

Supplementary data

Scenario-Based Land Cover and Land Use Change Modeling in Mae Chang Watershed, Lampang Province, Thailand

Table S1. Information about data used in this study

Data	Type	Detail	Source
Landsat satellite imageries	Raster	Scenes contain Path 130 / Row 47 & 48 1) Landsat 5 Level 2 Product: January, 1989 2) Landsat 5 Level 2 Product: January, 2005 3) Landsat 7 Level 2 Product: March, 2013 4) Landsat 8 Level 1 Product: February, 2021	United States Geological Survey (USGS) Earth Explorer (https://earthexplorer.usgs.gov/)
Land use, Lampang Province	Vector	Multi-year land use and land cover (LULC) data in geospatial format	Land Development Department (LDD) of Thailand
Digital Elevation Model (DEM)	Raster	5-meter spatial resolution digital elevation model	Land Development Department (LDD) of Thailand
Mae Moh mine boundary	Vector	Mining boundary data layer of Mae Moh Mine, Electricity Generating Authority of Thailand (EGAT)	Mae Moh mine, Electricity Generating Authority of Thailand (EGAT) (https://data.go.th/dataset/maemohmine-boundary)
Mae Moh mine final area	Document	Final operational area of Mae Moh Mine before closure	Electricity Generating Authority of Thailand (EGAT)
Thailand mining concession database	Table/etc.	Thailand mining concession database	Department of Primary Industries and Mines (DPIM) of Thailand (https://www.dpim.go.th/webservices/con_report.php)
Conserved forest	Vector	Protected forest areas, for example, national park	Department of National Parks, Wildlife, and Plant Conservation (DNP) of Thailand
National reserved forest	Vector	Forest area boundaries designated as zones belonging to the national reserved forest	Royal Forest Department (RFD) of Thailand
Forest type	Vector	Forest type coverage in 2000, this data was used as the interpretation guide for land use land cover interpretation	Royal Forest Department (RFD) of Thailand
Agricultural land reform area	Vector	Agricultural land reform area boundary in Lampang Province	Agricultural Land Reform Office (ALRO) of Thailand
Forest plantation	Vector	Boundary of forest plantations, dominated by teak plantations	Forest Industry Organization (FIO) of Thailand
Watershed Classification Class 1	Vector	Thailand's watershed classification is a national system that categorizes watersheds into five classes (Class 1 to Class 5) primarily based on physical factors and forest covers. It is used primarily for land-use planning, natural resource management, and conservation policy. For class 1 – steep, high-elevation headwaters (slope >50%), often pristine forests. These are the most ecologically sensitive areas and are strictly protected; human activity is prohibited (Tongdeenok, 2023).	Office of Natural Resources and Environmental Policy and Planning (ONEP) of Thailand
Administrative boundary	Vector	Thailand - Subnational Administrative Boundaries	Royal Thai Survey Department, OCHA Regional Office for Asia and the Pacific (ROAP), Information Technology Outreach Services (ITOS) (https://data.humdata.org/dataset/cod-ab-tha)

Table S1. Information about data used in this study (cont.)

Data	Type	Detail	Source
Road	Vector	Transportation network in geospatial format	NOSTRA
Stream	Vector	Stream network from topographic map	Royal Thai Survey Department (RTSD)
Population count	Raster	The unconstrained 100 m spatial distribution of population in 2020, with country total adjusted to match the corresponding UNDP estimate, Thailand	WorldPop (https://dx.doi.org/10.5258/SOTON/WP00660)

Table S2. Future LULCC scenarios setting up

CI layer	Scenarios		
	BAU	CON	DEV
Constraints			
• National reserved forest conservation zone (Zone C)	×	0	×
• National Park	×	0	×
• Watershed Class 1	×	0	×
Incentives			
• Recent and future mining activity	×	×	1.1
• Agricultural land reform area	×	×	1.1

Remark: ×=no CI layer applied in scenario, 0=absolutely constraint, 1.1=incentive value

Table S3. Land use and land cover (LULC)

	LULC classes	LULC area							
		1989		2005		2013		2021	
		km ²	%						
-	Paddy Field	165.73	10.13	163.46	9.99	161.63	9.87	160.09	9.78
+	Field Crop	84.11	5.14	111.46	6.81	152.65	9.33	172.21	10.52
+	Perennial	75.47	4.61	68.33	4.17	144.08	8.80	148.93	9.10
-	Orchard	14.37	0.88	24.55	1.50	22.95	1.40	22.34	1.36
+	Other Crop	1.50	0.09	1.49	0.09	5.95	0.36	6.73	0.41
+	Aquaculture	n/a	n/a	0.09	0.01	0.44	0.03	0.38	0.02
	Evergreen Forest	66.06	4.04	65.93	4.03	65.84	4.02	65.80	4.02
-	Deciduous Forest	1,070.41	65.40	979.78	59.86	850.72	51.97	821.40	50.18
-	Rangeland and Scrub	36.94	2.26	37.56	2.29	21.58	1.32	19.29	1.18
	Swamp	0.82	0.05	1.87	0.11	0.67	0.04	2.04	0.12
+	Mine and Pit	26.26	1.60	77.65	4.74	87.27	5.33	89.49	5.47
+	Other Miscellaneous	0.16	0.01	0.16	0.01	0.20	0.01	0.52	0.03
+	Urban and Built-up	71.95	4.40	76.62	4.68	88.50	5.41	92.67	5.66
+	Water Body	23.00	1.41	27.83	1.70	34.33	2.10	34.90	2.13
	Total	1,636.79	100.00	1,636.79	100.00	1,636.79	100.00	1,636.79	100.00

Remark: 1) The area was calculated based on LULC from vectorization; 2) Symbols of “+” and “-” indicate overall increase and decrease in LULC class, respectively since 1989.

Table S4. LULC transition from 1989 to 2021

	Class	LULC 2021 area (km ²)														Total 1989	
		AAQC	AFLD	AORC	AOTH	APAD	APER	FDCD	FEVG	MINE	MMSW	MOTH	MRNS	URBA	WATR		
LULC 1989 Area (km ²)	AFLD	0.05	48.50	5.44	0.89	3.93	15.65	4.91		0.07	0.07	0.03	2.05	2.23	0.29	84.11	
	AORC	0.03	1.53	6.86	0.01	0.21	3.71	0.72		0.05	0.00		0.30	0.84	0.10	14.37	
	AOTH		0.93	0.12		0.05	0.26	0.07	0.00	0.02	0.00		0.03	0.01		1.50	
	APAD	0.03	4.32	0.99	0.12	141.05	5.73	3.52		2.91	0.15	0.04	2.16	3.44	1.28	165.73	
	APER		0.95	0.36		0.47	58.40	6.13		5.33	0.00		0.10	2.43	1.30	75.47	
	FDCD	0.18	105.84	7.21	5.56	11.63	58.44	800.67	0.32	50.30	0.74	0.14	2.88	14.35	12.16	1,070.41	
	FEVG		0.37	0.01	0.01	0.02	0.02	0.13	65.48					0.01		66.06	
	MINE		0.06	0.01		0.00	0.01	0.34		24.88		0.02	0.17	0.58	0.20	26.26	
	MMSW	0.01	0.07			0.03	0.03	0.16			0.35		0.06	0.06	0.05	0.82	
	MOTH	0.01		0.03			0.00			0.06					0.05	0.16	
	MRNS	0.03	8.53	0.80	0.13	1.76	5.61	3.95		1.63	0.16	0.16	10.70	3.12	0.36	36.94	
	URBA	0.01	1.09	0.51	0.00	0.94	1.01	0.75		1.04	0.00	0.09	0.81	65.44	0.25	71.95	
	WATR	0.02	0.03	0.00		0.01	0.06	0.05		3.20	0.56	0.04	0.03	0.10	18.90	23.00	
	Total 2021		0.38	172.21	22.34	6.73	160.09	148.93	821.40	65.80	89.49	2.04	0.52	19.29	92.67	34.90	1,636.79

Remark: LULC Code; APAD=Paddy Field, AFLD=Field Crop, APER=Perennial, AORC=Orchard, AOTH=Other Crop, AAQC=Aquaculture, FEVG=Evergreen Forest, FDCD=Deciduous Forest, MRNS=Rangeland and Scrub, MMSW=Swamp, MINE=Mine and Pit, MOTH=Other Miscellaneous, URBA=Urban and Built-up, and WATR=Water Body.

Table S5. The overall CVC test results

Exploratory variables	Overall CVC
a) elevation	0.1492
b) slope (degree)	0.0196
c) distance to road	<u>0.1755</u>
d) distance to stream	0.0423
e) distance to agricultural land reform area	<u>0.1569</u>
f) distance to mine and pit (2021)	<u>0.1909</u>
g) distance to urban (2021)	<u>0.1625</u>
h) population distribution	0
i) evidence likelihood	<u>0.2853</u>

Remark: The underlined CVC indicated the selected variable used in LCM model

Table S6. The sub-model and its structure

Sub-model	Description	Transition	LULCC (2005-2013)
DEF_01	Deforestation situation based on paddy field and field crop activity	FDCD to APAD	Deciduous forest to Paddy field
		FDCD to AFLD	Deciduous forest to Field crop
DEF_02	Deforestation situation from perennial land	FDCD to APER	Deciduous forest to Perennial
DEF_03	Deforestation situation which not related to agriculture including urban and built-up and mine and pit demand	FDCD to MINE	Deciduous forest to Mine and pit
		FDCD to URBA	Deciduous forest to Urban and built-up
AGRI	Agricultural transformation	MRNS to AFLD	Rangeland and scrub to Field crop
		AFLD to APER	Field crop to Perennial

Table S7. The final sub-model structure and performance

Sub-model	Accuracy rate (%)	Skill measure
AGRI	52.87	0.3716
DEF_01	55.33	0.3300
DEF_02	73.35	0.4670
DEF_03	92.40	0.8860

Table S8. Future scenario and its area

Class	LULC area (km ²)						
	LULC 2021	Predicted LULC 2029 Scenarios			Predicted LULC 2037 Scenarios		
		BAU	CON	DEV	BAU	CON	DEV
Paddy Field	160.09	173.69	173.71	173.71	180.42	180.43	180.43
Field Crop	172.21	200.70	200.68	200.68	207.19	207.19	207.19
Perennial	148.93	271.13	271.10	271.10	319.06	319.02	319.02
Orchard	22.34	22.95	22.95	22.95	22.95	22.95	22.95
Other Crop	6.73	5.95	5.95	5.95	5.95	5.95	5.95
Aquaculture	0.38	0.44	0.44	0.44	0.44	0.44	0.44
Evergreen Forest	65.80	65.84	65.84	65.84	65.84	65.84	65.84
Deciduous Forest	821.40	637.87	637.87	637.87	562.46	562.49	562.49
Rangeland and Scrub	19.29	16.42	16.42	16.42	16.87	16.87	16.87
Swamp	2.04	0.67	0.67	0.67	0.67	0.67	0.67
Mine and Pit	89.49	102.04	102.07	102.07	107.98	107.94	107.94
Other Miscellaneous	0.52	0.20	0.20	0.20	0.20	0.20	0.20
Urban and Built-up	92.67	104.57	104.58	104.58	112.45	112.49	112.49
Water body	34.90	34.33	34.33	34.33	34.33	34.33	34.33