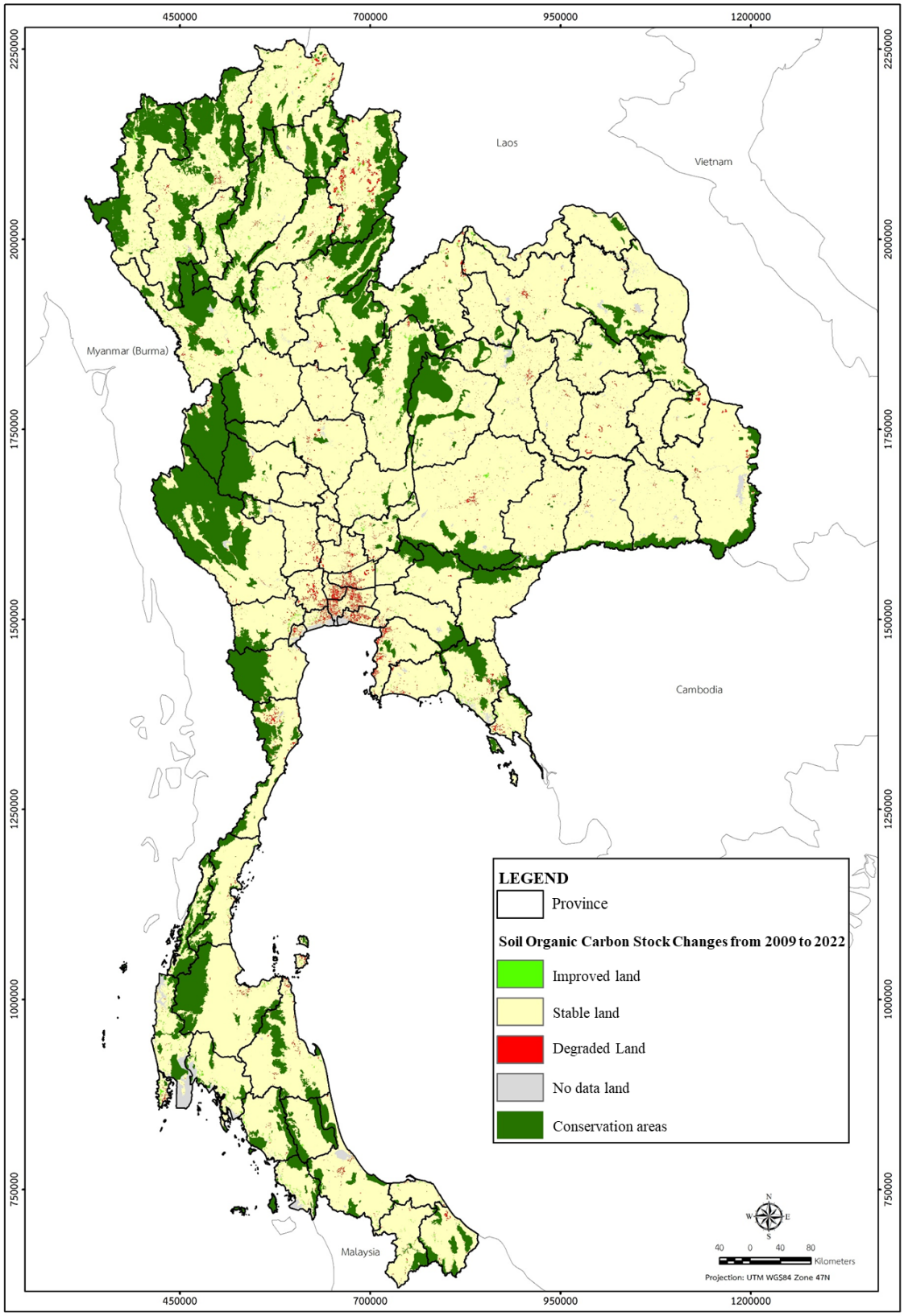


Figure 8. Map of land status changes based on soil Organic carbon stock indicator (2009 to 2022) from Trends.Earth Plugins

11. Results of Land Degradation Status Assessment for the Entire Country Using Three LDN Indicators Based on the One-Out, All-Out (1OAO) Principle

Thailand's land degradation status assessment results using the three LDN indicators for 2009 and 2023. (**Table 2** and **Figure 9**) show that in 2023, had 9,569,578.73 hectares, or 18.49% of the country's total land area, in a degraded status (with a low degradation level of 8,716,011.43 hectares or 16.84%, moderate degradation of 831,701.80 hectares or 1.61%, and severe degradation of 21,865.50 hectares or 0.04%). The land in improved status accounted for 3,815,419.15 hectares or 7.37%. Land in a stable condition accounted for 25,588,928.39 hectares or 49.43%. Furthermore, land with no data (N/A) covered 2,143,441.51 hectares or 4.14%, and conserved areas accounted for 10,648,683.23 hectares or 20.57% (**Figure 10**). When considered by region, the Northern region experienced the most negative change in land degradation status, with a total area of 3,342,735.25 hectares or 6.46% of the country's total area. Followed by the Northeastern region (2,359,757.63 hectares or 4.56%), the Southern region (1,800,790.80 hectares or 3.48%), the Central region (1,082,023.02 hectares or 2.09%), and the Eastern region (984,272.03 hectares or 1.90%) respectively. **Table 3** shows the changes in the land degradation status by province and the assessment results of land degradation levels based on LDN indicators from 2009 to 2023, which are classified by land type as illustrated in **Table 4.**

11.1 Results of Land Degradation Status Assessment by Land Type

The results of the land degradation status assessment for the entire country, categorized by the seven (7) classes, using the three LDN indicators for 2009 and 2023, summarize the degradation status and improvement status as follows;

Land Degradation Status			Land Improvement Status		
Land Type	**Area (hectares)**	**%**	**Land Type**	**Area (hectares)**	**%**
1. Forest lands	6,077,689.95	11.74	1. Croplands	2,047,001.71	3.95
2. Croplands	2,746,587.18	5.31	2. Grasslands	1,085,700.59	2.10
3. Grasslands	419,443.57	0.81	3. Forest lands	448,008.59	0.87
4. Wetlands	164,700.85	0.32	4. Water bodies	104,286.27	0.20
5. Artificial areas/ Settlements	62,241.94	0.12	5. Other lands	100,765.82	0.19
6. Other lands	49,990.87	0.10	6. Wetlands	21,880.08	0.04
7. Water bodies	48,924.37	0.09	7. Artificial areas/ Settlements	7,776.09	0.02
Total	**9,569,578.73**	**18.49**	**Total**	**3,815,419.15**	**7.37**

Table 2. Summary of land degradation status based on Thailand's land degradation neutrality (LDN) indicators for 2009 and 2023

Summary of Land Degradation Status	Land Area Changes from 2009 to 2023 Based on LDN Indicators (Reported in hectares and as a percentage of the total national land area)					National Total
	Central Region	Eastern Region	Northeastern Region	Northern Region	Southern Region	
Total Degraded Land	1,082,023.02 2.09	984,272.03 1.90	2,359,757.63 4.56	3,342,735.25 6.46	1,800,790.80 3.48	9,569,578.73 18.49
Low-Level Degraded Land	(986,320.42) (1.91)	(865,585.31) (1.67)	(2,248,157.88) (4.34)	(3,040,017.03) (5.87)	(1,575,930.79) (3.05)	(8,716,011.43) (16.84)
Moderately Degraded Land	(88,845.59) (0.17)	(115,071.51) (0.23)	(110,156.87) (0.21)	(294,951.40) (0.57)	(222,676.43) (0.43)	(831,701.80) (1.61)
Highly Degraded Land	(6,857.01) (0.013)	(3,615.21) (0.007)	(1,442.88) (0.003)	(7,766.82) (0.015)	(2,183.58) (0.004)	(21,865.50) (0.04)
Improved Land	383,030.46 0.74	230,407.98 0.45	1,940,057.03 3.74	983,661.53 1.9	278,262.15 0.54	3,815,419.15 7.37
Stable Land	3,402,781.75 6.57	1,539,927.11 2.97	9,610,698.93 18.57	8,536,259.60 16.49	2,499,261.00 4.83	25,588,928.39 49.43
No Data Land (N/A)	351,369.80 0.68	133,205.61 0.25	361,213.66 0.70	174,630.19 0.34	1,123,022.25 2.17	2,143,441.51 4.14
Conservation Areas	1,744,703.88 3.37	560,205.85 1.08	1,450,071.00 2.80	5,210,934.02 10.07	1,682,768.48 3.25	10,648,683.23 20.57
National Total	**6,963,908.91** **13.45**	**3,448,018.58** **6.65**	**15,721,798.25** **30.37**	**18,248,220.59** **35.26**	**7,384,104.68** **14.27**	**51,766,051.01** **100.00**
No Net Loss Calculation	-698,992.56 -1.35	-753,864.05 -1.45	-419,700.60 -0.82	-2,359,073.72 -4.56	-1,522,528.65 -2.94	-5,754,159.58 -11.12

Note: The red strip indicates areas of land that have degraded.
Green strip indicates areas of land that have improved.
Yellow strip indicates areas of land with no change (stable).
The land area values in the last row of the table (no net loss calculation) are absolute values.

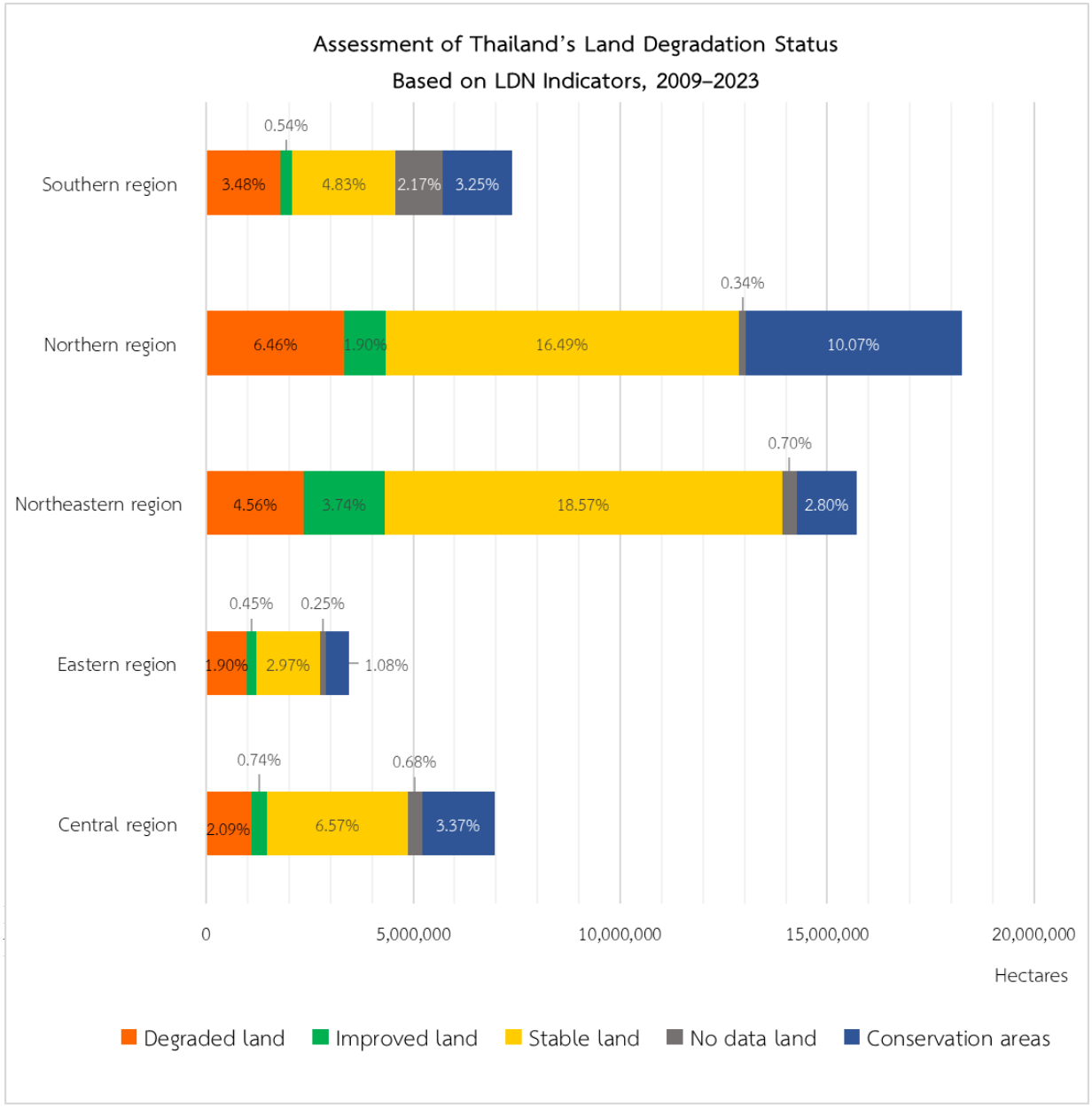


Figure 9. Graph showing the assessment results of Thailand's land degradation status based on LDN indicators from 2009 to 2023

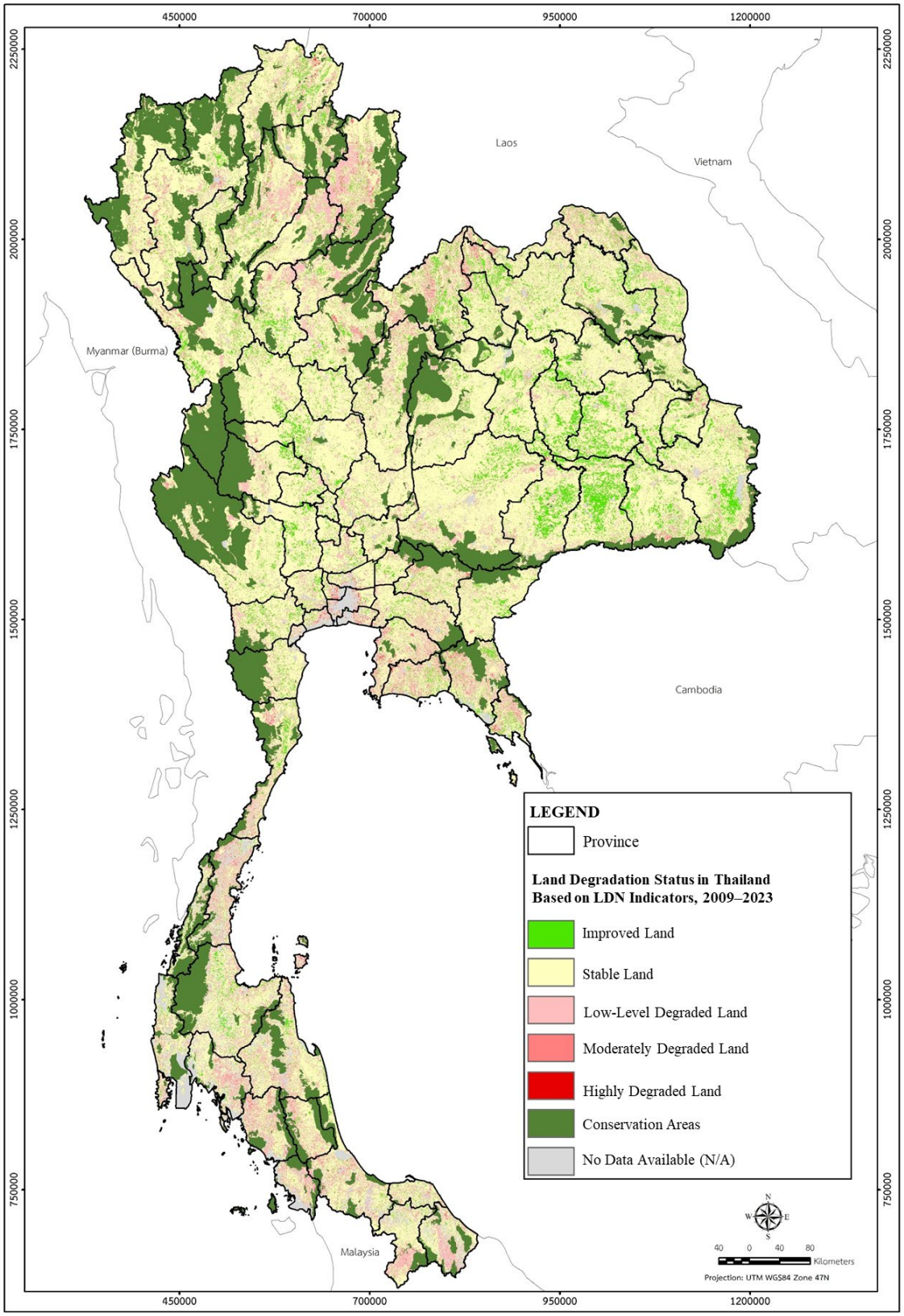


Figure 10. Map of land degradation status assessment results in Thailand based on land degradation neutrality (LDN) indicators from 2009 to 2023

Table 3. Assessment results of Thailand's land degradation status base on LDN indicators from 2009to 2023, categorized by province within each region and prioritized by the size of degraded land area

Region and Province	Total Land Area (in Hectares)	Severity Levels of Land Degradation (in Hectares)			Total Area of Degraded Land Status During 2009–2023	
		Low	Moderate	High	Hectares	Percentage
1. Central Region	**6,963,908.91**	**986,320.42**	**88,845.59**	**6,857.01**	**1,082,023.02**	**2.09**
Kanchanaburi	1,938,803.42	150,094.03	8,052.57	105.03	158,251.63	0.31
Prachuap Khiri Khan	641,320.26	145,801.93	15,462.54	778.41	162,042.88	0.31
Lopburi	650,272.93	107,584.77	5,101.11	94.14	112,780.02	0.22
Ratchaburi	519,004.75	103,188.26	3,436.02	117.18	106,741.47	0.21
Saraburi	348,823.25	67,339.28	5,477.40	184.95	73,001.63	0.14
Phetchaburi	617,191.62	69,605.48	4,474.08	118.44	74,198.00	0.14
Phra Nakhon Si Ayutthaya	254,742.27	51,835.51	3,921.30	274.86	56,031.67	0.11
Nakhon Pathom	214,231.73	45,612.64	4,513.86	245.34	50,371.84	0.10
Suphan Buri	540,672.16	45,514.54	1,618.83	20.07	47,153.44	0.09
Chai Nat	250,719.54	36,462.07	1,277.64	26.55	37,766.26	0.07
Bangkok	156,796.51	20,523.33	8,713.17	1,358.46	30,594.97	0.06
Pathum Thani	152,117.32	26,407.72	5,499.99	629.28	32,536.99	0.06
Nakhon Nayok	214,098.80	31,325.86	2,092.86	2.61	33,421.33	0.06
Samut Prakan	96,713.93	20,884.15	6,646.77	737.91	28,268.83	0.05
Samut Sakhon	86,649.23	17,927.55	4,769.73	690.03	23,387.32	0.05
Nonthaburi	63,640.01	12,855.60	5,581.62	1,333.08	19,770.30	0.04
Ang Thong	95,045.51	11,764.62	692.37	61.83	12,518.82	0.02
Sing Buri	81,726.59	12,052.35	315.36	3.51	12,371.22	0.02
Samut Songkhram	41,339.08	9,540.72	1,198.35	75.33	10,814.40	0.02
2. Eastern Region	**3,448,018.58**	**865,585.31**	**115,071.51**	**3,615.21**	**984,272.03**	**1.90**
Chanthaburi	641,483.43	175,745.11	25,456.24	326.16	201,527.51	0.39
Chonburi	450,775.28	147,259.48	26,091.82	1,573.29	174,924.58	0.34
Rayong	366,530.94	130,158.21	23,573.98	853.56	154,585.75	0.30
Chachoengsao	516,983.97	129,334.98	13,839.30	169.65	143,343.93	0.28
Prachin Buri	502,533.03	102,767.60	10,419.84	108.27	113,295.72	0.22
Sa Kaeo	683,134.45	98,089.85	3,951.72	36.72	102,078.29	0.20
Trat	286,577.44	82,230.05	11,738.61	547.56	94,516.22	0.18

Table 3. Assessment results of Thailand's land degradation status base on LDN indicators from 2009to 2023, categorized by province within each region and prioritized by the size of degraded land area (Continued-1)

Region and Province	Total Land Area (in Hectares)	Severity Levels of Land Degradation (in Hectares)			Total Area of Degraded Land Status During 2009–2023	
		Low	Moderate	High	Hectares	Percentage
3. Northeastern Region	**15,721,798.25**	**2,248,157.88**	**110,156.87**	**1,442.88**	**2,359,757.63**	**4.56**
Nakhon Ratchasima	2,073,510.68	261,763.26	17,774.46	155.25	279,692.98	0.54
Udon Thani	1,107,191.88	214,465.64	16,372.08	406.26	231,243.99	0.45
Ubon Ratchathani	1,562,725.01	200,814.62	11,432.79	184.59	212,432.00	0.41
Sakon Nakhon	957,976.70	172,927.48	3,817.62	2.88	176,747.98	0.34
Bueng Kan	400,172.77	159,325.69	2,525.40	0.00	161,851.09	0.31
Chaiyaphum	1,269,938.02	139,670.58	6,622.20	54.27	146,347.06	0.28
Buri Ram	1,007,934.72	128,917.56	6,195.33	39.06	135,151.95	0.26
Nakhon Phanom	563,490.32	119,454.60	2,705.31	0.99	122,160.90	0.24
Khon Kaen	1,065,959.09	115,546.08	5,368.14	85.59	120,999.81	0.23
Si Sa Ket	893,509.78	104,663.82	7,793.10	49.41	112,506.33	0.22
Nong Khai	327,600.62	94,260.62	7,943.22	14.49	102,218.33	0.20
Surin	885,436.14	92,452.88	4,816.98	14.31	97,284.17	0.19
Roi Et	787,251.70	75,718.28	2,611.98	8.46	78,338.72	0.15
Kalasin	693,631.16	75,614.33	1,634.49	5.22	77,254.04	0.15
Mukdahan	412,615.09	73,123.40	1,003.77	12.87	74,140.04	0.14
Nong Bua Lam Phu	409,930.57	63,032.42	3,656.52	3.51	66,692.45	0.13
Yasothon	412,940.08	56,763.37	2,362.14	0.00	59,125.51	0.11
Amnat Charoen	329,203.16	46,540.45	3,654.54	378.54	50,573.53	0.10
Maha Sarakham	560,780.78	53,102.80	1,866.78	27.18	54,996.76	0.11
4. Northern Region	**18,248,220.59**	**3,040,017.03**	**294,951.40**	**7,766.82**	**3,342,735.25**	**6.46**
Nan	1,216,303.67	324,701.36	42,847.93	2,887.47	370,436.76	0.72
Loei	1,050,017.65	307,653.28	38,380.51	513.54	346,547.33	0.67
Chiang Mai	2,204,112.86	273,832.54	23,360.41	726.84	297,919.78	0.58
Lampang	1,248,823.83	272,268.97	24,428.89	236.34	296,934.19	0.57
Chiang Rai	1,157,755.42	239,116.92	25,787.80	1,260.54	266,165.25	0.51
Phetchabun	1,233,974.46	230,807.67	20,810.17	243.45	251,861.28	0.49
Phitsanulok	1,059,565.67	185,536.30	19,426.86	223.29	205,186.46	0.40
Tak	1,730,388.03	163,914.52	22,536.82	688.23	187,139.57	0.36
Phrae	648,316.42	168,910.33	10,061.64	246.33	179,218.30	0.35
Uttaradit	787,239.37	152,432.59	12,464.28	88.02	164,984.89	0.32

Table 3. Assessment results of Thailand's land degradation status base on LDN indicators from 2009to 2023, categorized by province within each region and prioritized by the size of degraded land area (Continued-2)

Region and Province	Total Land Area (in Hectares)	Severity Levels of Land Degradation (in Hectares)			Total Area of Degraded Land Status During 2009–2023	
		Low	Moderate	High	Hectares	Percentage
4. Northern Region (cont'd)						
Mae Hong Son	1,278,061.06	116,379.12	10,975.68	75.96	127,430.76	0.25
Sukhothai	666,451.06	111,510.93	9,256.68	67.23	120,834.84	0.23
Nakhon Sawan	952,574.99	108,442.92	7,392.51	120.42	115,955.85	0.22
Phayao	618,781.29	95,631.95	13,075.02	97.56	108,804.54	0.21
Kamphaeng Phet	851,208.51	89,676.11	3,778.56	118.71	93,573.38	0.18
Uthai Thani	664,901.44	79,804.46	3,736.98	51.75	83,593.19	0.16
Lamphun	447,841.01	67,678.22	4,774.68	93.42	72,546.32	0.14
Phichit	431,903.89	51,718.87	1,855.98	27.72	53,602.57	0.10
5. Southern Region	**7,384,104.68**	**1,575,930.79**	**222,676.43**	**2,183.58**	**1,800,790.80**	**3.48**
Nakhon Si Thammarat	988,091.61	219,996.32	28,677.25	318.33	248,991.90	0.48
Surat Thani	1,307,971.31	216,926.78	19,691.46	523.98	237,142.23	0.46
Songkhla	774,146.80	169,880.89	29,354.05	306.81	199,541.75	0.39
Chumphon	599,621.72	160,137.94	26,679.70	184.14	187,001.78	0.36
Trang	473,012.21	132,437.10	26,037.55	148.32	158,622.97	0.31
Krabi	532,325.20	125,041.17	21,412.63	36.18	146,489.98	0.28
Yala	447,500.54	124,774.05	9,783.09	139.95	134,697.09	0.26
Narathiwat	449,123.87	110,699.04	11,622.42	216.36	122,537.82	0.24
Phatthalung	386,058.60	80,600.06	15,866.64	2.88	96,469.58	0.19
Satun	302,019.91	66,088.46	11,549.52	126.18	77,764.16	0.15
Phangnga	549,361.66	66,314.27	8,212.59	22.86	74,549.72	0.14
Pattani	197,679.02	49,657.78	6,276.24	44.19	55,978.21	0.11
Ranong	322,505.18	37,387.27	3,852.27	5.76	41,245.30	0.08
Phuket	54,687.07	15,989.67	3,661.02	107.64	19,758.33	0.04
National Total	**51,766,051.01**	**8,716,011.43**	**831,701.80**	**21,865.50**	**9,569,578.73**	**18.49**

Note: * Regional divisions are based on the provinces under the jurisdiction of Land Development Regional Offices 1–12

Table 4. Assessment results of land degradation levels base on LDN indicators from 2009 to 2023, classified by land type

Land Type	Assessment Results of Land Degradation Levels Based on LDN Indicators, 2009–2023 (in Hectares)					Total National Land Area (ha)
	Central Region	Eastern Region	Northeastern Region	Northern Region	Southern Region	
1. Forest Lands						
- Degraded land	460,166.78 0.89	593,710.08 1.15	1,666,267.69 3.22	2,569,888.97 4.96	787,656.43 1.52	6,077,689.95 11.74
● Low level	423,944.83 (0.82)	515,915.50 (1.00)	1,587,295.10 (3.06)	2,315,751.05 (4.47)	624,842.16 (1.21)	5,467,748.64 (10.56)
● Moderate level	35,077.60 (0.07)	76,785.86 (0.15)	77,906.36 (0.15)	247,590.06 (0.48)	161,858.02 (0.31)	599,217.90 (1.16)
● High level	1,144.35 (0.002)	1,008.72 (0.002)	1,066.23 (0.002)	6,547.86 (0.01)	956.25 (0.002)	10,723.41 (0.02)
- Improved land	54,252.37 0.10	28,683.37 0.06	111,480.87 0.22	236,950.71 0.46	16,641.27 0.03	448,008.59 0.87
- Stable land	780,617.62 1.51	353,385.80 0.68	1,669,614.61 3.23	4,691,605.73 9.06	355,144.77 0.69	7,850,368.53 15.17
- No data land	27,705.43 0.05	24,289.11 0.05	44,499.34 0.09	36,892.09 0.07	238,258.86 0.46	371,644.83 0.72
- Conservation areas	1,620,342.66 3.13	535,652.68 1.04	1,315,972.94 2.54	5,058,479.93 9.77	1,166,989.33 2.25	9,697,437.54 18.73
2. Grasslands						
- Degraded land	26,950.06 0.05	35,496.37 0.07	103,367.00 0.20	144,452.38 0.28	109,177.76 0.21	419,443.57 0.81
● Low level	23,183.38 (0.05)	31,898.35 (0.06)	93,200.06 (0.18)	130,279.44 (0.25)	104,633.12 (0.20)	383,194.35 (0.74)
● Moderate level	3,354.48 (0.01)	3,339.00 (0.01)	10,040.67 (0.02)	13,656.33 (0.02)	4,399.29 (0.01)	34,789.77 (0.07)
● High level	412.20 (0.001)	259.02 (0.0005)	126.27 (0.0002)	516.60 (0.001)	145.35 (0.0003)	1,459.44 (0.003)
- Improved land	66,093.76 0.13	75,485.00 0.15	400,418.02 0.77	430,683.13 0.83	113,020.68 0.22	1,085,700.59 2.10
- Stable land	77,568.95 0.15	85,624.85 0.17	244,707.18 0.47	270,741.04 0.52	133,755.60 0.26	812,397.62 1.57
- No data land	24,096.33 0.04	11,119.14 0.02	34,906.60 0.07	29,869.39 0.06	71,726.87 0.14	171,718.33 0.33
- Conservation areas	13,744.62 0.03	10,535.22 0.02	17,417.71 0.03	37,717.93 0.07	122,541.78 0.24	201,957.26 0.39

Table 4. Assessment results of land degradation levels base on LDN indicators from 2009 to 2023, classified by land type (Continued-1)

Land Type	Assessment Results of Land Degradation Levels Based on LDN Indicators, 2009–2023 (in Hectares)					Total National Land Area (ha)
	Central Region	Eastern Region	Northeastern Region	Northern Region	Southern Region	
3. Croplands						
- Degraded land	499,348.83 0.96	297,166.30 0.57	525,702.55 1.02	587,842.52 1.14	836,526.98 1.62	2,746,587.18 5.31
● Low level	457,098.86 (0.88)	268,492.57 (0.52)	507,132.84 (0.98)	557,739.31 (1.08)	783,549.01 (1.51)	2,574,012.59 (4.97)
● Moderate level	37,733.86 (0.07)	26,930.98 (0.05)	18,391.59 (0.04)	29,512.90 (0.06)	52,097.95 (0.10)	164,667.28 (0.32)
● High level	4,516.11 (0.01)	1,742.76 (0.003)	178.11 (0.0003)	590.31 (0.001)	880.02 (0.002)	7,907.31 (0.02)
- Improved land	207,111.02 0.40	84,192.77 0.16	1,351,888.97 2.61	291,042.88 0.56	112,766.07 0.22	2,047,001.71 3.95
- Stable land	2,388,538.30 4.61	990,432.24 1.91	7,573,949.66 14.63	3,514,740.42 6.79	1,860,695.19 3.59	16,328,355.81 31.53
- No data land	105,192.39 0.20	18,160.20 0.04	90,199.91 0.18	57,890.08 0.11	446,844.53 0.86	718,287.11 1.39
- Conservation areas	25,580.08 0.05	11,200.41 0.02	68,107.79 0.13	66,064.60 0.13	131,703.69 0.25	302,656.57 0.58
4. Wetlands						
- Degraded land	36,903.97 0.07	22,850.38 0.04	34,724.53 0.07	18,576.81 0.04	51,645.16 0.10	164,709.85 0.32
● Low level	30,830.59 (0.06)	20,737.09 (0.04)	32,911.30 (0.06)	16,753.14 (0.03)	49,024.72 (0.10)	150,256.84 (0.29)
● Moderate level	5,652.45 (0.01)	2,076.12 (0.004)	1,782.90 (0.003)	1,787.49 (0.003)	2,534.85 (0.005)	13,833.81 (0.03)
● High level	420.93 (0.0008)	37.17 (0.0001)	30.33 (0.0001)	36.18 (0.0001)	85.59 (0.0002)	610.20 (0.001)
- Improved land	2,927.07 0.005	6,119.91 0.01	2,259.09 0.004	582.39 0.001	9,991.62 0.02	21,880.08 0.04
- Stable land	25,876.18 0.05	32,453.83 0.06	9,665.10 0.02	6,131.07 0.01	116,088.51 0.23	190,214.69 0.37
- No data land	20,421.36 0.04	20,788.30 0.04	23,783.68 0.05	5,116.05 0.01	133,032.18 0.25	203,141.57 0.39
- Conservation areas	6,522.21 0.01	262.26 0.0005	5,409.45 0.01	5,955.21 0.01	85,348.28 0.17	103,497.41 0.20

Table 4. Assessment results of land degradation levels base on LDN indicators from 2009 to 2023, classified by land type (Continued-2)

Land Type	Assessment Results of Land Degradation Levels Based on LDN Indicators, 2009–2023 (in Hectares)					Total National Land Area (ha)
	Central Region	Eastern Region	Northeastern Region	Northern Region	Southern Region	
5. Artificial areas/Settlements						
- Degraded land	21,999.25 0.04	7,407.36 0.02	17,441.46 0.03	12,055.41 0.02	3,338.46 0.01	62,241.94 0.12
● Low level	18,983.35 (0.04)	6,720.93 (0.01)	17,143.74 (0.03)	10,979.01 (0.02)	3,079.80 (0.01)	56,906.83 (0.11)
● Moderate level	3,011.31 (0.01)	684.99 (0.001)	297.18 (0.001)	1,076.31 (0.002)	257.85 (0.0005)	5,327.64 (0.01)
● High level	4.59 (0.000009)	1.44 (0.000003)	0.54 (0.000001)	0.09 (0.0000002)	0.81 (0.000001)	7.47 (0.00001)
- Improved land	1,445.49 0.003	355.50 0.001	4,933.62 0.01	915.03 0.002	126.45 0.0002	7,776.09 0.02
- Stable land	20,469.87 0.04	6,922.35 0.01	42,653.44 0.08	23,031.19 0.05	5,932.35 0.01	99,009.20 0.19
- No data land	74,883.98 0.15	5,363.10 0.01	14,497.03 0.03	11,622.87 0.02	7,189.02 0.01	113,556.00 0.22
- Conservation areas	11.07 0.00002	3.78 0.00001	185.40 0.0004	136.44 0.0002	84.69 0.0002	421.38 0.0008
6. Other lands						
- Degraded land	11,977.56 0.02	16,107.58 0.03	8,044.92 0.02	6,529.32 0.01	7,331.49 0.02	49,990.87 0.10
● Low level	8,690.22 (0.02)	10,442.62 (0.02)	6,378.66 (0.01)	5,214.33 (0.01)	5,921.73 (0.01)	36,647.56 (0.07)
● Moderate level	2,980.26 (0.005)	5,109.12 (0.01)	1,627.83 (0.003)	1,240.83 (0.002)	1,299.51 (0.003)	12,257.55 (0.02)
● High level	307.08 (0.001)	555.84 (0.001)	38.43 (0.0001)	74.16 (0.0001)	110.25 (0.0002)	1,085.76 (0.002)
- Improved land	23,311.00 0.04	15,201.63 0.03	38,282.23 0.07	13,585.59 0.03	10,385.37 0.02	100,765.82 0.19
- Stable land	8,104.59 0.015	4,256.74 0.01	7,602.93 0.01	4,782.96 0.01	2,832.93 0.005	27,580.15 0.05
- No data land	6,973.92 0.014	4,896.28 0.01	6,541.11 0.01	2,075.13 0.004	5,333.67 0.01	25,820.11 0.048
- Conservation areas	267.75 0.001	135.18 0.0003	4,647.33 0.009	766.35 0.001	1,331.10 0.003	7,147.71 0.01

Table 4. Assessment results of land degradation levels base on LDN indicators from 2009 to 2023, classified by land type (Continued-3)

Land Type	Assessment Results of Land Degradation Levels Based on LDN Indicators, 2009–2023 (in Hectares)					Total National Land Area (ha)
	Central Region	Eastern Region	Northeastern Region	Northern Region	Southern Region	
7. Water Bodies						
- Degraded land	24,676.57 0.05	11,533.95 0.02	4,209.48 0.008	3,389.85 0.007	5,114.52 0.01	48,924.37 0.095
● Low level	23,589.19 (0.045)	11,378.25 (0.02)	4,096.17 (0.01)	3,300.75 (0.006)	4,880.25 (0.01)	47,244.61 (0.09)
● Moderate level	1,035.63 (0.002)	145.44 (0.0003)	110.34 (0.0002)	87.48 (0.0002)	228.96 (0.0004)	1,607.85 (0.003)
● High level	51.75 (0.0001)	10.26 (0.00002)	2.97 (0.00001)	1.62 (0.000003)	5.31 (0.00001)	71.91 (0.0001)
- Improved land	27,889.75 0.05	20,369.80 0.04	30,794.23 0.06	9,901.80 0.02	15,330.69 0.03	104,286.27 0.20
- Stable land	101,606.24 0.20	66,851.30 0.13	62,506.01 0.12	25,227.19 0.05	24,811.65 0.05	281,002.39 0.55
- No data land	92,096.39 0.18	48,589.48 0.09	146,785.99 0.28	31,164.58 0.06	220,637.12 0.43	539,273.56 1.04
- Conservation areas	78,235.49 0.15	2,416.32 0.005	38,330.38 0.07	41,813.56 0.08	174,769.60 0.34	335,565.35 0.65
All Types						
- Degraded land	1,082,023.02 2.09	984,272.03 1.90	2,359,757.63 4.56	3,342,735.25 6.46	1,800,790.80 3.48	9,569,578.73 18.49
● Low level	986,320.42 (1.91)	865,585.31 (1.67)	2,248,157.88 (4.34)	3,040,017.03 (5.87)	1,575,930.79 (3.05)	8,716,011.43 (16.84)
● Moderate level	88,845.59 (0.17)	115,071.51 (0.23)	110,156.87 (0.21)	294,951.40 (0.57)	222,676.43 (0.43)	831,701.80 (1.61)
● High level	6,857.01 (0.013)	3,615.21 (0.007)	1,442.88 (0.003)	7,766.82 (0.015)	2,183.58 (0.004)	21,865.50 (0.04)
- Improved land	383,030.46 0.74	230,407.98 0.45	1,940,057.03 3.74	983,661.53 1.90	278,262.15 0.54	3,815,419.15 7.37
- Stable land	3,402,781.75 6.57	1,539,927.11 2.97	9,610,698.93 18.57	8,536,259.60 16.49	2,499,261.00 4.83	25,588,928.39 49.43
- No data land	351,369.80 0.68	133,205.61 0.25	361,213.66 0.70	174,630.19 0.34	1,123,022.25 2.17	2,143,441.51 4.14
- Conservation areas	1,744,703.88 3.37	560,205.85 1.08	1,450,071.00 2.80	5,210,934.02 10.07	1,682,768.48 3.25	10,648,683.23 20.57
Total (hectares) **Percentage**	**6,963,908.91** **13.45**	**3,448,018.58** **6.65**	**15,721,798.25** **30.37**	**18,248,220.59** **35.26**	**7,384,104.68** **14.27**	**51,766,051.01** **100.00**

11.2 Summary of Land Degradation Status Assessment Based on LDN Indicators

The assessment results of the land degradation status in Thailand, using the indicators of LDN, include three indicators: Land Cover Change (LCC), Land Productivity (LP), and Soil Organic Carbon (SOC Stock). The summary of the degradation and improvement status is as follows:

Land Degradation Status			Land Improvement Status		
Indicator	**Area (hectares)**	**Percentage**	**Indicator**	**Area (hectares)**	**Percentage**
Land Cover Change (LCC)	6,443,119.91	12.45	Land Productivity (LP)	2,958,866.63	5.72
Land Productivity (LP)	3,985,376.73	7.70	Land Cover Change (LCC)	1,426,293.79	2.76
Soil Organic Carbon (SOC Stock)	517,465.47	1.00	Soil Organic Carbon (SOC Stock)	282,571.45	0.55
Total *	**9,569,578.73**	**18.49**	**Total ***	**3,815,419.15**	**7.37**

Note: ** Total degraded and improved land areas were determined using the "One Out, All Out" principle, as applied to the LDN indicators.*

11.3 Summary of Land Degradation Status Assessment Using LDN Indicators in Conservation Areas

An additional assessment in conservation areas (conservation areas according to the legal regulations of the Department of National Parks, Wildlife and Plant Conservation, and the Department of Forestry such as national parks, wildlife sanctuaries, forest parks, and non-hunting areas) with a total area of 10,648,683.23 hectares, or 20.57% of the entire country, found that the conservation areas had 2,532,871.15 hectares of land degradation, or 23.79% of the total conservation area (with low severity level covering 2,460,049.34 hectares, or 23.10%; moderate severity level covering 71,101.64 hectares or 0.67%; and high severity level covering 1,720.17 hectares, or 0.02% of the conservation area). There were 286,412.29 hectares, or 2.69%, of the land that had improved, and 7,303,324.28 hectares, or 68.58%, of the land remained stable. Additionally, 526,075.51 hectares, or 4.94%, of the conservation area had no data (N/A). When considering by region, it was found that the Northern region had the most significant negative change in land degradation status, with a total area of 1,259,219.20 hectares, or 11.83% of the conservation area. This was followed by the Southern region (484,487.85 hectares, or 4.55% of the conservation area), the Northeastern region (346,850 hectares, or 3.25% of the conservation area), the Central region (265,138.89 hectares, or 2.50% of the conservation area), and the Eastern region (177,175.21 hectares, or 1.66% of the conservation area), respectively.

12. Changes in Soil Organic Carbon (SOC) Stock from the SOC Prediction Model Data for the Northeastern region

The assessment of the changes in land status based on the Soil Organic Carbon (SOC) Stock indicator between 2009 and 2023, using data from the SOC Prediction Model for the Northeastern region, with a total area of 16,771,815.89 hectares (20 provinces including Loei), revealed that in 2023, there was a land degradation status of 1,755,883.95 hectares, or 10.47% of the total area in the Northeastern region (**Figure 11**). The findings are summarized as follows

- Land degradation change: 1,755,883.95 hectares, or 10.47%
- Improvement in land status: 6,173,979.17 hectares, or 36.81%
- No change in status (Stable): 8,507,280.85 hectares, or 50.72%
- Areas with no data (N/A): 334,671.92 hectares, or 2.00%

The evaluation of land degradation status using the LDN indicators (LCC, LP, and SOC) based on the SOC Prediction Model between 2009 and 2023 for the Northeastern region (19 provinces excluding Loei), with a total area of 15,721,798.24 hectares (**Figures 12**), found that

- Land degradation change: 3,853,304.76 hectares, or 24.51%, with low severity of 3,420,917.84 hectares (21.76%), moderate severity of 422,682.49 hectares (2.69%), and high severity of 9,704.43 hectares (0.06%)
- Improvement in land status: 5,821,913.21 hectares, or 37.03%
- No change in status (Stable): 5,538,908.6 hectares, or 35.23%
- Areas with no data (N/A): 507,671.67 hectares, or 3.23%

When comparing the land degradation assessment result based on LDN indicators for the Northeastern region between 2009 and 2023 using data from the SOC Prediction Model and Trends.Earth, it was found that the SOC Prediction Model showed 24.51% degradation, while the Trends.Earth showed 17.22% degradation.

13. Results of Land Degradation Assessment Based on Soil Moisture Data

The calculation of drought risk areas from the Drought Risk Index (DRI) by analyzing the frequency of recurrence and grouping the data based on recurrence frequency into two groups: 1) areas affected by drought in at least 1–3 out of 8 years, and 2) areas affected by drought in at least 4 out of 8 years. The analysis revealed that Thailand has areas with high and very high drought risk, covering 14,709,093.6 hectares, or 28.41% of the country (**Figure 13**). The Northeastern region has the most area at risk of drought (6,871,428.48 hectares, or 13.27%), followed by the Northern region (4,438,377.53 hectares, or 8.57%), the Central region (1,678,635.58 hectares, or 3.24%), the Eastern region (1,277,894.02 hectares, or 2.47%), and the Southern region (442,757.99 hectares, or 0.86%), respectively.

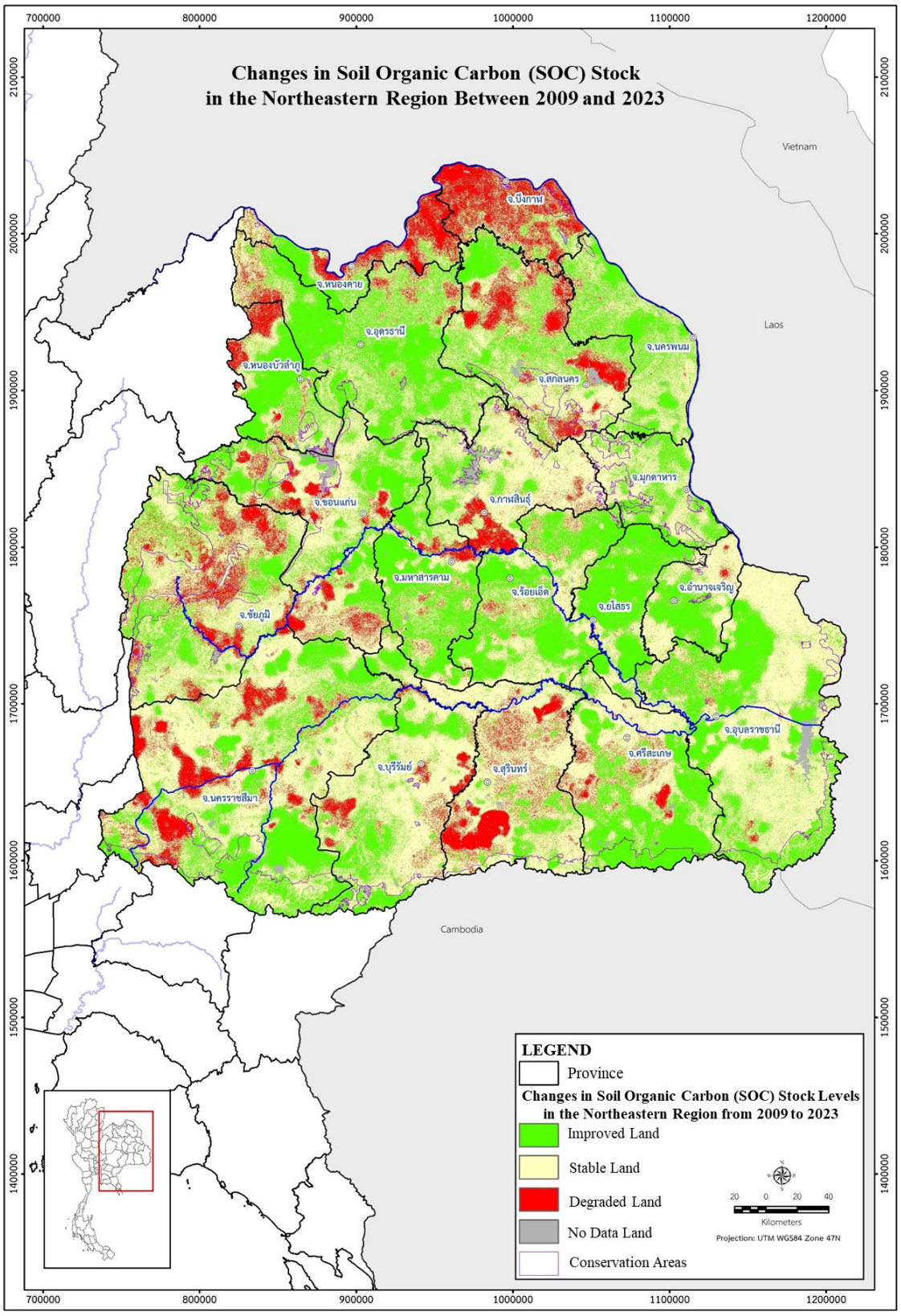


Figure 11. Map of changes in land status using the soil organic carbon (SOC) stock indicator from the SOC prediction model data for the Northeastern region between 2009 and 2023

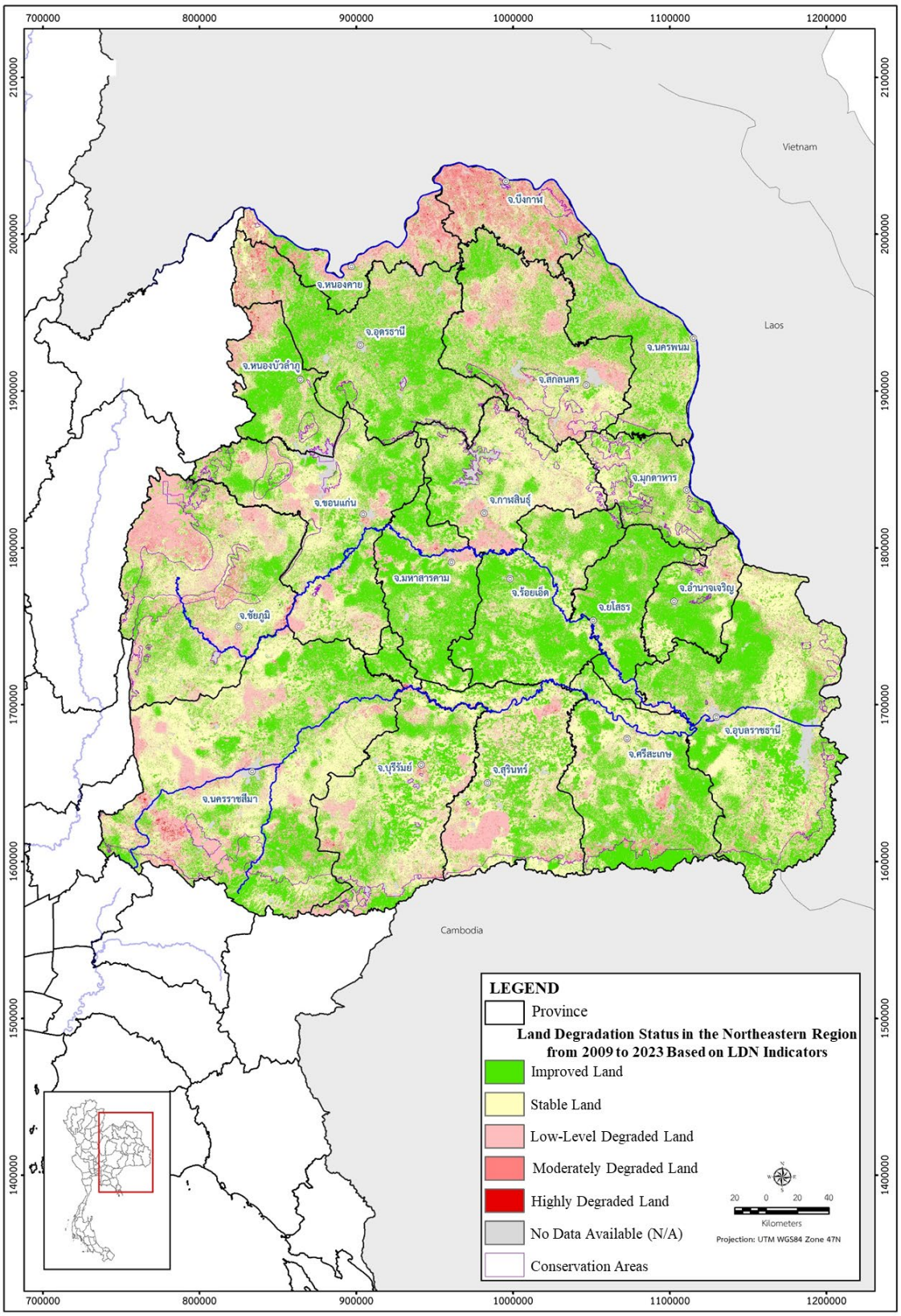


Figure 12. Assessment results of land degradation status using the LDN indicators (SOC data from the SOC prediction model) for the Northeastern region between 2009 and 2023

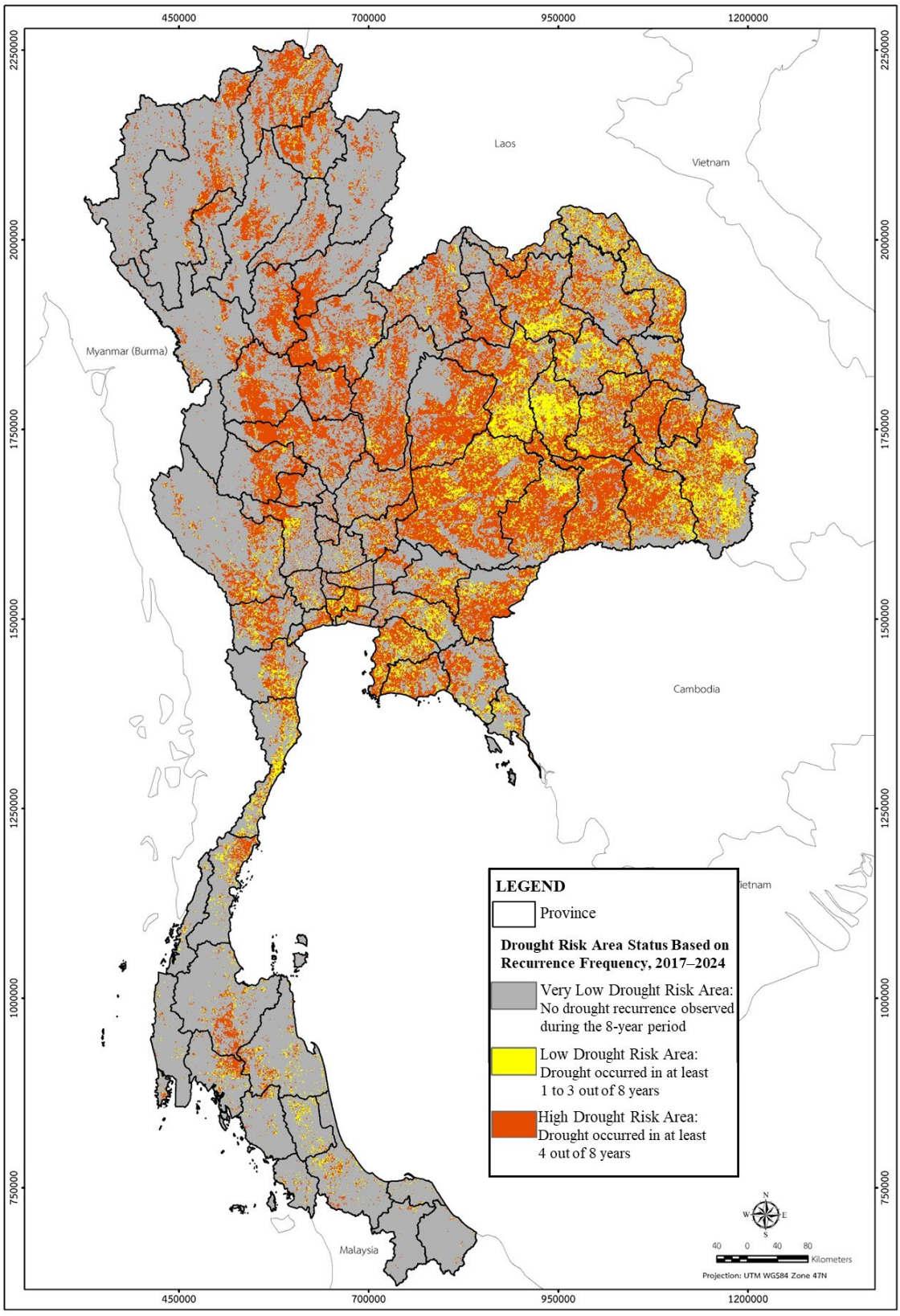


Figure 13. Focal areas of drought risk from 2017 to 2024, grouped by recurrence frequency

14. Results of Prioritization Using Economic Model Analysis

The prioritization analysis using an economic model (Prioritization Analysis by Economic Model Analysis) is conducted for planning and policy decision-making. The project considers selecting an economic model to analyze prioritization (Prioritization Analysis) for use in planning and policy decision-making, based on the analytical framework shown in **Figure 14.**

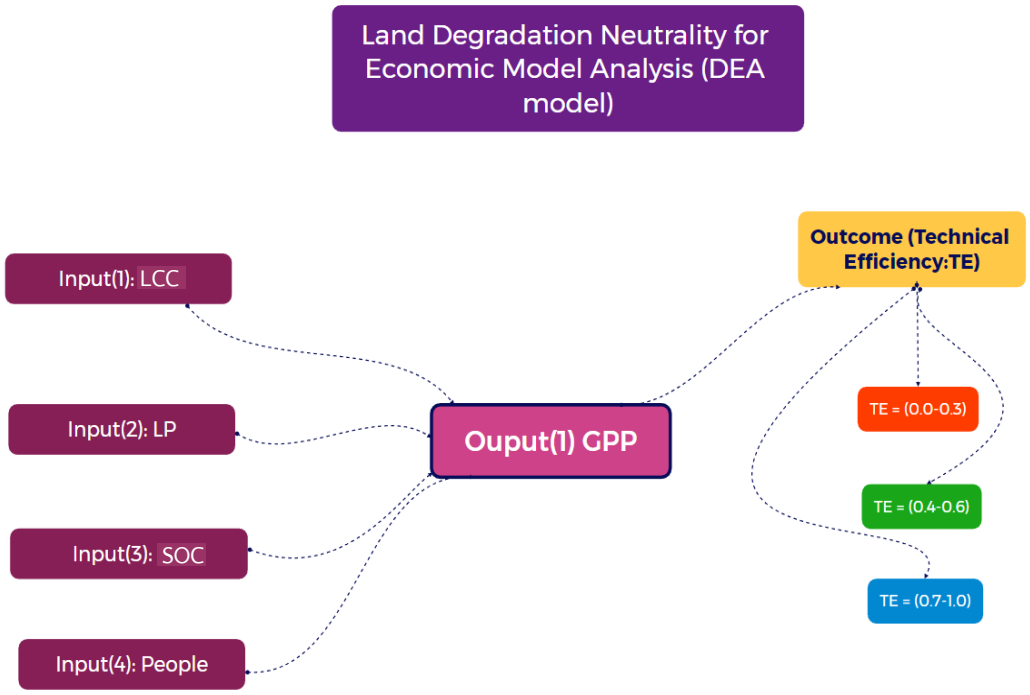


Figure 14. Analytical framework for assessing the technical efficiency of land degradation neutrality for policy formulation

Based on the analytical framework for measuring technical efficiency according to the economic concept of LDN (Land Degradation Neutrality) for prioritizing effective policies with a focus on economic benefits, the process begins by considering four input factors: 1) the LCC factor of each province, 2) the LP factor of each province, 3) the SOC factor of each province, and 4) the population factor of each province studied. For the output factor, there is only one: The Gross Province Product (GPP) of each province analyzed. The data from both input and output factors were analyzed using an economic model. In this study, the Data Envelopment Analysis (DEA) model was used to measure technical efficiency (TE) based on the economic concept. This DEA model can be represented in Model (1) and Model (2).

The Constant Returns to Scale Model (CRS)

$$\text{Min} \quad \theta$$

subject to :

$$-Y_{j0} + \sum_{k=1}^{n} Y_{jk}\lambda_k \geq 0 \quad j = 1,...s$$

$$\theta X_{j0} - \sum_{k=1}^{n} X_{ik}\lambda_k \geq 0, \quad i = 1,...,r$$

$$\lambda_k \geq 0 \quad \forall k$$

In the CRS model, Yj0 represents the output factor, which includes the Gross Province Product (GPP) of each province, and Xj0 represents the input factors used in production, consisting of four input factors: 1) the LCC factor, 2) the LP factor, 3) the SOC factor, and 4) the population factor (People) of each province under study.

The Variable Returns to Scale Model (VRS)

$$\text{Min} \quad \theta$$

subject to:

$$-Y_{j0} + \sum_{k=1}^{n} Y_{jk}\lambda_k \geq 0 \quad j = 1,...s$$

$$\theta X_{j0} - \sum_{k=1}^{n} X_{ik}\lambda_k \geq 0, \quad i = 1,...,r$$

$$\sum_{k=1}^{n} \lambda_k = 1$$

$$\lambda_k \geq 0 \quad \forall k$$

In the VRS model, Yj0 represents the output factor, which includes the Gross Province Product (GPP) of each province, and Xj0 represents the input factors used in production, consisting of four input factors: 1) the LCC factor, 2) the LP factor, 3) the SOC factor, and 4) the population factor (People) of each province under study. Both the CRS model and the VRS model are used to measure the technical efficiency of each province. The technical efficiency can be categorized into three levels: low (TE = 0.0 - 0.39), medium (TE = 0.40 - 0.69), and high (TE = 0.70 - 1.00). For prioritizing policies with a focus on economic benefits, policy actions will first be implemented in provinces with the lowest technical efficiency, followed by provinces with medium and high efficiency levels.

The efficient use of land will lead to the development and sustainable economic growth of the province. However, if land resources are used inefficiently, it will result in the province not having sustainable development and economic growth. Therefore, it is essential to use the DEA model to effectively rank the balance between economic growth and land use. Policies for land development that align with sustainable economic development must be implemented first in regions and provinces with low efficiency. Once the land use efficiency of provinces or regions with low efficiency is improved, sustainable economic development based on sustainable land development will contribute to the overall development and sustainable growth of the economy in Thailand.

Therefore, this study ranks the efficiency of land use that affects the economy at the regional and provincial levels by using Technical Efficiency or TE Score to measure efficiency and prioritize the implementation of land development policies in Thailand.

14.1 Regional Efficiency Ranking Results

The results of the regional efficiency ranking, using the DEA economic model analysis to measure Technical Efficiency (TE Score) for ranking purposes, show that the region with the lowest efficiency, or the region that requires immediate intervention, is the Eastern region, with a TE Score of 0.221. The following regions in the ranking are the Central, Southern, Northeastern, and Northern regions, respectively (**Table 5**). Therefore, policies for land development aligned with sustainable economic development must first focus on developing the regions with the lowest efficiency.

Table 5. Comparison of TE score efficiency ranking in each region

Regions	TE score	Ranking
Eastern Region	0.221	1
Central Region	0.388	2
Southern Region	0.509	3
Northeastern Region	0.548	4
Northern Region	0.570	5

14.2 Results of Ranking Efficiency at the Provincial Level

When the data from each province in each region are used to rank the efficiency at the provincial level of that region, the ranking of priority at the provincial level is divided into 5 regions: Central, Eastern, Northeastern, Northern, and Southern. The results show the ranking of technical efficiency values or TE Scores, separated by region and listed by province, based on the Economic Model Analysis (DEA), as shown in **Table 6.**

Table 6. Comparison of TE score rankings by region and province

Region	Output-Orientated DEA model TE score	Ranking TE Score (from low to high)
Central Region		
Ratchaburi	0.001	1
Saraburi	0.001	2
Nakhon Pathom	0.002	3
Phra Nakhon Si Ayutthaya	0.006	4
Samut Sakhon	0.010	5
Nonthaburi	0.046	6
Pathum Thani	0.069	7
Samut Prakan	0.116	8
Bangkok	0.194	9
Sing Buri	0.465	10
Samut Songkhram	0.530	11
Prachuap Khiri Khan	0.542	12
Chai Nat	0.638	13
Nakhon Nayok	0.654	14
Phetchaburi	0.709	15
Kanchanaburi	0.740	16
Ang Thong	0.787	17
Lopburi	0.869	18
Suphan Buri	1.000	19
Eastern Region		
Prachinburi	0.003	1
Rayong	0.007	2
Chanthaburi	0.007	3
Chachoengsao	0.043	4
Chonburi	0.162	5
Sa Kaeo	0.322	6
Trat	1.000	7
Northeastern Region		
Nakhon Ratchasima	0.023	1
Khon Kaen	0.023	2
Ubon Ratchathani	0.039	3
Mukdahan	0.208	4
Yasothon	0.238	5
Nakhon Phanom	0.348	6
Bueng Kan	0.406	7
Amnat Charoen	0.43	8
Nong Bua Lamphu	0.468	9
Maha Sarakham	0.6	10
Sakon Nakhon	0.656	11
Nong Khai	0.688	12

Table 6. Comparison of TE score rankings by region and province (continued)

Region	Output-Orientated DEA model TE score	Ranking TE Score (from low to high)
Surin	0.715	13
Kalasin	0.723	14
Roi Et	0.851	15
Si Sa Ket	0.998	16
Buriram	1	17
Chaiyaphum	1	18
Udon Thani	1	19
Northern Region		
Chiang Mai	0.023	1
Nan	0.182	2
Mae Hong Son	0.203	3
Phrae	0.286	4
Phayao	0.359	5
Tak	0.374	6
Lampang	0.405	7
Phichit	0.431	8
Uthai Thani	0.466	9
Phetchabun	0.53	10
Sukhothai	0.645	11
Phitsanulok	0.675	12
Lamphun	0.748	13
Uttaradit	0.931	14
Loei	1	15
Chiang Rai	1	16
Nakhon Sawan	1	17
Kamphaeng Phet	1	18
Southern Region		
Phuket	0.001	1
Nakhon Si Thammarat	0.023	2
Surat Thani	0.023	3
Songkhla	0.023	4
Phatthalung	0.284	5
Ranong	0.397	6
Yala	0.493	7
Satun	0.504	8
Narathiwat	0.543	9
Krabi	0.830	10
Phang Nga	1.000	11
Chumphon	1.000	12
Trang	1.000	13
Pattani	1.000	14

14.3 Results of Performance Ranking at the Regional and Provincial Levels Using GPP Agricultural Sector Data

The prioritization based on the economic model using DEA (Economic Model Analysis) in Sections 14.1 and 14.2 has defined the Output variable as the Gross Provincial Product (GPP) for the province (covering all production sectors). An additional analysis was carried out by setting the Output variable to be specifically the GPP in the agricultural sector. This involved using the GPP in the agricultural sector of each province to analyze and rank the performance at both the regional and provincial levels.

The results of the performance ranking at the regional level using the DEA model to analyze the Technical Efficiency (TE Score) or TE Score for land use affecting the economy at the regional level, with the Output variable being the agricultural sector's GPP data, showed that the region with the lowest efficiency, or the first region requiring action, was the Central region (TE Score = 0.263). Following this were the rankings of the Central, Northeastern, Northern, Eastern, and Southern regions, respectively (**Table 7**). Therefore, the land development policy that aligns with sustainable economic development must prioritize the regions with the lowest efficiency first.

When using the GPP in the agricultural sector data as the Output economic variable for each province, the performance ranking results at the provincial level changed accordingly, just as it did at the regional level.

Table 7. Comparison of TE score rankings using GPP agricultural sector data by region

Region	TE score	Ranking
Central Region	0.263	1
Northeastern Region	0.345	2
Northern Region	0.352	3
Eastern Region	0.494	4
Southern Region	0.534	5

15. Framework for LDN Implementation in the Context of Thailand

The review of policies and plans at various levels, both internationally and in the context of Thailand, related to LDN in driving it into practice aims to counterbalance land degradation neutrality and to define existing frameworks that support LDN implementation and leverage LDN across different land types. Special attention is given to cropland and forest land (including grassland and wetland). This aligns with providing information for monitoring and evaluation activities with various agencies beyond the Land Development Department, which is responsible for driving the plan into practice toward achieving Thailand's LDN goals. The operational approach for LDN implementation across different land types in various relevant agencies is summarized as follows.

1) Sustainable Land Management (mainly forest lands and croplands): When considering the LDN goals at the local level in Thailand, land management for achieving land degradation neutrality focuses on two main types: forest land and cropland (including grasslands and wetlands). The forest areas focus on increasing green areas to boost the proportion of forests, including natural forests, economic forests for utility, and green spaces in urban and rural areas. Agricultural areas emphasize sustainable land management, reducing the proportion of land utilized inappropriately based on its potential and soil capacity and increasing the proportion of rehabilitated or improved for productive use. Additionally, attention is given to reducing carbon loss in the soil and increasing carbon storage in forest land and cropland types. This should align with the UNFCCC and CBD conventions.

The policy and planning for land and soil resource management in Thailand is primarily governed by the Office of the National Land Policy Board (ONLB), which operates under the Prime Minister's Office. The Board has developed a 15-year long-term plan (2023 – 2037) and a 5-year action plan (2023 – 2027) for all land types regarding conservation and sustainable use to ensure long-term land use and soil resource sustainability.

2) Forest Lands: Thailand has developed a long-term plan to increase green spaces, as outlined in the National Strategy for 20 years under the environmental-friendly quality-of-life growth agenda. The plan focuses on maintaining and expanding green spaces, halting deforestation, managing areas at risk of encroachment, promoting the restoration of degraded natural forest ecosystems, conserving legally protected forest areas, maintaining upstream forest areas on steep slopes, and promoting green space in urban areas. Furthermore, it aims to define community rights for utilizing forests and encourages reforestation, the planting of economic forests, and the development of industries based on plantation forests. This aligns with the LDN goal for target area 1. The long-term policies and plans at level 2 and level 3 focus on the conservation, restoration, and utilization of forest land, aiming to increase the proportion of forest land in the country to 50% by 2037.

The review of policies and long-term plans in Level 2 plans and Level 3 action plans of relevant agencies set the goal of increasing green spaces in the area as natural forests by 33%, economic forest areas for utilization by 12% (total forest area of 45%), and green spaces in urban and rural areas, including urban and community forests, by 3%. The goal is to achieve carbon neutrality in the forestry and land-use sectors by reducing greenhouse gas emissions and maintaining biodiversity. The conservation, restoration, and utilization of land are divided into the following.

(1) **Conservation** – especially conservation forest areas and restoration of watershed forests on steep areas, including mangrove forests and coastal forests (natural forest areas as conservation forests are 25%, managed by the Department of National Parks, Wildlife and Plant Conservation).

(2) **Utilization** – focusing on land management, promoting the development of economic forests community forests, managing forest areas along boundaries, enacting regulations that promote public participation in land management decisions, preserving and utilizing ecosystems, reducing encroachment on state land, and ensuring fair land distribution to increase the country's land ownership balance (decreasing the proportion of landless or landless farmers, increasing income levels, and improving satisfaction of land recipients).

The management of forest areas must include public participation and engagement from all sectors, reducing carbon loss in soil and increasing carbon sequestration in soil through soil and water conservation measures, controlling forest fires, and conserving and enhancing biodiversity. Three main agencies under the Ministry of Natural Resources and Environment are responsible: the Department of Royal Forest, the Department of National Parks, Wildlife and Plant Conservation (protected forests), the Department of Marine and Coastal Resources (mangrove and coastal forests), and agencies related to land utilization such as the Forest Industry Organization, the state land administration agencies, and the Ministry of Interior (local administrative organizations, Bangkok, Department of Local Administration).

3) Croplands: According to the national strategy, the development in line with the Sufficiency Economy Philosophy (SEP) is incorporated into the Vision of Thailand 2037, aiming to develop towards using technology and innovation to create value, develop mechanisms to drive a new economy, and enhance competitive potential to raise income and distribute benefits across sectors. The Ministry of Agriculture and Cooperatives has formulated long-term plans for land, soil, and water resource management to increase production, raise income, and ensure food security while also developing agricultural ecosystems through sustainable and balanced resource management, particularly land management and the rehabilitation of degraded land, which aligns with the LDN goal of target area 2.

Thus, the key LDN target areas under current policies and plans include promoting agriculture according to SEP principles, sustainable land management, organic farming, integrated farming, land-use change in unsuitable areas (Zoning by Agri-Map), promoting the reduction of crop residue burning, adapting agricultural systems to climate change, integrating local wisdom at the community level, supporting learning processes, and managing land resources to balance land use, improve soil productivity, and develop strategies and action plans for the rehabilitation of degraded land. The primary responsible agencies include the Ministry of Agriculture and Cooperatives (Permanent Secretary Office, Land Development Department, Office of Agricultural Economics, Department of Agricultural Extension, Department of Agricultural Science, Land Reform Office, Rice Department, Royal Rainmaking and Agricultural Aviation Department, Department of Sericulture).

When considering approaches to improving and rehabilitating degraded soils in line with sustainable agriculture practices, Thailand's approach to addressing land degradation issues under the LDN concept includes key principles aimed at achieving neutrality.

(1) Reducing Degraded Land through Sustainable Land Management (SLM) involves minimizing anticipated future degradation (anticipated future losses), reducing the proportion of land used appropriately relative to its soil potential and capability, improving productivity, and enhancing the ability to adapt to climate change. Managing and restoring land based on its production potential, whether high or low potential and specific areas. Ensuring the benefit of land sustainably use by reducing the land for planting unsuitable crops. In the Thailand context, this approach encompasses agriculture safety (Good Agricultural Practices (GAP)), bio-agriculture, smart agriculture, and agricultural ecosystems, including organic farming guided by the philosophy of the Sufficiency Economy and sustainable agriculture, sustainable use of natural resources and building farmers' capacity to adapt to climate.

(2) Reversing Degraded Land by restoration and rehabilitation to reverse degraded land to better quality (proposed future gains) involves increasing the proportion of land that has been restored or developed for productive use, which is a focal area of land degradation from the assessment of land degradation status by LDN indicators, including an area of high soil erosion or a high drought risk area. The management of soil rehabilitation and degraded land restoration in the cropland can be integrated into the UNCCD strategic plan to drive LDN into practice, contributing to disaster risk reduction related to climate change, such as drought or floods. These efforts also align with the objectives of the UNFCCC and CBD conventions in the agricultural sector.

The Land Development Department has set performance indicators under its operational plans for 2023-2030, aiming for the balanced and sustainable land development of at least 2.4 million hectares and reducing unsuitable agricultural land by 10%. Moreover, the Department plays a key role in conserving and restoring land and soil resources in croplands by increasing the efficiency of water management, including:

(3) Water management for cropland reduces carbon loss in soil and increases soil carbon storage in forest and agricultural areas, particularly in sloping and floodplain agricultural areas. Measures for soil and water conservation, including mechanical and vegetative methods and corrective and appropriate soil management techniques, are used. These efforts should align with the UNFCCC and CBD conventions for reducing greenhouse gas emissions and conserving biodiversity, as well as promoting the reduction of crop residue burning, controlling forest fires, and managing agricultural waste. Developing national databases on soil productivity and organic carbon content in soils is also critical.

Essential elements to support the planning and implementation of LDN involve creating an enabling environment, particularly regarding policies, plans, and assessments to gather necessary data. Achieving the target of LDN requires collaboration among land degradation prevention, reduction, and restoration.

4) Water bodies: In Thailand, water-related areas are linked to forest and agricultural landscapes. Forest lands include conserving headwater sources, restoring degraded forests to full-functioning forests, and water management for environmental purposes. In agricultural areas, efforts focus on developing water resources to improve land productivity, ensure food security, enhance incomes, and provide water management during crises. Adaptation strategies are crucial for mitigating the impacts of climate change, particularly, floods and droughts, including establishing monitoring of these impacts. Integrating disaster risk reduction into local

development planning is essential to reduce mortality rates and the number of individuals affected by natural hazards. The leading agencies responsible are the National Water Resources Office, the Ministry of Agriculture and Cooperatives (Office of the Permanent Secretary, Department of Irrigation), the Ministry of Natural Resources and Environment (Department of Water Resources, Department of Groundwater Resources), and the Ministry of Interior (Department of Disaster Prevention and Mitigation).

5) Artificial areas/Settlements: Thailand's land use planning aligns with town planning regulations, promoting local/community participation in protecting, maintaining, and benefiting from ecosystems. The goal is to increase the proportion of green areas in both urban and rural areas, develop eco-friendly cities, and meet the World Health Organization's green space standard (9 square meters per person). Model cities are developed based on eco-geological principles, and industrial cities follow ecological industrial standards. Mining establishments and basic industries are certified for Corporate Social Responsibility in Mining (CSR-DPIM) and Green Mining. The main agencies responsible include the Prime Minister's Office (the Office of the National Land Policy Board: ONLB) and the Ministry of Natural Resources and Environment (Royal Forest Department, Office of Natural Resources and Environmental Policy and Planning, and the Department of Climate Change and Environment).

6) Wetlands: Thailand has established regulations for the control and conservation of wetlands. The primary responsible agency is the Ministry of Natural Resources and Environment (Office of Natural Resources and Environmental Policy and Planning, and the Department of Water Resources).

7) Grasslands and Other lands: In Thailand, management focuses on ensuring appropriate use in accordance with the national land use plan. It aims to reduce land that is unsuitable for use and/or land used for purposes inconsistent with its intended use. The amount of abandoned land in the country is also being reduced. Land use must align with urban planning regulations. The main responsible agency is the Prime Minister's Office (Office of the National Land Policy Board).

16. Guidelines for Capacity Building in Land Degradation Management Based on Project Findings

16.1 Analysis of the Study Results and Recommendations

1) Overview of the Study Results on the Trends of Land Resource Degradation.

The assessment of land degradation status for the years 2009 and 2023 indicates that Thailand had a total of 9,569,578.73 hectares of degraded land, accounting for 18.49% of the country's total land area (with low severity at 8,716,011.43 hectares or 16.84%, moderate severity at 831,701.8 hectares or 1.61%, and high severity at 21,865.5 hectares or 0.04%). In contrast, 3,815,419.15 hectares (7.37%) showed improved status, while 25,588,928.39 hectares (49.43%) remained unchanged or stable. Additionally, there are conservation areas and areas with no data (N/A) comprising 12,792,124.74 hectares or 24.71%. When these results are compared with the localized land degradation assessment conducted by the Land Development Department between 2021 and 2024 across 42 provinces (Table 1), it was found that approximately 23.05% of the land showed signs of degradation based on LDN indicators within this total, 19.68% identified as low severity, 3.01% as moderate severity, and 0.17% as high severity. However, this comparison may not be appropriate due to differences in the

sources of indicators used to assess the land degradation status, as well as differences in the methods used to assess SOC and the classification of land types and areas used for calculations.

Therefore, developing the LDN indicator dataset (LP and SOC) at the national level by enhancing the data on Land Productivity (LP) and Soil Organic Carbon Stock (SOC Stock) to the same resolution, such as 30x30 meters, will assist in monitoring, evaluating, and reporting results. This includes creating baseline data at the national level to use the same reference data in cases where calculations are required under the "no net loss" approach, which aligns with the scientific framework for implementing LDN.

2) Land Degradation Management According to Land Types and LDN Indicators

Forest land has clearly shown a negative trend, while wetlands and artificial areas/settlements have shown relatively minor negative changes. Other land types and water areas have shown more positive changes. Cropland, however, has experienced the greatest amount of both positive and negative changes. It ranks second in terms of land degradation (5.31%) after forest areas and also ranks first in terms of the most significant improvement (3.95%). This demonstrates the dual nature of land use changes. Similarly, grasslands have experienced the third most degradation (0.81%) and the second most improvement (2.10%). Therefore, the most important land types for land degradation management are forest land, cropland, grasslands, and wetlands, in that order, to restore degradation and determine the response priorities based on the LDN principles under the "like for like" criteria.

The assessment of the status of land degradation using LDN indicators between 2009 and 2023 showed that the most significant change occurred in the Land Cover Change (LCC) indicator, with a total area of 6,443,119.91 hectares or 12.45% of the total country area. The second most significant change was in the Land Productivity (LP) indicator, with 3,985,376.73 hectares or 7.70%. The third indicator, Soil Organic Carbon (SOC) Stock, showed a total area of 517,465.47 hectares or 1.00%. When considering the relationship of these indicators with land types, it was found that the greatest changes occurred in forest and agricultural land.

The changes in LDN indicators in Cropland: The Department of Land Development has established measures for managing soil resources and land degradation, including measures for managing degraded soil according to LDN indicators and conservation systems for soil and water. It is recommended to apply the LDN response hierarchy in managing and planning LDN, using the approach of avoid > reduce > reverse of land degradation. The priority should be given to land that can avoid degradation first, followed by land that can reduce degradation, and finally, land that is suitable for activities designed to restore land degradation (Global Mechanism of the UNCCD, 2019). The following management approaches can be applied in ongoing activities or projects as appropriate.

(2.1) Interventions to avoid and prevent land degradation Involve addressing the drivers of degradation and implementing proactive measures to prevent negative changes. It applies to non-degraded land and intact natural systems. The management approach mainly focuses on sustainable land management (SLM), sustainable forest management (SFM), and practices that conserve soil fertility (e.g., nutrients and organic matter), reduce disturbance and erosion, and avoid contamination. Practices include wise chemical inputs, reduced/zero tilling, crop rotations, residue retention, green manure cropping, improving organic matter, sustainable biochar, pasture phase, agroforestry,

intercropping, permaculture, modifying logging practices to avoid future degradation, law enforcement, raising awareness, and building capacity.

(2.2) Interventions to reduce land degradation This can be applied to cropland and forest land that have experienced partial degradation and reduced productivity. The approach mainly uses sustainable land management (SLM) and sustainable forest management (SFM), with a more vigorous intensity on avoiding and reducing land degradation. Interventions include increasing organic matter, pasture phase, cattle rotation, fence management, water conservation, proactive measures to reduce soil erosion (e.g., embankments, vegetated hedges, windbreaks, terracing), and proper decomposition processes (e.g., acidification and salinization through liming and strategic reforestation according to strategies).

(2.3) Reverse by restoring and rehabilitating Land degradation can be reversed or rehabilitated by seriously restoring the ecosystem's functioning. This should be done with degraded and inefficient land. Key interventions (which may involve changes) to enhance productivity include using high rates of organic fertilizers (compost, manure) to improve nutrient levels and biological activity; amendments to address soil limitations, such as lime, gypsum, clay (for sandy soils), biochar, water harvesting, etc.; and focusing on vegetation restoration through agroforestry systems, afforestation, reforestation or mine reclamation practices.

3) Prioritization using economic models

Prioritizing land use efficiency that impacts regional economies is done using the DEA economic model, which calculates technical efficiency (TE Score) to measure and rank the effectiveness of land development policies in Thailand. The output variable is economic data, such as the GPP of each province, and input variables include LUC, LP, SOC, and population factors for each province. The findings show that the region with the lowest efficiency, or the one that needs the first intervention, is the Eastern region, followed by the Central, Southern, Northeastern, and Northern regions, respectively. If we consider the regional ranking, it contrasts with the ranking based on the status of land degradation. Therefore, the project's results of measuring efficiency and ranking land development policies in Thailand are intended to prioritize land use management at the regional level. The policy at the deeper level suggests further study on specific areas within provinces and field data collection to identify additional factors, variables, or supplementary indicators. Furthermore, an additional evaluation was carried out using agricultural GPP data at the provincial level. The results show that the region with the lowest efficiency, or the one that needs the first intervention, is the Central region, followed by Northeastern, Northern, Eastern, and Southern regions. The analysis of agricultural GPP data provided different TE Scores compared to the overall GPP.

The efficiency analysis at the regional level is still suitable for implementing Thailand's land development policies. It can be applied to the LDN response hierarchy, which focuses on avoiding and reducing land degradation in areas at risk of degradation. Sustainable land management should be considered alongside land potential data to make decisions about land use, supporting the selection and prioritization of areas for intervention to halt land degradation in the highest-priority areas. For reversing degraded land, the priority should be based on the size of the area, as indicated by the results of the land degradation status assessment.

4) Assessment of land degradation status in drought-prone areas

Important drought-prone areas were identified using the annual Drought Risk Index (DRI) data from 2017 to 2024, which calculates drought-prone areas based on the severity and frequency of recurring events. The analysis revealed that 14.71 million hectares, or 28.41% of the country's total area, is highly vulnerable to drought. The majority of these areas are in the Northeastern region, followed by the Northern, Central, Eastern, and Southern regions, respectively.

This data can be integrated with the results of land degradation assessment to identify critical areas that face both land degradation and drought risk. These areas serve as preliminary targets for land degradation management alongside drought risk management. By combining this information, it can be incorporated into the UNCCD strategic plans to drive actions to mitigate the impacts of climate change disasters such as droughts or floods. This approach aligns with the objectives of the UNCCD and aims to implement measures to prevent and rehabilitate degraded lands, improving soil quality through conservation practices for land and water management.

16.2 Proposals for implementing LDN in the current plans

To integrate the results of the project into existing plans with the concept of LDN, it is proposed as a three-phase plan: short-term (1-2 years), medium-term (2-3 years), and long-term (4-5 years). This will serve as information for policy decisions and land and soil resource management to achieve the objectives of the SDGs and the UNCCD.

1) Short-Term Plan (1-2 Years)

- The short-term plan can be immediately implemented by prioritizing the conservation and restoration of focal degradation areas, categorized as forest land, cropland, grassland, and wetlands, in order to achieve counterbalancing within the same type of land. The plan is divided into

1. Avoidance and Reduction for lands that have not yet degraded but are at risk of degradation, using sustainable land management practices, sustainable forest management, and prioritizing economic factors in conjunction with land potential data.

2. Restoration of Land Degradation for lands that have already degraded, based on the assessment of degradation status using LDN indicators, with priorities set according to the size and severity of degradation.

3. Water Management for Agricultural Areas for the conservation of watershed areas, restoration of degraded forests to become healthy forests, and water management for environmental purposes, including developing of water sources for agriculture. This aims to enhance land productivity, ensure food security, increase income, manage water in crisis situations, reduce carbon loss from the soil, and increase soil carbon sequestration. Actions should follow soil and water conservation system measures, including promoting adaptation to reduce climate change impacts such as floods and droughts. The use of drought-risk area data can help define initial areas for land degradation management alongside drought risk management.

- In-situ Validation Local knowledge is used to verify and interpret data and reports on land degradation, including methods for identifying false positive or false negative results. This is done through a participatory process involving various stakeholders and local knowledge. Indicator datasets may lead to "false positives" or "false negatives" in some situations, such as shrub encroachment leading to higher NPP and SOC or removing invasive weeds causing a decrease in NPP. The process also includes monitoring SOC, a key indicator, and checking NPP changes in rainfall amounts.

- Integrating Land Potential Data and Resilience Assessment Linking the basic characteristics of different land types and supporting land-use decision-making is critical in assessing adaptive capacity. This information plays a key role in ensuring that the path toward LDN goals is achieved.

- Balancing Economic, Social, and Environmental Sustainability Decision-making in land resource use should be based on multi-variable assessments, encompassing all relevant stakeholders in planning, implementation, and monitoring. This process should use multi-stakeholder platforms that are either established or improved to ensure broad participation and conflict resolution. The process should be gender-sensitive, address power imbalances, and ensure equitable access to information. It should also take into account available resources (human and economic) and utilize existing creative thinking and innovations tied to local organizations. Participatory processes in verifying in-situ validation, monitoring, and reporting on LDN implementation should aim to produce win-win outcomes. This will ensure that vulnerable communities are not displaced. The principles and standards of voluntary guidelines on the responsible governance of tenure of land, fisheries, and forests (VGGT) should be followed to avoid violations or the nullification of tenure rights, including those of women and vulnerable groups who hold secondary rights (rights to use land and resources without clear title).

- Supplementary Indicators for Monitoring Progress In addition to the three main indicators (land cover, land productivity, and organic carbon stock in soil), supplementary indicators should be added to cover all relevant issues. These indicators can be based on activities or projects, biodiversity indicators, or other SDG indicators. The recording of supplementary indicators should be integrated into the activities or projects being implemented. These additional indicators will assess the factors, pressures, impacts, and responses (DPSIR framework), helping to interpret actions toward achieving LDN for each land type. Furthermore, a continuous learning approach should be adopted, which involves forecasting, planning, monitoring, interpreting, reviewing, adjusting, creating the next phase plan, and regularly verifying progress to allow for process adjustments if results do not meet expectations.

- Promoting SLM to Avoid/Reduce Land Degradation SLM practices that address land degradation processes and are economically and socially feasible should be incorporated into ongoing or planned activities of relevant agencies. This ensures alignment with LDN implementation objectives.

- LDN Planning and Implementing should be integrated into existing planning processes rather than an additional step. LDN planning and associated measures should be incorporated into the National Action Plan (NAP) of UNCCD. Additionally, LDN implementation should be integrated into national development plans and other national

policy processes (e.g., NAP of UNFCCC or NBSAP of CBD) to leverage investment in related measures.

2) Medium-Term Plan (2-3 Years)

- The medium-term plan can be implemented through planning or decision-making by authorities in relevant agencies, or through necessary coordination among agencies to summarize detailed implementation strategies. This includes national biodiversity strategy and action plans (NBSAP) under CBD, national greenhouse gas inventories related to land use, land-use change, and forestry (LULUCF) of UNFCCC and REDD, among others.

- Development of LDN Indicator Dataset for Thailand It is proposed to develop an LDN indicator dataset with a resolution of 30x30 meters at the national level. This dataset will include indicators such as Land Productivity (LP) and Soil Organic Carbon Stock (SOC Stock), along with an assessment of land degradation during the baseline reference period.

- Establishment of Agricultural Cooperatives (or improvements) This aims to create channels for the participation of small landowners, in collaboration with industries and the supply chain, for managing large land areas. This facilitates scaling up efforts, with the state having the authority to regulate and minimize environmental and social risks.

- Provision of Financial Resources It is essential to mobilize resources from various sources, including national budgets, external donors, and innovative funding sources. The UNCCD facilitates the necessary integration to help countries implement LDN more effectively. The LDN fund focuses on investing in large-scale land restoration projects and projects aimed at preventing land degradation and integrating smallholder farmers and local communities. The GEF fund provides financial support to countries in pursuit of LDN objectives, such as in areas of critical land degradation, food systems impact, land use and restoration to natural conditions, and sustainable forest management in dryland landscapes.

- Continuous Planning Integration of LDN into the existing plans over the next 5 years, including land management plans, environmental management plans, and agricultural and cooperative plans, in line with Thailand's long-term development plan.

3) Long-Term Plan (4-5 Years)

- The long-term plan can be implemented by using the timeline for operations to define the direction of national development, which includes maintaining a balance between land resource management and the UNCCD strategic plan, aligning with SDG goals, the Rio Conventions (UNFCCC and CBD), or relevant national development plans.

-The monitoring and evaluation principle should use the three indicators: land cover (assessed as changes in land cover), land productivity (assessed as NPP or appropriate), and soil organic carbon stock (assessed as SOC) as the minimum set of indicators for reporting. This should include assessing the success of SDG Indicator 15.1.3 or LDN indicators according to the "No Net Loss" approach. The goal of LDN is to stabilize or reduce land degradation levels in the future or during the reporting period compared to the baseline period, with no net loss. In cases where the goal of LDN is to be assessed at the national level, the same land type criteria, "like for like," should be used to counterbalance gains and losses to monitor the achievement of the LDN goal by 2030.

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