THE APPLICATIONS OF REMOTE SENSING AND GIS IN THE ASSESSMENT OF SOME ECOLOGICAL CRETERIA AND INDICATORS FOR SUSTAINABLE MANAGEMENT OF TROPICAL FOREST IN EAST KALIMANTAN, INDONESIA

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ABSTRACT

Tropical forest degradation and/or deforestation are issues raising great concern among conservation scientists the world over. In particular, the rate of destruction of tropical forests, through the large extent of commercial logging has attracted a lot of attention. Moreover, many studies and reports indicate that this destruction is still increasing, given the rising demand for agricultural land, and wood products from tropical forests, as a consequence of the rising world population. As tropical forest destruction increases, so does the demand for their sustainable management from sections of people with environmental or conservation concerns. Consequently, at both international and national levels, a number of initiatives have come with suggestions of criteria and indicators for sustainable forest management determination. However, most of their propositions are still very broad and rarely find appropriate applicability at the forest management unit level. This study looks at some ecological criteria and indicators developed by one such type of organisation in Indonesia, known as Lembaga Ekolabel Indonesia (LEI). The objective of the study is to demonstrate how remotely sensed data could support sustainable forest management by verifying some ecological criteria and indicators for tropical timber certification.

1. INTRODUCTION

The issue of tropical forest degradation/deforestation has been at the centre stage of controversy in terms of its environmental consequences for almost three decades. This has raised a lot of concern at international scale, particularly regarding the impact of logging activities on the sustainable function of forests. A study by the International Timber Trade Organization reported that at the end of the nineteeneighties less than one-tenth of tropical forests were managed on a sustainable basis (Poore, 1989). The growing international concern has led to an increasing demand for the sustainable management of forests, which has led to the development of criteria and indicators for assessing sustainable forest management.

The ecological criteria, indicators and verifiers used in this research were selected from among a set already developed by the Indonesian Ecolabeling Institute or Lembaga Ekolabel Indonesia (LEI, 1998). As a first step of working towards a credible forest certification system, LEI has come up with a list of criteria and indicators grouped under the three major categories; namely productive, social and ecological functions. Under the ecological functions, 2 criteria and 19 indicators have been listed Criterion 1 (the stability of ecosystem) has 11 indicators, and criterion 2 (the survival of endangered/endemic/protected species), has 8 indicators.

The objective of the study was to demonstrate how remotely sensed data could support sustainable forest management by verifying some ecological criteria and indicators for tropical timber certification. Within the framework of this study, one ecological criterion, two indicators and five verifiers were selected from a list already developed by LEI (Table 1). Specifically, the study aimed at using optical satellite remotely sensed images (i.e. Landsat-TM data) to detect deforestation in protected area and assess how significant these deforested area in comparison to the overall forest land in the study site. Moreover, an attempt was made to find a relationship between a sustainably managed forests biodiversity and spectral radiance.

Criterion	Indicator	Selected Verifiers
Stability of ecosystem	E 1.3 The intensity of damage in the protected areas which includes the danger of forest fires	-Size and type of damaged protected area. -Condition of damaged protected area
	E 1.4* Condition of tree species diversity in protected area in various forest formations/types within management units	-Tree species diversity in virgin (unlogged forest) -Tree species diversity in logged over area -Tree species diversity in protected area.

Table 1: Selected ecological criteria, indicators and verifiers (after LEI, 1998).

***This indicator and its associated verifiers were modified to cover "tree species diversity" instead of "flora and fauna diversity" in order to fit them within the scope of this work.**

2. STUDY AREA, MATERIALS AND METHODS

Labanan concession area is found in Berau regency, East Kalimantan, Indonesia. This province is located in the eastern Indonesian part of the island of Borneo. It lies west of the Kelai river. The entire concession area covers about 83,240 ha of which 54, 567 ha is under fixed production, 26,997 ha under limited production and 1676 ha has been left for other uses such as transmigration, camping (by the logging and cruising crew), settlement and agriculture (Fakultas Kehutanan, 2000). Figure 1 shows the location of the study area. The concession area is managed by P.T. Inhutani I, which is a government owned concession company. The natural vegetation of East Kalimantan is dominated by lowland mixed dipterocarp forest. Dipterocarps represent 50% of basal area and 60% of stand volume. The Berau area is characterized by high botanical diversity of the tree species. Large parts of natural forest in East Kalimantan have already been logged.

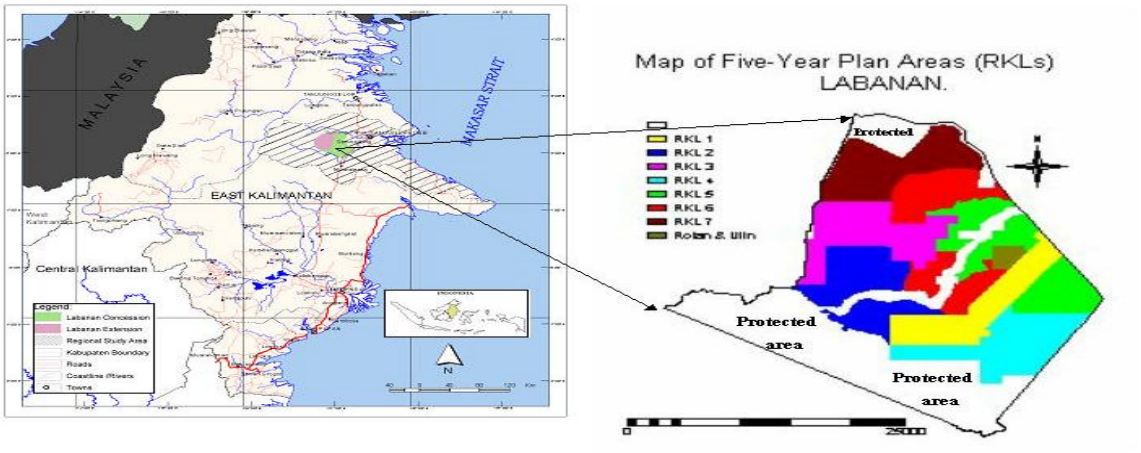
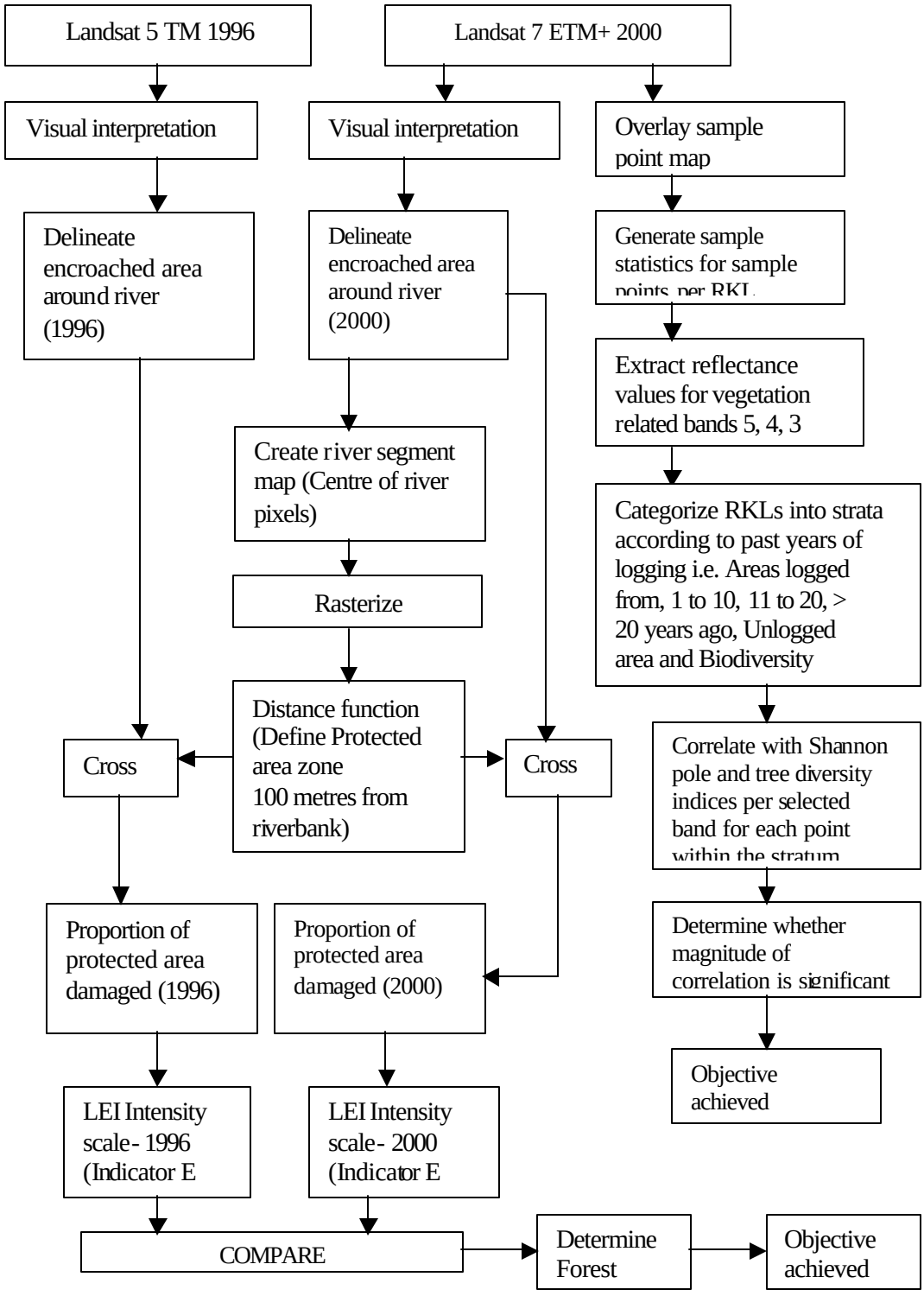


Figure 1. Location of study area and the five-year plan (RKL) compartments

Two satellite images: Landsat-7 ETM+ acquired on 26th August 2000 and Landsat-5 TM acquired on 12th April 1996 were used in this research. The methodology flowchart (Figure 2) explains the approach used in this research.

Figure 2. Flowchart of the research methodology



According to the Indonesian national forest management guidelines, an average of 8 trees per hectare are felled at 35-year interval. The forest management unit has been divided into seven five-years working plan areas called RKL (*Rencana Karya Limatahun*) in Indonesian language. Thus, the forest concession land in

this area divided into 7 RKLs. Each RKL divided into 5 year felling plans. By the end of the felling cycle (35 years rotation) the logging company will start logging again in RKL 1.

3. RESULTS AND DISCUSSIONS

3.1 Assessment of damage within the river and other protected area

This section demonstrates the use of remote sensing techniques to assess damage within the river-protected area, and then relates this assessment with the intensity scale of indicators for Sustainable Natural Production Forest Management Damage within the river-protected area was considered because the rest of the protected area to the south of the concession has not suffered any degradation, deforestation or observable change, which means it is still intact. This can be evidenced by the color composites of Landsat TM 1996 and 2000, with the Middle Infrared, Near Infrared and Green bands in the Red, Green and Blue channels respectively. This color composite gives a clear picture of the terrain properties of the southern protected area, which is rugged. Mutuagung Lestari, the certification body accredited by LEI, also reported no evidence of severe damage within the southern protected area.

3.2 Delineation of areas of damage

Using the two Landsat TM images of 1996 and 2000 damaged (encroached) areas were assessed. Encroachment around the river-protected area were delineated in each image using visual interpretation. An example of such delineated area from Landsat TM 2000 using the 542-color composite is shown in Figure 3, 4 and 5. These areas were later polygonized and then rasterized. The encroached areas were derived from summing up the areas of all the pixels. The resulting sizes of encroached areas (within the protected area) for the years 1996 and 2000 are shown in Table 2. The proportion of protected area encroached in each of the years 1996 and 2000, was computed by expressing each of the encroached areas in hectares as a percentage of the total protected area given in Table 2.

According to the intensity scale rating associated with indicator E 1.3 i.e. “the intensity of damage in the protected areas which includes the danger of forest fires”, the ranking for this particular indicator, with regard to encroachment within the river-protected area, is “GOOD”. This is because as specified in the scale, the area size of the damage in protected area is small (<25%), which is considered a low degree of damage. Alternatively it could be stated that the damaged protected area is very small (<10%). This means that the degree of damage is very small and the control efforts are adequate.

3.3 The relationship between spectral reflectance of satellite images and biodiversity

An attempted was made to find out whether a relationship existed between reflectance values of Landsat TM and tree diversity indices, with the hope that if this yielded a considerable relationship, then it would provide a basis for tree diversity estimation, which would consequently reduce the costs usually encountered in carrying out field surveys. However, no significant relationship was found in this respect. With regard to rating on the intensity scale of indicators for Sustainable Natural Production Forest Management, the overall rating for tree species diversity was rated “POOR”, whereas that of intensity of damage within the river-protected area was “GOOD”. Using the similarity index, the overall rating was “FAIR”. Comparatively, the assessors assessed the forest both in terms of species diversity as well as intensity of damage within the protected area as “FAIR”.

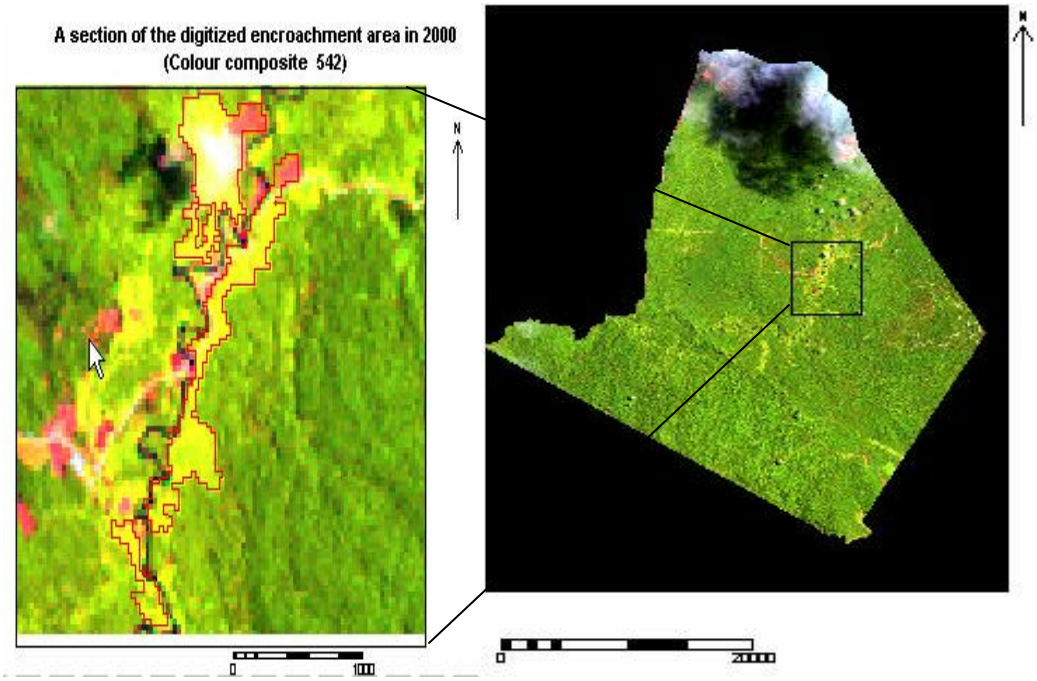


Figure 3. An example of digitised encroachment area around the river (In the year 2000)

Table 2. Showing the size of encroached area in 1996 and 2000 within the river protected area

Year	Encroached area (ha)	Total river protected area (ha)	Area encroached expressed as a percentage of total protected area
1996	22	1144	1.92%
2000	86	1144	7.52%

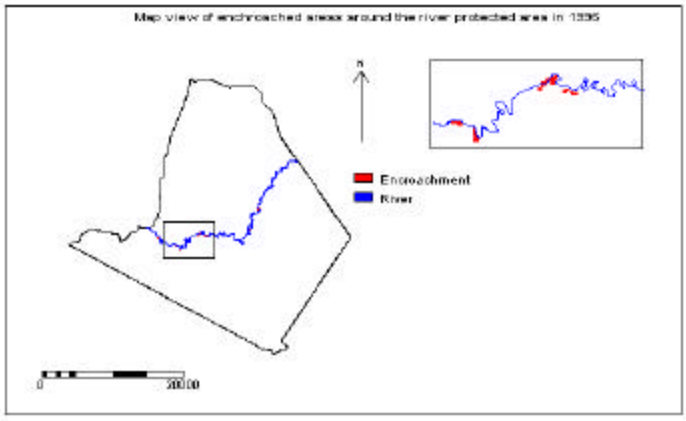


Figure 4. Encroachment map around the river-protected area in Labanan concession in the year 1996.

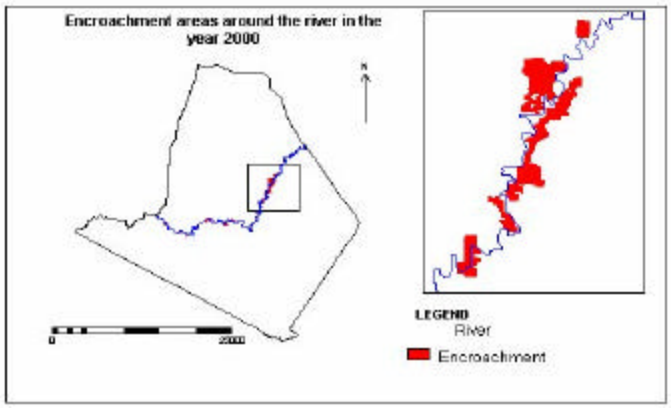


Figure 5. Encroachment map around the river-protected areas in Labanan concession in the year 2000.

CONCLUSION

The study concluded that remote sensing can be used to support some criteria and indicators for sustainable forest management. Specifically, the study aimed at using optical satellite remotely sensed images (i.e. Landsat-TM data) to detect deforestation in protected area and assess how significant these deforested area in comparison to the overall forest land in the study site. The study was successfully able to detect deforestation and assess that the area was not significant as far as the intensity scale of indicator E 1.3 of the ecological function of the C&I. Moreover, an attempt was made to find a relationship between a sustainably managed forests biodiversity and spectral radiance, if the relationship exist, then consequently optical satellite images can be used to assess indicator E 1.4 of the ecological function. However, no significant relationship was found in this respect.

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