TROPICS Vol. 5 (1/2): 115-128 Issued December, 1995

Land-use Changes and their Causes in the Tropics: A Case Study in South Sumatra, Indonesia in 1969-1988

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ABSTRACT Land-use changes in the period between 1969 and 1988 of 38, 480 sq km areas in South Sumatra were examined. Those two periods of land-use map were digitized and input as Geographical Information System (GIS) data base using Arc/Info software packages. Quantitative analysis of land-use changes was carried out by overlay technique. Other related factors such as timber concession, and land tenure system changes, were also examined.

It has been believed that the deforestation in South Sumatra was caused by timber concession exploitation that have mostly been started in 1968. Our observation, however, shows that most deforestation had occurred before 1968. In 1969, forest area only covered about 35%, while regrowth and cultivated land accounted for 37% and 26% of the total area, respectively. Therefore, the loss of forest might be related to other factors such as cash crop introduction in the early nineteenth century and road construction for oil exploration in the beginning of twentieth century.

There was clear evidence that in South Sumatra, timber concessions' exploitation that was started in 1968, had less impact on forest cover than other land uses. This was demonstrated by the fact that during 1969-1988, in concession area about 74% of forest areas still remained unchanged, in comparison with only 42% in non concession. Moreover, there was much more forest regeneration from regrowth and cultivated land. In total, during 19 years period, forest cover area decreased by less than 10%. This was partially explained by forest regeneration, and the changes of land tenure system (marga system) that made farmers difficult to access forest land.

Key Words: deforestation / timber concession / geographical information system / population / land-use

For over two decades, rapid destruction of tropical forests has been an international concern. Approximately 7 million sq hectares of humid tropical forests have been destroyed annually (Barbier *et al*., 1991). If the deforestation continues at present rates tropical forests could disappear within the next one to two centuries (Grainger, 1993).

Researchers, attempting to explain the deforestation processes have concluded that there were various contributing factors: population growth (Palo, 1994), logging operations (Kummer, 1991), shifting cultivation (Thapa & Weber, 1990), resettlement (Hurst, 1990), road construction (Hirsch, 1987), international debt (Kahn & McDonald, 1994) and government policies (Repetto & Gillis, 1988). However, deforestation processes vary depending on the natural environment, socio-economic conditions and historical context. For instance, on one hand researchers found that deforestation was accelerated by increasing population but on the other hand Kummer (1991), stated that deforestation has no relation with population growth after investigating the deforestation process in the Philippines. In Kenya, Holmgren *et al*. (1994) found that the volume of standing trees increased in more densely populated areas.

Most researches on deforestation using cross-national data and regression analysis have limited application, because regression analysis does not provide information about the deforestation process in any specific country; there are often great variations in socio-economic

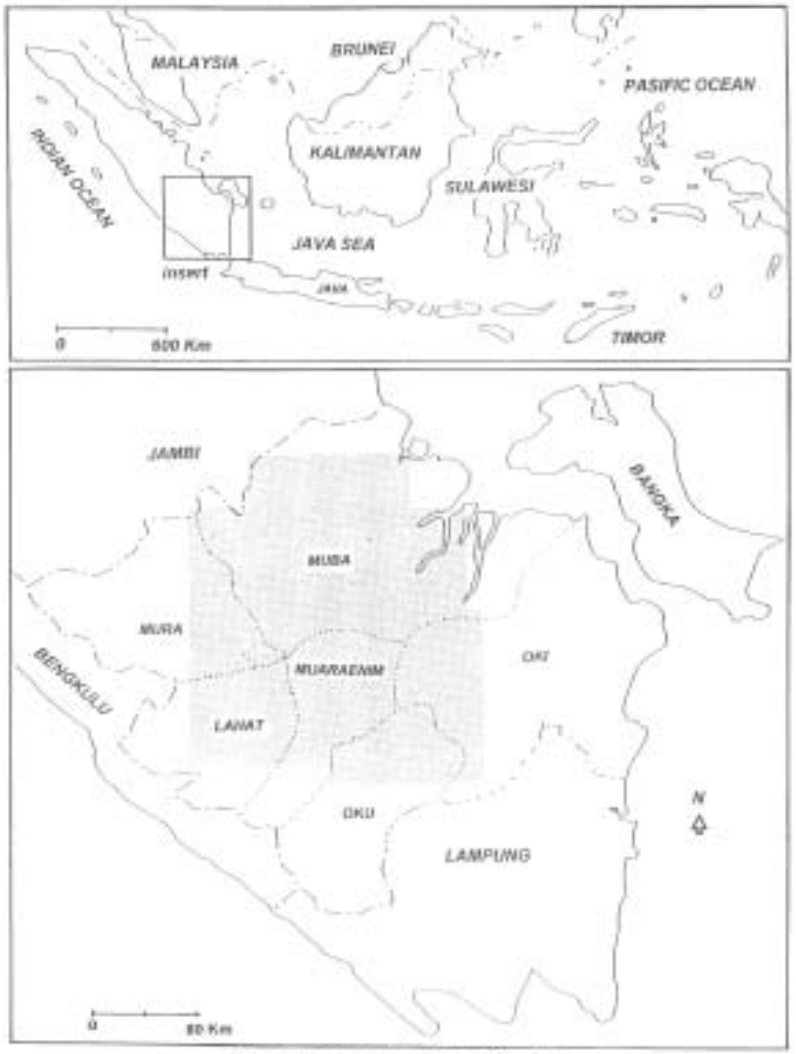

Fig. 1. Study area, South Sumatra.

based on these data may be too general to apply in a specific situation. Therefore, in order to develop effective counter-measures against deforestation, detailed study of deforestation processes within a small area is required. Deforestation is not merely a problem of forest utilization, but is also closely related to other land uses. It is important that studies evaluate general land use changes to gain a better understanding of the deforestation processes.

This paper will examine the impact of different factors such as oil exploration, introduction of cash crops, changes in regulations, commercial logging, and transmigration, on land-use changes in South Sumatra, Indonesia. A Geographical Information System (GIS) was used to analyze the land-use changes between 1969 and 1988.

THE STUDY AREA

Location

The study area is located in South Sumatra Province, between 2 and 4 degrees South latitude; and 102 and 104 degrees East longitude. It covers 42 sub-districts (Kecamatans) of the following areas: Palembang Municipality, OKU, OKI, Lahat, MUBA, Mura and Muaraenim district

(Kabupaten), comprising a total area of about 38, 480 sq km (Fig. 1).

Geographic and natural environment conditions

The elevation of the study area, relatively evenly distributed, ranges from swampy coastal plains in the east to 150 meters above sea level in the mountainous terrain in the west. In the low plateau area, the forest was dominated by the Dipterocarp family such as *Dipterocarpus gracilis* Bl., *Shorea guiso* Bl., *S. macroptera* Dyer, *Anisoptera costata* Korth., and *Hopea myrtifolia* Miq. In swampy places, there are *Shorea sumatrana* Sloot., *S. palembanica* Miq. and *Hopea mengarawan* Miq. (Blasco *et al.*, 1983).

In the study area, there are nine large rivers, called Batanghari Sembilan: Musi, Rawas, Batanghari Leko, Lematang, Ogan, Komering, Lalang, Calik and Mesuji. Their lengths range from 150 km (Batanghari Leko River) to 490 km (Musi River). These rivers play an important role in transport, communication and irrigation, and their environs have been inhabited by approximately 70% of the population of South Sumatra. Most of the district headquarters are connected by these rivers. The study area receives precipitation ranging from 1500 to 3200 mm/year. The rainy season is from November to April, while the dry season extends from May to October. The annual average humidity is about 85%. There are 19 soil types which are dominated by gley humic organosol (31. 93%), red yellowish podzolic (20. 46%) and mixed between latosol and andosol (Haeruman *et al.*, 1979).

Historical context and socio-economic conditions

The study area was the land where the Hindu Kingdom of Sriwijaya was founded in 683, whose territories ranged from all of South Sumatra, to the Malay Peninsula and Cambodia. The kingdom was defeated by the Javanese Kingdom of Majapahit, and later became an Islamic kingdom (Schnitger, 1964). It was well known as a trading center of guttapercha, jelutong, rattan, rubber, coffee, and pepper. The place has become important economically, with discovery of coal, tin and oil in the beginning of the twentieth century. Trades over the years were controlled by a succession of rulers, including the Dutch (1617-1942) and Japanese (1942-1945). In recent years South Sumatra has been governed from the political capital of Palembang.

According to statistical data, in 1991 the population of South Sumatra was 6, 305, 275 inhabitants (Bapeda Sumsel, 1991), and has increased more than two-fold since the first population census in 1961, or about at rate of 1. 9% per year (BPS Palembang, 1981). The population is unevenly distributed: Palembang municipality is the most densely populated area.

The population consists of many ethnic groups: Palembang (orang asli Palembang), Bugis, Java, Pegagan, Meranjat, Komering, Pedamaran, Ogan, Kisam, Semendo darat, Lematang, Enim, Kubu, Lintang, Kikim, Pasemah, Rejang, Kusi ulu, Musi rawas, Saling, Mapur, Suku laut and Chinese (Departemen Pendidikan dan Kebudayaan, 1981).

Although the agricultural sector is still the main source of income, it is gradually decreasing, as observed from the declining ratio of people engaged in farming (69. 3%, 65. 1%, 61. 4% and 61. 6% of the working population in 1976, 1980, 1984, 1990, respectively) (MOF, 1987; Bappeda Sumsel, 1991). Most agricultural activities still involve traditional techniques of shifting cultivation.

METHODS

Data type

In this study the following maps were used: 1988 land-use map, 1969 land use-map, timber

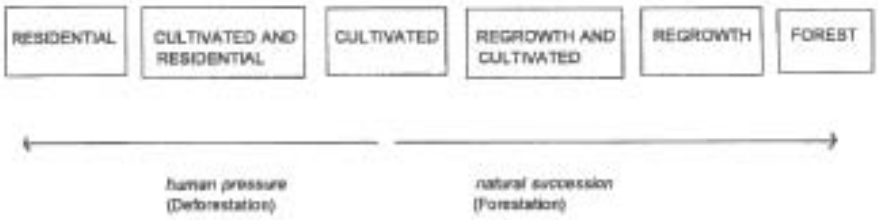

Fig. 2. Ecological arrangement of each class. (after Akiyama, 1986)

concession development map (peta perkembangan Hak Pengusahaan Hutan), and forest survey maps. Other sources of information, such as data about present land-use conditions were collected through primary sources.

Data entry

The first step was digitizing the maps. By employing Arc/Info Version 6. 1. 1 package software, maps were digitized using a D-scan model No. DH. 8500s digitizer device. After correcting errors and generating map topology and attributes, maps were transferred into Universal Transfer Mercator (UTM) projection data.

Data arrangement

Indonesia does no have a U. S.-style uniform system for land-use classification (Avery & Berlin, 1985). The study area in the land-use map was classified into 11 land-use types in 1969, but was increased to 32 types in 1988, allowing for a more detailed classification of agricultural area. In this paper the present land-use classifications have been further classified into broader categories in order to make an easier comparative analysis. The details of the reclassification are presented in Tab. 1. Cultivated land represents all types of agricultural land, while regrowth includes bush, grass land and swamp area. Between cultivated field and residential area there is an intermediate form of mixed cultivated and residential land, while between cultivated and regrowth there is mixed regrowth and cultivated land.

Theoretically, this reclassification is based on a secondary succession process. Cultivated fields, if left fallow in the absence of human disturbance, will regenerate into regrowth (grass and bush) and finally forest (Odum, 1989). Conversely, human interference often leads to the creation of residential areas (Akiyama *et al.*, 1986). A schematic figure of these process is presented in Fig. 2.

ANALYSIS

Overlay analysis using 1969 and 1988 land-use maps was conducted for both non-concession and concession areas. "Non-concession" refers to an area where there has been no timber concession exploitation activity. The analysis was attempted to make an assessment of the impact of agricultural expansion (especially shifting cultivation) as a major factor in this area. "Concession" refers to an area where there are/were timber concession logging. Here, analysis was done to recognize the impact of timber concession logging as the main factor.

RESULT AND DISCUSSION

Historical context of land-use changes

Figure 3 shows land-use patterns in 1969. Forests were located mostly in the northern part of

Table 1. Reclassification of 1969 and 1988 land-use categories.

1969 land-use category	1988 land-use category	Land-use reclassification
Forest	Forest	Forest
Bush Grassland Swamp	Bush Grassland Bush and grassland Bush and swamp Swamp	Regrowth
	Bush and shifting cultivation Bush and upland crops Bush and paddy field Bush and sugarcane Bush and oil palm Bush and rubber Bush and coconut Grassland and shifting cultivation	Regrowth and cultivated
Rubber Shifting cultivation Paddy field Mixed agricultural crops Upland agriculture	Rubber Shifting cultivation Paddy field Tidal wetland rice Upland agriculture Paddy field and coconut Coconut Oil palm Tea Sugar cane	Cultivated
	Shifting cultivation and settlement Paddy field and settlement Upland crops and settlement Coconut and settlement Plantation and settlement Tidal wetland rice and settlement	Cultivated and residential
Residential	Residential	Residential
River/sea	River/sea Lake/dam	Surface water

the study area, whereas in the southern part, where roads were abundant, forest near the rivers had already been converted into regrowth and cultivated areas.

From the observations of these land-use patterns of 1969, it is clear that the most conversion of forests into cultivated and regrowth areas happened before 1969. Since timber concessions started in 1968, the land-use changes were likely related to other factors such as cash crop introduction during the Dutch colonialization period.

One of the important cash crops introduced into South Sumatra is coffee. Cultivation of coffee in tropical areas was driven by the increase of coffee demand in Europe and the Mediterranean. European colonial powers began searching for places in their overseas possessions where the crop could be cultivated profitable on a large scale (Smith *et al.*, 1992). In Sumatra, the Dutch East Indies Government introduced coffee cultivation by force. Swidden cultivators were forced to transport coffee to the coast and sell it at low cost, causing great hardship in the process. After about 1880, coffee production expanded as a result of better prices and facilities for transport. In South Sumatra coffee was especially planted in the

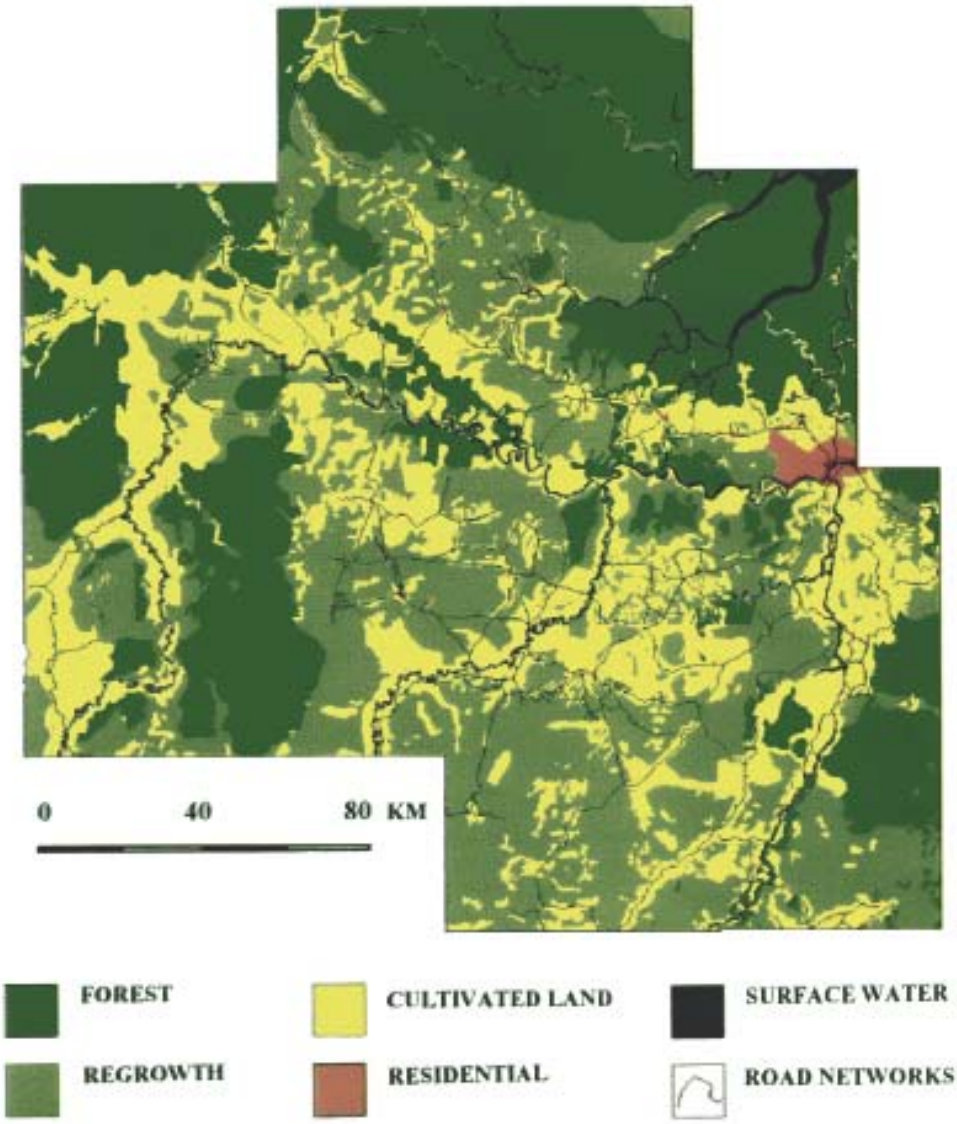

Fig. 3. Land-use in 1969.

area surrounding Palembang. The coffee seed was planted together with rice, maize or sweet potatoes and in the third year farmers could harvest the first coffee crops (Pelzer, 1978). From 1962 to 1966, 77. 72% of Indonesia's coffee exports came from South Sumatra, Lampung, East Java and Bali (Partosoedarso & Makmur, 1968).

After coffee, rubber was introduced as a perennial crop. However, the process was different from that of coffee, since the introduction of rubber into South Sumatra was not by force. In 1915, a boom in demand for rubber during World War I, natives began cultivating rubber plants (*Hevea brasiliensis*) after receiving seeds from Chinese merchants (Helmi, 1954). At that time, farmers cleared the forests with the primary intention of establishing rubber plantations (Sinaga & Kasryno, 1968). Usually staple and secondary food crops were planted between rubber crops for two to three years (Pelzer, 1978). Supported by suitable

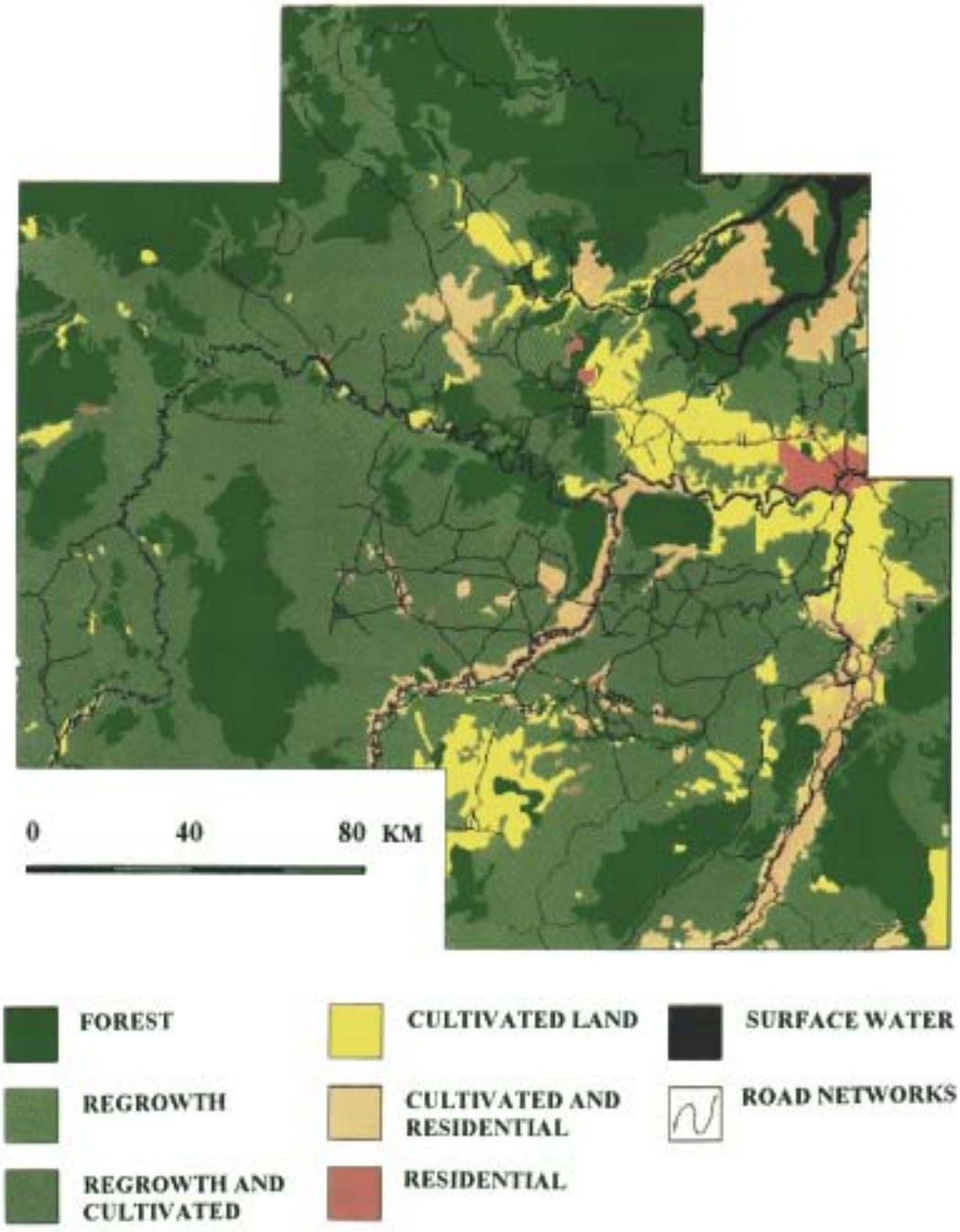

Fig. 4. Land-use in 1988.

environmental conditions, rubber cultivation spread from the east coast all over Sumatra Island. In 1942, the rubber growing area in South Sumatra was estimated as 359, 430 hectares and 377, 000 hectares in 1967 (Sinaga & Kasryno, 1968).

Another factor affecting land-use changes is road construction for oil exploration. Most road systems in the study area initially were for this purpose. Therefore the conversion and clearance of forest that occurred before 1969 was possibly related with such road and railway development as well. In addition, an indirect impact of this activity on deforestation was increased human mobility and easy access to forest land.

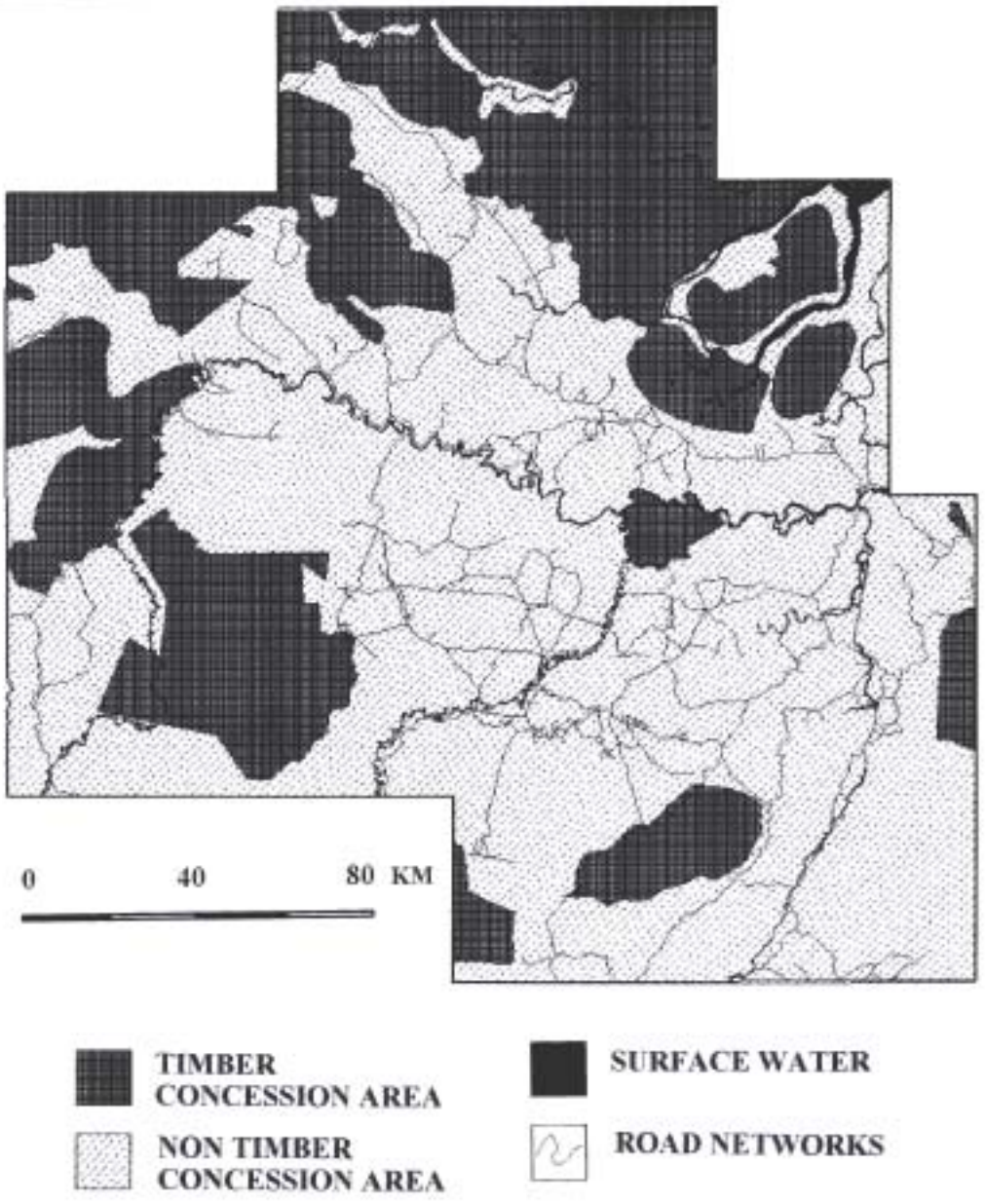

Fig. 5. Distribution of timber concession and non-timber concession areas.

Oil exploration in South Sumatra was started in the early 1900s by De Bataafsche Petroleum Maatschapij (BPM). BPM managed several oil wells at Jambi and Sumatra, which were connected with a refinery station at Plaju (Palembang) (Djawatan Penerangan, 1956). Another oil company, Nederlandsche Koloniale Petroleum Maatschappij (NKPM), first discovered oil at Talang Akar (Muaraenim district) in 1921. Six years later, in 1927, the Pendopo oil well was established. NKPM then developed these two oil wells, and provided workers with housing, hospitals, schools and water supply facilities. Besides road construction connecting the oil wells with a refinery station at Sungai Gerong (Palembang), a ferry port and an air port were developed (Vernon & Wilkins, 1976). Nowadays, these wells are managed by Pertamina (Indonesian Oil Company).

Table 2. Land-use pattern and changes.

Land-use class	1969			1988			Changes		
	non-concession area (A) (sq.km)	concession area (B) (sq.km)	total area (C) (sq.km)	non-concession area (D) (sq.km)	concession area (E) (sq.km)	total area (F) (sq.km)	non-concession area (D/A)	concession area (E/B)	total area (F/C)
Forest	5,484.07	8132.51	13,616.58	4,954.77	7,373.65	12,328.42	0.90	0.91	0.91
Regrowth	11,287.31	2,929.19	14,216.50	6,569.98	2,219.66	8,789.64	0.58	0.76	0.62
Regrowth & cultivated	0.00	0.00	0.00	9,279.40	1,809.21	11,088.61	na	na	na
Cultivated	8,619.90	1,201.75	9,821.65	2,598.78	294.54	2,893.32	0.30	0.25	0.29
Cultivated & residential	10.00	0.00	0.00	1,925.93	558.77	2,484.70	na	na	na
Residential	314.81	4.90	319.71	375.71	9.63	385.34	1.19	1.97	1.21

note, na: not available.

Land use changes 1969 - 1988

Land-use in 1988 and the distribution of timber concession areas are presented in Figs. 4 and 5, respectively.

Table 2 is a summary of land-use changes between 1969 and 1988. It shows that forest, regrowth and cultivated land decreased almost equally both in concession or non-concession area, but changes in residential area were not so consistent. Changes of residential area for cultivated land and mixed regrowth/cultivated areas were different since most cultivated land, regrowth and residential land was in non-concession areas. The growth of residential and cultivated land in non-concession areas was influenced by demographic changes, either from natural increases in population or from spontaneous and sponsored transmigration. Government sponsored transmigration in South Sumatra began in 1937, but an extensive program was initiated in 1969. Between 1969 and 1989, about 164, 910 families (676, 051 persons) were moved in transmigration schemes (Kanwil Transmigrasi Sumatera Selatan, 1991). Even if we consider that only 1. 5 hectares (the lowest figure) were given to each family, 247, 365 hectares of forest, bush or grass were cleared to make cultivated land. The actual area cultivated of land might be higher than the above estimation, since the transmigrants were permitted to clear more land on their own.

Since there is no exact data available concerning spontaneous transmigration, its impact on population and cultivated land area growth cannot be accurately assessed, however during the period 1975 to 1980 the ratio between spontaneous and sponsored transmigrants was 1. 7: 1 (Arndt, 1983). This implies that the number of spontaneous transmigrants may have been almost twice the official numbers.

Figures 6 and 7 show the details of land-use type changes in timber concession and non-timber concession areas. By comparing these figures, we know that the percentage of unchanged forest and regenerated forest from regrowth and cultivated fields in concession area is higher than in non-concession areas. Moreover, most of the forest area lost in concession areas were converted into regrowth but not for cultivated or residential use. This implies that cultivation in logged forest areas was limited. Therefore after logging, forests have a high capability to regenerate through natural succession. Cultivation of logged forests in concession areas was usually conducted by spontaneous immigrant who came in the wake of logging companies, looking for unoccupied lands for cultivation. Typically they were landless farmers from urban areas, who came in search of land or opportunities to make a living. Most had little or no knowledge about the forest environment since they came from

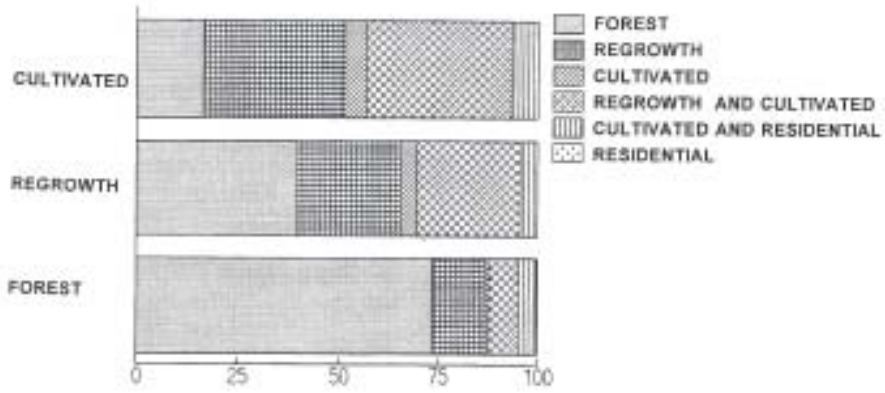

Fig. 6. Land-use change in timber concession areas.

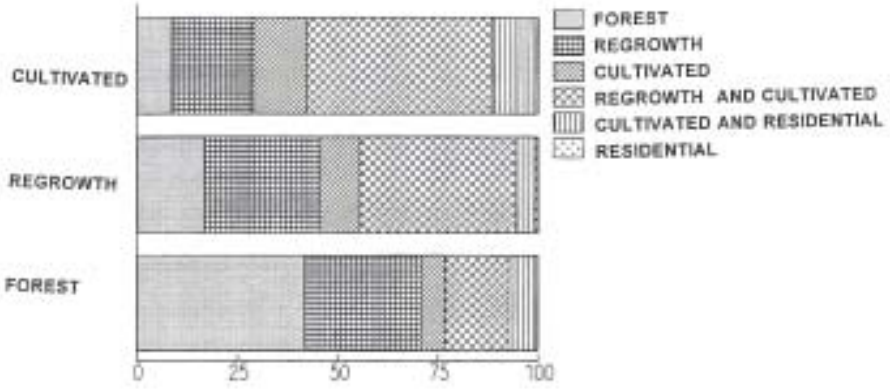

Fig. 7. Land-use change in non-timber concession areas.

sedentary permanent agriculture. They also practiced slash and burn agriculture, but with the primary intention of establishing permanent agricultural production (MOF, 1990). Figure 6 shows that at least 40% of regrowth and 20% of cultivated land in concession areas was already regenerated into forests. This was an important finding, since researchers are still arguing about the ability of forests to recover after logging operations and shifting cultivation (Myers, 1994).

Another important finding from Figs. 6 and 7 is that, in non-concession areas cultivators preferred to cultivate regrowth or previously cultivated fields rather than forest. Cultivation in non-concession areas was usually practiced by native people, who engaged in traditional shifting cultivation. Cultivation of regrowth indicates that they changed cultivation techniques from forest fallow (long fallow period) to bush fallow system (shorter fallow period). This shift was necessary because of the increase of population density and the lack of available forested land for agricultural expansion. Limitations on forested land for agricultural expansion during rapid population growth forced farmers to shorten the fallow period and cultivate their farms more intensively. In order to fulfill their food requirements from smaller area, the farmers also gradually started to use fertilizers and pesticides to

improve their land productivity. Statistical data show that upland rice productivity in South Sumatra increased from 1. 479 ton/ha in 1979 to 2. 057 ton/ha in 1989, or about 40% increase (Widodo, 1990). These changes reinforce Boserup's theory on agricultural growth (Boserup, 1965; Turner II *et al*., 1977). The same changes were also found in other parts of Indonesia. In Borneo, to accommodate a growing population, Dayak Malay cultivators gradually changed their cultivation from shifting to continuous wet cultivation (Seavoy, 1973) and from tree crops to paddy fields (Seavoy, 1980).

The limited access of forest land to agriculture expansion was possibly caused by land tenure system changes rather than by the lack of forest land availability. In the study area there was a traditional marga system (community headed by a pesirah) for using the forest land since decades ago. Based on Simbur Cahaya (traditional law of marga), a marga member could open the forest for farming anywhere in the area that was declared as marga forest, after paying a fee (pancung alas) and getting pesirah approval (Budenani, 1939). This system gradually changed with the introduction of modern (formal) legislation. The first introduction of formal legislation was in 1960, when Basic Agrarian Law (BAL) was enacted. Article 5 of this law states that traditional law (adat) must not be contrary to the national interests of the state. In other words adat law would have to be adjusted to conform with BAL. Next was the Basic Forestry Law (BFL) in 1967 in which all forest land was declared national land. Article 17 of the BFL states that traditional law must not be against the achievement of the BFL. Traditional law and administration systems in South Sumatra were totally abolished in 1979, after the promulgation of Village Administration Legislation (UURI nomor 5 tahun 1979). Based on this legislation the marga system was replaced by the desa system adopted from the Javan administration system. This law was effectively applied in 1983, with the enactment of Surat Keputusan Gubernur kepala daerah tingkat I Sumatra Selatan No. 142/Kpts/III/1983. Under this regulation the pesirah was replaced by a village head and marga forest was given to the central government. As a result agricultural cultivation could not be expanded into new areas.

CONCLUSION

Deforestation was began with the introduction of cash crops in early nineteenth century and road construction for oil exploration in the beginning of the twentieth century. Clear evidence exists showing that during the period 1969 to 1988, timber concessions had less impact on forest cover than other uses. During this 19-year period, forest area decreased by less than 10%, partially explained by the fact that forest regeneration occurred within forest concession areas. Moreover, within non-concession areas, farmers that were prohibited from cultivating forest land by the new land tenure system, could improve their farming technology to respond to demands of population growth. Farmers shortened fallow periods and some started to use fertilizers and pesticides, a temporary condition that can continue only as long as farming technology and carrying capacity of the land can support population growth. When the soil is depleted farmers will start to look for relatively fertile forested land. Therefore in the long term, improvements of farming techniques and population planning are required. Industrial sector development in urban areas is also good way to absorb rural migrants and reduce rural population pressure on forests.

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Received Sept. 1, 1995
Accepted Nov. 20, 1995