APPLICATION OF REMOTE SENSING FOR MONITORING LAND COVER AND LAND USE CHANGE IN PHANG-NGA PROVINCE, THAILAND

Dithanan SENRIT*, Sangdao WONGSAI

Graduate student, Faculty of Technology and Environment Prince of Songkla University, Phuket Campus

80 Moo 1 Vichit Songkram Rd., Amphur Kathu, Phuket, THAILAND;
Tel: +66-676-276-142; Fax. +66-7627-6002
E-mail: dithanan@gmail.com*, sangdao.w@phuket.psu.ac.th

KEY WORDS: Remote Sensing, Land use, Land cover, Forest, Agriculture

Abstract: The aim of this study was to monitoring to land use and land cover change in Phang-Nga province, southern Thailand, using Land sat satellite images for years 1989, 1999 and 2002. The study was performed in three interval periods 1989-1999, 1999-2002, and 1989-2002. Newer imaged data are available with the high cost and thus limited to our study. Using the object-based concept, land use was classified into seven categories, including forest area, urban area, agriculture area, water body, other areas, cloud area, and shadow area. Majority of the land use and land cover change was analyzed. Our findings show that the forest areas have the most significant change. The forest areas decreased approximately by 20 % during an 11-year period (1989-1999) whereas a dramatic decrease was 15% within a period of four years (1999-2002). Such changes were accounted for by the increasing of agricultural expansion, 31% in 1999 and 15% in 2002, and of urban growth (17% and 51%, respectively). These suggest that continued population growth has led to an increase in requirements of natural resource uses, resulting in deforestation for agricultural expansion. In this issue, policy-makers, local authorities and farmers should pay more attention on impacts of deforestation. Further studies based on the up-to-date data are needed to continue monitoring of land use and land cover change in this area, focusing on sustainable development of agriculture with the minimum expense of deforestation.

INTRODUCTION

Land use and land cover are continuously changing, mainly a consequence of human activities and the rapid growth of economy (Wannasai and Shrestha, 2008; Patarasuk and Binford, 2012). Land use and land cover change (LULCC) is driven by combinations of social, biophysical, and economic factors (Lambin et al., 2001; Meyer and Turner, 1994). Expansions of agriculture into forest areas have resulted in adverse impacts on natural resources, including soil, water, forest, and living organisms (Niloubun, 2006).

Phang-Nga province is located on the Andaman Sea coast, the South of Thailand, having abundance of natural resources and beautiful tourist attraction places (Junyar et al., 2009). Economy of the province depends not only on tourism but also agriculture. The majority crops are para rubber plantation and oil palm agriculture. With the economic driving force, LULC in the area has been changed continually in order to serve human activities, particularly for urbanization and agricultural expansion. To our best knowledge, there have been no reports on LULCC in this area. Monitoring LULCC is essential to understand the existing LULC in the area and to prevent unintended negative consequences from any changes. The objective of this study was to monitor LULCC in Phang-Nga Province from 1989 to 2002 using application of remote sensing. The results can be applied for planning the land-use sustainable development in the future.

METHODS

Study Area

The study area is Phang-Nga province, located in the area between 7º N to 9º N and 98º E, covering an area of 4,170 square kilometers with a coastline of 240 kilometers and 105 islets (Fig. 1). The terrain consists of mountain complex and forests. The weather conditions are dominated by the southwest monsoon winds that blow year round. There are only 2 seasons in Phang-Nga, summer and rainy. The summer begins in January and lasts till April. The rainy is from May through December. The average temperature ranges between at 17-38 degree Celsius.

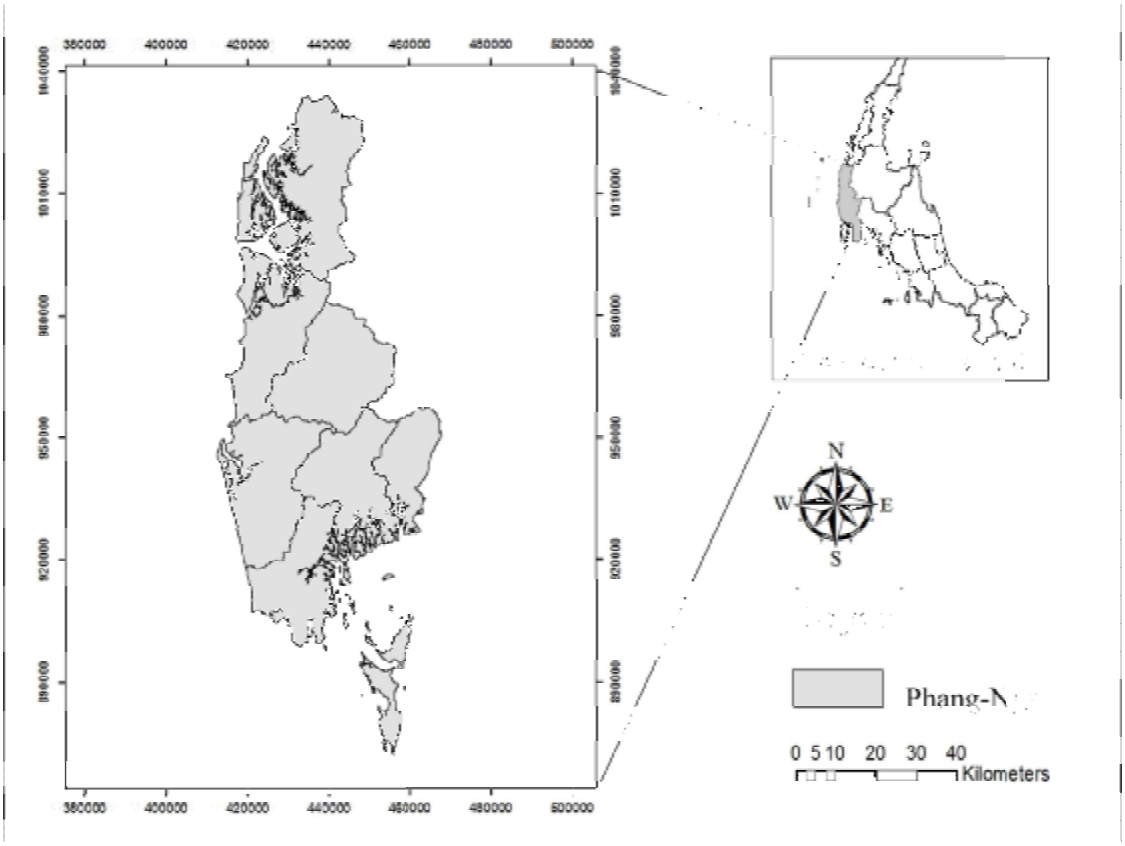

Figure 1: The study area of province, southern Thailand.

Data sets

The satellite images used in the study were the Landsat-4 TM image in 1989 and the Landsat-7 ETM images in 1999 and 2002, obtained from www.glovis.usgs.gov. The datasets with 30 m resolution were acquired on 15 February1989, 6 October 1999 and 15 January 2002.

Data preprocessing, classification, and change detection

Figure 2 shows a study process of data preprocessing, classification, and change detection. Satellite image data were geometrically corrected to remove spatial distortions by transforming all images into the same size and projection value, using the ground control point method with the 1989 image as a base map. Classifications using maximum likelihood were then applied to classify the LULC types. Seven classes were delineated in the images, namely agricultural area, forest area, urban area, water body, other areas, cloud area, and shadow area. For each of the three-year images, a number of sampling regions for each classes were selected based on the visual interpretation of a false color composite along with available information from the Google Earth and Google map. These datasets were then randomly divided for classifier training and accuracy assessment. Change detection was then employed to detect the differences between each pair of LULC maps. The comparisons were divided into three periods, 1989-1999, 1999-2002, and 1989-2002, respectively.

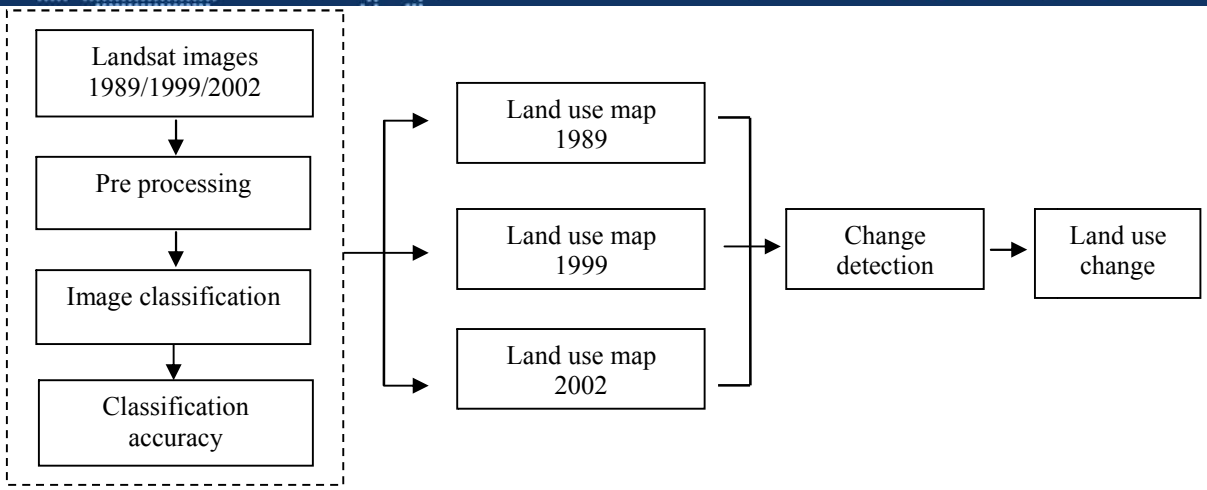

Figure 2: The study process.

RESULTS

Classification results for each year are illustrated in Figure 3 and LULCC detections between each pair of years are shown in Tables 1-3. The overall accuracy for the classification was 94.17%, 85.40%, and 98.66% for years 1989, 1999, and 2002, respectively.

In the first period of eleven years (1989-1999), Phang-Nga lost 20.57% of its forest areas whereas an increase of agricultural areas (31.65%) and urban areas (17.64%) was evident (Table 1). In the second period of four years (1999-2002), a similar pattern of LULCC was observed (Table 2). Forest areas have continually decreased by 15.46% whereas agricultural areas have gradually increased by 15.87%. Urban land use has growth progressively and rapidly with being approximately 3 times (55.95 % increasing) of the first period. A decline of water body was noticeable by 22.95%. When considering the LULCC over the 13-year period of study 1989-2002, we found that deforestation was marked for agricultural expansion and urban growth (Table 3).

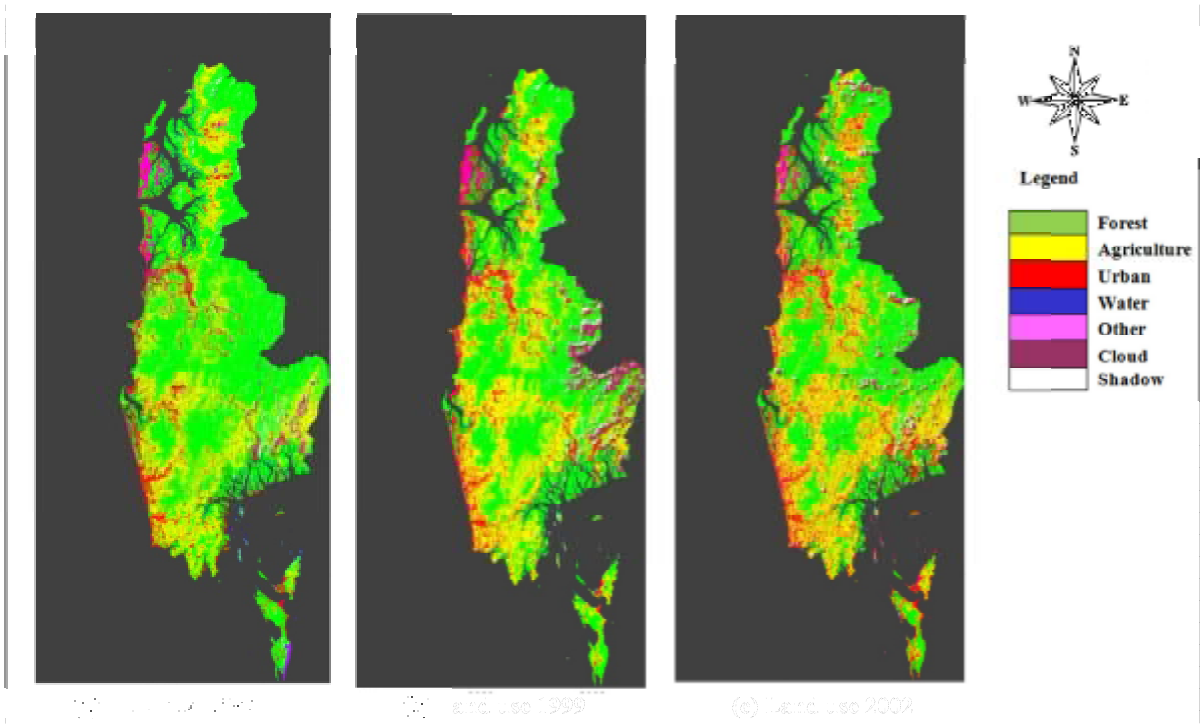

Figure 3: Maps of land use classifications of Phang-Nga province; (a) Land use 1989, (b) Land use 1999, and (c) Land use 2002. Note that islets covering by forest area were excluded from the maps because of no significantly changes in their land use.

Table 1: Comparison of land use changes between 1989 and 1999 in term of area percentage.

1999 \ 1989	Forest	Agricultural	Urban	Water	Other	Cloud	Shadow
Forest	67.64	17.45	13.41	13.07	2.46	23.77	56.72
Agricultural	18.61	66.54	35.19	0.60	14.22	23.78	1.62
Urban	4.26	10.56	40.71	9.35	41.53	32.88	1.58
Water	0.35	0.19	2.47	66.71	1.87	1.47	0.45
Other	0.39	0.58	5.81	2.90	35.71	3.17	0.24
Cloud	6.17	3.56	1.99	2.65	3.40	12.65	8.18
Shadow	2.57	1.12	0.40	4.72	0.82	2.29	31.21
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Class Changes	32.36	33.46	59.29	33.29	64.29	87.35	68.79
Image Difference	-20.57	31.65	17.64	-1.69	-10.85	229.21	12.80

Table 2: Comparison of land use changes between 1999 and 2002 in term of area percentage.

2002 \ 1999	Forest	Agricultural	Urban	Water	Other	Cloud	Shadow
Forest	67.67	9.41	7.42	27.15	1.35	51.59	50.24
Agricultural	18.92	67.71	33.44	4.93	16.01	25.23	16.66
Urban	6.16	19.34	47.86	24.17	43.79	10.89	8.21
Water	0.83	0.22	1.84	29.50	4.65	0.63	1.29
Other	0.07	0.86	5.43	0.30	30.34	0.28	0.17
Cloud	2.82	1.24	2.95	10.50	2.46	5.41	4.71
Shadow	3.53	1.22	1.05	3.45	1.39	5.96	18.73
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Class Changes	32.33	32.29	52.14	70.50	69.66	94.59	81.27
Image Difference	-15.46	15.87	55.95	-22.95	-16.36	- 49.30	12.35

Table 3: Comparison of land use changes between 1989 and 2002 in term of area percentage.

2002 \ 1989	Forest	Agricultural	Urban	Water	Other	Cloud	Shadow
Forest	59.78	9.94	12.27	30.03	1.85	17.54	56.67
Agricultural	23.88	67.37	38.37	4.14	25.06	40.25	7.59
Urban	9.17	18.73	38.82	19.54	39.24	31.74	8.77
Water	0.74	0.20	2.44	30.13	1.53	1.03	1.11
Other	0.27	1.13	4.54	0.20	27.23	3.14	0.07
Cloud	2.69	1.49	2.64	11.33	3.91	4.86	4.36
Shadow	3.46	1.13	0.93	4.62	1.17	1.45	21.43
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Class Changes	40.22	32.63	61.18	69.87	72.77	95.14	78.57
Image Difference	-31.13	50.48	76.73	-24.25	-25.09	66.26	26.74

DISCUSSION

Our study showed that the forest in Phang-Nga province have been cleared predominantly for agricultural activities and urban development during 1989-2002. This pattern of LULCC is a key global issue that has created significant adverse impacts on natural resources and biodiversity (Semwal et al., 2004; Yuan et al., 2005; Long et al., 2007; Wannasai and Shrestha, 2008; Patarasuk and Binford, 2012). The forest decreased approximately by 20% of total forest area during 11-year period (1989-1999) whereas a dramatic decrease was about 15% within four years (1999-2002) later. This indicated that a threefold declination of forest covers was evident in the area studied and thus prompting concerns about a balance between sustainable development and natural conservation at both national and regional levels.

In total, Phang-Nga shows a high increase in agricultural development (50.48%) over the thirteen years. Conversions of forest cover to para rubber plantation and oil palm agriculture have been exhibited in our study and other studies (Reis, 2008; Wicke et al., 2011). Being the famous tourist destination, Phang-Nga exhibits a growing tendency in urban land use. It was obvious that its growth has threatened the areas that were reserved for forest and agricultures. With these ongoing agriculture-economic developments, there is a high possibility that natural resources in the area may have been invaded and cleared for serving human activities in the future.

CONCLUSIONS & RECOMMENDATIONS

The objective of this study was to monitoring the land use and land cover changes in Phang-Nga Province, using remote sensed data from the Landsat satellite images 1989, 1999 and 2002. Our findings show that the forest areas have the most significant change. Phang-Nga lost approximately threefold forest covers between 1989 and 2002. Such changes were accounted for by the increasing of agricultural expansion, 31% % and 17% during 1989-1999 and 1999-2002, respectively, and urban development, 15% in the first period and 55% in the second period.

Continued population growth in the area has led to an increase in requirements of natural resource uses, leading to deforestation scenarios for agricultural production and urban growth. This is regarded as a significant change that has been related to the social-economic development. In other word, the developments are leading to land use changes. The developments have both positive and negative impacts depending on appropriate of land use. If the land uses are unsuitable, for example, forest area changing to agricultural area, it can be making some undesirable impacts in the future. In this issue, policy-makers, local authorities and farmers should pay more attention on impacts of deforestation. Further studies based on the up-to-date data are needed to continue monitoring of land use and land cover change in this area, focusing on sustainable development of agriculture with the minimum expense of deforestation.

REFERENCES

Junyar, B., Pramote, Ng., Nisa, Ch., 2009. Marketing Strategies for Ecotourism : Trekking and NatureStudy in Phang-Nga. Rajabhat University Academic Journal, 5(1), pp. 69-102.

Lambin, E.F., Turnerb, B.L., Geista, H.J., Agbolac, S.B., Angelsend, A., Brucee, J.W., Coomesf, O.T., Dirzog, D., Fischerh.G.U., Folkei.C, Georgej, P.S., Homewoodk, K., Jacques, I., Leemansm, R., Lin, X., Morano, E.M., Mortimorep, M., Ramakrishnanq, P.S., Richardsr, J.F., Skaness, H., Steffent, W., Stoneu, G.D., Svedinv, U., Vogelx, T.C., and Xuy, J., 2001. The causes of land-use and land-cover change:moving beyond the myths. Global Environmental Change, 11(1), pp. 261–269.

Long, H., Tangc, G. Lia, X., and Heiligb, G.K., 2007. Socio-economic driving forces of land-use change in Kunshan, theYangtze River Delta economic area of China, Journal of Environmental Management, 83(1), pp. 351–364.

Meyer, W.B., and Turner, B.L. (Eds.)., 1994. Changes in land use and land cover: A global perspective. Cambridge: Press Syndicate of the University of Cambridge.

Niloubun, V., 2006. Application of Geographic Information System for the Study of the Conditional Tendency of Land Use Change in Nakornnayok Watershed. (Master's thesis, Kasetsart University, Bangkok Thailand). Retrieved from URL: http://www.lib.ku.ac.th/KUthesis/2549/ NinubonWai /index.html.

Patarasuk, R., and Binford, M.W., 2012. Longitudinal analysis of the road network development and land-cover change in Lop Buri province, Thailand, 1989-2006. Applied Geography, 32(1), pp. 228-239.

Reis, s., 2008. Analyzing Land Use/Land Cover Changes Using Remote Sensing and GIS in Rize, North-East Turkey. Sensors, 8, (1), pp.6188-6202.

Semwal, R.L., Nautiyal, S., Sen, K.K., Rana, U., Maikhuri, R.K., Rao, K.S. and Saxena, K.G., 2004. Patterns and ecological implications of agricultural land-use changes: a case study from central Himalaya, India. Agriculture, Ecosystems and Environment 102, (1), pp. 81–92.

U.S. Geological Survey. The Land sat satellite. Retrieved April 04, 2012, from http:// www.glovis.usgs.gov.

Wannasai, N., and Shrestha, R.P., 2008. Role of land tenure security and farm household characteristics on landuse change in the Prasae Watershed, Thailand. Land Use Policy, 25(1), pp. 214–224.

Wicke, B., Sikkema, R., Dornburg, V., and Faaij, A., 2011. Exploring land use change and role of palm oil production in Indonesia and Malaysia. Land Use Policy, 28(1), pp. 193-206.

Yuan, F.,Sawaya, K.E., Loeffelholz, B.C., and Loeffelholz, M.E., 2005 Land cover classification and change analysis of the Twin Cities (Minnesota)Metropolitan Area by multitemporal Landsat remote sensing. Remote Sensing of Environment, 98(1), pp. 317 – 328.