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THE UNDERLYING CAUSES AND IMPACTS OF FIRES IN INDONESIA

THE ROLE OF FIRE IN CHANGING LAND USE AND LIVELIHOOD IN PETAPAHAN AREA, RIAU PROVINCE

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ABBREVIATIONS AND TERMS

Adat rights	Customary ownership or use rights recognized by local customary law
AVHRR	Advanced Very High Resolution Radiometer
EU	European Union
EC	European Commission
EU-JRC	Joint Research Centre of the European Union
HH	Household
ha	Hectare
KKPA	Credit system from the government for the member of cooperative. In this case, the cooperative lend money from the bank for built the oil palm plantation, and they choose a company for being their partner to built and managed the estate. The company will give the whole area and its management to the cooperative member after the first harvest.
km	Kilometre
LAPAN	*Lembaga Penerbangan dan Antariksa*
m	Meters
MDF	Medium Density Fibreboard
NES	Nucleus Estate Smallholder project, a government-sponsored plantation development program in which transmigrant receive title to a portion of the developed plantation project
NOAA	National Oceanic and Atmospheric Administration, USA
RTRWP	Provincial land use plan
Stakeholders	People or groups of people interested or responsible for forest management, including landowners, local communities, industry and government organizations.
TRFIC	Tropical Rain Forest Information Center

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SUMMARY

This report describes an analysis of the underlying causes of fire in Petapahan, Riau Province, Sumatra, Indonesia. The site is located in an expired logging concession and consists mostly of oil palm plantations, industrial timber plantations and transmigration and local community settlements. Socio-economic research and hot-spot analysis suggest that fires used in land clearing for oil palm and timber plantations and the development of transmigration settlements were the most common cause of vegetation fires in the site. The development of timber plantation and oil palm plantation has also created land tenure conflicts between communities and companies. In many cases, tenure conflict often become a trigger for forest and land fire as fire is often used to destabilize livelihoods as a means of forcing the vacation of an area. The nature of partnerships between communities and companies in the development of oil palm and timber plantations is also a very important factor in reducing the incidence of fire as communities with partnerships have a vested interest in protecting their assets.

1. INTRODUCTION

The focus of this report is the study site of Petapahan in Riau Province, Sumatra. The site represents a case study of the use of fire for industrial timber and oil palm plantation development, transmigration and local communities as a tool for land preparation. Many institutions including government agencies and environmental NGOs believe that large-scale land clearing for plantations of fast growing trees for pulpwood and oil palm were a major cause of fire in 1997 and 1998.

The development of industrial timber plantations was planned in the Five Year Plan (Repelita IV) in 1984. By the end of October 1998, 5.6 million ha land had been allocated for establishing timber plantations. By 1999/2000, only 2.4 million ha or less than 50 percent of the total area of land allocated had been planted. Appendix I show an overview of industrial timber plantations in Indonesia. Similarly, there was rapid development of oil palm plantations in Indonesia (Casson, 2000), which has increased from 120,000 ha in 1969 to almost 3.0 million ha in 1999 as shown in Appendix II.

Fire is commonly used in land clearing for oil palm and timber plantation, because it is cheap and effective (Tomich et al. 1998b). Previous studies have shown that the development of oil palm and timber plantations contributed significantly to fire and smoke problems in Indonesia, (Barber and Schweithelm 2000, ADB/Bappenas 1999; Applegate et al. 2001).

The allocation of land for the plantation developments has often been undertaken without recognising the rights of local people who already occupy and cultivate the land. Fires are often used to force local communities from their land (Tomich et al., 1998a). The feeling of perceived injustice by small holders decreases their incentive to control the spread of fire to large-scale tree plantations (Suyanto et al. 2000). As a consequence of land tenure conflicts, local communities frequently burn plantation grown trees that have been established by large companies (Suyanto et al. 2000). Since the start of the political reformation period in Indonesia in mid-1998, the manifestation of land tenure conflicts between local communities and large companies has increased (Suyanto et al. 2000). There are increasing visual signs of violence and

burning of property, as companies can no longer rely on armed security to quell the unrest.

The objective of the research is to study the impact of fire on the development industrial timber and oil plantation and transmigration areas and its role in land tenure conflicts with the communities that live around the timber and oil palm plantation areas.

Two approaches to the study have been developed; the landscape level and site wide level. The landscape level (Landsat TM-level) study concentrates on general land cover type and change over time and compares this pattern with the site wide level findings. At the site wide level, the study focuses on the relationship between fire and land cover change, while the location of the fires came from hotspot analysis and fieldwork. A general level analysis was also carried out to determine fire density from the hotspot number comparisons for the whole of Sumatra Island and those in the province and the site.

The site was chosen for a number of reasons. For the last ten years, the rate of deforestation on this site has been high. Land use and land cover has changed dramatically. Those changes have triggered the fire issue in this site.

2. SITE DESCRIPTION

Petapahan is located in the Tapung Sub District, Kampar District, Riau Province, Sumatra as shown in Figure 2-1. The Petapahan study site is approximately 25 km from Bangkinang City, with a low and undulating topography and with slopes under 15 %. It has a tropical climate, with an average annual rainfall of 3,045 mm and average temperatures ranging from 26^{o}C to 32^{o}C (Book of Feasibility Study of PT Akasia, 1996).

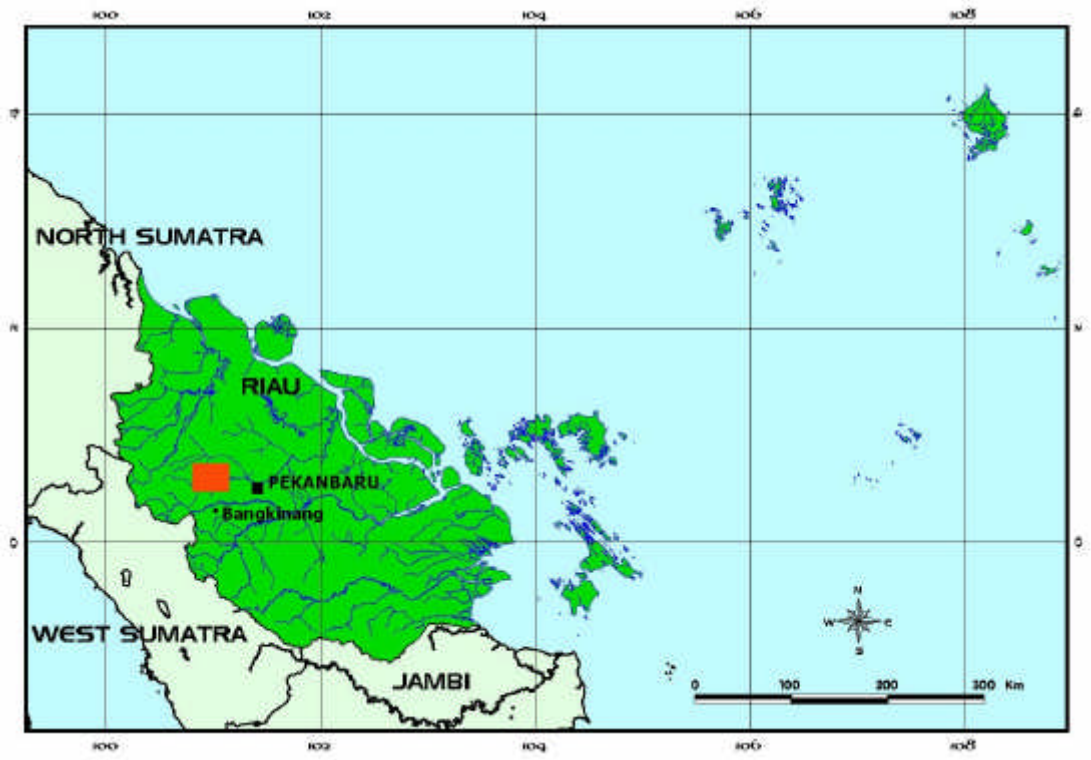


Figure 2-1. Map of Riau Province, the red box is Petapahan site research.

The Tapung Kiri, River flows from the Siak River, one of the largest rivers in Riau Province, through Petapahan Village. Until the 1980's this river provided the major transportation route to the area. However, since the 1980's the major mode of transport has shifted from river to road. The main road (asphalt road) in this site is located in the north. This road was established in the 1970's by the CALTEX[1] Company and connects their refinery stations in Minas, Petapahan, and Suram. This

[1] CALTEX is refers to PT Caltex Pacific Indonesia, commonly known as CPI, is a production-sharing contractor to Pertamina, the Indonesian state oil company. PT CPI started explores for and produces oil and natural gas from more than a hundred oil fields in central Sumatra since 1940's. In our site, their Petapahan Fields, started production in January 1973.

road is one of the main roads in Riau. In addition, there is another branch road (asphalt road) in the site. This road connects Bangkinang to the CALTEX road as shown in Figure 2-2.

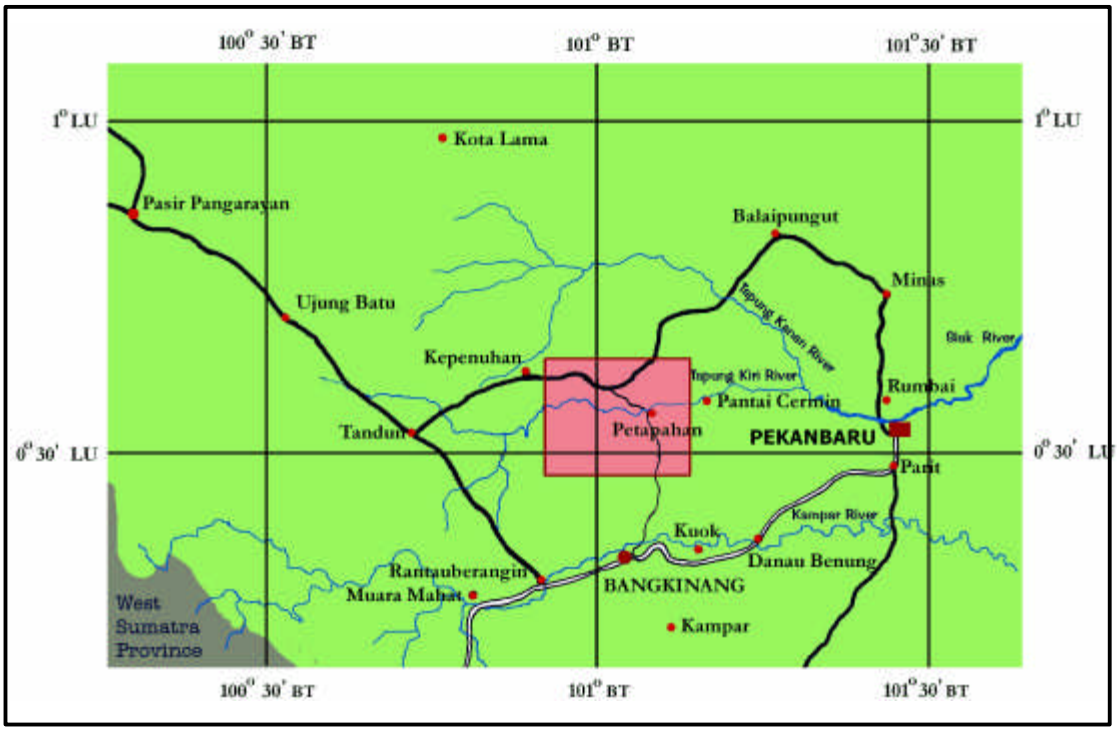


Figure 2-2. Map of Petapahan Site.

There are two old settlements in this site; Petapahan and Batu Gajah. These settlements are inhabited by ethnic Melayu-Riau. According to the Book of Petapahan Kingdom History (Arsyad, 1986), Petapahan has been established since the Sriwijaya[2] Era. At that time, Petapahan was the market center for surrounding areas such as; Minangkabau (West Sumatra), Kampar and Rokan. Petapahan Kingdom was led by a king named Bendahara. In the 14 Century, Petapahan was ruled by Bendahara Sapiyah, a Queen from Sriwijaya.

During the period of Dutch colonization, the Traktat Siak Agreement in 1858 placed Petapahan under the Siak Kingdom administered by Tapung Kiri Province. In 1915, the Siak Kingdom was separated into Districts, and Order Districts, and Kampong. Petapahan became an Order District led by Penghulu.

[2] Sriwijaya, one of big kingdom in Indonesia, was established in 7th Century and placed in Palembang, South Sumatra. Sriwijaya was well known with their army and also a center for Buddhist religion and culture.

The Japanese removed the kingdom system in Riau during their occupation, and the kingdom was renamed Riau Syu Cokan. The District changed to Gun and was led by Gunco. The Order District changed into Ku and was led by Kuco, and in each kampong, a penghulu was appointed. Petapahan became the capital of Tapung Kiri Kuco in 1977.

Under the Bupati Kampar Agreement No. 17/Kpts/1/2/1977, Petapahan became a village and was led by a Wali Desa. The village consisted of 2 hamlets, Kampung Asli and RK Petapahan Pillial (near the Caltex Oil Refinery Station). Recently, Petapahan was divided into 3 sub-villages; sub-village 1st, 2nd, and 3rd.

Local communities have undertaken shifting cultivation for a long time in this area. Most of the Petapahan communities cultivated areas along the Tapung Kiri River and established upland rice fields. During the Japanese colonisation period in the 1940s, 120 ha of wet rice fields were established, but these stopped production in 1972 due to pest attacks. Some villagers obtained private land and planted tree crops (mostly rubber trees) under communal ownership. At present, rubber gardens are mainly located along the Tapung Kiri River.

The second largest settlement is Batu Gajah, which has existed since the Dutch colonised Indonesia. The name of Batu Gajah came from the community's oral history, and the belief that there was a group of elephants, which ate the Kapau plant, and they became so thirsty, they drank water from the Tapung Kiri River. After that, they became intoxicated. Communities believe, if the Tapung Kiri River dries up, they will see the elephant's back and soon the river will flow again.

Formerly, Batu Gajah was an isolated settlement. The main transportation was via the Tapung Kiri River. In the 1970's, a logging company (HPH) improved the accessibility by constructing a road for their logging activities. This accessibility also increased migration from Batu Gajah to outside the area. In 1980's, there were a number of work projects such as road works, transmigration contracts and plantation developments, and this caused the people to move away from their settlement to worked abroad. As a result, in 1984, the Batu Gajah settlement was empty.

In 1996, PT Akasia[3], obtained a concession to develop timber plantations. They marked a 500 ha enclave for the Batu Gajah settlement and deleted this from their concession area. Road establishment has now improved accessibility to the Batu Gajah settlement. In 1996, 8 households (HH) of Batu Gajah returned and began to rebuild the settlements (See Figure 2-3). Recently, the number of households has grown to 45 HH. Five of these are not locals from Batu Gajah. These households are primarily fishermen and farmers raising rice, chilly, and tomatoes. They also planted oil palm, but the elephants destroyed these. *Datuk* (Communal Leader) provides the regulation relating to land tenure. He allows anyone in this community who has the ability and willingness to open and manage land. Commonly, each HH is able to open 2-4 ha of land.

In 1998, the Batu Gajah communities invited Bupati Kampar to return to this area and also announced to all the Batu Gajah communities to return to their settlement. Based on the interview, one of reasons for their return was to claim their customary land (*tanah ulayat*). They objected to the forest being cleared by PT Akasia and insisted their customary land be returned.

Figure 2-3. Batu Gajah Settlement.

[3] Pseudonyms are used throughout to protect the privacy of those interviewed (oil palm and timber plantation companies and transmigration settlements).

By 2001 the number of households in Petapahan was 812 and in Batu Gajah was 45. The population of local ethnic groups in those two settlements in 2000 was approximately 223 HH. Compared to other ethnic groups, the proportion of the local ethnic population in the study site is very low (20 %). Following the establishment of transmigration schemes in 1984, the ethnic Javanese and Sundanese have become the major ethnic groups in this site. In addition, spontaneous migration from North Sumatra (Batak and Javanese) occurred after 1984 and increased until the 1990's. These migrants live in 3rd sub-village of Petapahan, which is located along the CALTEX road as shown in Figure 2-4.

Figure 2-4. Spontaneous migrants developed oil palm along the CALTEX road.

Transmigration areas were established in the 1980's. There are two types of transmigration schemes, which are the Regular Transmigration and the Transmigration with NES[4] (Nucleus Estate and Smallholders) scheme. The Regular Transmigration settlement was established in 1985, and consists of five settlement units. In 1991, those five settlements were converted into villages with a population of 2,024 HH. The villages are SP1, SP2, SP3, SP4, and SP5. In 1997, they joined PT *Sawit* 4 as a company partner to develop oil palm plantation using KKPA[5] (Koperasi Kredit Primer untuk Anggota - Primer Cooperative Credit for Member) scheme.

[4] NES (Nucleus Estate for Smallholders) is a joint cooperation between a private company or state and the community/smallholders. The company built the plantation area for themselves (nucleus) and smallholders. The smallholders harvest the fruits and have to sell it for crushing to its company industries.

[5] KKPA (Koperasi Kredit Primer untuk Anggota) is a credit system from the government for the member of cooperative. In this case, the cooperative lend money from the bank for built the oil palm plantation, and they choose a company for being their the partner to built and managed the estate. The company will give the whole area and its maintenance to the cooperative member after the first harvest.

The other transmigration scheme is transmigration with NES, and was established in 1991. There were five transmigration units and PT *Sawit* 1 was a partner company for developing and managing their oil palm plantations. The villages are NES 1, NES 2, NES 3, NES 4, and NES 5. Since 1996, the oil palm plantations have been transferred to the farmers.

Currently, the major land use in this site is oil palm plantation owned both by large corporations and smallholder farmers. There are four oil palm companies in this site; PT *Sawit* 3, PT *Sawit* 2, PT *Sawit* 1 and PT *Sawit* 4. The first two companies, PT *Sawit* 3 and PT *Sawit* 2 manage only their own private oil palm plantations. The last two companies manage oil palm plantations through a partnership with farmers. The partnership types, however, are different. PT *Sawit* 1 follows the NES schemes and PT *Sawit* 4 follows the KKPA scheme. PT *Sawit* 1 was the first company to establish oil palm plantations and has the largest area of oil palm plantation. They commenced in 1990, through the NES scheme and built a partnership with five transmigration settlements. As of March 2001 they had planted almost 8,500 ha

In the period 1991 to 1993, PT. *Sawit* 1 developed 4,461 ha of oil palm plantation with the NES scheme involving five transmigration settlements; NES 1 Village, NES 2 Village, NES 3 Village, NES 4 Village and NES 5 Village. The company continues to assist the transmigrants with advisory help on pest and disease problems, fertilizer distribution and purchasing. Recently (March 2001), PT *Sawit* 1 also began another partnership as a Farmer Cooperative for Petapahan Community (KOPTAMASTA-Koperasi Tani Masyarakat Petapahan) to develop and manage oil palm plantation under the KKPA scheme as shown in Figure 2-5.

The other company, PT *Sawit* 2, developed oil palm plantations based on Government Degree for Released Area No. 486/Kpts-II/1991 dated August 1st, 1991, and has an area of 1,753 ha. Most of the concession however, was cultivated land of Petapahan community, who live in areas surrounding the concession. Thus, PT *Sawit* 2 has paid compensation to the community for developing their oil palm plantation.

The establishment of oil palm started in 1990 and in 1999 all concession areas had been planted. They added to the concession area in 1996 approximately 1,000 ha and recently they've developed a further 2,571.17 ha. One of PT *Sawit* 3 concession areas

is in Petapahan. It is approximately 4,300 ha. This area was formerly developed and managed by PT *Sawit* 6. PT *Sawit* 6 is in the same company group as PT *Sawit* 3. The area was opened in 1991 and by 1995, the whole concession area had been planted. In 1995, PT *Sawit* 3 took over the management of the estate. In 1995, PT *Sawit* 3 began to replant some of the area, because elephants had destroyed much of the young plantations. The re-planting continued until 1997.

Figure 2-5. PT Sawit 1 established oil palm plantation for Petapahan Community

In 1995, PT *Sawit* 4 offered a partnership under KKPA scheme to six regular transmigration settlements (five of them were in the study site). Almost all the transmigrants joined the KKPA scheme and gave their land to the company. PT *Sawit* 4 collaborated with KUD (Koperasi Unit Desa - Village Unit Cooperative) *Sawit Jaya*, to establish oil palm plantation. KUD *Sawit* Jaya is a joint venture between six KUD in those villages. The villages are: SP1, SP2, SP3, SP4, SP5, and SP6. By 2001, PT *Sawit* 4 had established 5,105 ha of oil palm plantation.

The second major land use is timber plantation as shown in Figure 2-6, which covers almost 12,925 ha. The company commenced the development of timber plantations in 1996. The timber plantation is owned by PT Akasia, who obtained 31,415 ha of concession area. This area was formerly a logging concession belonging to PT Tanjung Budi Sari and PT Indra Pusaka. However, based on the feasibility study that was conducted in 1996, around one third of the concession was occupied by the local community. In order to avoid conflict with local communities, PT Akasia reduced the concession area to 19,095 ha. Around 6,000 ha were allocated for conservation,

infrastructure, and research. Unlike the oil palm development schemes, there was no scheme for developing a partnership with farmers for this timber plantation. The company hired only 5% of its workforce from the local community to work in their company. This has caused continuing problems with the community.

Figure 2-6. Timber Plantation of PT Akasia.

More detail site description focusing on land use characterisation can be seen in sketch map of study site (Figure 2-7).

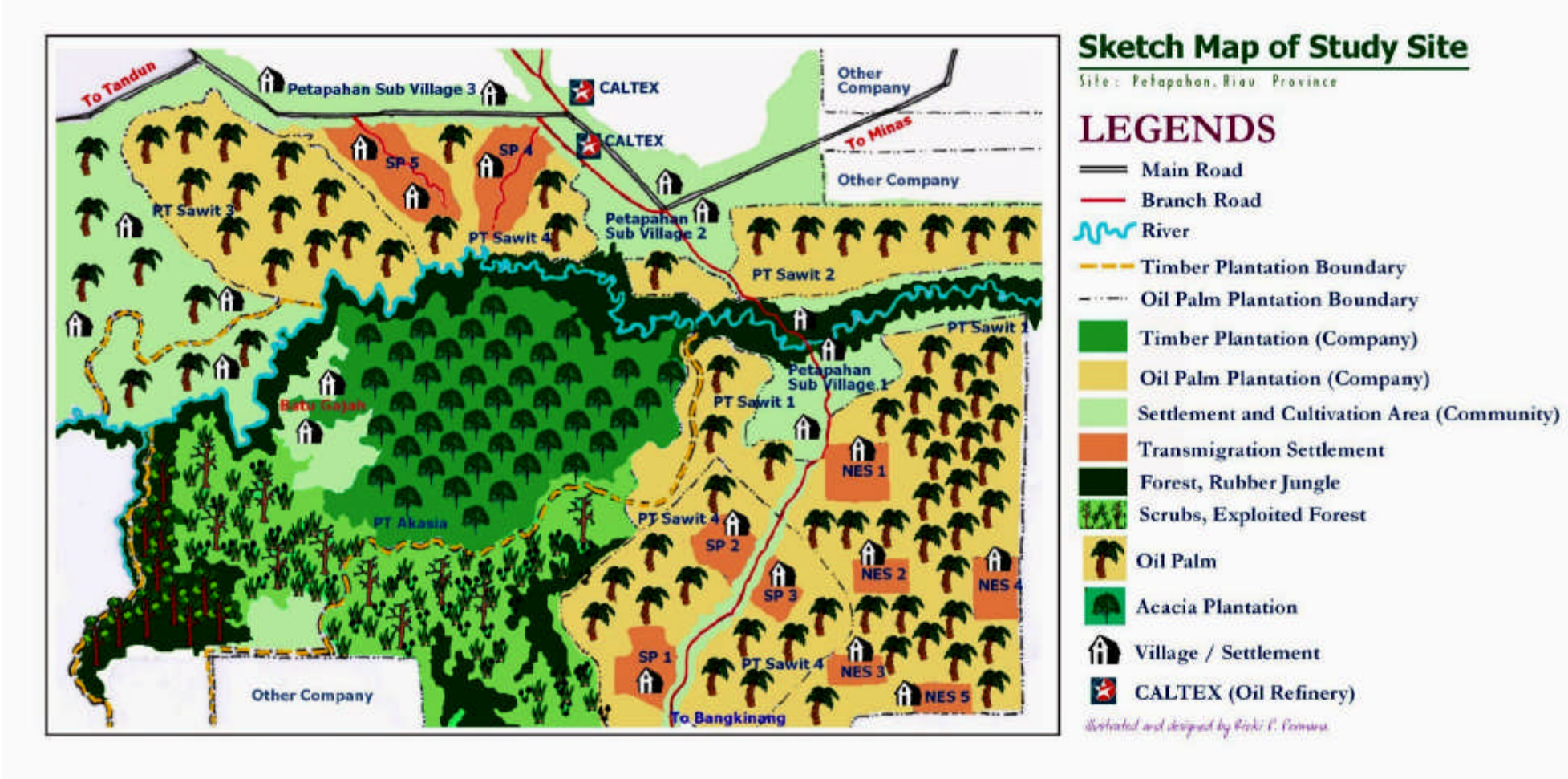


Figure 2-7. Landscape level sketch map of Petapahan site.

3. METHODOLOGY

3.1 Socio-Economic Study Methods

Sketch mapping at the landscape level and a rapid rural appraisal were conducted between April and May 2001. The sketch map was developed based on a landscape map with a scale of 1:50,000, issued by BAKOSURTANAL (Badan Koordinasi Survey dan Pemetaan Nasional – Coordination Institute of National Survey and Mapping) and Landsat ETM Image dated 26 April 2000. Data collected during interviews with oil palm plantation managers, timber plantation managers, community leaders, local Government officers, and additional field observations, were overlaid onto the base map. This information included the history of the plantations and villages, the history of land clearing and planting, details on land clearing techniques, fire history, demography, land use, agricultural activities, and land tenure conflicts. In addition, a survey was conducted with 75 households in three different types of communities (local, spontaneous migrants and transmigrants) who lived adjacent to the timber and oil palm plantations.

3.2 Remote Sensing and GIS

3.2.1 Landscape level mapping and change analysis

Using remote sensing techniques, historic land cover type, current patterns of land cover change were analysed at the landscape level. The data that was used for the land cover mapping and land cover change analysis in the Petapahan site is Landsat Satellite imagery that covers the period June 1992, November 1998, and April 2000 (see Table 3-1 and Figure 3-1).

Table 3-1. Imagery used for the analysis

Date	Sensor	Scene (path/row)	Image Source
15 June 1992	Landsat TM	127/60	TRFIC
23 November 1998	Landsat TM	127/60	LAPAN
26 April 2000	Landsat +ETM	127/60	TRFIC

The earliest image in the sequence is Landsat TM dated 15 June 1992 and the most recent dated 26 April 2000. Those images were purchased from the Tropical Rain Forest Information Center (TRFIC) which is a NASA Earth Science Information

Partner based in Michigan State University. The quality of both images is excellent with no cloud cover that might causes problems with the interpretation process. Another image in the sequence is dated 23 November 1998. This image was purchased from *Lembaga Penerbangan dan Antariksa* (LAPAN) based in Jakarta-Indonesia. The quality of the image is quite good; cloud cover and drop line error appeared but are clear enough for accurate interpretation.

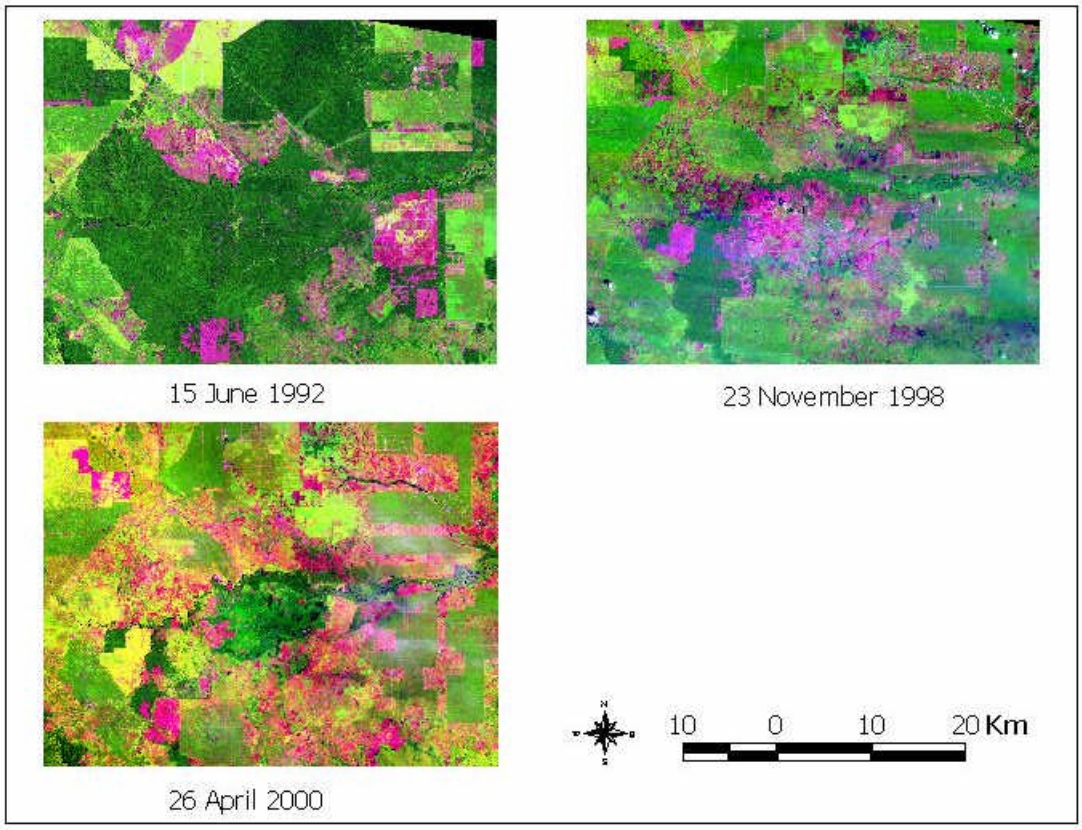


Figure 3-1. Satellite imagery selected for the Riau site

Pre-processing of the imagery involved geo-referencing using 1:50,000-scale topographic map as the base. The map projection used for the imagery is Universal Transverse Mercator (UTM) zone 47 North with Datum WGS 1984. The image classification process was carried out digitally using Unsupervised Classification method. A visual interpretation was used to merge, split and edit the class resulting from the digital process. The land cover change analysis was undertaken after the classification of all images was complete. The process was archived using PC ER-Mapper 6.1. Vector based mapping and analysis for each class individually, including burn scar mapping with the result processed in PC ArcView 3.2.

3.2.2 Derivation of fire hot spots

The 1997 hot-spot data was obtained from Forest Fire Prevention and Control Project of the European Union based in Palembang, South Sumatera-Indonesia. To obtain a better idea of the vulnerability of this site to fire, hot-spot densities at the landscape level were compared to hot-spot densities for the entire Riau Province and Sumatra Island. Furthermore, hotspot maps were overlaid onto land cover maps of the study site to investigate the connection between land cover type in the study area and fire.

3.2.3 Integration of social science and remote sensing using GIS

In order to improve the analysis, a methodology was developed that integrates some of the results of the socio-economic research with the results of the remote sensing-based land cover mapping and change analysis. A Geographic Information System (GIS) was used for this integration. Not all outputs from the socio-economic research are compatible with remote sensing; so the types of output vary slightly. For the Petapahan site, the focus was on integrating local people's narratives and sketch maps. The sketch map can provide additional land cover data that can't be obtained from remote sensing techniques due to its limited spatial resolution. Using the functionality of the GIS, it was possible to calculate the types and more accurately the size of the land cover changes in the study area rather than doing an individual analysis with remote sensing or social research only. In addition, local people's narratives could be added to the land cover change results to provide an insight into how and why these changes occurred.

4. RESULTS

4.1 Land Cover and Land Use Changes

World Bank (2001) stated that the main causes of deforestation (defined here as the permanent loss of forest cover) can be grouped into three broad categories: large-scale conversion to timber or estate crop plantations (in particular, oil palm), smallholder conversion, and unsustainable and illegal logging. Over the Outer Islands as a whole, well over 20 million ha of natural forest have been lost over the past twelve years. This equates to an average overall deforestation rate of 1.7 million ha/yr for the period. In Sumatra, the total forest area has decreased from 23 million ha to probably less than 16 million ha (World Bank, 2001).

Until 1970, the forests were still abundant on this site. The exploitation of forest, however, begun with the allocation of logging concessions in the 1970's. There were five companies who had logging concessions in the area. They were PT Tanjung Budi Sentosa, PT Indra Pusaka, PT Sindotim, PT Nanjak Makmur and PT Chandra Dirgantara (See Table 4-1 and Figure 4-1).

Table 4-1. Logging companies (HPH) who had operated in site research

No.	Company	Minister decrees	Areas (ha)
1	PT Tanjung Budi Sari	SK HPH No. 412/Kpts/Um/8/1970	100,000*
2	PT Indra Pusaka	SK HPH No. 152/Kpts/Um/3/1974	30,000
3	PT Sindotim	SK HPH No. 235/Kpts/Um/7/1969	8,000*
4	PT Nanjak Makmur	SK HPH No. 231/Kpts/Um/3/1979	91,000*
5	PT Chandra Dirgantara	SK HPH No. 228/Kpts/Um/4/1980	128,000*

* Some of the areas were outside the site research

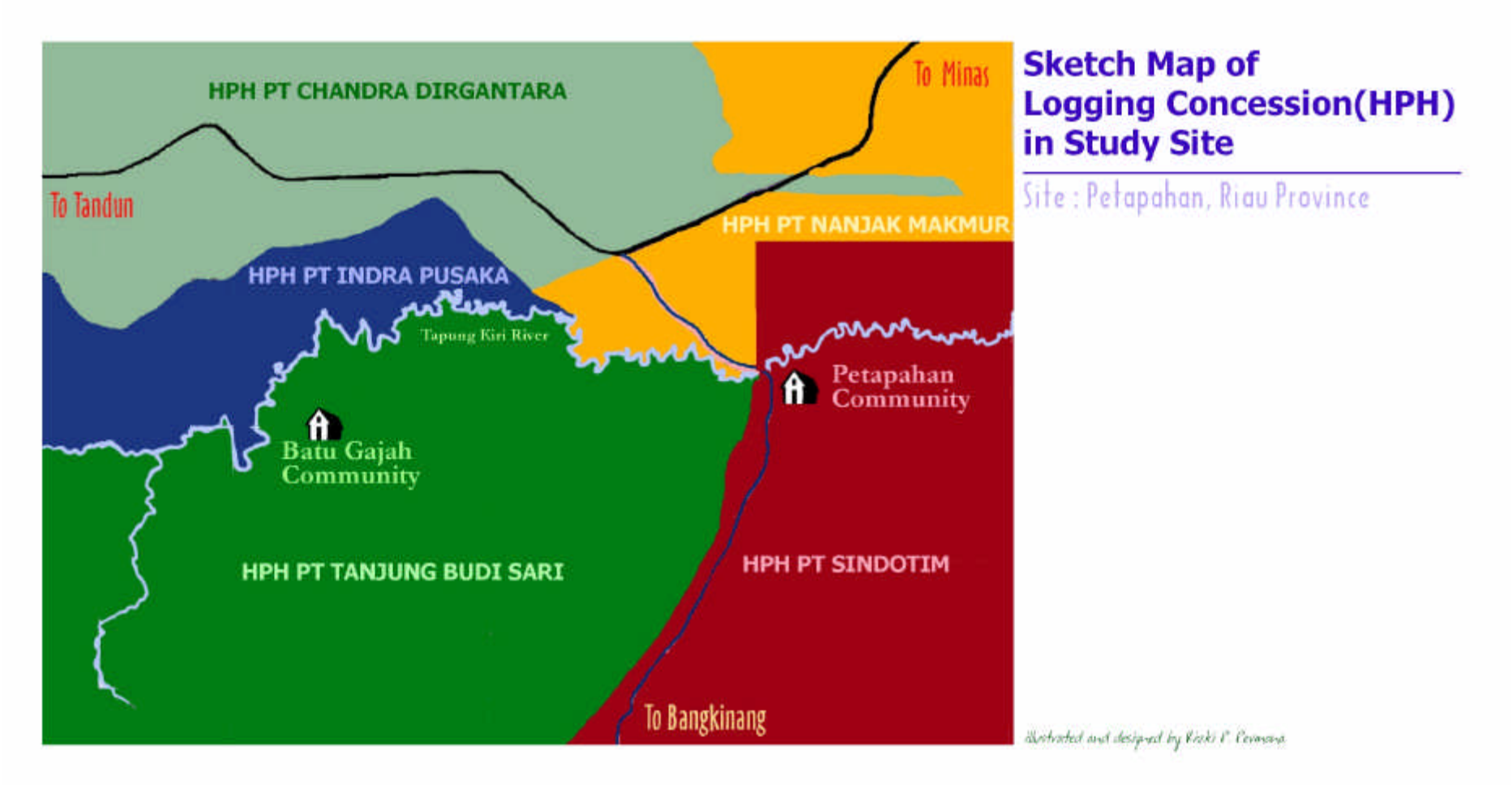


Figure 4-1. Sketch map of logging company (HPH) concession in site research.

The second major land cover and land use change occurred on this site in 1982 with the establishment of transmigration settlements. From 1982 to 1987, five transmigration settlements were established. Table 4-2 shows the total households in the establishment year were 1,896. These transmigrant was categorized as regular transmigrant, in which each household received 2 ha of land that consists of 0.25 ha of land for housing and home gardens; 0.75 ha of *lahan satu*[6] and 1.0 ha of *lahan dua*[7]. The government carried out land clearing for housing land and *lahan satu*. However, transmigrants were responsible for clearing and developing *lahan dua*.

Table 4-2. Establishment years of regular transmigration in site research.

No.	Village	Establishment		
		Year	HH	Population
1	SP 1	1982/1983	649	2,082
2	SP 2	1986/1987	325	1,262
3	SP 3	1986/1987	376	1,456
4	SP 4	1983/1984	276	1,199
5	SP 5	1983/1984	270	1,251
	Total		**1896**	**7,250**

In 1995, *lahan dua* land was converted to oil palm plantation through KKPA scheme, collaboration with PT *Sawit* 4. Table 4-3 shows the total *lahan dua* planted by oil palm trees under the KKPA scheme is 5,105 ha.

Table 4-3. Planted area of PT Sawit 4 for each regular transmigration.

No.	Village	Planted Area (Ha)	Year Planted
1	SP 1	1,250	1997-1998
2	SP 2	860	1998
3	SP 3	1,015	1997-1998
4	SP 4	1,300	1996-1997
5	SP 5	680	1997
	Total	**5,105**	

The establishment of transmigration settlements continued from 1991 to 1999. Unlike the previous transmigration settlement schemes, these transmigration settlements were established under the NES scheme (see Table 4-4). Under this scheme, five villages that were occupied by around 9,577 households were established. Each household

[6] Lahan satu is the land first cultivated to produce subsistence food and income for the family.

[7] Lahan dua is the secondary land to provide an income beyond subsistence.

received 2.5 ha of land, consisting of 0.5 ha land for housing and home gardens and 2 ha land for oil palm plantations.

Table 4-4. Establishment and released years of NES transmigration in site research.

No.	Unit/Settlement	Establishment			Released		
		Year	HH	Pop.	Date	HH	Pop.
1	UPT I (NES 1)	1991/1994	500	2,030	19-01-1996	500	2,311
2	UPT II (NES 2)	1992/1993	540	2,230	26-02-1997	540	2,230
3	UPT III (NES 3)	1993/1994	447	2,119	17-02-1998	460	2,158
4	UPT IV (NES 4)	1994/1995	400	1,566	17-09-1998	400	1,566
5	UPT V (NES 5)	1995/1996/ 1998/1999	402	1,632	14-12-2000	402	1,783
	Total			**9,577**			**10,048**

The third major land use change in this site is the development of oil palm and timber plantations. Commencing from 1991 to 2001, around 21,000 ha of land have been planted to oil palm under different schemes. The development of timber plantations started in 1996. From 1996 to 1999, over 13,000 ha of acacia plantations were established.

4.2 Quantitative landscape mapping and changes analysis

Quantitative assessment of land cover change at the landscape level was undertaken for three different dates; 15 June 1992, 23 November 1998 and 26 April 2000. The change analysis is reported for two time periods 1992–1998 and 1998–2000. Cloud and shadow did not present problems for the interpretation, as the image quality was good. The results of the classifications can be seen in Figure 4-2.

The analysis compared cumulative figures and percentages between years, thus giving a general overview of changes. This type of analysis gives an insight into the predominant land cover change processes. Change trajectory matrices were also calculated. These matrices are provided in Appendix III.

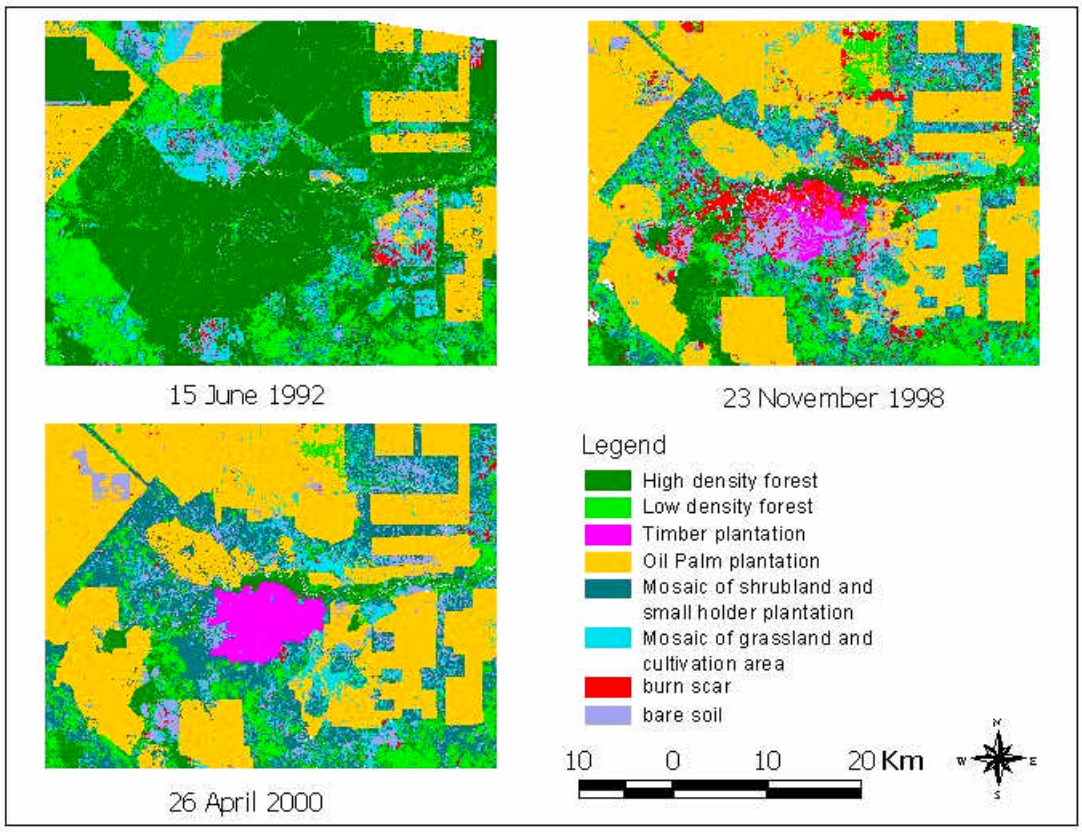


Figure 4-2. Land cover classifications 1992-1998-2000

During 1992 to 1998, there were considerable changes in the extent and quality of the forest. The total decrement over this six-year period was 86%, or 14.3% per annum for high-density forest and 14.8% or 2.5% per annum for low-density forest (see Table 4-5). Analysis of the change trajectory matrix table in Appendix III shows that 26% of the high-density forest in 1992 and 30% of low-density forest had become oil palm plantation in 1998. Logging roads already accessed most of the forest area in 1992 as seen from the satellite imagery.

According to the information from the fieldwork in 2001 the area had been logged since the 1970's and then the logged over areas began to be used by the timber and oil palm plantation companies in late 1980's. Timber plantations appeared in 1998 classification and covered 2,616 ha or 1.5% of the study areas, with 95.1% of its area previously under forest cover.

Other land cover types identified are mosaics of shrub land and smallholder plantation and mosaics of grassland and cultivation. Fieldwork identified that this area was comprised of transmigration areas, local people villages, and also unused area covered

by grass, shrubs and alang-alang. The other land category covered 15% of the study area in 1992 and this had increased to 22% in 1998. It shows the increment in migrants and their activities over this short time period.

Table 4-5. Cumulative land cover change estimates 1992–1998

Class name	1992		1998		Change	
	Ha	%	Ha	%	Ha	%
High density forest	86690.43	49.5	12114.63	6.9	-74575.80	-86.0
Low density forest	27344.34	15.6	23300.91	13.3	-4043.43	-14.8
Timber Plantation	0.00	0.0	2616.84	1.5	2616.84	-
Oil Palm plantation	23475.60	13.4	72613.71	41.5	49138.11	209.3
Mosaic of shrub land and small holder plantation	14082.03	8.0	20067.57	11.5	5985.54	42.5
Mosaic of grassland and cultivation	12411.36	7.1	17691.57	10.1	5280.21	42.5
Burn scar	1925.55	1.1	12482.82	7.1	10557.27	548.3
Bare soil	6795.81	3.9	11867.76	6.8	5071.95	74.6
Water and no data	2269.44	1.3	2238.75	1.3	-30.69	-1.4
Total	174994.56	100.0	174994.56	100.0		

Table 4-5 also shows that there was a 209% increase in oil plantation area (+ 49,138 ha) and 548% increase in burn scar area (+10,557ha). Analysis of the change matrix in Appendix III shows that 42% of the area converted to oil palm plantations in 1998 was forest in 1992 and only 26% was non-forest area. The following result shows that the pre-burn composition of the burn scars was 90 % forest area, 8.7% non- forest area and 0.4% previous burn scar. Note that in 6 years the forest area could have already been converted into another land cover type before being converted into oil palm plantation areas or burn scars shown in the in 1998 images.

During 1998 to 2000, forest cover decreased both for high density and low-density forest in the range of 40% and 21% (see Table 4-6). During this 2-year period, there was an overall reduction in burn scars of 91%. Fieldwork confirmed that much of the fires took place during the El Niño of 1997 and the 1998 image used in the analysis was taken after the 1997 fires. Appendix III shows after-burn composition of the burns scars was 15% timber plantations, 18% oil palm plantations, 16% a mosaic of shrub land and small holder plantations, 36% a mosaic of grassland and cultivation, 1% burn scar, and 13% bare soil.

Table 4-6. Cumulative land cover change estimates 1998-2000

Class name	1998		2000		Change	
	Ha	%	Ha	%	Ha	%
High density forest	12114.63	6.9	7249.14	4.1	-4865.49	-40.2
Low density forest	23300.91	13.3	18330.03	10.5	-4970.88	-21.3
Timber Plantation	2616.84	1.5	6863.40	3.9	4246.56	162.3
Oil Palm plantation	72613.71	41.5	80197.02	45.8	7583.31	10.4
Mosaic of shrub land and small holder plantation	20067.57	11.5	12142.71	6.9	-7924.86	-39.5
Mosaic of grassland and cultivation	17691.57	10.1	35441.82	20.3	17750.25	100.3
Burn scar	12482.82	7.1	1046.34	0.6	-11436.48	-91.6
Bare soil	11867.76	6.8	12981.69	7.4	1113.93	9.4
Water and no data	2238.75	1.3	742.41	0.4	-1496.34	-66.8
Total	174994.56	100.0	174994.56	100.0		

4.3 Fire hotspots analysis

Compared to other areas of Sumatra, Riau Province displayed a high number of fire hot spots during the 1997 fire event in Indonesia. The total number of hotspot for Sumatra in 1997 was 25,148 and 5,870 covered Riau province or 23% of the total Sumatran hotspot. At the landscape level, there were 475 hotspots detected in 1997. The overlap of 1997 hotspot on the 1998 land cover map (see Table 4-7 and Figure 4-3) shows 33% of the total hotspots are on oil palm plantations and 19% in the mosaic of grassland and cultivation. Most of the hotspots that covered both areas occurred in May, June and July, exactly at the beginning of the long dry season in 1997.

Table 4-7. Result on overlapping the 1997 hotspot on 1998 land cover map

Land Cover	Hot spot number	(%)
High density forest	19	4.0
Low density forest	65	13.7
Timber plantation	8	1.7
Oil Palm plantation	157	33.1
Mosaic of shrub land and small holder plantation	50	10.5
Mosaic of grassland and cultivation area	91	19.2
Burn scar	42	8.8
Bare soil	30	6.3
Water and no data	13	2.7
Total	**475**	**100.0**

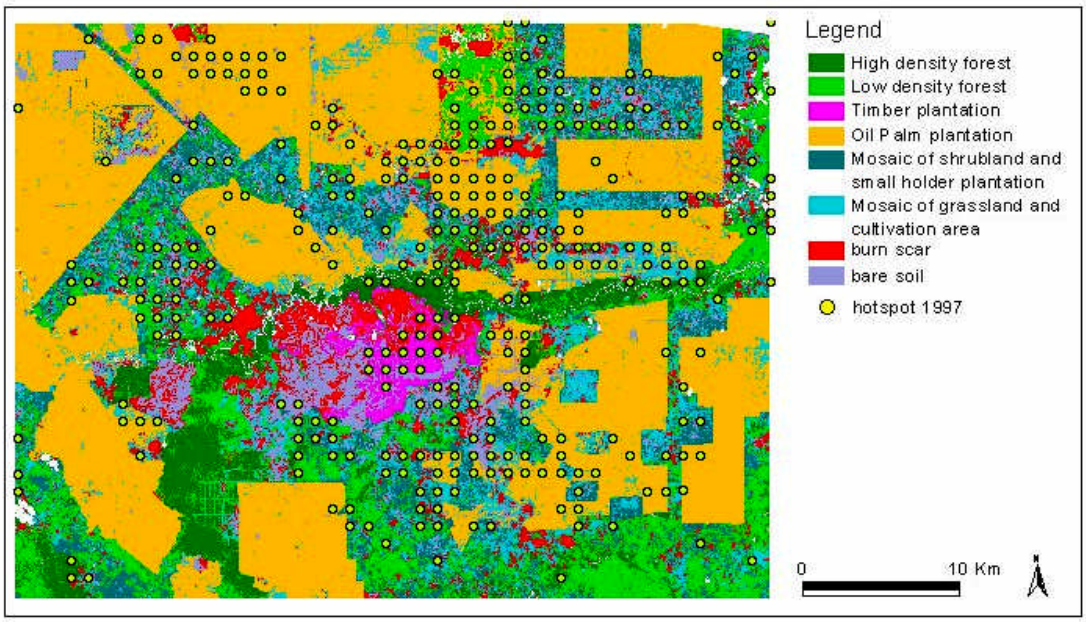


Figure 4-3. Hotspot 1997 over 1998 land cover map

4.4 Fires information from field surveys

Information from the socio economic surveys suggested that the cause of burning up until 1998 was caused by land clearing, mostly for the establishment oil palm and timber plantations.

From 1991 to March 2001, around 20,000 ha of land was planted to oil palm by large-scale companies. Around 98% of the oil palm plantations were planted during 1991 to 1998, in which fire was used as a tool in land preparation. The remaining oil palm plantations, (2%) was planted after 1998. The companies declared that they used mechanical techniques and not fire in land preparation. The reason is because the Government of Indonesia banned the use of fire for land clearing by large-scale companies in 1988.

The second major cause of fire in this site was from burning debris during the establishment of timber plantations. The total planted area of timber plantation in this site is almost 13,000 ha. These areas were planted from 1997 to 1999, in which fire was used in land preparation.

Fire, was also reported as a tool used in land preparation by smallholders. It is the third major cause of fire. Smallholders are the local and migrant communities. These migrants played an important part in causing the fire and smoke in this area. Migration in this area has increased since the 1990's along with the development of transmigration and oil palm plantations. The highest migration occurred between 1996 and 1998 and most settled on land along the CALTEX road. Most of this land belonged to the original Petapahan communities. The migrants purchased the land and used fire for land preparation.

4.4.1 Fires as a tool in land preparation by oil palm companies.

In this study site, there are four oil palm plantation companies with three different development schemes. One scheme is the nucleus estate and smallholders (NES). One company, PT *Sawit* 1, developed oil palm plantation through this scheme. From 1991 to 2001, PT *Sawit* 1 established around 4,000 ha of nucleus plantation and around 4,400 ha of plasma plantations (see Table 4-8).

Another scheme is based on private company investment without partnerships with farmers. Two oil palm plantation companies, PT *Sawit* 2 and PT *Sawit* 3 adopted this scheme. Between 1991 and 2001, both companies established around 6,800 ha of oil palm plantation.

The third scheme is the Prime Cooperative Credit for Members (*Koperasi Kredit Primer Anggota* = KKPA). Under this scheme, a private oil palm company should establish oil palm plantations for the farmers under the credit scheme. The company maintains the plantations until they are mature and then transfers them to the farmers after the first harvest. The transmigrants should provide the credit for the establishment. For paying the credit, each village established the Village Unit Cooperative (KUD-Koperasi Unit Desa) to manage the credits and also as the facilitator between the transmigrants and the company. PT *Sawit* 4, following the KKPA scheme established 5,105 ha oil palm plantation in five transmigration villages during 1996 to 1998. Table 4-8 shows the planted areas for each company since 1991. During 1996 to 1998, almost 10,000 ha were planted to oil palm, in which fire was used in land preparation.

Table 4-8. Planted area of Oil Palm Plantation in study site.

Years	PT *Sawit* 1		PT *Sawit* 2 (ha)	PT *Sawit* 3 (ha)	PT *Sawit* 4 (ha)	Total (ha)
	Private (ha)	NES (ha)				
1991	636.00	400.00	382.53	0.00	0.00	1,418.53
1992	1,470.00	1,666.00	205.94	1,048.00	0.00	4,389.94
1993	50.00	2,351.00	598.35	866.00	0.00	3,865.35
1994	0.00	0.00	382.10	399.60	0.00	781.70
1995	0.00	0.00	78.73	376.60	0.00	455.33
1996	**1,129.00**	**0.00**	**414.11**	**46.60**	**1,300.00**	**2,889.71**
1997	**376.00**	**0.00**	**389.41**	**1,523.90**	**2,945.00**	**5,234.31**
1998	**71.46**	**0.00**	**120.00**	**0.00**	**860.00**	**1,051.46**
1999	171.54	0.00	0.00	0.00	0.00	171.54
2000	29.00	0.00	0.00	0.00	0.00	29.00
2001*	115.50	0.00	0.00	0.00	0.00	115.50
Total	**4,048.5**	**4,417**	**2571.17**	**4,260.7**	**5,105**	**20,402.37**

* Until March 2001

Based on interviews with the staff of PT *Sawit* 1, fire was used to clear areas from 1991 to 1998. This activity started by slashing and cutting the trees and shrubs. Once dried, the cut material is burned. After the burning, the burned trash is stacked into rows, called *gawangan*. If necessary, the burning is repeated until the land is clear enough for planting. *Gawangan* is the name given to two kinds of rows. G*awangan*, can refer to *live gawangan* for planting rows or *dead gawangan* which are rows in which the trash is stacked and burned.

Since 1998, the companies stated that they have not used fire in land preparation, because the government banned the use of fire for land preparation more strictly. In the study site, however, after 1998, only PT *Sawit* 1 opened and planted around 300 ha. of oil palm. The companies stated that now they used a fully mechanical system to clear the land, but based on the investigation, the contractor they hired still used fire to burn off the dead *gawangan*. The dead *gawangan* needs to be burned because if too high impedes accessibility for planting the seedlings.

A common reason given for using fire in land preparation is economics. The cost of mechanical techniques is higher than using fire. Table 4-9 shows a cost comparison of establishing oil palm plantation by using fire and mechanical techniques. The cost estimate is based on price in 1997 and physical unit in 2000 data. The economic analysis shows the land preparation cost per hectare by using fire is 300 thousand *Rupiah* cheaper than the cost of using mechanical techniques. This suggests a weak incentive to implement zero burning techniques for land preparation.

Table 4-9. Cost comparison of land preparation techniques in PT Sawit 1.

Activity	Using Fire (Rupiah/ha)	Mechanical System (Rupiah/ha)
Slash	148,500	108,000
Cut	396,000	156,000
Slice	148,500	117,000
Burn	33,000	0
Mechanical Prone	0	663,000
TOTAL	**726,000**	**1,044,000**

4.4.2 Fires as a tool in land preparation for industrial timber plantations

The establishment of industrial timber plantation started in 1996 with *Acacia mangium* and *Acacia crassicarpa*. However, the expansion of these plantations has ceased since 1998, due to tenure conflicts with local communities who live around the plantations.

The company obtained a logging license (IPK-*Ijin Pemanfaatan Kayu*) to clear the concession area and establish timber plantations. They contracted the land clearing activity to PT Meranti, a member of their company group. PT Meranti cut the trees with diameters above 15 cm. They sold the logs to the pulp industry (chip wood), and some of the high quality logs were sold to sawmills and plywood industries. The contractor also cut the remaining logs and shrubs with diameters under 15 cm, and stacked and burned them. The stacking and burning was repeated until the land was clear enough to be planted. Planting was undertaken less than a month after the burning was completed. Since 1998, the companies have stated they used mechanical systems for land preparation.

Until 2000, the land cleared was 17,466 ha, with 12,925 ha of their concession area planted in Petapahan Unit. The cleared and planted area for each year is shown in Table 4-10. Both activities were stopped in 1999, due to land tenure conflicts.

Table 4-10. Cleared and planted areas of PT Akasia.

Year	Cleared Area (ha)	Planted Area (ha)
1996/1997	2,700	1,707
1997/1998	6,860	6,828
1998/1999	7,906	4,390
1999/2000	-	-
TOTAL	**17,466**	**12,925**

Source: Annual Work Planning PT Akasia

Similar to the establishment oil palm plantations, the cost of zero burning using mechanical techniques is higher than using fire for land preparation. Table 4-11 shows the cost comparison between using burning techniques and mechanical techniques for land preparation in PT Akasia in 1997. The cost of zero burning per

hectare is almost 200 thousand Rupiah higher that the cost of using fire. The cost of the first three activities involving slashing, cutting and slicing is similar between the two techniques. The difference is due to the cost of using heavy equipment (Figure 4-4) such as bulldozers and excavators. The cost of mechanical spreading is 5 times more expensive than the cost of burning.

Table 4-11. Cost comparison of land preparation techniques in PT Akasia.

Activity	Used Fire (Rupiah/ha)	Mechanical System (Rupiah/ha)
Slash	75,000	75,000
Cut	105,000	105,000
Slice	40,000	40,000
Burn	45,000	0
Mechanical Spreading	0	230,000
TOTAL	**265,000**	**450,000**

Figure 4-4. Heavy equipments usually used for land preparation in mechanical system and those machines significantly increased the cost of land preparation.

One of the large timber plantation companies in Riau also stated (see inbox below) that the zero burning system has a high cost of implementation and requires some incentives for applying it.

A staff member of a big industrial tree plantation company was interviewed about the organization's land preparation system. The company stated that they have been practicing 'zero burning' in its land preparation activities since 1994. These are some considerations in the company's applied system, i.e.:

Optimising Resources. All wood materials from 6 centimetres in diameter are utilized. The residual wood in the field after harvest is generally about 10 – 20 m^3 per hectare and these are spread manually or mechanically in the harvesting compartment during the land preparation, allowing the wood materials to decompose for nutrient cycling. In most instances, the residual wood in the field is less than 15 m^3 per hectare.

General Cost. Initially, the cost of land preparation without burning is high. But land preparation by burning will increase fertilizer needs during maintenance because of the loss of organic matter and nutrients. Growth of the plantations is also affected and in the long-term productivity is decreased resulting to higher production costs. .

Activity Items	Cost (in USD)
For ex Bushes Area	
Land Clearing	455
Infrastructure Improvement	9.9
Planting	183
Fertilization	67.4
Blanking/Sisipan	21.6
Weeding	126.2
Pruning/Singling	10.6
Pest and Disease	0.5
Fire Protection	1.5
Survey and Census	2.3
Total	878
Note: Above cost do not include infrastructure cost.	
For ex Logged-over area	
Land clearing	230
(Other activities as above)	423
Total	653

Burning as a land preparation option is cheap and convenient. It is generally followed with a significant growth during the first few years after land preparation. However, in the long term the growth and productivity will radically decline due to the loss of soil nutrients and reduction of microorganism essential for sustained growth.

4.4.3 Fire as a tool in land preparation by smallholders

Based on household surveys, Table 4-12 shows average land holdings by different types of farmers. Local farmers have the highest average area of land holding that is 8 ha per household. The average land holding per household of spontaneous migrant farmers and transmigrant farmers is 3.6 ha and 2.4 ha respectively. None of the three types of farmers have wet rice fields. The major land use is tree cropping. More than 69 % of the average land holdings of the three types of respondents have tree crops in their fields, with the remainder being upland fields and bush-fallow.

Table 4-12. Average area of land holding by different land use (ha)

Type of farmers	Wet rice field	Upland field (*Ladang*)	Bush-fallows	Tree crops field	Total
Local	0	0	1.8	6.2	8.0
Spontaneous migrants	0	0.4	0.7	2.5	3.6
Transmigrant	0	0	0	2.4	2.4

Oil palm is a major tree crop, with 64 % to 96 % of tree crops being oil palm (Table 4-13). Oil palm was attractive to farmers who came to this area, especially those that were spontaneous migrants. The main objective of spontaneous migrants is to establish oil palm plantation. Thus, spontaneous farmers have the biggest proportion of oil palm plantation (96 % of total plantation).

The second most important tree crop is rubber. However, rubber is only important for local farmers (24% of total tree plantation) and transmigrant farmers (36 % total tree plantation). Spontaneous migrants are not interested in establishing rubber, as indicated by the small proportion of rubber plantations they own (only 4 %).

Table 4-13. Percentage of trees planted of communities.

Type of farmers	Oil palm (%)	Rubber (%)	Others Plant (%)
Local	71	24	6
Spontaneous Migrants	96	4	0
Transmigrant	64	16	0

Facilitated by the development of transmigration settlements in the early 1980's and the development of oil palm plantations in the early 1990's, in-migration to this site

has been increasing. Mostly, the migrants from North Sumatra Province had experience with growing oil palm. They obtained the land by purchasing it from local communities. The increase in the establishment of smallholder oil palm plantings by spontaneous migrants is the highest among the communities on this site.

Most farmers have experience with using fire in land preparation, 96 % of respondents stated that they used fire for their land preparation. 72 % of the respondents argued that cheap and easy are the main reasons for using fire in land preparation, 7 % stated that accessibility to planted is more easier because the land is clear, and 12 % stated that the land is become more fertile because they assumed that the fire can provides ashes for fertilizer.

The survey also enquired about the sanction system in the case of a fire spreading and destroying a neighbour's field (Table 4-14). Most farmers (76%-84%) stated that there are sanctions to cover fire spreading and destroying a neighbour's field. The sanctions however, were not rigid and not strictly enforced. The kind of compensation can be discussed and negotiated amongst villagers such as money or seed.

Table 4-14. Percentage of farmer's perception about sanction if fire is spreading

Type of farmers	Sanction	
	There is a sanction (%)	No sanction (%)
Local	84	16
Spontaneous Migrant	80	20
Transmigrant	76	24

The survey also covered farmers perception of government bans on use of fire by smallholders for land preparation and the government offering alternative techniques to using fire (Table 4-15). The results vary among farmer types.

Table 4-15. Percentage of community's perception about zero burning techniques

Type of farmers	If the government apply the zero burning policy	
	Agree (%)	Not Agree (%)
Local	8	92
Spontaneous Migrant	20	80
Transmigrant	56	44

4.5 Land Tenure Conflicts

The development of oil palm and industrial timber plantation has a strong potential to create social conflict between companies and local communities who live surrounding the plantations especially if there is not a clear land ownership status and a weak partnership with farmers.

Clear land ownership is the most important variable in reducing the conflict between communities and companies. Two examples in the study site show the importance of clear land ownership. The first example shows that even if there is no partnership with farmers, there is less land conflict because the status of land ownership is clear. In this case, PT *Sawit* 2 obtained 2,574.17 ha of land for timber plantations. However, local communities surrounding the concession had already cultivated more than 90 percent of the concession. To reduce a potential land conflict in the future, the company was willing to compensate the community. With a transparent mechanism for ensuring all farmers received the correct compensation, a conflict was eliminated.

On the other hand, one timber plantation company in our study site, which also does not have any partnership with farmers and has serious land tenure conflict problems on this site. Initially, this timber plantation company obtained 31,416 ha of concession in 1996 (see Figure 4-5). However, local communities had cultivated some of the concession area. To reduce the potential land tenure conflict, the company released around one third of the concession to local communities. The communities, however, still claimed the rest of the concession. They believe that all of the concession belonged to communal land (*ulayat*). In addition, there was also some land encroachment by migrants. As a result, some conflicts arose. The study documented three of the conflicts as follows:

1. The first tenure conflict arose in the western part of the PT Akasia concession area (See the blue area in Figure 4-5). Local communities claimed approximately 2,427 ha of land that had been planted with acacia trees (1996/1997 Annual Plantation Area) and they demanded to establish oil palm plantations with a partnership scheme. The company, however refused their claim. As a result, the villagers destroyed the acacia plantation and replanted it with oil palm trees.

Then, the company cleared out the oil palm trees and re-planted the area with acacia trees. As a consequence, the villagers burned the plantation camp and destroyed the acacia plantation. The land is treated as a *status quo,* forbidden to be cultivated either by villagers or by the company. However, recently, some migrants and some local communities from surroundings areas have built houses and opened the land for oil palm plantation.

2. The second tenure conflict arose in the Batu Gajah settlement, indicated by yellow in Figure 4-5. The Batu Gajah Community returned to their settlement to reclaim their customary land (*tanah ulayat*). They argued that PT Akasia had over cleared their customary forest and claimed 6,000 ha of their customary land back. PT Akasia refused to release the areas, because the government has already allocated it to their concession area. Then the community burned 300 ha of 2.5 year old acacia trees as a result. As a consequence, PT Akasia could not plant their concession area for *RKT* 1999/2000. Recently, following an agreement between the Batu Gajah Community and PT Akasia, the company released 5,400 ha of concession land to the Batu Gajah community. However, since the status of the land is still under Forest Production classification, they cannot invite investors to develop oil palm plantation on this land.

3. The third example arose in the northern part of the PT Akasia concession (see the red area in Figure 4-5). Because of the success of the NES Scheme of PT *Sawit* 1 with the transmigrants, the local community in Petapahan demanded PT Sawit 1 to include them in their oil palm plantation scheme. Actually, in the beginning of the NES program, PT *Sawit* 1 had invited the Petapahan community to join this program. However, most of the Petapahan community were not interested and refused it. They were asked to join in the partnership in 1996. In 2000, PT *Sawit 1* agreed to build a partnership with the Petapahan community under KKPA scheme. However, the area that was offered by the Petapahan community for this partnership scheme was located in the timber plantation concession. PT Akasia, had already planted the area with acacia trees. The Petapahan community argued that the area belonged to their *Ulayat* Land, and they claimed it. After a meeting between PT Akasia, Petapahan community, and State Government, on June 20th, 2000, based on Governor of Riau Province Agreement No. 525/EK/1458 about

preserving areas for partnership plantations for Farmers Cooperative of Petapahan Community (KOPTAMASTA), PT Akasia released 1,500 ha of their concession to the Petapahan community. It included some acacia plantation. The community then gave the right to PT Sawit 1 to establish oil palm plantations. After about 400 ha area had been cleared, the community found that the rest of the area was located in swampy areas, closed to the river. As a consequence, the cost of establishment of the oil palm plantation was more expensive than planned. The total credit for establishment of 2 ha oil palm plantation in swamp areas (20 million rupiah) is 30% higher than in non-swamp areas (16-17 million rupiah). Because of that, the local community asked PT Akasia to substitute that land with other land located further from the river. The land that local community demanded is already acacia plantation (3 years old). PT Akasia again refused the demand of the local community. The rejection caused the community to attack the camp and threw out the employees. As a result, the plantation activities have been stopped since March 2001. PT *Sawit* 1 itself, as a contractor, does not want to clear the land until the conflict is resolved, even if the community asks and guarantees the security of land clearing activity. Recently, following an agreement between PT Akasia and KOPTAMASTA, the Petapahan Community received 400 ha of the land requested.

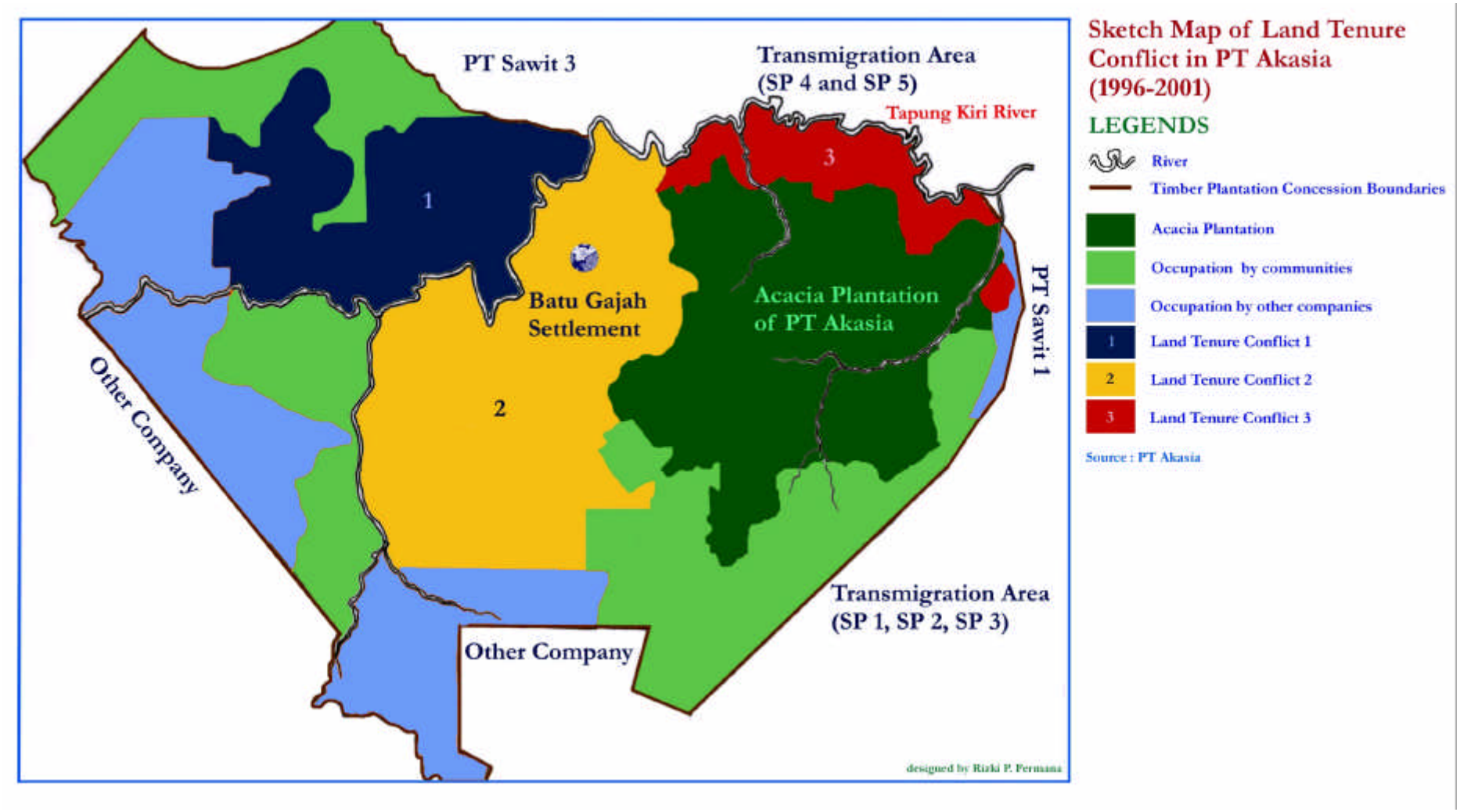


Figure 4-5. Sketch map of land tenure conflict and encroachment problem in PT Akasia.

Many people believe that a good partnership between farmers and companies in developing oil palm or timber plantations will reduce land tenure conflict. The result of this study supported this popular belief. Two examples of companies who have a partnership with farmer will be described. PT *Sawit* 1 has a good partnership with farmers in establishing oil palm plantations. The company has good reputation managing oil palm plantations, so farmers received a productive oil palm plantation when the company transferred it to farmers.

On the other hand, PT *Sawit* 4 collaborates with KUD *Sawit* Jaya, in establishing oil palm plantation for transmigrants. According to the agreement, PT *Sawit* 4 should develop and care for the oil palm plantation for the members of KUD *Sawit* Jaya, and market the fruit to the oil palm factory, and also help in administration, management, and technical training for the cooperative members. For establishing oil palm plantation, the credit is 7.5 million rupiah per hectare.

PT *Sawit* 4's partnership with farmers is not good. The company shows less commitment and a lower responsibility for developing oil palm plantations for farmers. The company used low quality seedlings and inappropriate maintenance techniques. As a result, the oil palm plantation is not developing well. Farmers have refused to receive bad oil palm plantation. Farmers also realize with bad oil palm plantation, they could not pay back the credit for establishing the plantation.

A good partnership between communities and companies for developing oil palm or timber plantations is a key factor in successful resource management. As the household surveys show, there is a weak incentive to help if there is fire in the plantation company if no partnership scheme exists. On the other hand, the willingness to fight fire in the plantations with good partnership schemes is high. This is reflected in the result in Table 4-16, in which only 4 % of farmers are willing to help if there is a fire in a company timber plantation and 68%-92 % are willing to help to fight fire if it occurs in an oil palm plantation. In contrast, all of the farmers are willing to help if there is fire in a farmer's field. Mostly because of the social relationship and to avoid fire spreading to their fields. The study found that the willingness of local farmers to fight fire in forest areas is higher than the willingness of spontaneous migrants and transmigrant. This shows that local farmers have a higher affinity towards the forest than spontaneous migrants and transmigrant.

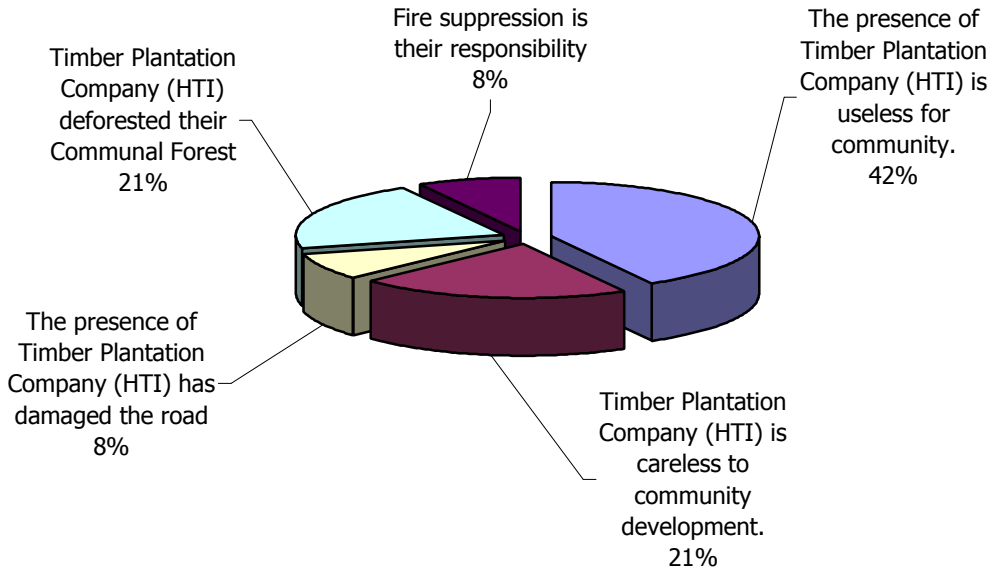
Table 4-16. Percentage of community's perceptions about fires at different land use type

Type of farmers	Number of sample	Willingness to help if there is a fire at			
		Farmer's Fields	Forest land	Timber plantation [1)]	Oil palm plantation [2)]
Local farmers	25	100	84	4	92
Spontaneous migrants	25	100	12	n.a	68
Transmigrant	25	100	48	n.a	76

1) No Farmer's Partnership scheme
2) With Farmer's Partnership scheme

One of the questions asked was why there is a weak willingness of local farmers to fight fire in timber plantations. Most of farmers feel that existing timber plantations do not provide benefits for them (52%). Another 35 % of local farmers argued that timber plantation companies took their communal forestland (Table 4-17).

Figure 4-6. Farmer perception about their refusing for helping fire fighting at timber plantation



5. UNDERLYING CAUSES OF FIRE

In this study site the use of fire for large-scale oil palm and timber plantation establishment was the main cause of fire. The establishment of transmigration settlements through nucleus estate schemes has increased the area of oil palm plantation. Therefore, it has significantly contributed to the fire and smoke problem in Indonesia. Smallholders also use fire for establishing oil palm plantations. There is also evidence that recent spontaneous migrants have established small-scale oil palm plantations. The economic incentive to use fire in land clearing is very high because it is cheap to use. Moreover, the establishments of oil palm and timber plantations potentially create land tenure conflicts with communities surrounding the plantations. In many cases, tenure conflicts often become a trigger for forest and land fires. The nature of the partnership between communities and companies in the development of oil palm and timber plantations is also a very important factor in reducing the incidence of fire.

It is evident from image analysis undertaken at the landscape level of the study area that from 1992 to 2000, 88,456 ha natural forest was lost, or about 9.7% per annum. From the forest converted, the biggest part, 29,1% became oil palm and timber plantations, with 23.2% converted for cultivation. The use of hotspots in detecting the historic fires in 1997 also show that most of the fires occurred in areas-that were used for oil palm and timber plantations. In excess of 204 hotspots or 43% of total hotspot in 1997 were in this land use category.

6. POLICY IMPLICATIONS

Based on the analysis of the underlying causes of fire in the Petapahan site, some policy implications for both the national and provincial level are outlined:

a. Review the zero burning policy.

   A total ban on the use of fire in land clearing is currently impractical. An alternative, intermediate-level regulation and policy change appears to be more feasible, including the following policy alternative (1). Total bans on the use of fire in land clearing only apply during El Nino years or at other critical times. Fire in land clearing can still be allowed in normal years (2). Apply a technique of using fire in land clearing that reduces smoke, and (3). Applied and adaptive research on zero or less reduced burning technology.

b. Reduce the amount of timber that is burned:

   (1) develop a method of selling the residual timber both from large and small scale logging industries to medium density fibreboard (MDF) or pulp factories. (2) Remove all policy barriers (tax and levy) at national and regional level in marketing timber residue (3) Improve the infrastructure to increase the demand for the residue.

c. Work in cooperation with large-scale operations to develop and implement suitable forest and fire management plans. These efforts should include setting up facilities to prevent and suppress accidental or escaped fires in plantations.

d. Build the rewards system for anyone who keeps their environmental clean. For example: using no fire in land preparation can be accepted as positive environment service that worth for reward, for the company, this can be a rule to do their future activities.

e. Review and strengthen law-enforcement mechanisms that could help curb land and forest fires.

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APPENDICES

APPENDIX I: Overview of Oil Palm Development in Indonesia

The oil palm industry in Indonesia develops by large-scale (Private and State enterprise) companies. In 1999, the total area planted with oil palm in Indonesia amounted to almost 3 million ha (See Figure I-1). Around 50 % of all Indonesian oil palm plantations is owned by private firms. Four Indonesian cartels, Sinar Mas, Astra, Salim and Raja Garuda Mas, controlled around 68 % of the privately owned oil palm plantations (Cohen and Hiebert, 1997); State enterprises control only around 17 % of all oil palm plantations, and the rest of the oil palm area is in the possession of smallholders.

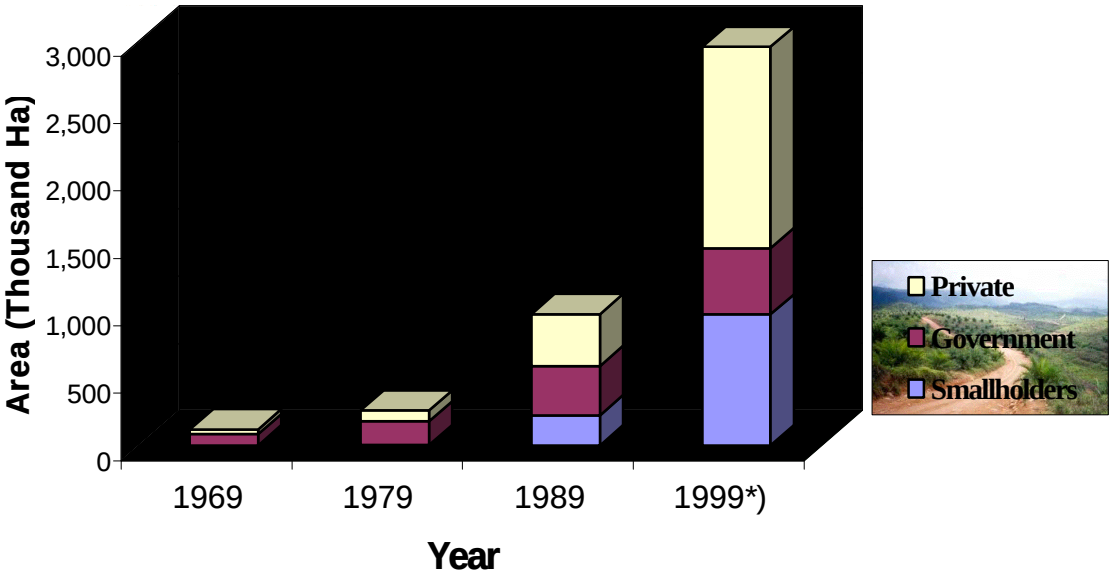

Figure I-1. Oil palm plantation area in Indonesia

In 1999, Indonesian smallholder rubber and coffee plantations accounted for respectively 85 % and 95 % of the countries total area. Unlike in the former two tree crops that were developed on a smallholder basis, the involvement of smallholders in oil palm is low. Before 1979, there was no smallholder involvement in oil palm plantation, at all, while, in 1979, the area of smallholder oil palm was only 3,000 ha or 1 % of total oil palm area. Since the early 1990s, the involvement of smallholders in oil palm has considerably increased to 973,000 ha or 33 % of the total oil palm plantation area in 1999. Most of the smallholder activities were arranged under the NES (Nucleus Estate and Smallholder) scheme.

Figure I-2 shows the distribution of oil palm plantation by island in Indonesia. The biggest area of oil palm plantation is located on Sumatra. In 1999, the oil palm plantation areas in Sumatra amounted to almost 1.9 million ha or 75 % of the total oil palm area in Indonesia. The second biggest area of oil palm plantation, 411,000 ha or 19 % of the total, is located in Kalimantan.

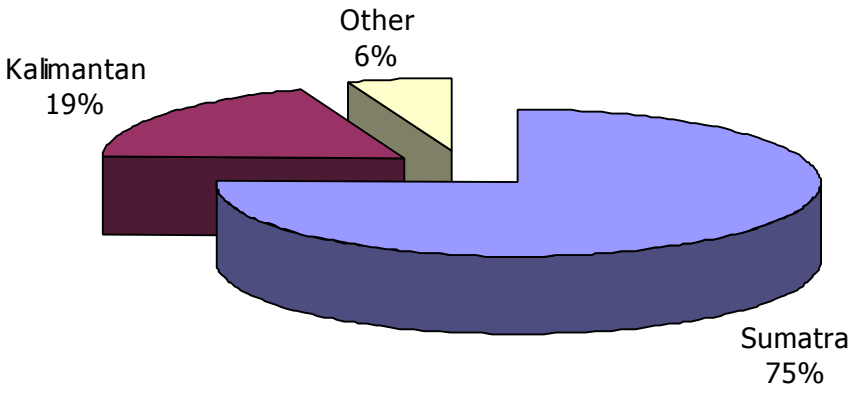

Figure I-2. Distribution of oil palm plantation area by island in 1999.

The first oil palm plantations were established in North Sumatra in the early 1900s, and the industry developed rapidly in the 1930s (Potter and Lee, 1998). Currently, North Sumatra Province has the largest area of oil palm in Sumatra, accounting for 576,000 ha, or around 30 % of the total oil palm plantation area in Sumatra. Because of the long history of oil palm plantation in North Sumatra, this province also has the largest area of mature trees, i.e. about 87 % of the oil palm trees were mature in 1997. The second most rapid development of oil palm plantation occurred in Riau Province; the total area of oil palm in 1997 was 522,000 ha, with 33 % of the immature trees.

More recently, oil palm industries have developed in Riau, South Sumatra and Jambi Provinces. Table I-1 provides development of the oil palm areas in 1990 and 1999 in each Sumatran province, and the area of immature trees in these provinces in 1999. Based on the absolute increase in oil palm area Riau, following by South Sumatra and Jambi Provinces, is likely to have the biggest contributed to the fire and smoke problems related to oil palm development.

Table I-1. Oil Palm Plantation by Province In Sumatra for the last ten years

Province	Oil Palm areas				
	1990 (000 ha)	1999 (000 ha)	Change (Ha)	Change (%)	% of Immature trees in 1999
Aceh	91	208	118	130	**36**
North Sumatra	490	615	124	25	**13**
West Sumatra	36	137	102	286	**50**
Riau	238	606	368	155	**33**
Jambi	46	236	190	417	**50**
South Sumatra	62	310	248	400	**41**
Bengkulu	23	57	34	146	**38**
Lampung	15	75	60	398	**53**
Sumatra	**1,001**	**2,243**	**1,243**	**124**	**31**

Source: General Directorate of Estate Crops (2000)

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APPENDIX II: Overview of industrial timber plantation in Indonesia

Starting in the early of the Five-Year Development Plan (Repelita IV) in 1984, the government of Indonesia targeted to establish 6.2 million ha timber plantation in 2000, in which 1.8 million ha was targeted to be planted in Java and 4.4 million ha to be planted in outer Java (Manurung *et.al*, 1999). The reason of this policy is to anticipate of a raw material deficit due to the expanding of wood demand and the expanding of pulp and paper industry.

Until 1998, Government of Indonesia has been approved to allocate around 5.9 million ha land for establishing timber plantation (See Table II-1). To accelerate the development of HTI, government of Indonesia provide a financial assistance, the interest-free loans from the reforestation fund that collected from logging concession (Barber and Schweithelm, 2000; Kartodjhardjo and Supriono, 2000).

Table II-1. Allocated areas for timber plantation (until 1998).

Islands	Allocated/Concession Area (ha)
Sumatra	2,148,964
Kalimantan	2,928,414
Sulawesi	255,791
Others	266,755
Total	**5,599,924**

Source: Barber and Schweithelm, 2000

According to Kartodiharjo and Supriono (2000) almost 2.2 million ha of timber plantation or 47% of the total timber plantation area has designed to receive financial fund from reforestation fund. From the total timber plantation under the reforestation fund scheme, HTI for pulp is assigned to absorb 83% the reforestation fund, while HTI for non-pulp only absorbs 17%. There is no financial assistance from reforestation fund for establishment HTI-transmigration.

The number of planted area, however, is very slow, especially in the beginning of the implementation HTI policy in 1989/1990 and 1990/1991. Table II-2 shows that the realization of planted area until 1999/2000 was only 2,350,357 ha (MoFEC, 2000) or less than 50 % of concession area.

Figure II-1 shows the distribution of timber plantation (planted area) by island in Indonesia. The biggest area of planted timber plantation is located on Kalimantan. In 1998/1999, the planted timber plantation areas in Kalimantan amounted to around one million ha or 46 % of the planted timber plantation area in Indonesia.

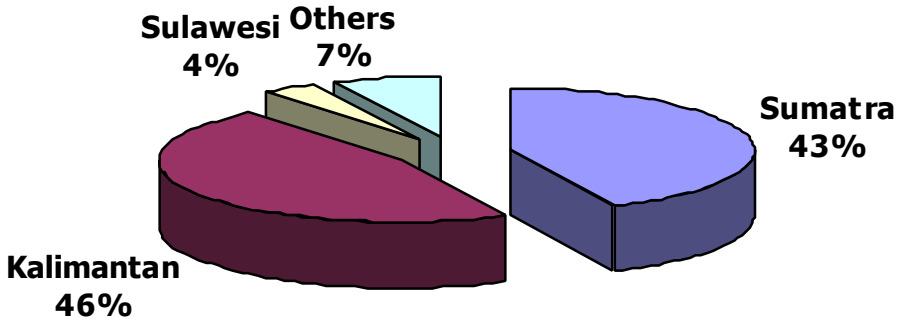

Figure II-1. Distribution of establishment timber plantation in Indonesia by Island

Table II-2. Development of Timber Plantation in Indonesia

ISLANDS	Years											TOTAL(ha)
	1989/1990	1990/1991	1991/1992	1992/1993	1993/1994	1994/1995	1995/1996	1996/1997	1997/1998	1998/1999	1999/2000	
Sumatra	***22,636***	***57,065***	***75,346***	***69,028***	***141,552***	***117,821***	***133,152***	***145,191***	***100,897***	***66,280***	***81,738***	***1,010,706***
1. DI Aceh	2,649	1,721	729	491	8,526	13,914	17,451	15,245	12,275	5,454	959	79,414
2. North Sumatra	11,320	13,564	8,059	15,003	11,042	10,423	9,226	7,507	7,887	5,196	2,358	101,585
3. West Sumatra	0	0	620	1,463	787	1,762	2,283	2,490	1,151	420	315	11,291
4. Riau	3,101	5,766	6,252	13,179	69,154	39,928	51,606	69,216	52,613	34,199	51,014	396,028
5. Jambi	1,000	1,880	1,014	5,170	8,399	12,100	18,038	21,017	19,027	13,260	23,007	123,912
6. South Sumatra	500	31,007	52,177	28,556	35,778	31,308	26,372	21,290	6,144	4,994	4,085	242,211
7. Bengkulu	0	0	0	0	265	450	0	825	300	13	0	1,853
8. Lampung	4,066	3,127	6,495	5,166	7,601	7,936	8,176	7,601	1,500	2,744	0	54,412
Kalimantan	***24,613***	***16,075***	***50,395***	***56,555***	***137,433***	***144,603***	***173,508***	***206,512***	***127,756***	***95,229***	***51,126***	***1,083,805***
1. West Kalimantan	3,208	3	5,747	7,294	20,637	16,832	19,813	38,921	31,089	14,000	4,265	161,809
2. Center Kalimantan	0	0	0	549	5,721	17,735	21,968	27,887	20,621	11,976	5,854	112,311
3. South Kalimantan	8,402	7,551	16,850	21,627	15,827	33,839	55,027	44,145	4,010	7,465	3,762	218,505
4. East Kalimantan	13,003	8,521	27,798	27,085	95,248	76,197	76,700	95,559	72,036	61,788	37,245	591,180
Sulawesi	***3,822***	***2,538***	***2,116***	***13,330***	***13,156***	***13,012***	***8,175***	***11,803***	***11,065***	***4,484***	***625***	***84,126***
1. South Sulawesi	2,622	2,070	667	3,321	7,565	3,619	3,196	2,253	1,518	605	10	27,446
2. Center Sulawesi	0	0	0	2,361	4,150	6,923	2,548	5,100	4,646	2,721	72	28,521
3. South East Sulawesi	1,200	468	1,449	7,648	1,441	580	1,233	2,235	2,702	400	543	19,899
4. North Sulawesi	0	0	0	0	0	1,890	1,198	2,215	2,199	758	0	8,260
Others	***1,608***	***3,874***	***9,100***	***12,005***	***41,588***	***21,350***	***11,613***	***27,036***	***26,891***	***14,513***	***2,142***	***171,720***
1. West Nusa Tenggara	360	323	1,460	2,052	11,128	296	0	658	695	112	0	17,084
2. East Nusa Tenggara	1,150	2,430	4,058	4,361	10,393	0	1,924	1,936	1,309	0	0	27,561
3. Maluku	0	882	2,286	4,889	16,488	14,813	5,333	11,350	11,847	7,535	2,142	77,565
4. Papua	0	0	0	0	0	6,241	2,356	12,460	12,698	6,866	0	40,621
5. East Timor	98	239	1,296	703	3,579	0	2,000	632	342	0	0	8,889
Total	**52,679**	**79,552**	**136,957**	**150,918**	**333,729**	**296,786**	**326,448**	**390,542**	**266,609**	**180,506**	**135,631**	**2,350,357**

The total value is not including the number of local species plantation in 1993/1994 (71,895 ha) and Bali area in 1992/1993 (500 ha). Source: MoFEC, 1990-2000

Sumatra is the second large area of timber plantation that amounted to 43 % of the timber plantation area was established in this island. Until 1999, the total planted area in Sumatra is 1,01,706 ha, and Riau Province is the largest area of timber plantation in this island.

From the data of Regional Forestry Office of Riau, stated that until December 2000, the total concession (allocated) area of timber plantation (HTI) in Riau province amounted to almost 1.55 million ha for 32 companies (see Table II-3). The planted areas, however, was only around 410,000 hectare or 27% from the total allocated area by 22 companies.

Table II-3. Timber Plantation Concession and Establishment Area in Riau Province.

Type of HTI	Concession Area			Planted Area		
	Company	ha	%	Company	ha	%
HTI for Pulp	4	726,871	47	3	306,449	74
HTI for Wood Construction	17	586,825	38	10	53,143	13
HTI Sago	1	19,900	1	1	8,048	2
HTI for Transmigrant	6	96,200	6	6	43,751	11
HTI with Partnership Scheme	4	116,285	8	22	2,752	1
Total	**32**	**1,546,081**	**100**	**22**	**414,143**	100

Source: Regional Forestry Office of Riau (2000)

The major timber plantation in Riau is HTI for pulp that accounted to almost 74 % of total planted timber plantation. The objective of development HTI for pulp is to meet of high demand of woods for pulp industry in Riau. There are two major pulp industries in Riau, which are PT Indah Kiat Pulp and Paper and PT Riau Andalan Pulp and Paper. These two pulp industries have capacity more than two million ton per annum. For example, PT RAPP annually has capacity 1,3 million ton of pulp (they will increase the capacity in the future) and it is require 5,850,000 m3 of wood.

One social impact on the development of timber plantation is a land tenure conflict between companies and communities. The land allocation is often determined without recognizing the rights of local people who already occupy and cultivate that land. By 2000, the official data from Regional Forestry Office of Riau (See Table II-4) pointed out that around 263 thousand ha timber plantation areas in Riau province has been claimed by communities who lived around the timber plantation. This indicated that

around 17% of total HTI concession has been claimed. The data also shows that more than 50% of total HTI companies in Riau have tenure conflicts.

The presence of large tenure conflict between timber plantations and communities increases the risk of fires. Fires are often used to drive off local communities from their land (Tomich et al., 1998). Similarly, the feeling of perceived injustice by smallholders, decreases their incentive to control the spread of fire to large-scale tree plantations (Suyanto et.al., 2000).

Table II-4. Timber plantation areas in Riau that claimed by surrounding communities

No	Companies	Concession Area	Claimed Area	% Claimed Area
1	PT Arara Abadi	299,975	91,425	**30**
2	PT Riau Andalan Pulp	238,379	69,207	**29**
3	PT Sumatera Sinar Plywood Industri	112,500	0	**0**
4	PT Satria Perkasa Agung	76,017	0	**0**
5	PT Perawang Sukses Perkasa Industri	79,210	18,694	**24**
6	PT Ekawana Lestaridharma	9,300	0	**0**
7	PT Rimba Rokan Lestari	34,175	0	**0**
8	PT Sumatera Riang Lestari	9,137	6,657	**73**
9	PT Perawang Lumber Industri	32,720	32,720	**100**
10	PT Wana Nugraha Bima Lestari	7,600	5,570	**73**
11	PT Surya Dumai Agrindo	22,150	2,000	**9**
12	PT Surya Dumai Industri	14,300	2,779	**19**
13	PT National Timber And Forest Product	19,900	5,000	**25**
14	PT Sari Hijau Mutiara	20,000	0	**0**
15	PT Siak Raya Timber	23,000	6,000	**26**
16	PT Titian Tata Pelita	11,450	750	**7**
17	PT Ruas Utama Jaya	40,000	0	**0**
18	PT Suntara Gaja Pati	49,800	0	**0**
19	PT Inhutani IV (eks. HPH PT Chandra Dirgantara)	36,610	0	**0**
20	PT Inhutani IV (eks. HPH Dwi Marta)	57,873	NA	**NA**
21	PT Inhutani IV (eks. HPH Alam Wana Sakti)	70,000	0	**0**
22	PT Inhutani IV (eks. HPH PT Harapan Baru Wood)	69,500	0	**0**
23	PT Rimba Seraya Utama	12,600	4,575	**36**
24	PT Rimba Lazuardi	23,510	956	**4**
25	PT Peranap Indah	11,620	3,779	**33**
26	PT Rimba Rokan Hulu	12,500	7,510	**60**
27	PT Nusa Wana Raya	23,970	1,000	**4**
28	PT Riau Abadi Lestari	12,000	4,650	**39**
29	PT Mapala Rabda dg Koperasi Tani Hutan Tuah Sekato	46,230	0	**0**
30	PT Mapala Rabda dg Koperasi Tani Hutan Usaha Baru	30,000	0	**0**
31	PT Satria Perkasa Agung dg Kop.Tani Hutan Sinar Merawang	10,595	0	**0**
32	PT Dexter Timber Perkasa Indonesia dg Kop.Tani Hutan Wana Jaya	29,460	0	**0**
		1,546,081	263,272	**17**

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APPENDIX III: Change trajectory matrices

in percent	1998									
1992	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**total**
High density forest (1)	13.8	15.2	2.8	25.8	13.2	7.1	11.6	9.0	1.5	49.5
Low density forest (2)	0.0	36.0	0.2	30.2	11.7	12.3	4.5	4.6	0.5	15.6
Timber plantation (3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oil Palm plantation (4)	0.0	0.0	0.0	97.1	1.5	0.4	0.1	0.3	0.5	13.4
Mosaic of shrub land and small holder plantation (5)	0.0	0.0	0.4	58.8	12.5	19.3	2.2	6.3	0.4	8.0
Mosaic of grassland and cultivation (6)	0.0	0.0	0.4	35.8	17.5	33.2	5.1	7.4	0.6	7.1
Burn scar (7)	0.0	0.0	0.0	66.7	12.3	14.9	2.4	3.0	0.6	1.1
Bare soil (8)	0.0	0.0	0.1	64.1	10.5	12.0	1.6	11.3	0.4	3.9
Water and no data (9)	5.6	11.3	0.6	36.2	8.3	7.3	4.7	3.4	22.6	1.3
Total	6.9	13.3	1.5	41.5	11.5	10.1	7.1	6.8	1.3	100.0

in percent	2000									
1998	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
High density forest (1)	59.8	11.1	0.1	3.0	6.8	3.9	1.2	13.3	0.8	6.9
Low density forest (2)	0.0	72.9	0.7	4.3	6.6	7.7	1.3	6.1	0.5	13.3
Timber plantation (3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
Oil Palm plantation (4)	0.0	0.0	0.0	95.3	1.5	1.8	0.1	1.2	0.1	41.5
Mosaic of shrub land and small holder plantation (5)	0.0	0.0	0.1	20.1	17.5	47.5	0.8	13.7	0.4	11.5
Mosaic of grassland and cultivation (6)	0.0	0.0	0.1	1.7	9.6	77.8	0.8	9.6	0.3	10.1
Burn scar (7)	0.0	0.0	15.2	17.9	15.9	36.3	1.0	13.3	0.4	7.1
Bare soil (8)	0.0	0.0	17.3	21.7	10.6	26.2	0.5	23.5	0.3	6.8
Water and no data (9)	0.0	0.0	5.7	22.4	9.9	41.3	2.6	7.1	11.2	1.3
Total	4.1	10.5	3.9	45.8	6.9	20.3	0.6	7.4	0.4	100.0