A Comparative Study of Land Use Changes along the Mekong River at the Border of Thailand and the Lao PDR

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Rationales

- Land use change is one of the most important issues.
- Demands on land for production have been forced into the expansion of agricultural land.
- Serious consequences in land utilization: Soil erosion/degradation, salinization and loss in biodiversity.

- Degree and type of changes is of particular importance for projecting future land use and advance protection.

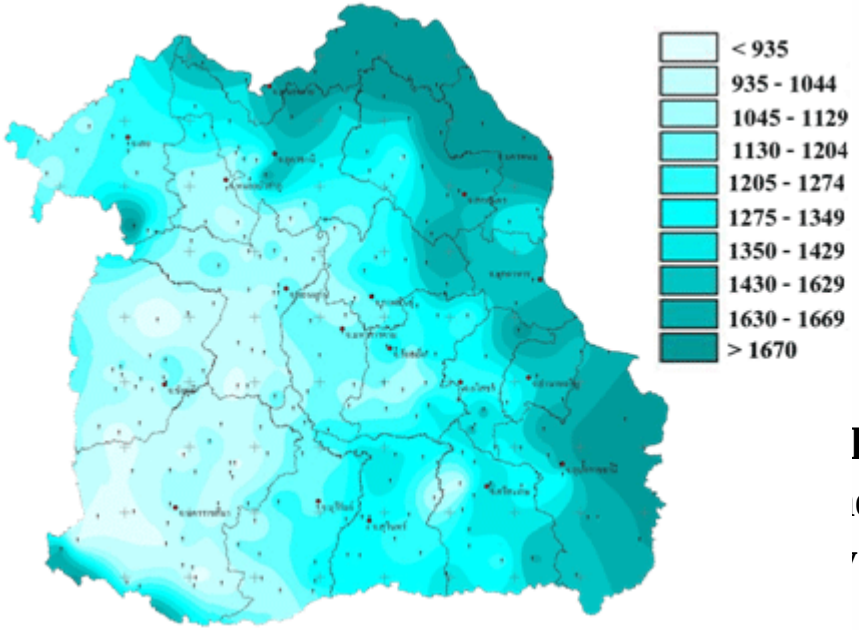
- The changes in Thailand and the Lao PDR with difference in population density may enhance our perspective in sustainable development for prosperity

Objective

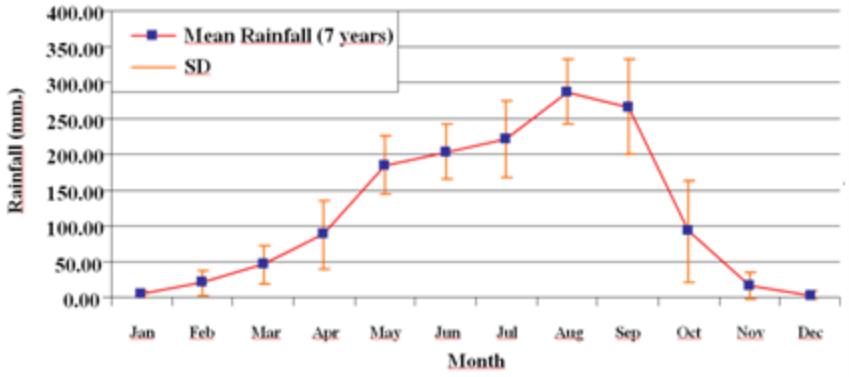
To comparatively explore the chrono sequence of land use patterns and its changes over the Mekong areas.

The information to be obtained can help support the awareness in using resources with respect to the advance control of the balance between development and conservation

Spatio – temporal Rainfall



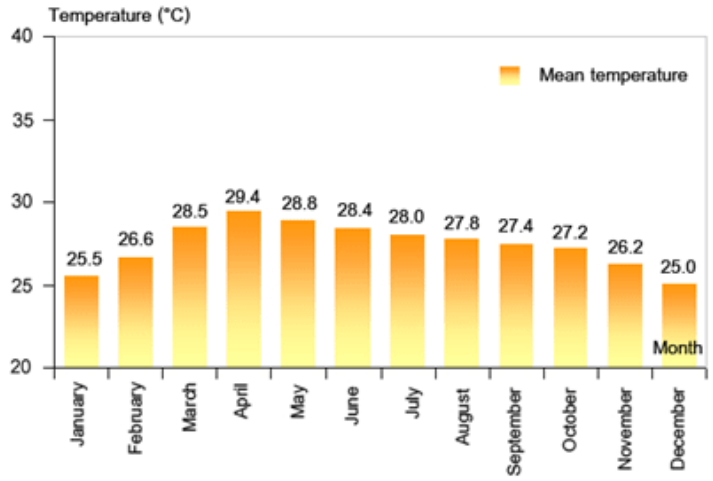
Rainfall patterns are dominated by both
e southwest monsoon and tropical
clones originating from south china sea.

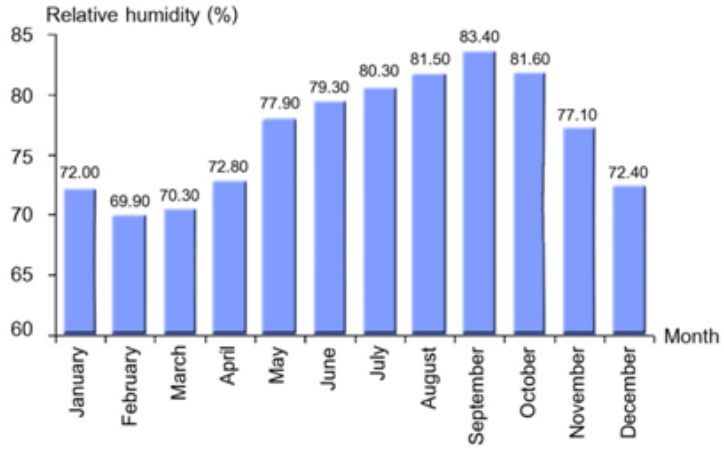


Rainy season

- May to October with mean annual rainfall varying from less than 1000 to 2000 m.m
- Peak in August & September with over 50 of total rain

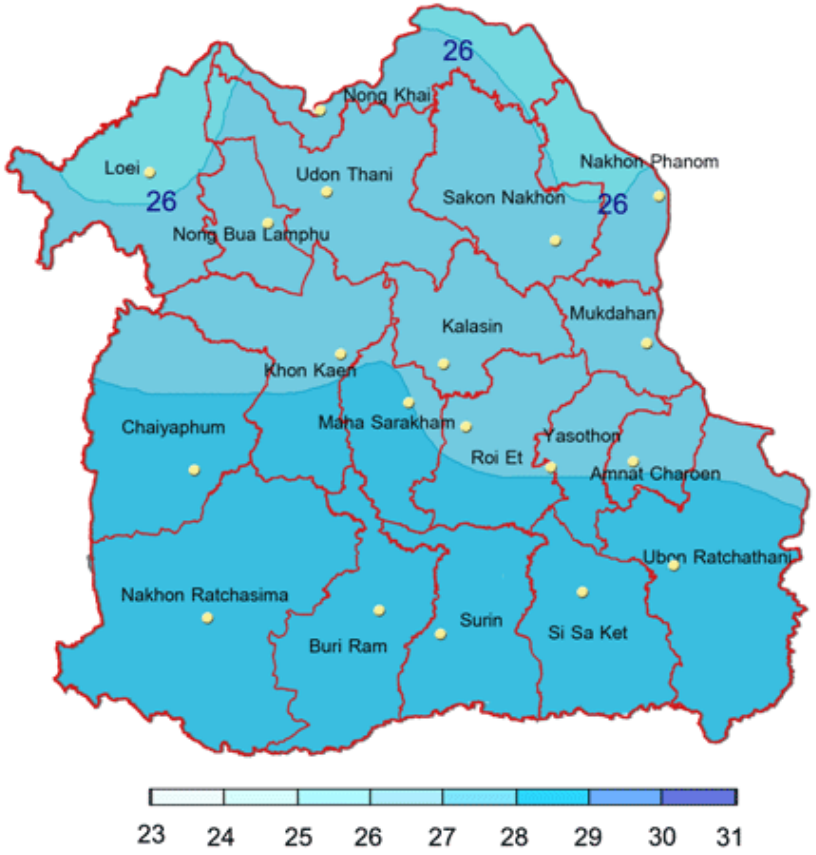
Temperature and Relative humidity



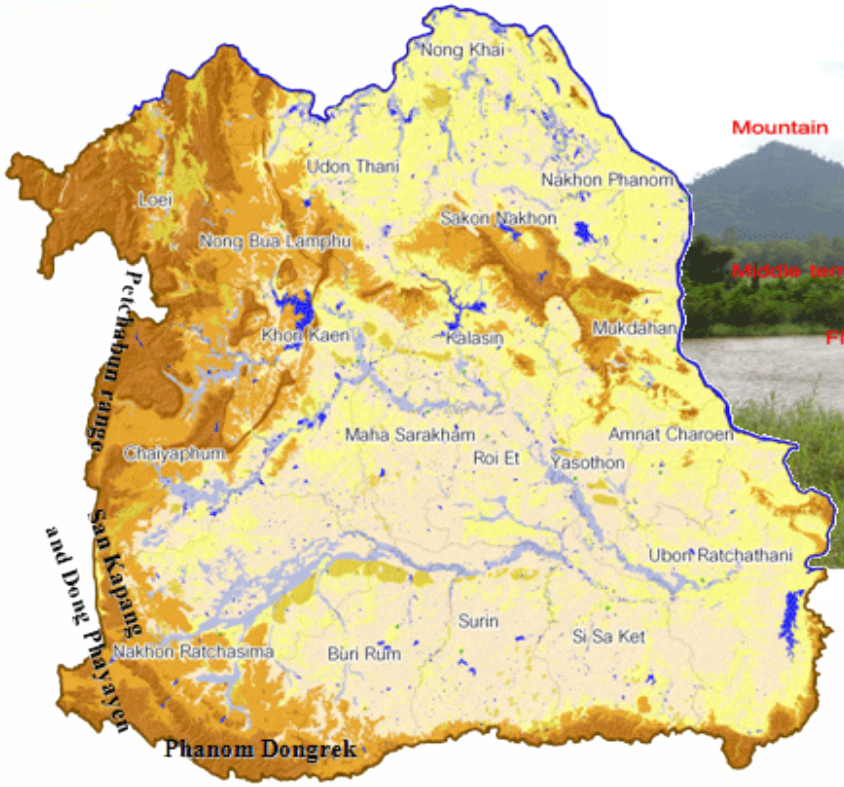


- Average temperature varies form 25 - 30 C

- Relative humidity ranges from 70 in February with peak in September 83.40



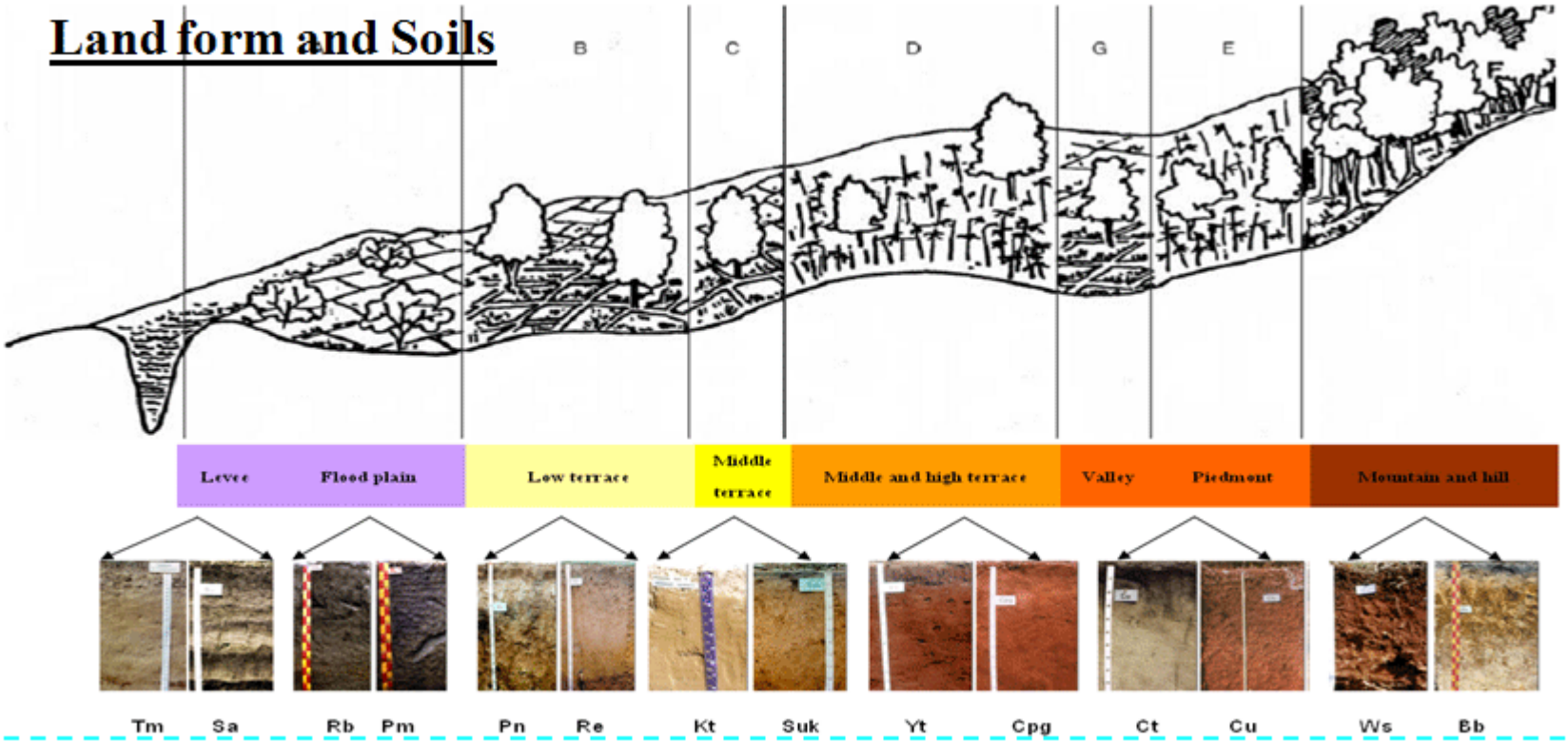
Land form



- Flood plain
- Low terrace
- Middle terrace
- High terrace
- Dissected erosion surface
- Mountain
- Water

The NE region is bounded to the North and East by the Mekong river and to the west and south by Petchabun and Phanom Dongrek ranges respectively.

Land form and Soils



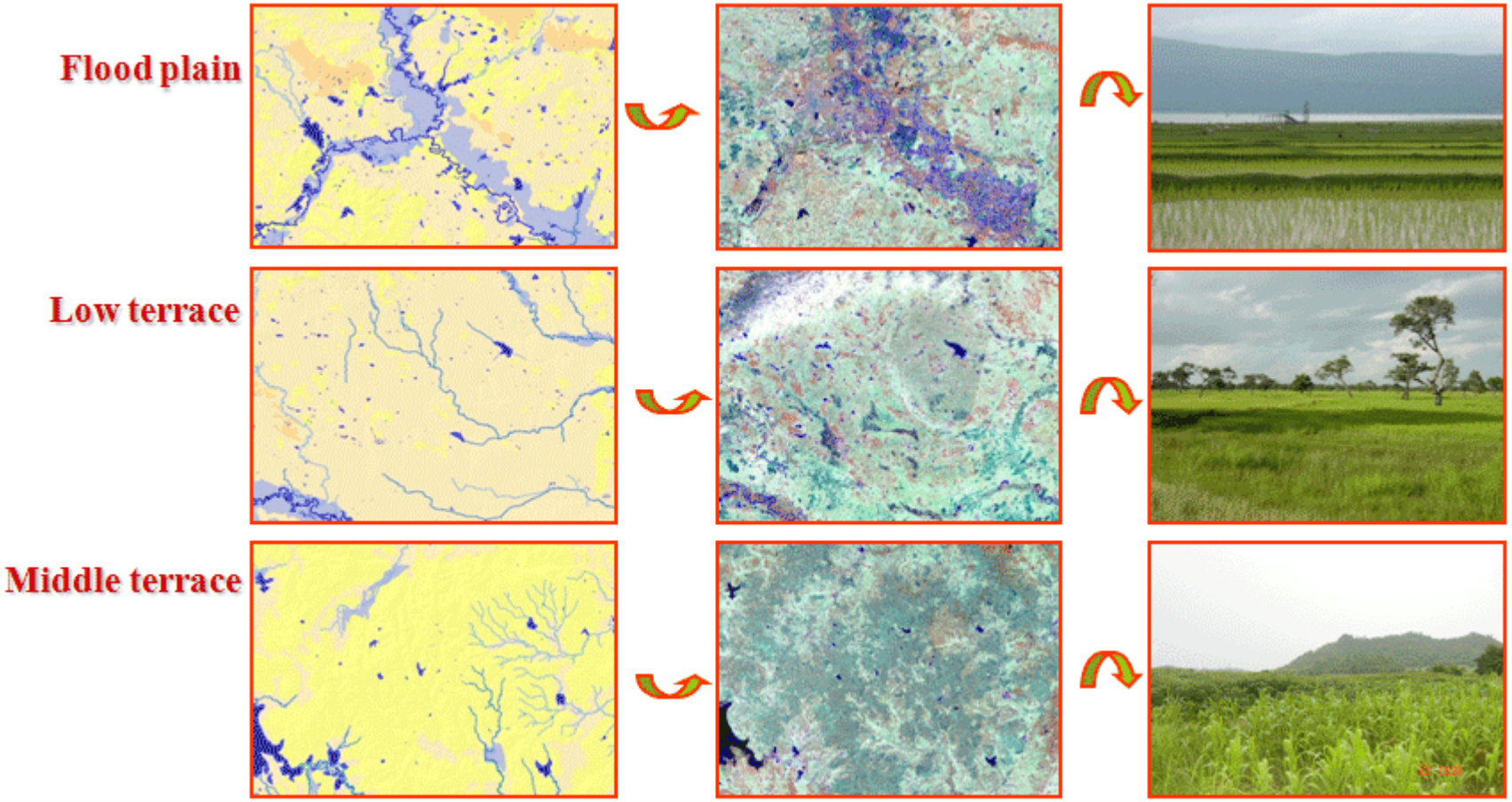
Soil series name	Soil Taxonomy
Tm	Typic Ustifluvents,l, mixed, nonacid.
Sa	Aquic Ustifluvents,l, mixed, nonacid.
Rb	Aeric Tropaquepts, vf, mixed, nonacid.
Pm	Vertic Tropaquepts, vf, mixed, nonacid.
Pn	Typic Plinthaquults, C-sk, kao.
Re	Aeric Paleaquults, ft, mixed.
Yt	Oxic Paleustults, fl, siliceous.
Kt	Oxic Paleustults, fl, siliceous.
Suk	Oxic Paleustults, fl, siliceous.
Cpg	Oxic Paleustults, col, siliceous.
Ct	Typic Haplustalfs, f, mixed.
Cu	Typic Ustipsamments, siliceous.
Ws	Ultic Haplustalfs, f, mixed.
Bb	Aquic Plinthustults, fl/sk, mixed

The mainland forms in the region are predominantly determined by the tremendous alluvial deposits of the Mekong river and its tributaries Flood plain, low terrace and high terrace are commonly found in the alluvial plains.

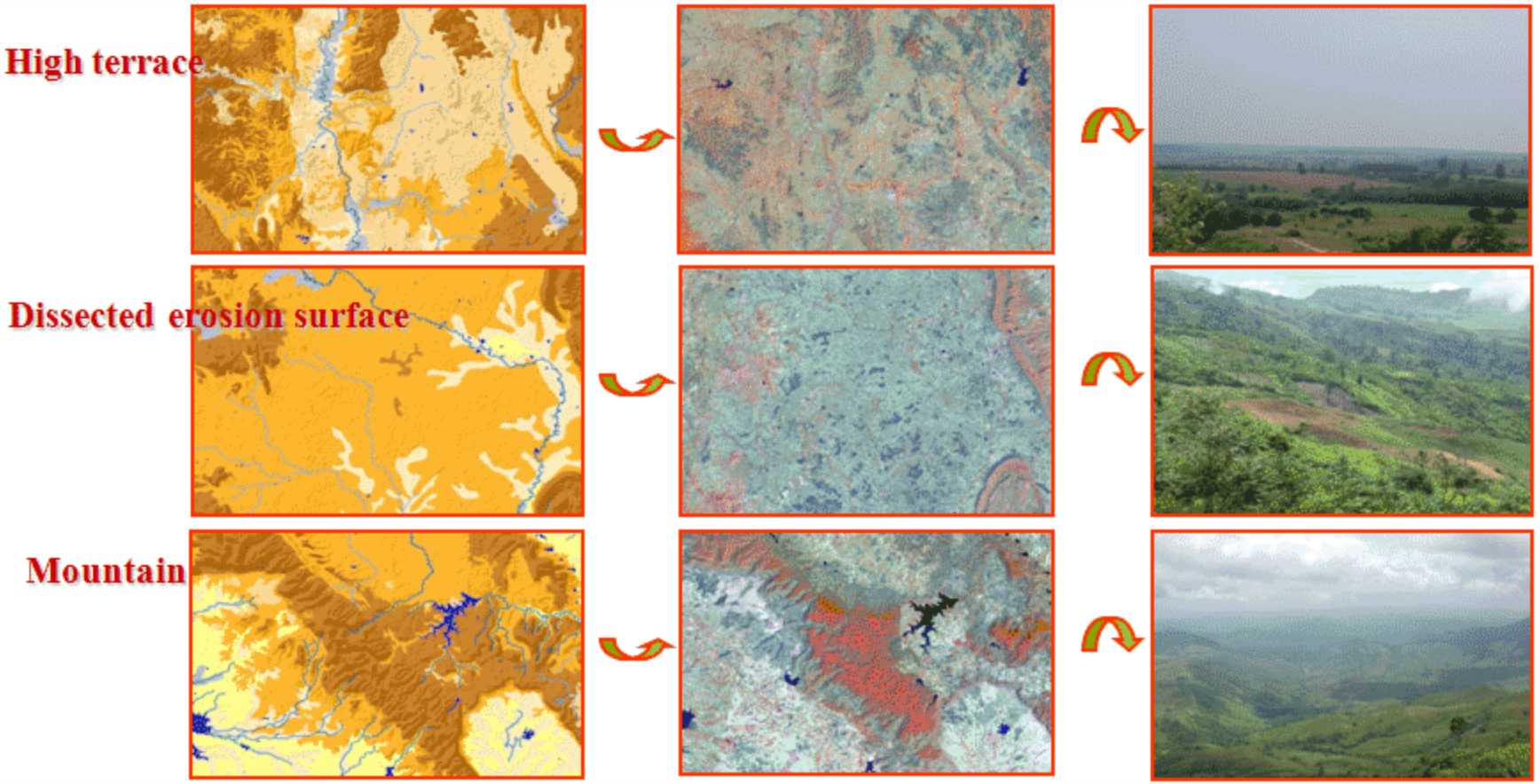
Land forms in residual material Dissected erosion surface, hill/mountain are also identified.

Land use pattern and Land form

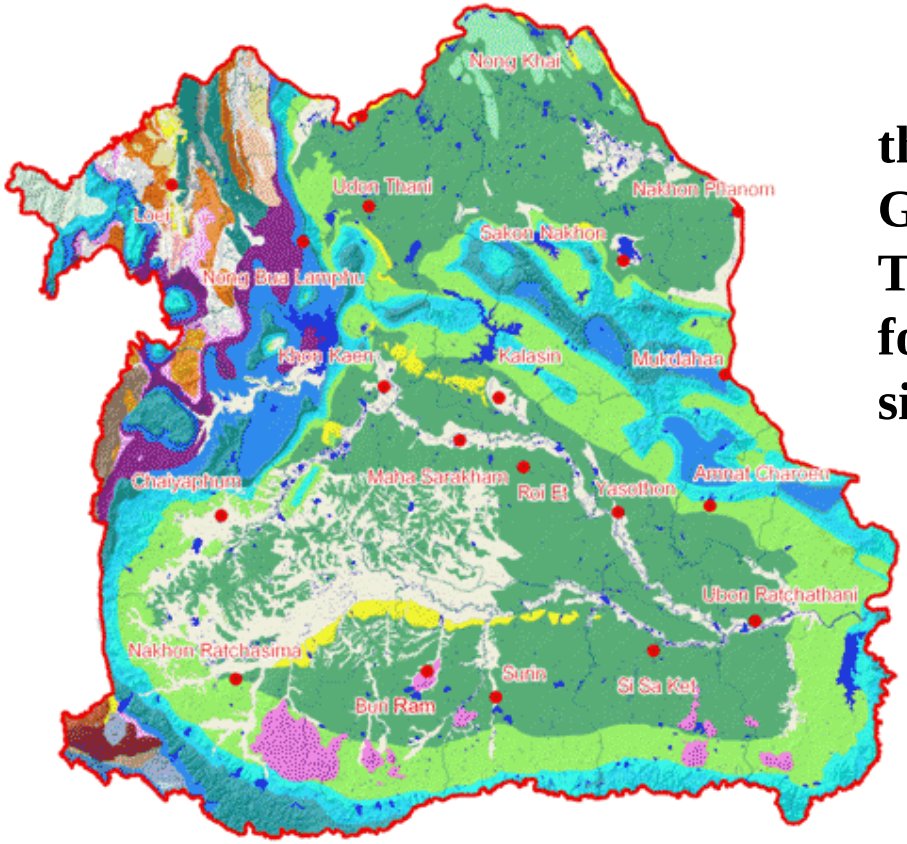
Gently undulating terrains are found extensively in the Northeast and are considered to cover the majority for the cropping area.



Dissected erosion surfaces occupy many portions of the Northeast in connection with hills and mountains. The combined activities of rock weathering and streams result in soil with variable compositions



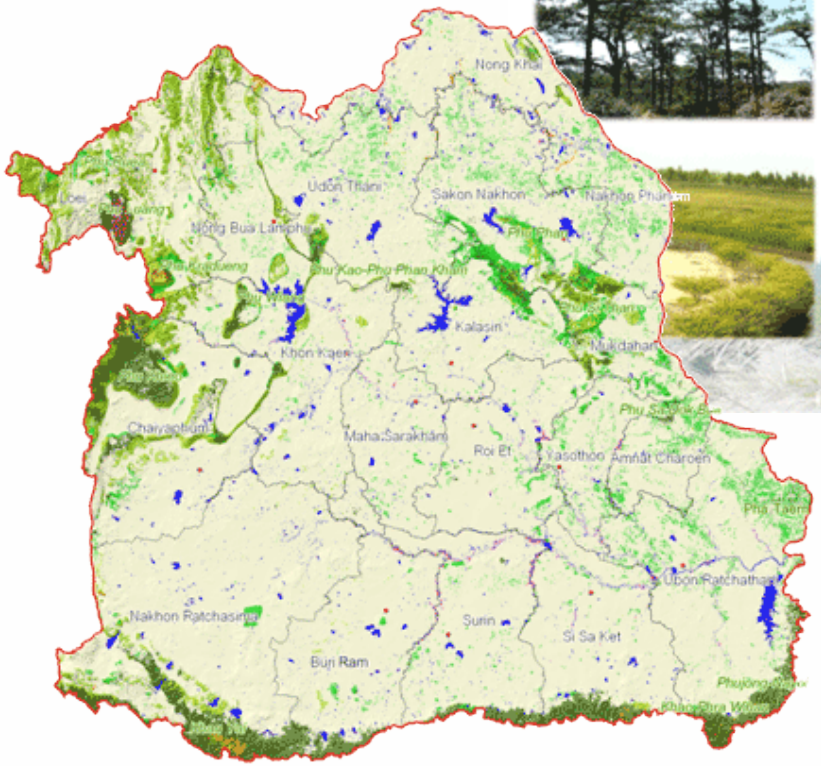
Geology



Geologically, the region is underlain by a thick sequence of Mesozoic rocks, the Korat Group ranging in age from upper Triassic to Tertiary, with numerous formations. These formations consists mainly sandstones, siltstones, shale and conglomerates.

Minor inclusions of limestone, basalt are found.

Forest types



Evergreen forest
Dry evergreen forest
Hill evergreen forest
Pine forest
Inundated forest
Mixed deciduous forest
Dry dipterocarp forest
Bamboo forest
Water
Others

Of a total NE area (170,000 square kilometers) forest acreage covers approximately 14%.

This figure is less than the average taken for the whole kingdom. The main forest types are Evergreen forest, Dry evergreen forest, Hill evergreen forest, Mixed deciduous forest and Dry dipterocarp forest.

The dry dipterocarp forest is characterized by annual leaf shedding during a dry spell in the summer.

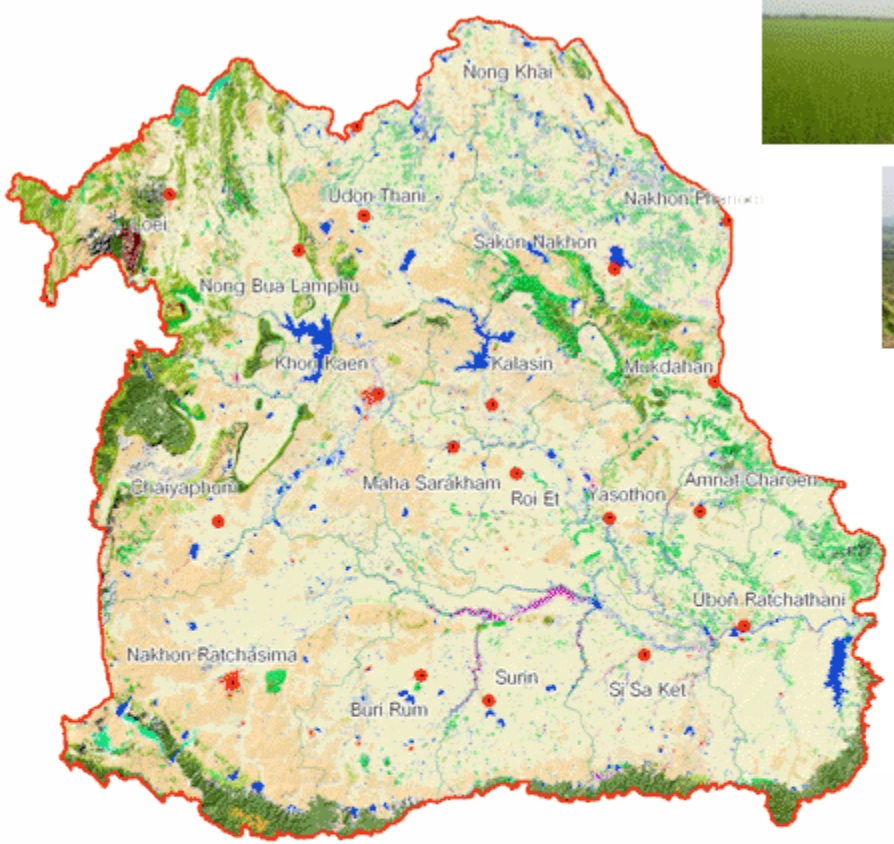
Different types of paddy lands in the Northeast

Paddy lands with slight to moderate covers of tree found on the low lands.

- **Field crops: sugarcane, cassava**
- **Rubber trees**

The uplands, well drained soils are restricted to field crops and rubber trees.

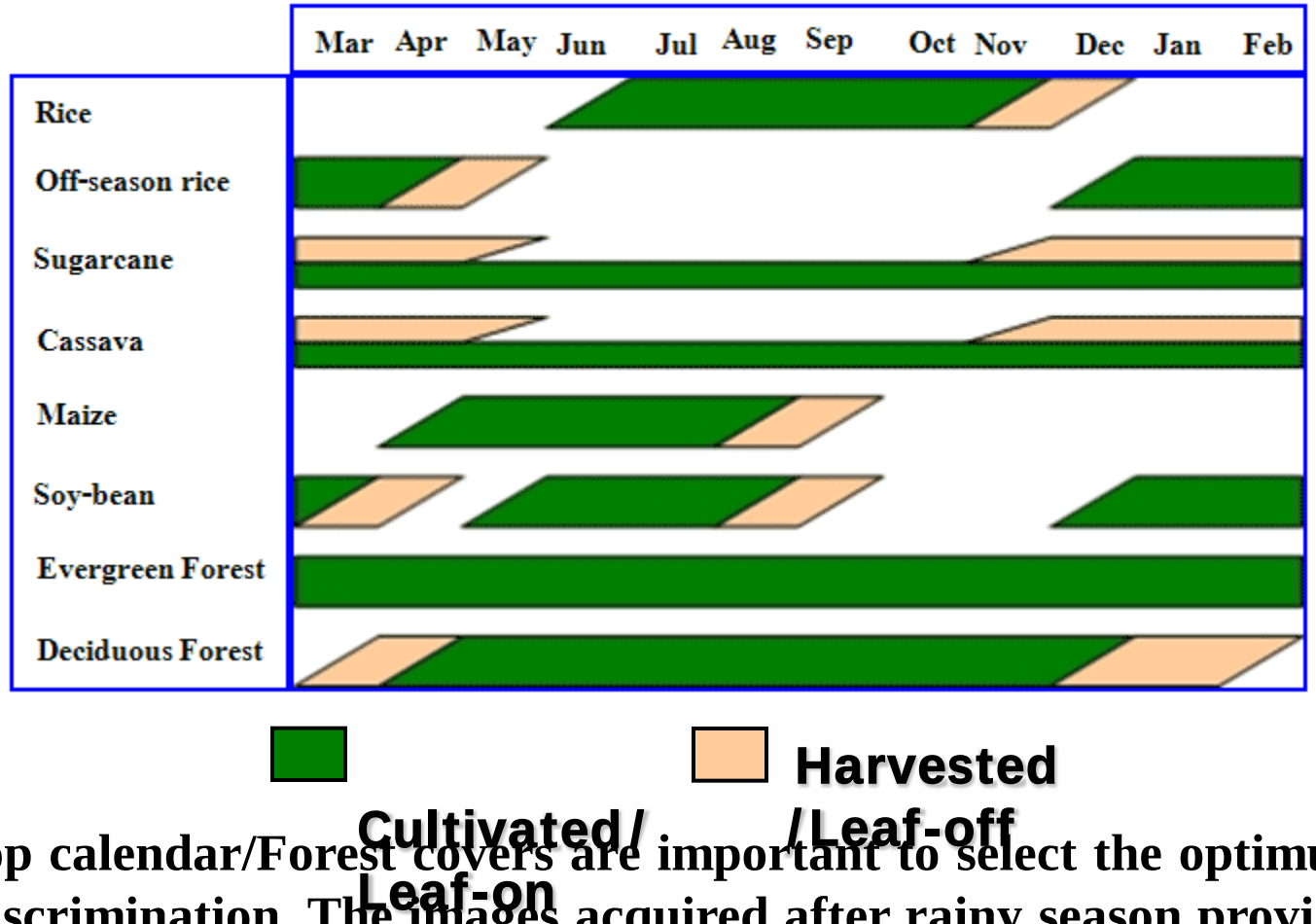
Land use



- Aquatic plants
- Riverine tree
- Water
- Grass land
- Wetland
- Mine operating
- Salt pan operating
- Urban and built-up land
- Paddy field
- Field crops
- Mixed perennial crops
- Orchards
- Mixed horticultural
- Rock out crop
- Beach and sand bar
- Evergreen forest
- Dry evergreen forest
- Hill evergreen forest
- Coniferous forest/ Pine forest
- Inundated forest
- Mixed Deciduous forest
- Dry dipterocarp forest
- Bamboo forest
- Forest plantation
- Old clearing
- Others

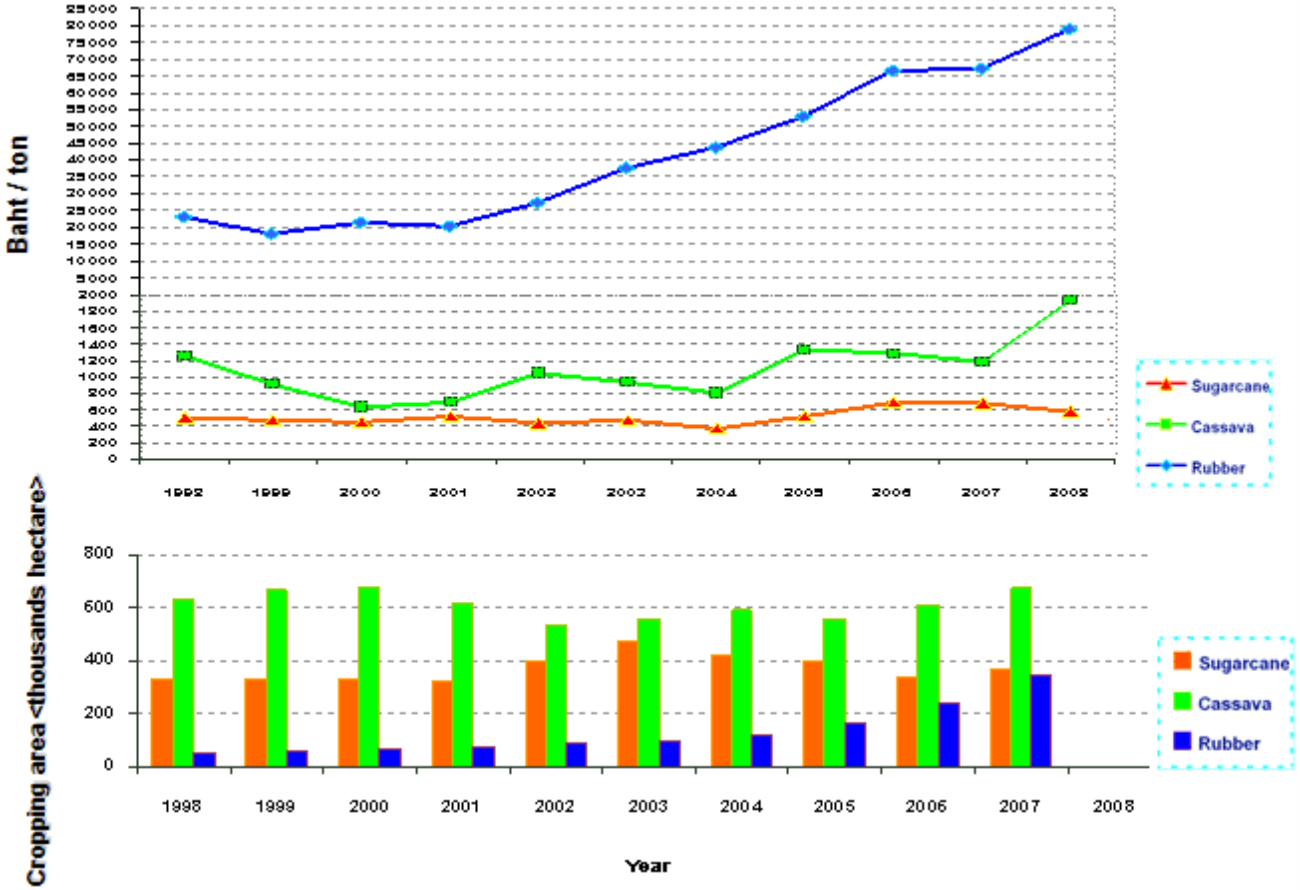
Different types of the major land use in the region are dominated by the land form, soil and rainfall.

Crop Calendar/Forest Cover



Crop calendar/Forest covers are important to select the optimum date for discrimination. The images acquired after rainy season provide good discrimination between low land and upland, evergreen forest and deciduous forest

Fluctuation in cropping areas in relation to economic return

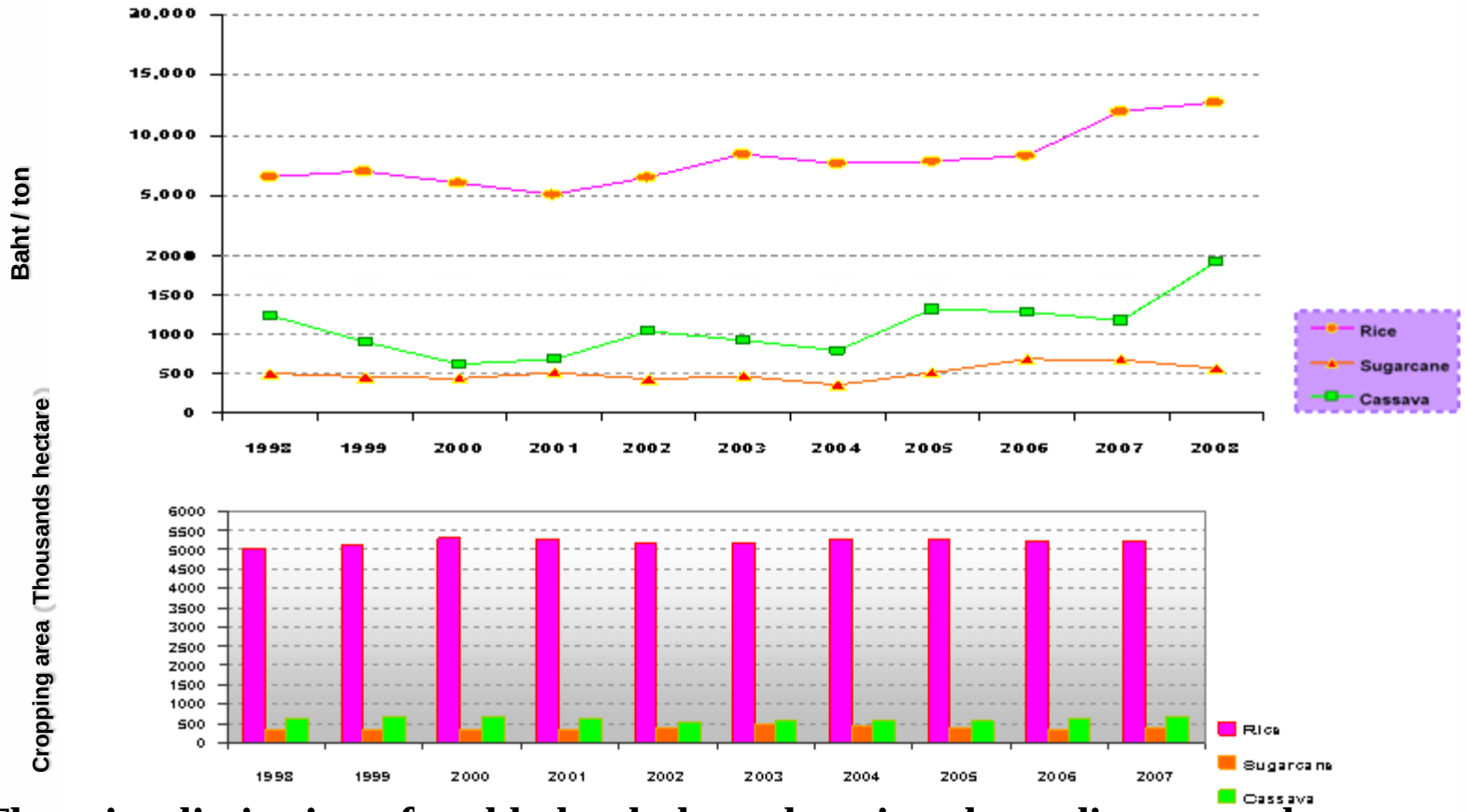


The expansion of area under rubber results from the attractive economic return.

The land planted to rubber tree increases from 20,000 ha in 1998 to 380,000 ha in 2007

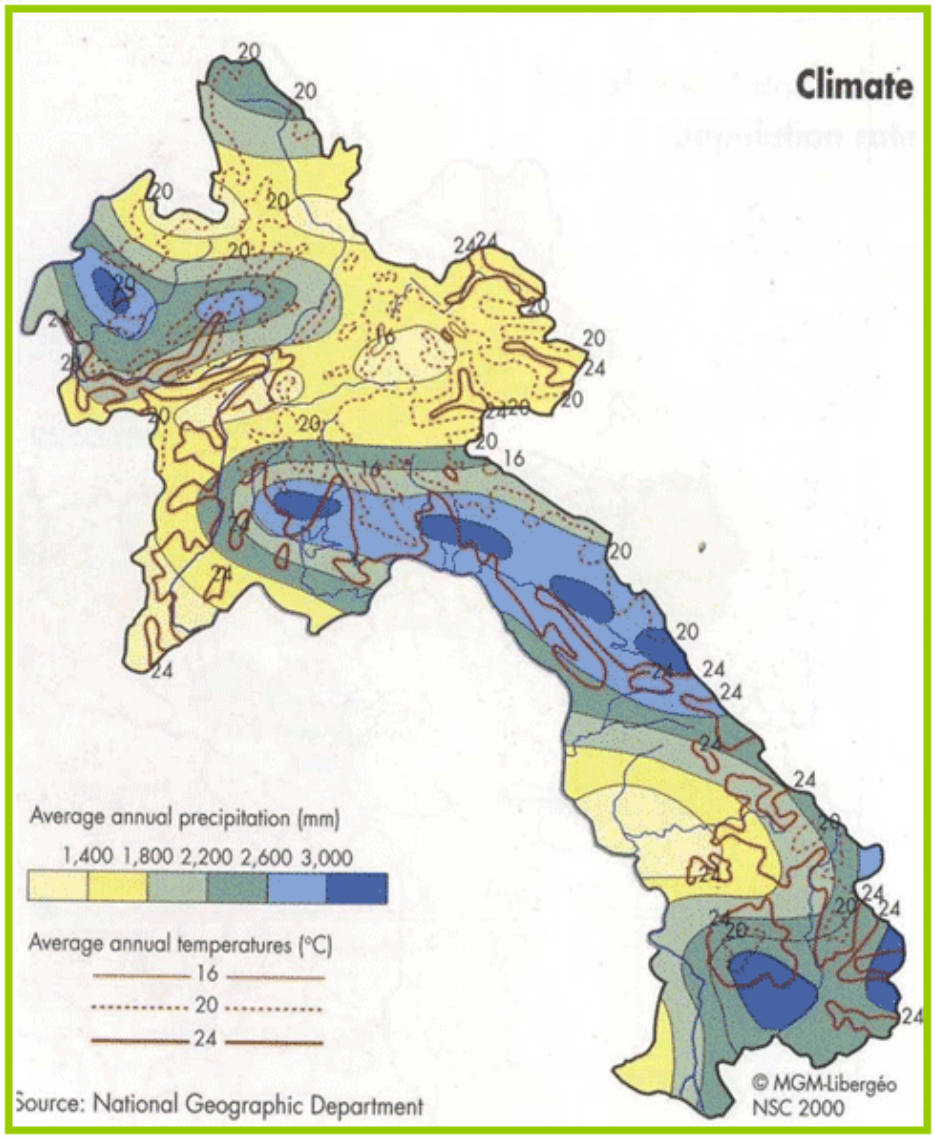
The competition of sugar cane and cassava is apparent, depending on the economic return.

Fluctuation in cropping areas in relation to economic return

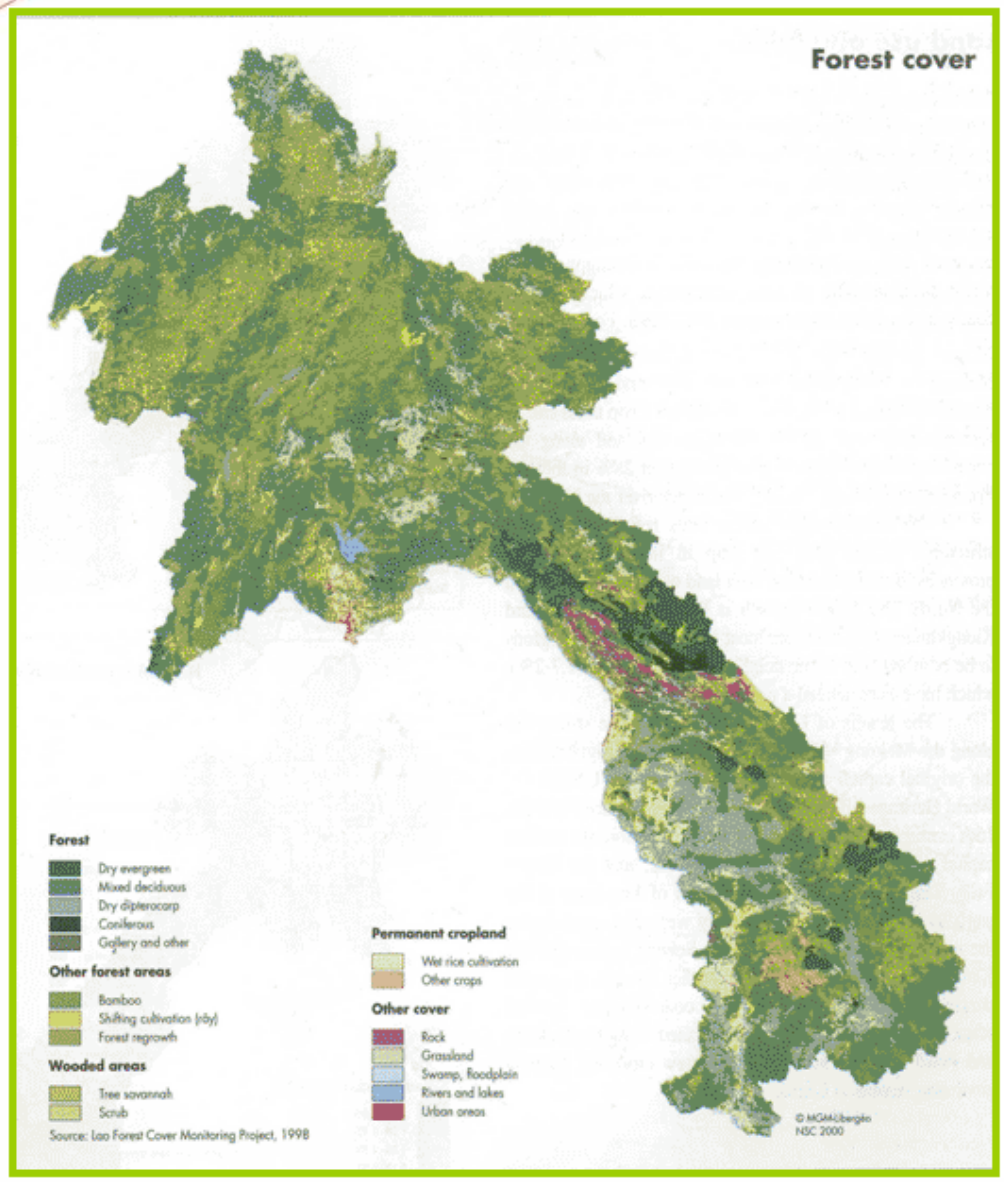


There is a limitation of paddy land planted to rice, depending not only amount of rainfall but also the low land. The lowland is not difficult to accumulate water, particularly during the rice-transplanting period.

The farmers are engaged in rice growing for subsistence that is culture of the Northeast people.

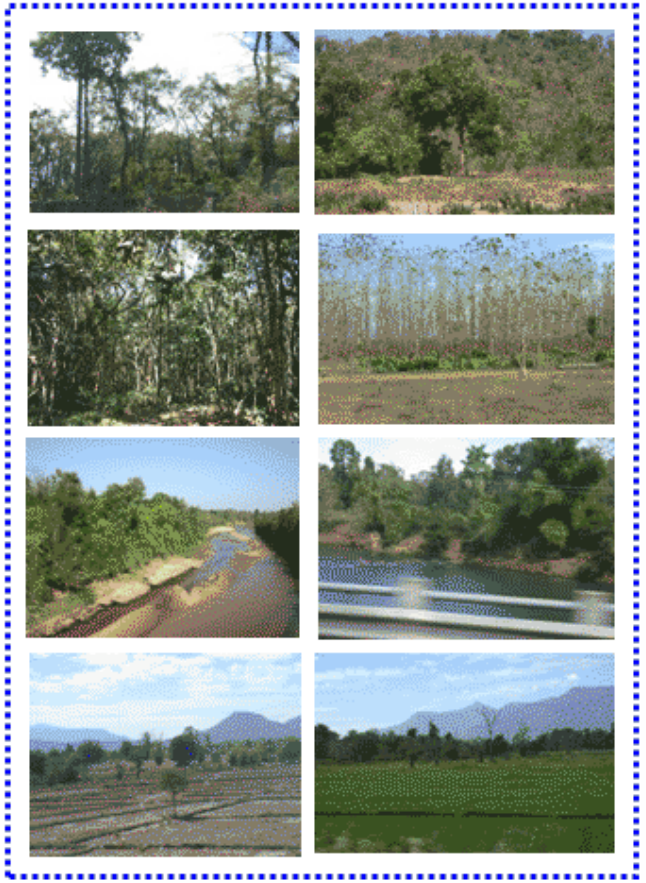


Rainfall and Temperature in Lao PDR



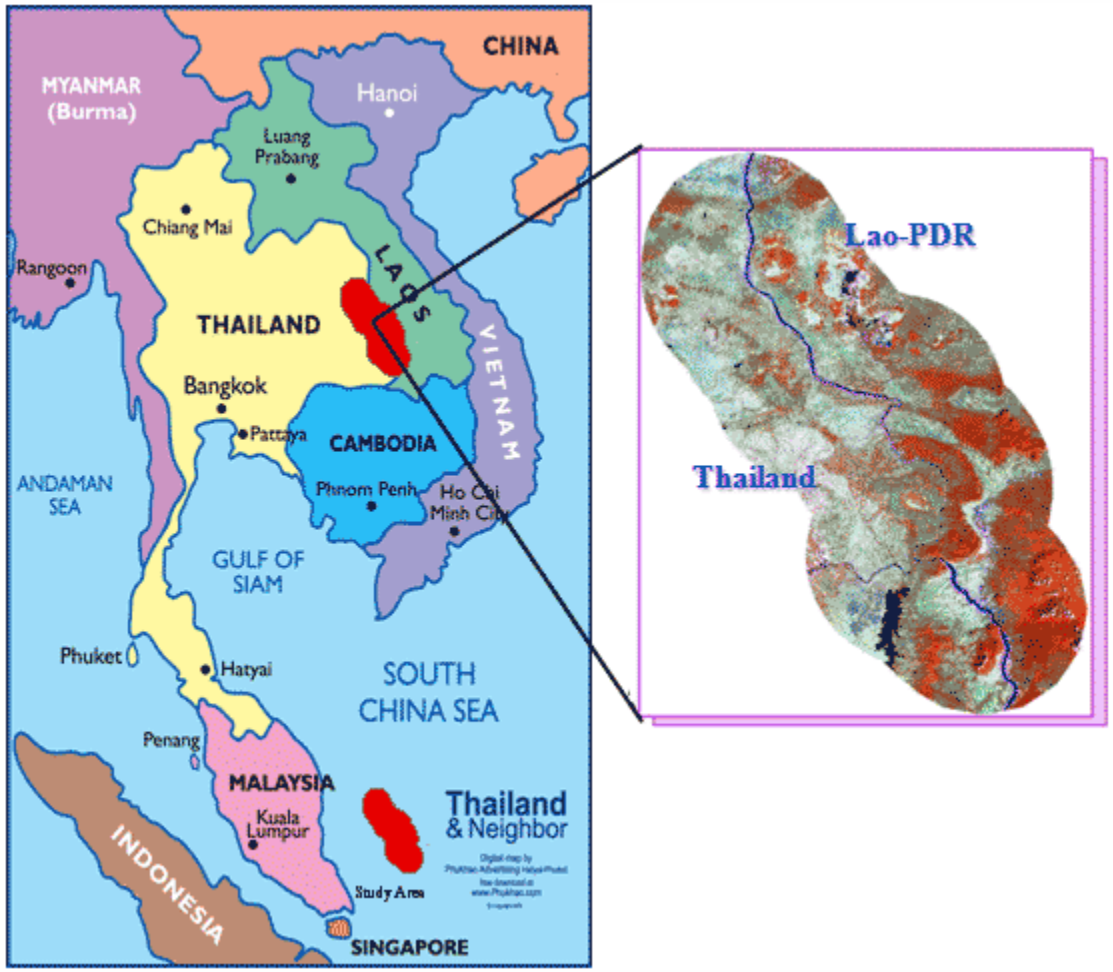
Forest cover

in Lao PDR

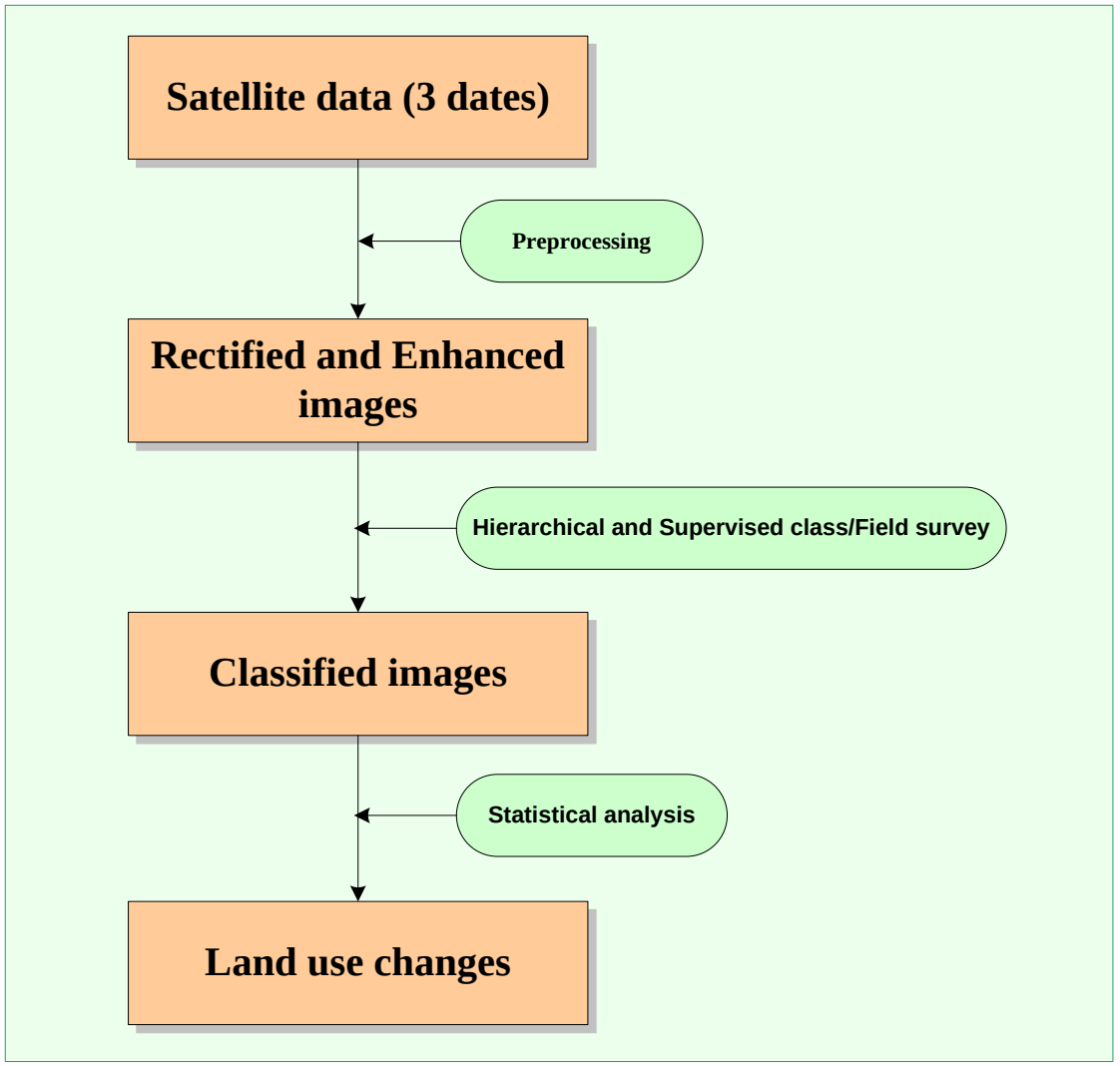


Study area

Study area



The study area covers the buffering area of 50 km from both side of the Mekong river bank with about 400 km along the meandering river

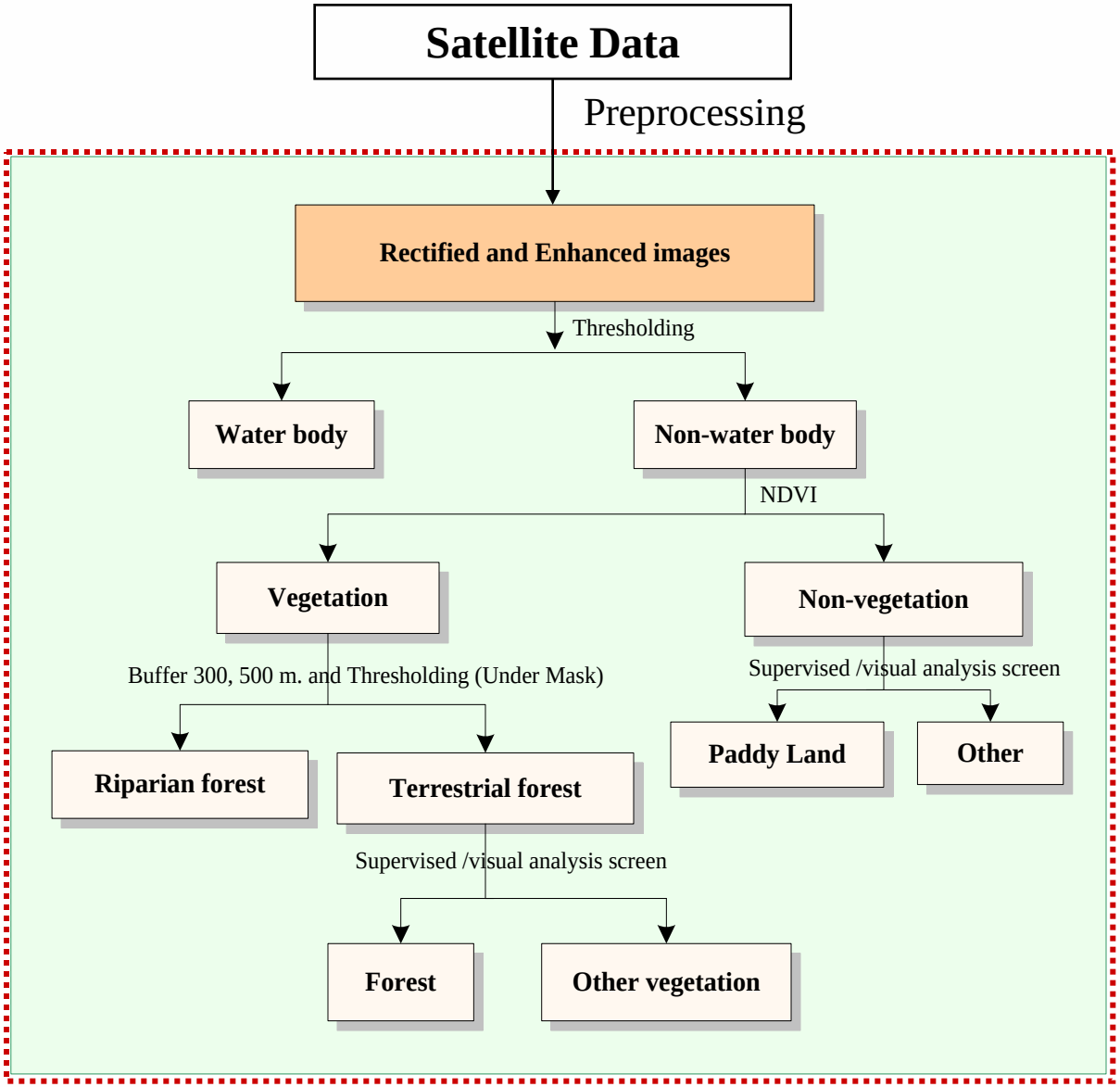


Method

Schematic chart of the methodology procedure used

Data sources

- Landsat TM data 30 m. resolution for two dates acquired in 1990 and 2001.
- SPOT data 10 m. resolution acquired in 2006.
- Topographic map of the Royal Thai Survey Department were used for geo-referencing and supplement information.



Procedure for Hierarchical and supervised method

Method

Pre-processing of satellite data

- To co-register the three dates–images into the same co-ordinate for subsequent analysis of land use change.
- Coordinate transformation-used Topographic map for the first date and resampling performed by nearest neighbor
- Image to image method performed by registering the two remaining images to the first image

Method

Thresholding

Distinguishing between water body and non water body was executed from an analysis of the threshold

1990		2001		2006	
Water body	*Non-water body*	*Water body*	*Non-water body*	*Water body*	*Non-water body*
0-40	THR>40	0-37	THR>37	0-40	THR>40

Method

NDVI

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

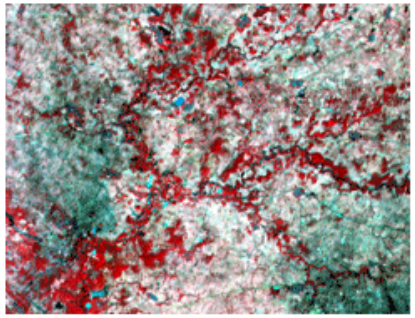
NDVI (bit) NIR-RED NIR RED

The vegetation and non-vegetation cover classes were differentiated over the area of non-water body, performing the normalized vegetation index (NDVI) analysis

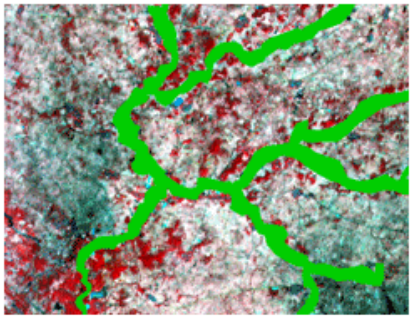
dates	NDVI	
	Vegetation	*Non-vegetation*
1990	100-160	100<NDVI or NDVI>160
2001	110-170	110<NDVI or NDVI>170
2006	90-150	90<NDVI or NDVI>150

Method

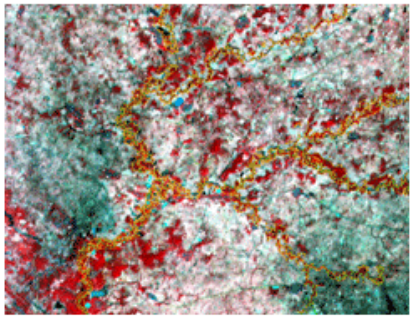
Separating the riparian vegetation form the terrestrial forest.



SPOT 3 2 1



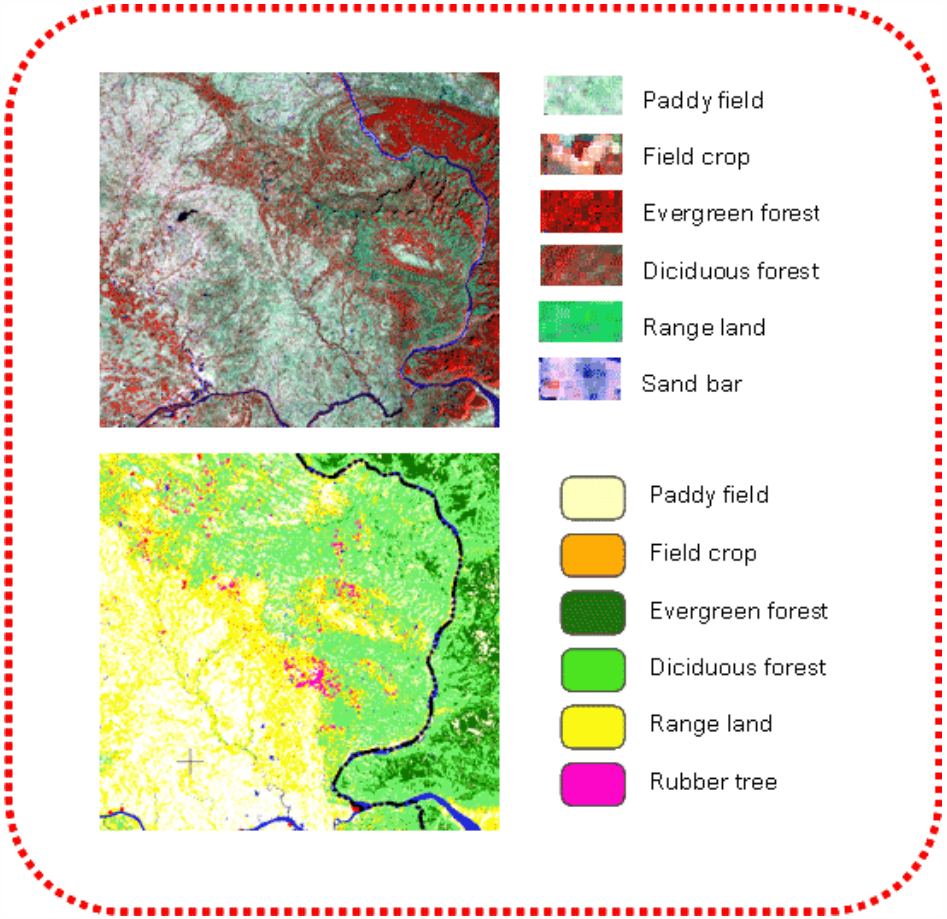
Buffer 300, 500 m.



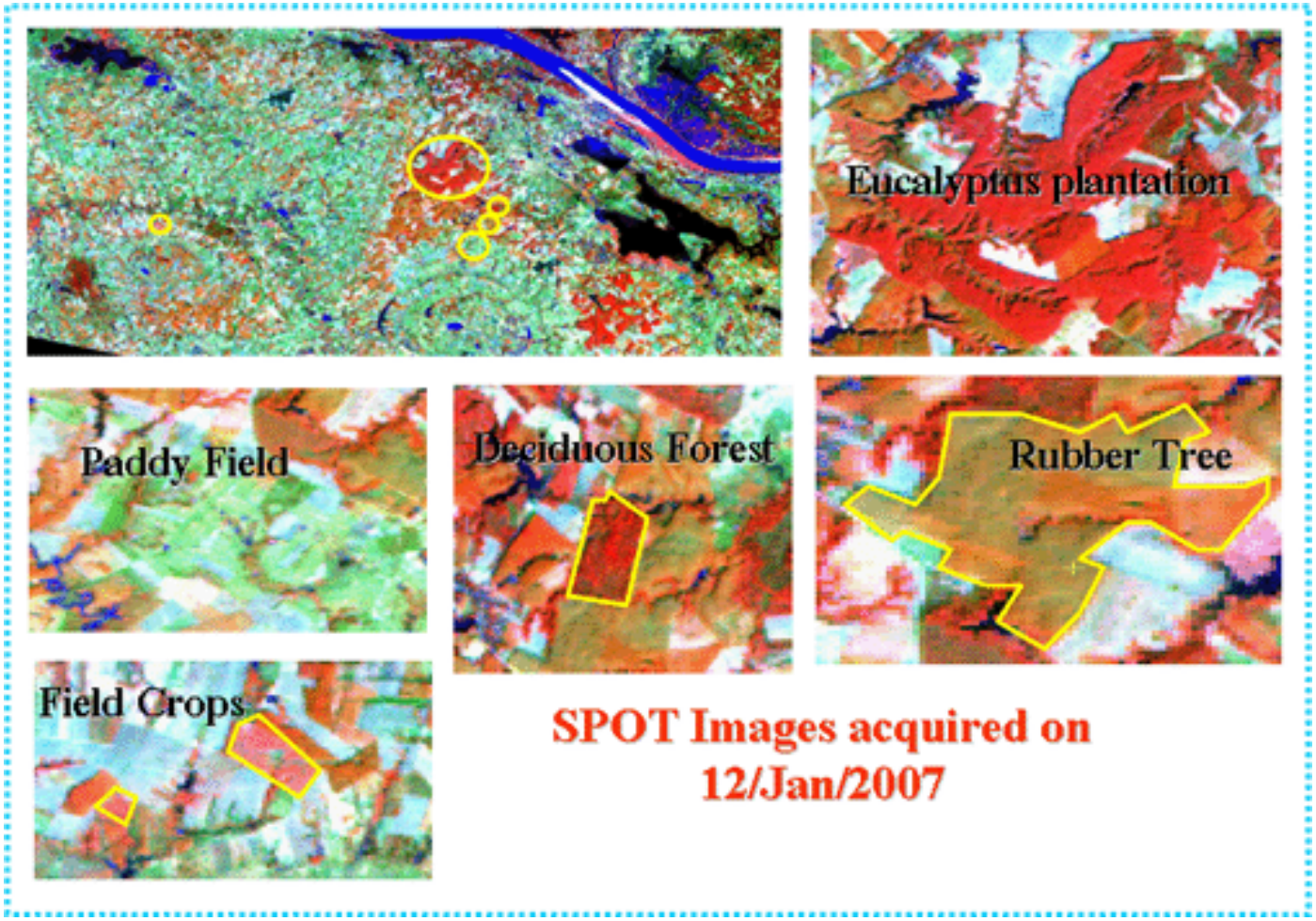
Riparian forest

Method

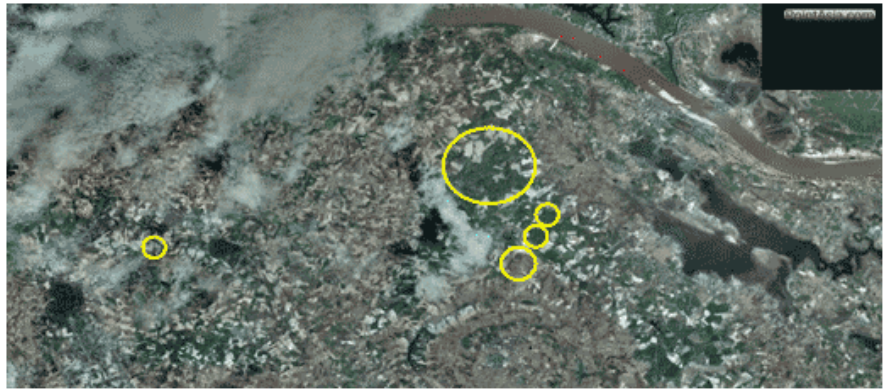
Supervised method used to differentiate the forest from other vegetation.

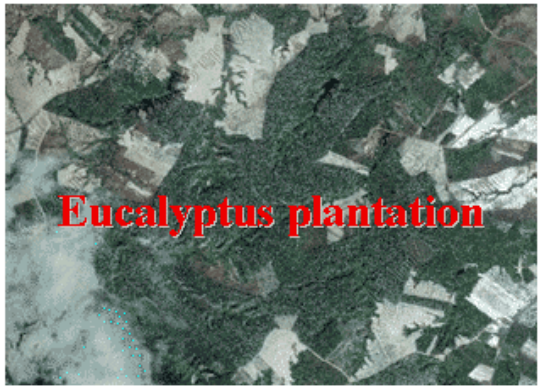


Method



Discrimination of the vegetation covers.





IKONOS Images
(From www. Point Asia.com)

Transformed Divergence

Land use 1990

Class	A1	A2	F2	F1	M1	M10
A1	1.999928					
A2	1.999987	1.640678				
F2	1.999980	1.830529	1.507827			
F1	2.000000	2.000000	1.999986	1.756941		
M1	1.999999	1.833763	1.999795	1.994653	2.000000	
M10	2.000000	1.999994	1.999274	2.000000	2.000000	2.000000

Land use 2001

Class	A1	F1	F2	A2	M10	M1
A1	2.000000					
F1	2.000000	2.000000				
F2	2.000000	1.964148	1.996903			
A2	1.999999	1.740716	2.000000	1.985343		
M10	2.000000	1.992984	2.000000	2.000000	1.999951	
M1	1.909983	2.000000	2.000000	2.000000	1.999999	2.000000

Land use 2006

Class	F2	F1	M1	M10	A1	A2
F2	2.000000					
F1	2.000000	1.842178				
M1	2.000000	1.388800	1.999397			
M10	2.000000	2.000000	2.000000	2.000000		
A1	1.999991	1.939281	2.000000	1.929461	1.999690	
A2	1.985850	1.547341	2.000000	1.805571	1.999997	1.522900

Remake **A1** = Paddy Field, **A2** = Field Crop, **F2** = Deciduous Forest, **F1** = Evergreen Forest, **M1** = Range land, **M10** = Sand bar

Method

Validation of land use

- Ground investigation was conducted to validate the result
- About test areas were inventoried and recorded, These included ground cover, land type, soil, floristic composition of the covers
- Allocation of the test areas use GPS and topographic map

Change Analysis

- Comparison of land use derived from the year 1990-2001, 2001-2006 and 1990-2006 was conducted.
- Changes in land use by types and its extent were determined

Implication of the land use changes

- Based on the bio-physical environment and economic trend with social attitude

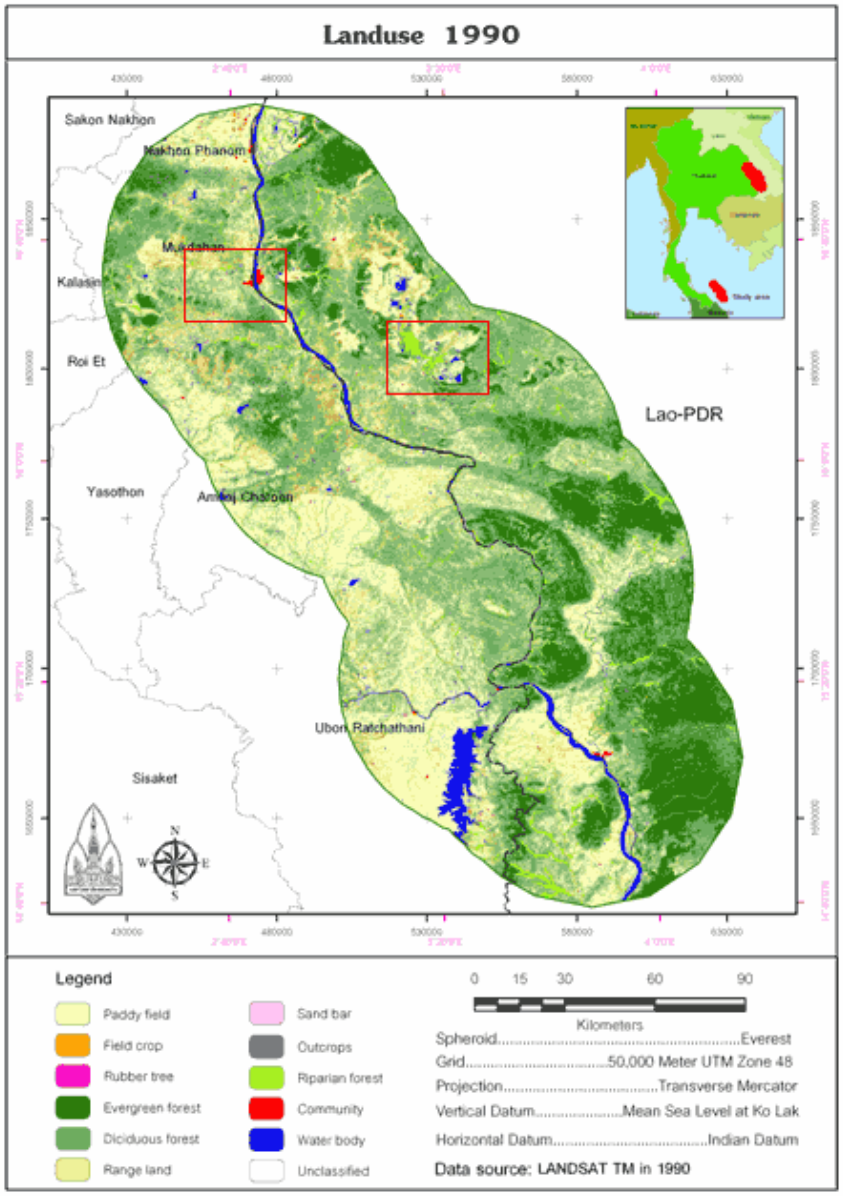
Results

- Land use in 1990, 2001 and 2006
- Land use change 1990-2001, 2001-2006 and 1990-2006
- Implication of land use changes in Thailand and Lao PDR
- Drivers for LUC

- **Land use in 1990**

Number	Land use	Thailand		Lao-PDR	
		Area Km2	percent	Area Km2	percent
1	Paddy field	6,140.64	43.88	3,653.47	21.55
2	Field crop	708.35	5.06	428.50	2.53
3	Rubber tree	9.74	0.07	0.00	0.00
4	Evergreen forest	641.68	4.59	4,163.22	24.55
5	Deciduous forest	5,310.40	37.95	7,038.68	51.51
6	Range land	301.38	2.15	387.29	2.28
7	Sand bar	15.25	0.11	38.16	0.23
8	Outcrops	25.50	0.18	31.60	0.19
9	Riparian forest	364.11	2.60	751.03	4.43
10	Community	29.80	0.21	32.55	0.19
11	Water body	447.41	3.20	430.76	2.54
12	Other	0.00	0.00	0.64	0.00
	Total	**13,994.25**	**100.00**	**16,655.91**	**100.00**

Results


Landuse 1990
Sakon Nakhon
Nakhon Phanom
Mukdahan
Kalasin
Roi Et
Lao-PDR
Yasothon
Amnat Charoen
Ubon Ratchathani
Sisaket
N
W
E
S
Legend
Paddy field
Field crop
Rubber tree
Evergreen forest
Diciduous forest
Range land
Sand bar
Outcrops
Riparian forest
Community
Water body
Unclassified
0 15 30 60 90
Kilometers
Spheroid.....Everest
Grid.....50,000 Meter UTM Zone 48
Projection.....Transverse Mercator
Vertical Datum.....Mean Sea Level at Ko Lak
Horizontal Datum.....Indian Datum
Data source: LANDSAT TM in 1990

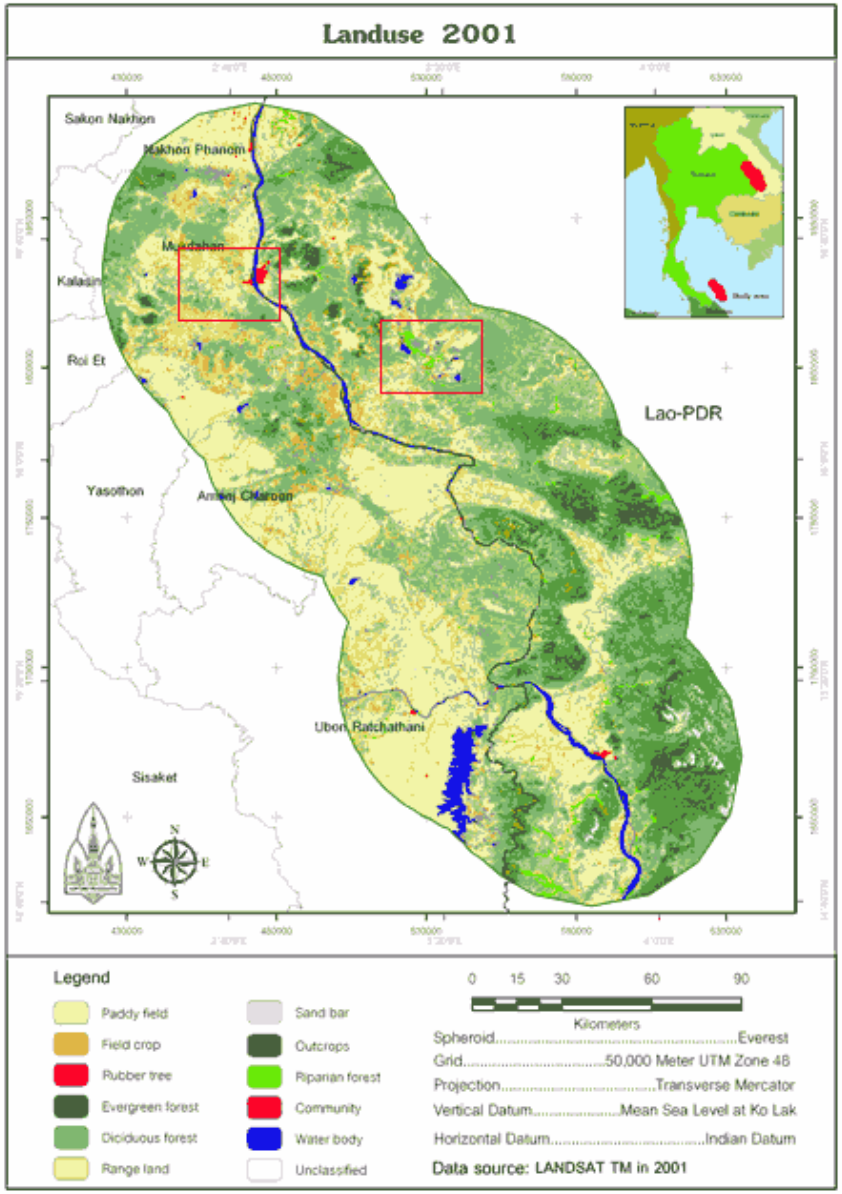
Mukdahan

Results

- **Land use in 2001**

Number	Land use	Thailand		Lao-PDR	
		Area Km2	percent	Area Km2	percent
1	Paddy field	6,790.20	48.52	3,963.80	23.38
2	Field crop	1,558.67	11.14	955.39	5.63
3	Rubber tree	48.68	0.35	0.00	0.00
4	Evergreen forest	452.90	3.24	2,678.08	15.79
5	Deciduous forest	4,209.16	30.08	7,636.56	45.04
6	Range land	188.92	1.35	383.47	2.26
7	Sand bar	24.17	0.17	46.07	0.27
8	Outcrops	25.52	0.18	31.60	0.19
9	Riparian forest	245.32	1.82	689.41	4.07
10	Community	34.22	0.24	47.67	0.28
11	Water body	407.48	2.91	396.90	2.34
12	Other	0.00	0.00	126.96	0.75
	Total	**13,994.25**	**100.00**	**16,955.91**	**100.00**

Results


Landuse 2001
Sakon Nakhon
Nakhon Phanom
Mukdahan
Kalasin
Roi Et
Lao-PDR
Yasothon
Amnat Charoen
Ubon Ratchathani
Sisaket
N
W
E
S
Legend
Paddy field
Field crop
Rubber tree
Evergreen forest
Deciduous forest
Range land
Sand bar
Outcrops
Riparian forest
Community
Water body
Unclassified
0 15 30 60 90
Kilometers
Spheroid.....Everest
Grid.....50,000 Meter UTM Zone 48
Projection.....Transverse Mercator
Vertical Datum.....Mean Sea Level at Ko Lak
Horizontal Datum.....Indian Datum
Data source: LANDSAT TM in 2001

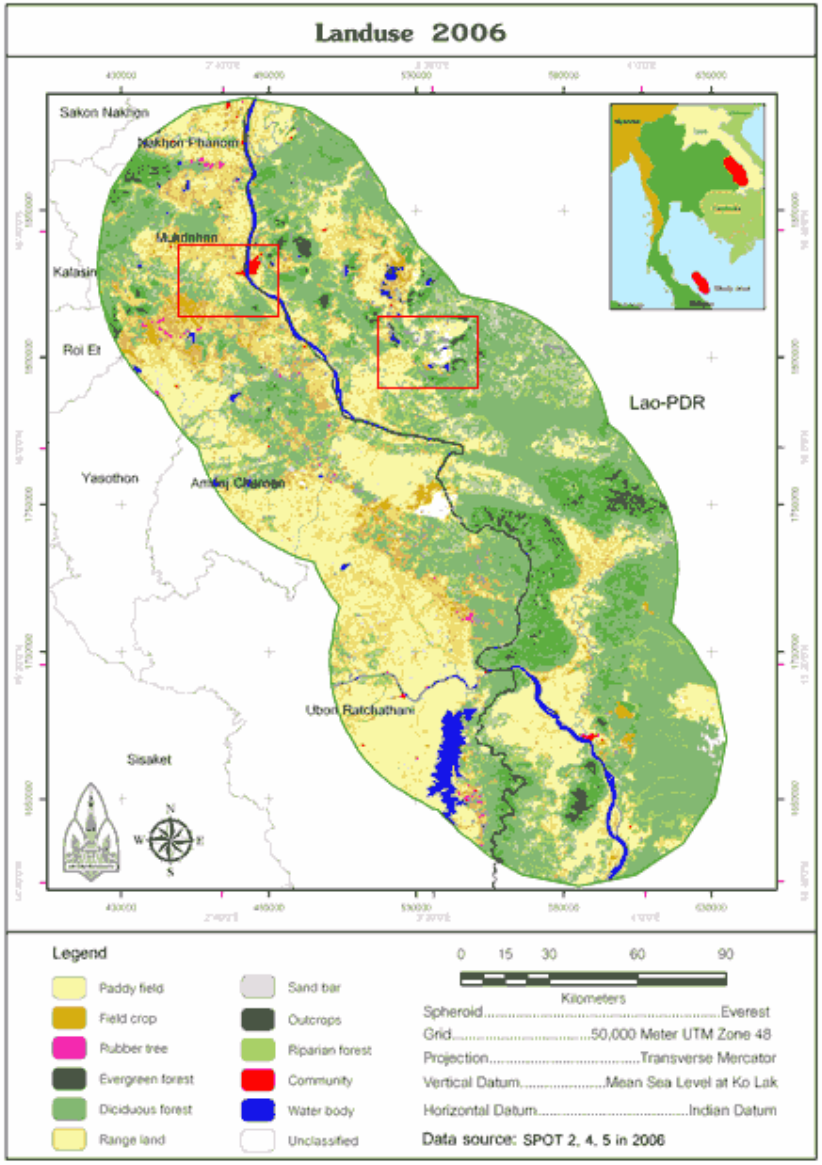
Mukdahan

Results

- **Land use in 2006**

Number	Land use	Thailand		Lao-PDR	
		Area Km2	percent	Area Km2	percent
1	Paddy field	6,477.05	46.28	4,384.19	25.86
2	Field crop	2,463.19	17.60	1,165.17	6.87
3	Rubber tree	118.30	0.85	0.31	0.00
4	Evergreen forest	258.62	1.85	1,169.66	6.90
5	Deciduous forest	3,489.13	24.93	8,632.92	50.91
6	Range land	49.49	0.35	389.29	2.30
7	Sand bar	0.64	0.00	3.26	0.02
8	Outcrops	25.41	0.18	31.63	0.19
9	Riparian forest	369.08	2.64	492.66	2.91
10	Community	42.88	0.31	47.64	0.28
11	Water body	510.00	3.64	468.13	2.76
12.	Other	190.45	1.36	171.06	1.01
	Total	**13,994.25**	**100.00**	**16,955.91**	**100.00**

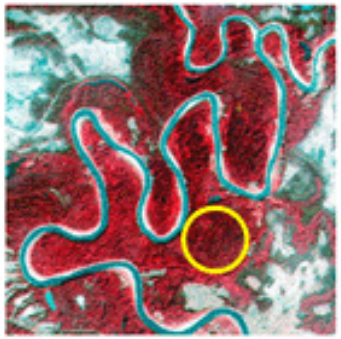
Results


Landuse 2006
Sakon Nakhon
Nakhon Phanom
Mukdahan
Kalasin
Roi Et
Lao-PDR
Yasothon
Amnat Charoen
Ubon Ratchathani
Sisaket
N
W
E
S
Legend
Paddy field
Field crop
Rubber tree
Evergreen forest
Diciduous forest
Range land
Sand bar
Outcrops
Riparian forest
Community
Water body
Unclassified
0 15 30 60 90
Kilometers
Spheroid.....Everest
Grid.....50,000 Meter UTM Zone 48
Projection.....Transverse Mercator
Vertical Datum.....Mean Sea Level at Ko Lak
Horizontal Datum.....Indian Datum
Data source: SPOT 2, 4, 5 in 2006

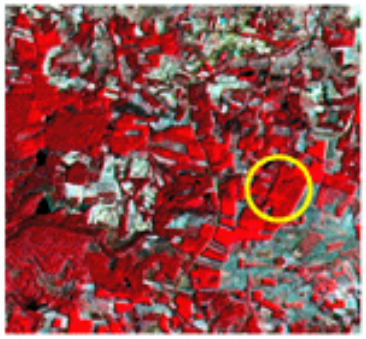
Mukdahan

Results

Riparian forest

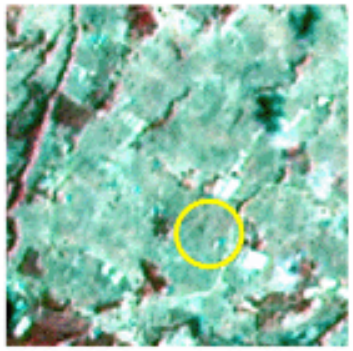


Rubber Tree

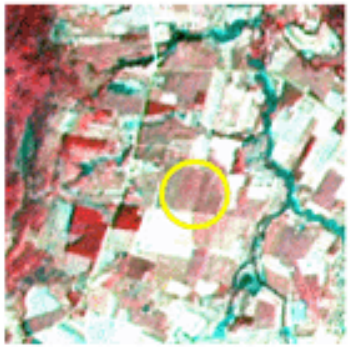


Results

Paddy field

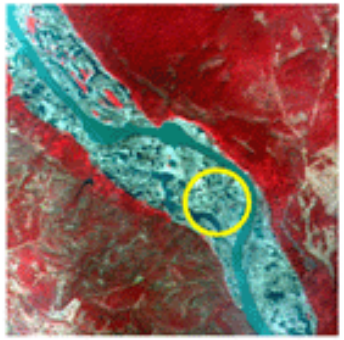


Field crop

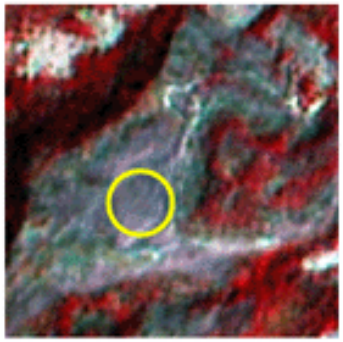


Results

Sand bar

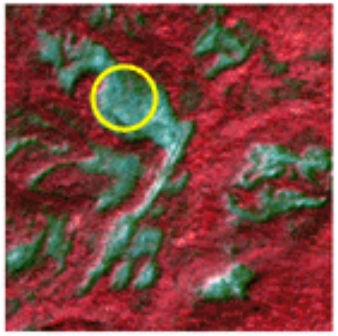


Outcrops

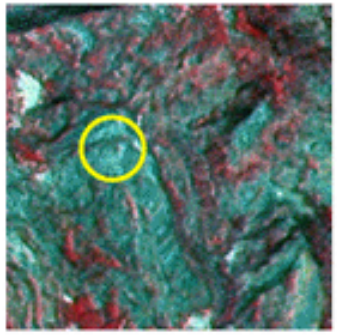


Results

Range land

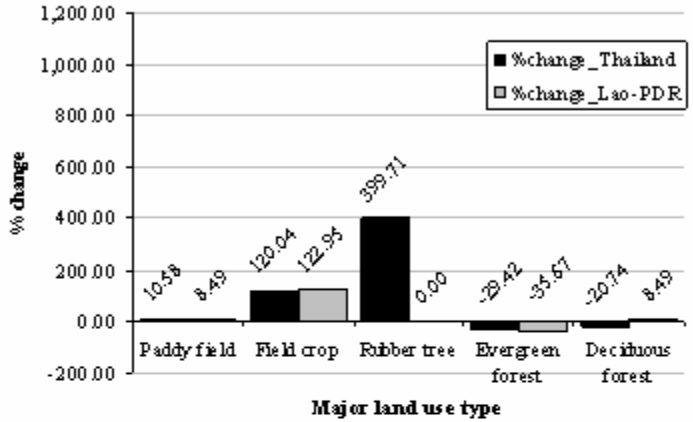


Deciduous forest

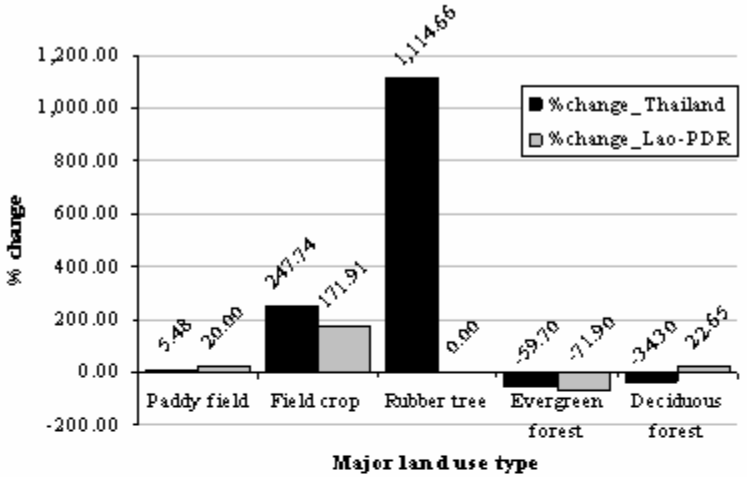


Results

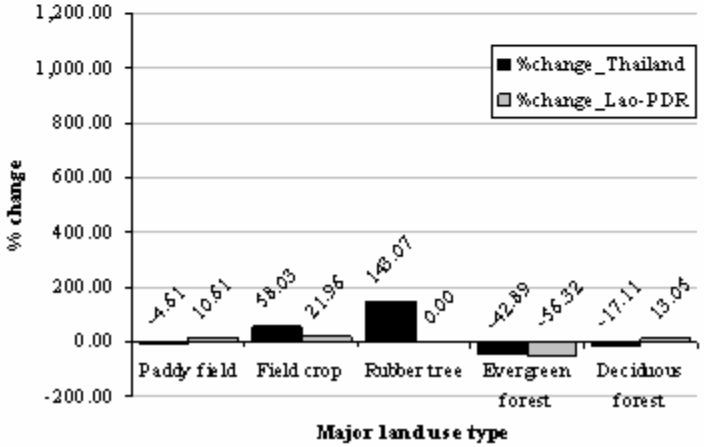
Land use change 1990-2001



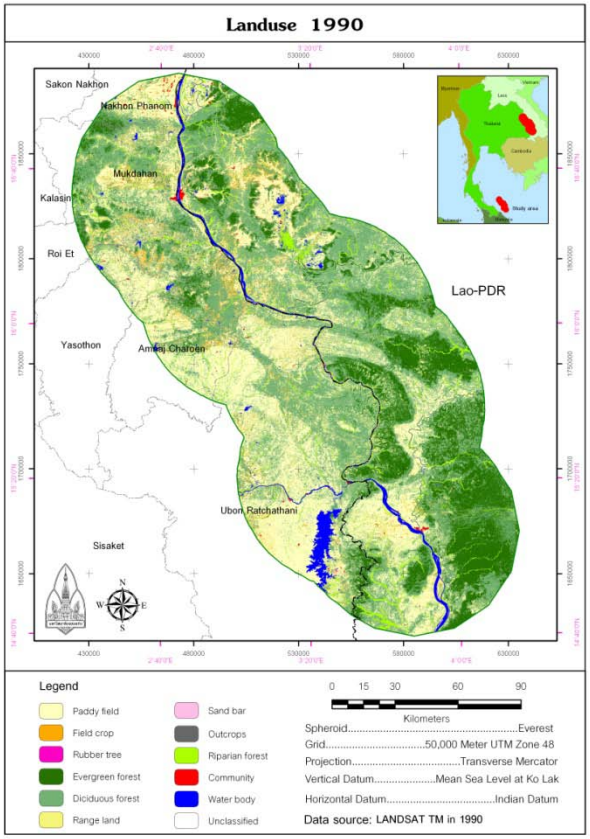
Land use change 1990-2006

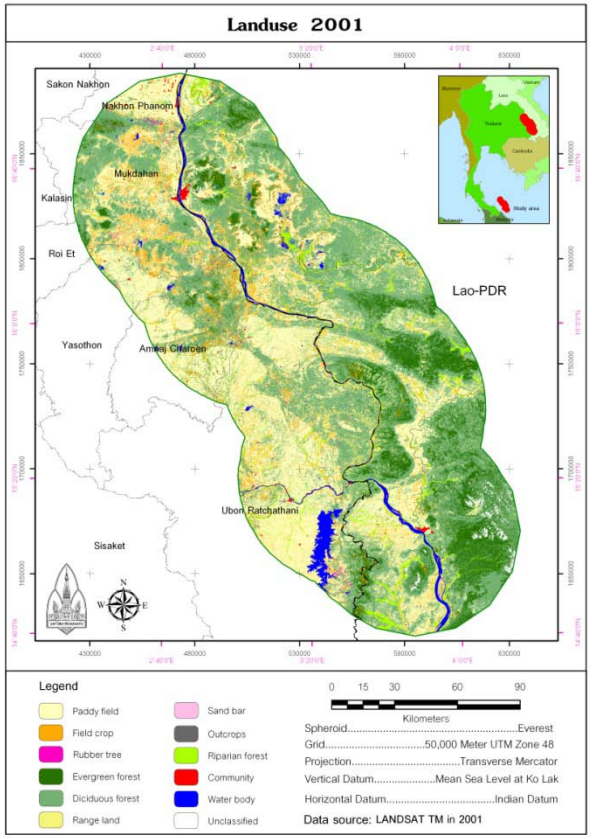


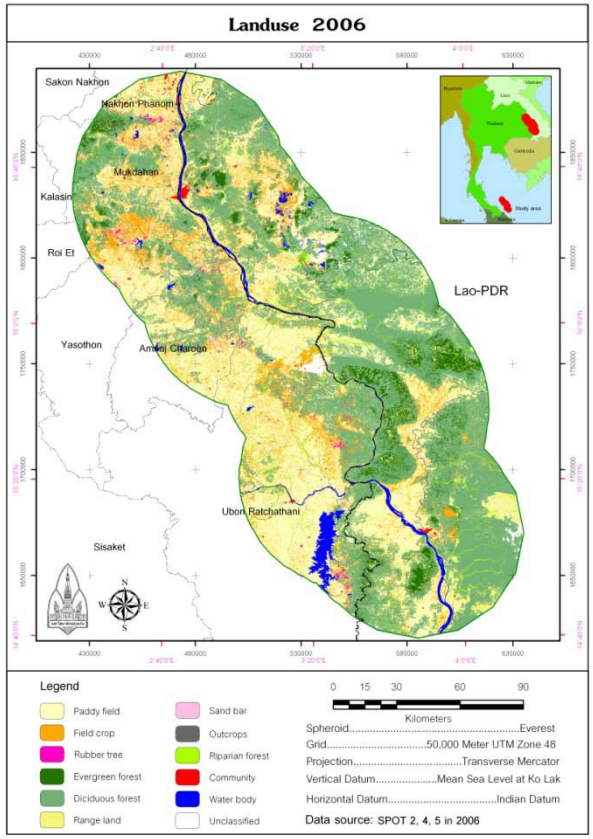
Land use change 2001-2006



Results







Land use map 1990, 2001 and 2006

Results

- **Implication of land use changes in Thailand and Lao PDR**

In Thailand

- Increasing demand of land for rubber tree as a result of rising the price of rubber (may reach 3 US dollars/kg.)
- Areas used for field crops (sugar-cane/cassava) will be declined as a consequence of the areas competition
- Cassava cultivation areas may be declined.
- Areas for paddy reach maximum a result of the capability of land.
- Forest reserves remain no changed.

Results

- **Implication of land use changes in Thailand and Lao PDR**

In Lao PDR

- Encroachment of agriculture on forest reserved will be continued at diminishing rate. The forest areas observed, mostly secondary forest. Regeneration rate of secondary forest is likely rapid due to less population in Lao.
- Agricultural extension may increase the field crop area and intenfication of land use in certain areas.
- Increasing demand of rubber may extend this promising tree.
- Fast growing trees Eucalyptus will continue the expansion of area.
- Paddy land planted to rice, its cultivation has spread to other area.

Main drivers for LUC

Criteria for a driver should be physically possible, economically viable, socially acceptable and technologically feasible.

Rice:

Land form/ soil, culture, rainfall

Cassava and sugar cane:

Landform/ soil, economic return, rainfall

Rubber:

Economic return, land form/ soil, Rainfall

Rice

- **Land form/ soil**

  Paddy lands cultivated to rice are restricted to land form, low lands are used for rice cultivation the upper paddy may not accumulate water sufficient to transplanting.

  The fine textured, poorly drained soil are favorable for rice.

Rice (cont.)

- **Culture**

  Farmers in the region have been engaged in rice cultivation for subsistence since many decades. Extensification of paddy land planted to rice has been apparent as a result of population increase. Illegal encroachment of paddy land on forest reserves covers large areas. Soil inherently unsuitable for planting rice i.e. upper paddy lands are utilized giving unstable yields.

Rice (cont.)

- **Economic Return**

  Attractive economic returns lead to expand the cultivation areas in the marginal lands. The off-season rices under irrigated area are intensified and increased.

Rice (cont.)

- **Rainfall**

  In the dry years the paddy land remains unplanted to rice due mainly to insufficient water for transplanting.

  In the wet years the lowland may be flooded, the upper paddy can be planted. Variability in rainfall distribution tends to have a greater influence on the relative proportion of total paddy area which is planted in a given year.

Cassava and Sugar cane

- **Land form/ soil**

  Lands cultivated to cassava and sugar cane are restricted to middle to high terraces and foot hills, where the soils are well drained. The coarse textured soils are highly suitable for cassava while sugar cane can grow in sandy to heavy soil texture.

Cassava and Sugar cane (cont.)

- **Economic return**

  Competition between cassava and sugar cane depends mainly on the marketing demands. Attractive price of cassava is a result of government policy to promote ethanol production. A number of cassava and sugar cane growers have switched to plant eucalytus and rubber tree, the perennial crops which can not be changed to annual crops in the short run.

Cassava and Sugar cane (cont.)

- **Rainfall**

  Cassava and sugar cane are annual crops that require relatively low amount of rainfall. The areas suitable in terms of water demand cover extensively in Northeast Thailand. It is expected that cassava and sugar cane continue to show a slight change trend for the next few years.

Rubber Tree

- **Economic return**

  Increasing demand for rubber during the past 2 years is a driving force to expand the rubber planted areas. Increase in the planted areas for rubber is over 400% as a result of attractive economic return. It is expected that the rubber tree can be tapping for the next 3 years exceeding 300%. In 2009, the economic return of rubber is declined in parallel to the lower oil price. Rubber tree is perennial plant, the farmers can not switch their lands to plant annual crops.

Rubber Tree (cont.)

- **Landform/ Soils**

  Rubber tree is perennial crop that requires upland, well drained and deep soils.

- **Rainfall**

  Rubber tree requires high annual rainfall of over 1,400 mm. in combination of deep soils. This is a limitation of areas planted to rubber tree.

Conclusions

With chrono-sequence of satellite data, land use patterns and its changes in Thailand and Lao PDR can be obtained. Projecting the future land use can be formulated with reliable information in terms of spatial and temporal distribution. Awareness on the resource exploitation, land use for development of prosperity and sustainable development is expected to achieved effectively and successfully.

Thank you for your attention

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