

MONITORING OF LAND USE AND LAND COVER CHANGES IN AND AROUND TANINTHARYI NATURE RESERVE (TNR), MYANMAR USING RS AND GIS

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Abstract: Land use and land cover change is a major force of ecological change in tropical regions. The pattern and process of deforestation and forest degradation have thus received considerable attention in ecological, socioeconomic, and policy studies to support effective management mechanisms. Realizing the need to provide information on the present status of major land cover types of the region and identify major land use and cover change areas for TNR, Remote Sensing and GIS section of Forest Department conducted monitoring of land use and land cover of in and around TNR areas using 2009 and 2010 ALOS imageries. And deforestation and forest degradation analysis was conducted by three areas; TNR area, 10 km buffer area of TNR and outside of TNR area and its buffer. The results revealed that although rates of deforestation and forest degradation were decreasing within TNR area, the rates were increasing within 10 km buffer area of TNR and its outside areas. (*Forest cover change patterns in Myanmar (Burma) 1990–2000. Environmental Conservation 32: 356–364.*)

Keywords – Tropical, Socioeconomic, Remote Sensing, GIS, ALOS imageries, Deforestation, Degradation.

1. BACKGROUND INFORMATION

The Taninthayi Nature Reserve Project (TNRP) area is situated at the Dawei District, between the Dawei River and the Myanmar-Thailand border, Taninthayi Division, consists of the eastern part of Heinze-Kaleinaung Reserve Forest and Luwein Reserve Forest. Geographically, it is approximately situated between latitudes 14°20'50" and 14°57'55"North, and between longitudes 98°5'10" and 98°31'32"East. This area encompasses approximately 1,700 km² or 169998.7 hectares (Appendix I). TNR lies within Biounit 5d, i.e. one of the global biodiversity conservation units, and Tenasserim-South Thailand semi-evergreen moist forest region which is nationally important, regionally significant and globally outstanding region in southern Myanmar. Accordingly, TNR was established by Ministry of Environmental Conservation and Forestry (MOECAF), formerly Ministry of Forestry (MOF), on the 30th of March 2005 to conserve tropical rainforests and their constituent biodiversity and to

contribute sustainable livelihood of local communities by getting involved in conservation works.

Although forest is associated with mixed deciduous and bamboo forest in the lowlands of TNR, there is almost tropical rain forest in high elevation mountain sites. There are 258 species of flora including 5 critically endangered species and 5 endangered species in TNR. 67 Mammal species and 244 bird species were recorded in TNR.

Land use and land cover status TNR were assessed using Remote Sensing and GIS in order to contribute the effective management activities. Satellite images of 1990, 2000 and 2006 were used to understand the trend of land use and land cover changes not only for TNR area but also within 10 km of TNR boundary (TNR buffer) and outside these areas (outside TNR). Based on previous results, land use and land cover changes were quite significant over time inside TNR and in the vicinity of TNR. Most of them might be due to human impacts such as encroachment and illegal village settlements, shifting cultivation, Subsistence hunting and logging, illegal logging and Small-scale tin mining etc. Land use and Land cover status of 1990 and 2006 were shown in Table 1.

Within and around TNR, closed forest including closed evergreen and closed semi-evergreen forest were decreased. On the other hands, open forest including open evergreen and open semi-evergreen forest were increased. Due to some disturbances like vast areas of bamboo brakes, bamboo representing areas were increasing in TNR and its neighbouring areas. Cultivated areas including agriculture lands and horticulture were also increasing and this might be due to increasing population and encroachment into forest lands. Similarly, areas of rubber and oil palm plantations were also increasing.

Although Landsat TM images were used in previous assessment, the quality of recent Landsat satellite scenes was not available and not acceptable for effective image classification due to band striping. Four ALOS satellite image

data sets acquired on 2009 and 2010 were used in current land use/land cover assessment (Table 2).

TABLE 1: LAND USE AND LAND COVER STATUS OF TNR AND ITS SURROUNDING IN 1990 AND 2006

No.	Lu/Lc categories	Area (ha)					
		TNR Area		10 km Buffer Area		Outside TNR	
		1990	2006	1990	2006	1990	2006
1	Closed Forest	132822.12	105470.94	58245.19	43992.78	53598.69	62357.28
2	Open Forest	18578.47	24948.82	9586.38	4728.96	17202.61	235.75
3	Water	336.47	1201.33	1229.93	1665.52	25287.12	27408.12
4	Agriculture	788.92	1218.02	11093.37	14931.62	22335.02	19415.20
5	Grass Land	227.51	2499.13	2187.16	7688.91	1513.72	1712.29
6	Sand	0.00	123.04	1.96	356.06	684.32	1270.23
7	Rubber	162.25	186.69	1012.10	1537.43	274.81	657.64
8	Bamboo	5120.06	14144.64	4615.93	15443.80	1200.79	8463.16
9	Scurb/grass	11915.62	19976.17	63739.26	53162.30	45708.83	40943.85
10	Horticulture	47.59	87.18	3482.04	11227.54	3241.35	8436.22
11	Others	0.00	141.63	0.00	226.49	0.00	133.63
12	Oil Palm	0.00	1.42	2.73	234.61	0.18	14.07
	Total	169999.00	169999.00	55196.03	155196.03	171047.45	171047.45

Notes: Closed forest represents evergreen forest (closed), semi-evergreen forest (closed).

TABLE 2: ALOS SATELLITE IMAGE USED IN LAND USE/LAND COVER ASSESSMENT

No.	Image	Acquired Date
1	ALOS image 1	05- December-2009
2	ALOS image 2	26-February-2010
3	ALOS image 3	26-February-2010
4	ALOS image 4	05-December-2009

1.1 Change assessment between 2006 and 2010

Actual change can be obtained by a direct comparison between classification results of one date with the other date. Temporal condition of land covers that have occurred between the two dates were measured by performing a change matrix. After checking the accuracy of the 2010 classified image by classification error matrix using ground verification records from field survey and Google Earth, two land cover thematic maps; i.e. 2006 and 2010 were exported and overlaid in ArcGIS 9.3 to detect the forest cover changes of the study area (Dorren et al, 2003; Thapa and Murayama, 2009). Due to different land use and land cover categories in two year assessment, change detection was conducted using seven major land use and land cover categories. Change detection between 2006 and 2010 was conducted TNR area and its 10 km buffer covering an area of 325195.04 ha consisting of 169999.00 ha of TNR area and 155196.03 ha of 10 km buffer area of TNR

1.2 Deforestation and forest degradation analysis

Definitions and rules used to calculate deforestation and forest degradation are explained in Table 3.

TABLE 3: DEFINITIONS AND RULES USED TO CALCULATE DEFORESTATION AND FOREST DEGRADATION

Change types	Definition and calculation of changes
Deforestation	complete conversion of forest to non-forest, i.e., closed and open forest to non-forests
Gross forest degradation	Closed forest to open forest (Saxena et al., 1997; Uryu et al., 2008)
Annual rate of net deforestation (%)	$[\text{net deforestation}/\text{Total forest areas at initial years or assessment}] \times [1/\text{assessment}] \times 100$
Annual rate of net forest degradation (%)	$[\text{net deforestation}/\text{Total forest areas at initial years or assessment}] \times [1/\text{assessment}] \times 100$

1.3 Land use and Land cover of TNR in 2010

Although the assessment covered an area of around 490000 ha, we divided the assessed areas into three areas, i.e. TNR core, 10 kilometer buffer of TNR core and outside of TNR (outside of 10 kilometer buffer of TNR and the area covers all land area until to costal line) regarding current land use and land cover of TNR and its surrounding areas (Appendix II). Table 4 represents the land use and land cover status of three assessed areas of TNR and its neighboring in 2010. Among 16 categories, forest area, evergreen and semi-evergreen types was one of the dominant land cover in TNR and it covered almost 80% of the total area of TNR, i.e. closed forest 58.65% (99705.04 ha) and open forest 20.88% (35503.41 ha). Second large cover was scurb land, i.e. 11.48% of TNR (19520.28 ha) and then followed by bamboo cover, 5.06% of TNR (8604.05 ha). Other land use and land cover areas were relatively low inside TNR.

TABLE 4: LAND USE AND LAND COVER OF TNR AND ITS SURROUNDINGS

No	Land use and Land cover categories	TNR Area	10 km Buffer of TNR	Outside TNR	all area
1	Closed Forest	99705.04	20280.89	3594.84	123580.77
2	Open Forest	35503.41	15102.52	10242.41	60848.34
3	Water body	724.59	985.88	24695.15	26405.62
4	Agriculture Land	587.01	6141.38	15382.05	22110.44
5	Mangrove Forest	0.00	0.00	7700.20	7700.20
6	Grass Land	3576.47	18050.84	25040.71	46668.02
7	Dry Grass	1093.47	2691.15	367.47	4152.09
8	Sand	127.23	212.42	905.32	1244.97
9	Young Rubber	60.74	1506.94	947.56	2515.24
10	Bamboo	8604.05	9268.32	7063.99	24936.36
11	Scrub Land	19520.28	77192.79	73202.79	169915.86
12	Horticulture Land	41.57	1249.50	53.75	1344.82
13	Others	139.59	517.74	749.79	1407.12
14	Oil Palm	0.00	162.19	551.04	713.22
15	Taungya	217.43	1364.34	504.52	2086.28
16	Old Rubber	98.11	469.14	45.88	613.13
		169999.00	155196.03	171047.45	496242.48

Notes: All area: All assessed areas

There was about 77192.79 ha of scrub land (49.79%), it was the largest dominant land cover within the 10 km buffer area of TNR. Forest covered more than 20 % of the respective area, i.e. closed forest 13.07 % (20280.89ha) and open forest 9.73% (15102.52 ha). Grass land and agriculture land covered 18050.84 ha and 6141.38, i.e. 11.63% and 3.96% respectively within the 10 km buffer of TNR.

Outside of TNR and its 10 km buffer, scrub land represented with highest area of land cover, i.e. 42.80% of the respective area (73202.79 ha). Within this area, forest covered only 8% (2.10 % by closed forest and 5.99% by open forest). Therefore, forest cover is relatively low outside of TNR and its 10 km buffer.

1.4 Change detection (TNR area and its 10 km buffer)

Change detection between 2006 and 2010 was also conducted to understand the changes of land use and land cover using the re-categorized seven major land use and land cover categories as mentioned in the methodology. Change detection was emphasized on TNR area and its 10 km buffer regarding to know the trends of changes to implement effective management.

Based on the results of change matrix, closed forest areas decreased from 45.96% to 36.90% TNR and its

buffer between 2006 and 2010. On the other hands, open forest areas and other wooded lands increased from 9.13% to 15.56% and 34.72% to 43.54% of TNR and its buffer respectively.

There were some positive changes between 2006 and 2010; 13959.23 ha of open forest positively changes into closed forest. Similarly, 14000.32 ha of other wooded land changed to closed forest and 16938.38 ha to open forest. However, positive changes were less than negative changes; i.e. forests, closed and open forests to other land categories and other wooded land into non-vegetative cover or others such as build-up areas. Detail changes of land use and land cover between 1996 and 2010 are shown in Table 5.

1.5 Land use and land cover changes in and around TNR

This study also conducted land use and land cover changes not only in TNR but also in its surroundings. There were twelve land use and land cover categories in the previous assessment of 1990 and 2006 and therefore current 2010 assessment were also used with 12 categories. Table 6, Table 9, Table 10 and Table 11 represent the areas of land use and land cover in 1990, 2006 and 2010 of TNR, 10 km buffer, outside TNR and all assessment areas respectively.

TABLE 5: CHANGE MATRIX FOR SEVEN MAJOR LAND USE AND LAND COVER BETWEEN 2006 AND 2010 (TNR AREA AND ITS 10 KM BUFFER.)

	Area (ha)								
	CF	OF	Water	Culti-area	OWL	Others	Plantation	2006-Total	%
CFor	92026.38	24752.31	0.00	594.93	31730.44	93.50	266.17	149463.72	45.96
OFor	13959.23	8878.31	0.00	115.65	6663.43	25.40	35.76	29677.78	9.13
Water	0	0.00	1266.16	105.48	1408.11	74.04	13.06	2866.85	0.88
Culti-area	0	0.00	100.00	3648.43	23060.47	359.95	295.51	27464.36	8.45
OWL	14000.32	16938.38	126.30	3467.96	78163.55	200.90	17.53	112914.95	34.72
Others	0	36.93	216.39	84.94	468.06	33.69	7.21	847.22	0.26
Plantation	0	0.00	1.62	2.07	85.07	209.51	1661.89	1960.16	0.60
2010-Total	119985.93	50605.93	1710.47	8019.46	141579.14	996.98	2297.12	325195.04	
%	36.90	15.56	0.53	2.47	43.54	0.31	0.71		

Notes: CFor- closed forest, OFor-open forest, culti-area-cultivated area, OWL-other wooded land, Plantation (rubber+oil palm)

TABLE 6: LAND USE AND LAND COVER OF TNR AREA IN 1990, 2006 AND 2010

No	Categories	1990	2006	2010
1	Closed Forest	58245.19	43992.78	20280.89
2	Open Forest	9586.38	4728.96	15102.52
3	Water	1229.93	1665.52	985.88
4	Agriculture	11093.37	14931.62	6141.38
5	Grass Land	2187.16	7688.91	20741.99
6	Sand	1.96	356.06	212.42
7	Rubber	1012.10	1537.43	1976.08
8	Bamboo	4615.93	15443.80	9268.32
9	Scurb land	63739.26	53162.30	78557.12
10	Horticulture	3482.04	11227.54	1249.50
11	Others	-	226.49	517.74
12	Oil Palm	2.73	234.61	162.19

TABLE 7: LAND USE AND LAND COVER OF TNR 10 KM BUFFER AREA IN 1990, 2006 AND 2010

No	Categories	1990	2006	2010
1	Closed Forest	191067.31	149463.72	119985.93
2	Open Forest	28164.84	29677.78	50605.93
3	Water	1566.39	2866.85	1710.47
4	Agriculture	11882.29	16149.64	6728.39
5	Grass Land	2414.67	10188.05	25411.93
6	Sand	1.96	479.10	339.66
7	Rubber	1174.35	1724.12	2134.94
8	Bamboo	9735.99	29588.44	17872.37
9	Scurb land	75654.87	73138.47	98294.84
10	Horticulture	3529.63	11314.71	1291.07
11	Others	-	368.12	657.33
12	Oil Palm	2.73	236.04	162.19

TABLE 8: LAND USE AND LAND COVER OF OUTSIDE TNR AREA IN 1990, 2006 AND 2010

No	Categories	1990	2006	2010
1	Closed Forest	53598.69	62357.28	123580.77
2	Open Forest	17202.61	235.75	68548.53
3	Water	25287.12	27408.12	26405.62
4	Agriculture	22335.02	19415.20	22110.44
5	Grass Land	1513.72	1712.29	50820.11
6	Sand	684.32	1270.23	1244.97
7	Rubber	274.81	657.64	3128.37
8	Bamboo	1200.79	8463.16	24936.36
9	Scurb land	45708.83	40943.85	172002.14
10	Horticulture	3241.35	8436.22	1344.82
11	Others	-	133.63	1407.12
12	Oil Palm	0.18	14.07	713.22

TABLE 9: LAND USE AND LAND COVER OF TNR AND ITS SURROUNDINGS (ALL ASSESSED AREA) IN 1990, 2006 AND 2010

No	Categories	1990	2006	2010
1	Closed Forest	244666.00	211821.00	3594.84
2	Open Forest	45367.45	29913.52	17942.60
3	Water	26853.52	30274.97	24695.15
4	Agriculture	34217.31	35564.85	15382.05
5	Grass Land	3928.38	11900.34	25408.18
6	Sand	686.28	1749.33	905.32
7	Rubber	1449.16	2381.76	993.44
8	Bamboo	10936.78	38051.60	7063.99
9	Scurb land	121363.70	114082.32	73707.30
10	Horticulture	6770.99	19750.93	53.75
11	Others	0.00	501.75	749.79
12	Oil Palm	2.90	250.11	551.04

TABLE 10: DEFORESTATION AND FOREST DEGRADATION RATES OF TNR AND ITS SURROUNDINGS

deforestation rate (%)	Outside TNR	10 km buffer	TNRP area
1990-2006	0.006	0.011	0.008
2006-2010	0.149	0.076	0.001
forest degradation rate (%)			
1990-2006	0.009	0.024	0.021
2006-2010	0.205	0.135	0.014

1.6 Deforestation and forest degradation analysis

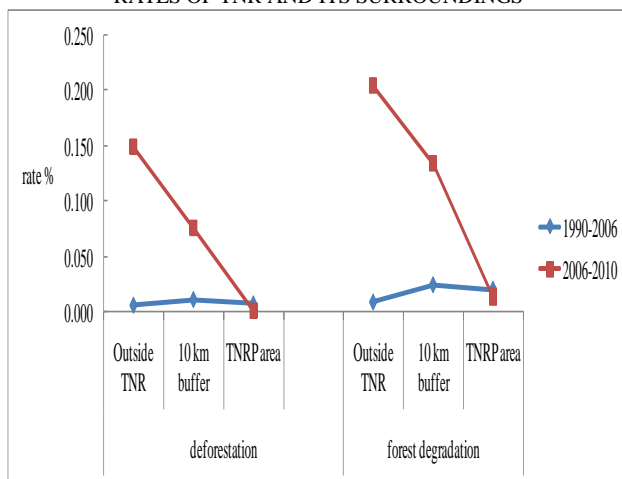
As deforestation and forest degradation are leading to major threats to the flora and fauna living therein (Zhao et al., 2006), deforestation and forest degradation analysis was also conducted in this study. TNR project was started in 2005 and therefore, deforestation and forest degradation analysis was conducted for the period 1990-2006 and 2006-2010 in order to compare how land use and land cover before and after establishing TNR. Table 10 and Figure 1 shows the comparison of deforestation rates and forest degradation rates of TNR and its surroundings.

Results on deforestation and forest degradation analysis show that rates of deforestation and forest degradation were higher than 1990-2006 in 2006-2010 periods except in TNRP area. Rates of deforestation and forest degradation in TNR area decreased from 0.008% to 0.001% and from 0.021% to 0.014% respectively between the assessment periods.

2. CONCLUSIONS

In Myanmar, TNRP is also an important one due to its unique biodiversity among the being established and proposed PASSs. It is necessary to practice biodiversity conservation in this region and to implement remedial measures for sustainable development. Assessment of the forest extents and conditions is also essential for the sustainable development of TNR. Land use and Land cover change has been attributed by various reasons and those reasons are site specific. Land cover conversion pattern varies from place to place (Giri et al., 2003). With this regards, assessment on land use and land cover changes was conducted to provide information for effective management. This study used integrated application of RS and GIS for land use and land cover changes. The results indicated that although rate of deforestation and forest degradation decreased inside TNR, there were still high in its 10 km buffer and outside of TNR. It is still needed to study why deforestation and forest degradation happen in TNR together with socio-economic and their related factors using RS and GIS.

FIGURE 1: DEFORESTATION AND FOREST DEGRADATION RATES OF TNR AND ITS SURROUNDINGS



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