The Underlying Causes and Impacts of Fires in South-east Asia

Site 7. Tumbang Titi, West Kalimantan Province, Indonesia

by

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In collaboration with Yayasan Dian Tama (YDT) West Kalimantan

Site Report

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Cover photo: *Imperata* grasslands in Kalimantan
Photo by: Erik Meijaard

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ABBREVIATIONS AND TERMS

Adat rights	Customary ownership or use rights recognized by customary law
AVHRR	Advanced Very High Resolution Radiometer
ERS	European Space Agency Radar Satellite
EU	European Union
EU-JRC	the Joint Research Centre of the European Union
GIS	Geographic Information system
ha	Hectare
km	Kilometer
Kanwil	*Kantor Wilayah* (Provincial Office)
Landsat MSS	Landsat Multispectural Scanner. An imaging system on board the first five Landsat satellites. The system collects multispectral data in four non-thermal radiation bands with a spatial resolution of 79 x 79 m.
Landsat TM	Landsat Thematic Mapper. A multispectral scanner imaging system on board the Landsat 4, 5 and 7 satellites. The imaging system collects multispectral data in seven bands. The six non-thermal bands have a spatial resolution of 30 X 30 m, and the thermal band has a spatial resolution of 120 x 120 m. The temporal resolution is 16 days.
m	Meters
MOFEC	Ministry of Forestry and Estate Crops
NOAA	National Oceanic and Atmospheric Administration, USA
RTRWP	Provincial land use planning
Stakeholders	People or groups of people interested or responsible for forest management. Includes landowners, community, industry and government organisations

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SUMMARY

This report provides an analysis of causes and impacts of vegetation fires in the Tumbang Titi area, Ketapang District, West Kalimantan Province, Indonesia. The Landstat TM and SAR Image level analysis indicated that natural forest decreased from 473,300 ha in 1989 to 127,335 ha in 1996. Socio-economic research at the landscape level indicated that *alang-alang* (*Imperata cylindrica*) accounted for almost 22% of the land cover of the study area. In 1997, large-scale fires burned up 29 % of the land area of the site, including *Imperata* grassland, remaining forest, and smallholder and largescale plantations. *Imperata* grasslands were most affected by the 1997 fires. Socio-economic research indicated that three main forces were responsible for land degradation from humid tropical rain forest to *Imperata* grassland: shifting cultivation, commercial logging and illegal gold mining.

Three phases of land use change were evident on this study site. First, the widespread development of *Imperata* grasslands as the final stage of land degradation, following the intensive exploitation and conversion of humid tropical rain forest. Second, the expansion of smallholder, large scale commercial, and local government interest in using the *Imperata* grasslands. And third, local community shift to more profitable land use activities such as gold mining in the wake of the economic crisis.

1. INTRODUCTION

Large-scale fires and associated smoke are an increasing problem in Indonesia and surrounding countries. For instance, major fires occurring in the El Niño years 1982/1983, 1987, 1991, 1994, and 1997/1998 (Dennis, 1999) devastated large areas of forest and caused significant economic losses, both in Indonesia where most fires occurred and in neighboring countries. The economic costs of the 1997/98 fires in Indonesia have been estimated to exceed 9 billion US$ with carbon emissions high enough to elevate Indonesia to one of the largest polluters in the world (Asian Development Bank, 1999; Barber and Schweithelm, 2000). The major causes of these fires are, however, still largely unclear. Some have blamed small-scale farmers, others large-scale estates for causing fires, suggesting that these actors deliberately set fires to forest to open up land for plantations or agriculture. In 1994, the Indonesian government blamed slash-and-burn activity by smallholders as the major cause of fire, and they estimated that these people were responsible for more than 85.2 % of the 5,000,000 ha burned (Jakarta Post, 7 October 1994). Environmental NGOs, however, blamed activities by forest concessionaires and plantation owners as the major cause of fires (Jakarta Post, 3 October 1994). In contrast, taking advantage of data obtained from fire hot-spot information and satellite imagery, all institutions including government agencies believe that large-scale land clearing for plantations of fast growing trees for pulpwood and oil palm were the major causes of fire in 1997 and 1998. Yet, fires occurred at multiple scales and for many reasons, and impacts on local communities and forest had a variety of complex causes.

In this report, the Center for International Forestry Research (CIFOR), the International Centre for Research in Agroforestry (ICRAF), and the United States Forest Service (USFS) provide a study of the underlying causes and impacts of vegetation fires in Indonesia. The aim is to answer questions about the reasons (why), nature (what), perpetrators (who), and locations (where) that were associated with the fires. Several methods of information gathering were used ranging from satellite-derived remote sensing imagery at the landscape level to in-depth field investigations at the village level. When used in combination, a more complete picture of the 1997 fires can be developed. For example, images from satellites provide information on the location, extent, and the type of land cover burned. However, only through extensive interviews with local people combined with on-the-ground participatory mapping, can an answer be found to whom was responsible for the fires and what were their underlying reasons. From the field investigations and the use of a Geographic Information

System (GIS), a more accurate estimate of what burned can be determined at the landscape level.

This study will apply three levels of spatial analysis: island-wide, province, and site. At the site-specific level, the study focuses on the relationship between fire and land cover/land use change. The province wide (Landsat TM-level) study will concentrate on general land cover change, burn scars and hot-spots, and compare these pattern with the site-level findings. Finally, hot-spots for Kalimantan as a whole will be compared to those for the province and the site.

The Tumbang Titi area was chosen as a research site because of the high frequency and density of hot spots in 1997 as compared to other parts of Kalimantan.

2. SITE DESCRIPTION

The Tumbang Titi site is located in Ketapang district, West Kalimantan Province (see Figure 2-1). The area is low-lying and elevation ranges from 10 to 75 meters a.s.l. Dominant soil types include red-yellow podzols and some alluvial organic soils. Average rainfall was 369 mm per month over the last eleven years, however, during the dry season, from June to September, average monthly rainfall decreases to 140 mm. Two levels (scales) of information were gathered for this site. The first level, the landscape scale (The Tumbang Titi site) covers 165,285 ha and consists of 21 villages with 9,196 households (Bureau of Statistic Tumbang Titi sub-district, 1999). The second level, the Landsat TM image scale covers 871,616 ha.

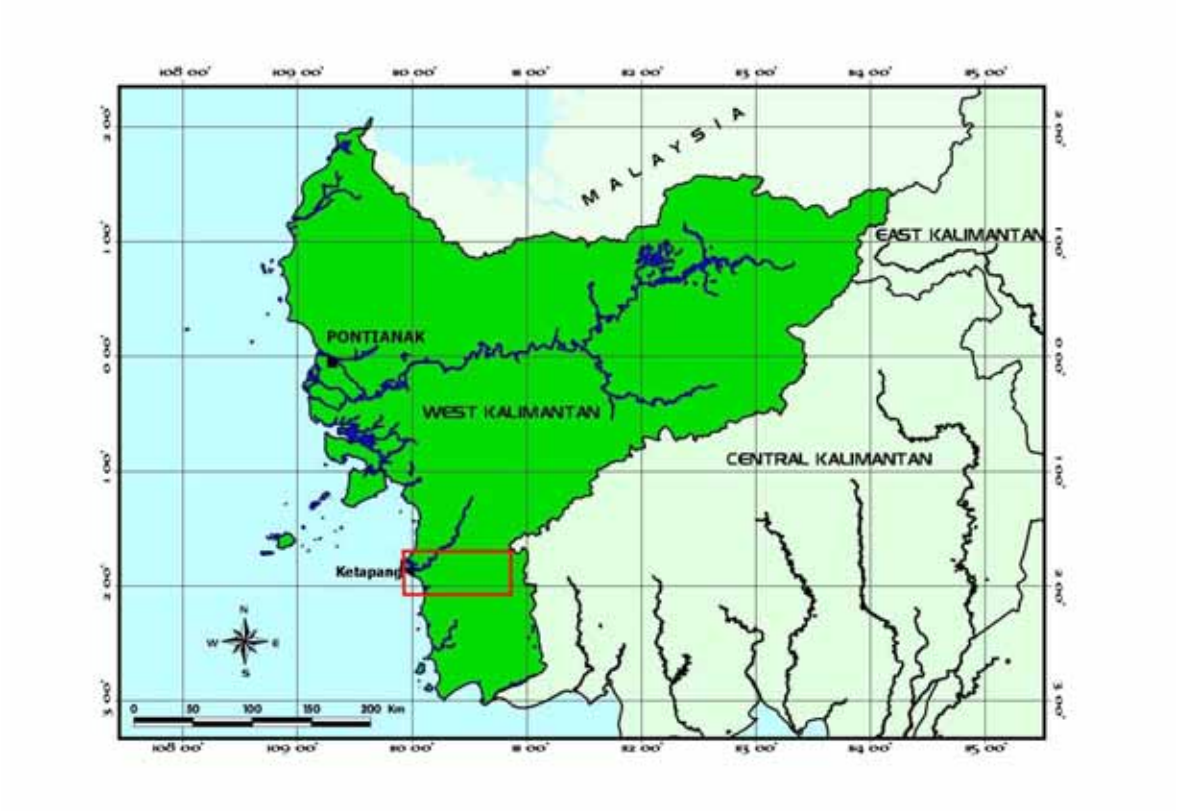


Figure 2-1 Location of study site

For the present research, the landscape level was divided into 3 sub-sites (see Figure 2-3). The first sub-site called Serengkah is located in the northeastern part of the study site. This sub-site covers 50,000 ha, contains a large (23,209 ha) tract of natural forest and two villages, Serengkah and Natai Panjang. In 1999, around 4,500 people or 1,350 households lived in this area. Most villagers are indigenous Dayak people who live in the foothills. This sub-site is the

most remote, with poor accessibility until 1996. The customary laws (*adat*) for land ownership and fire management are more strictly enforced on this sub-site.

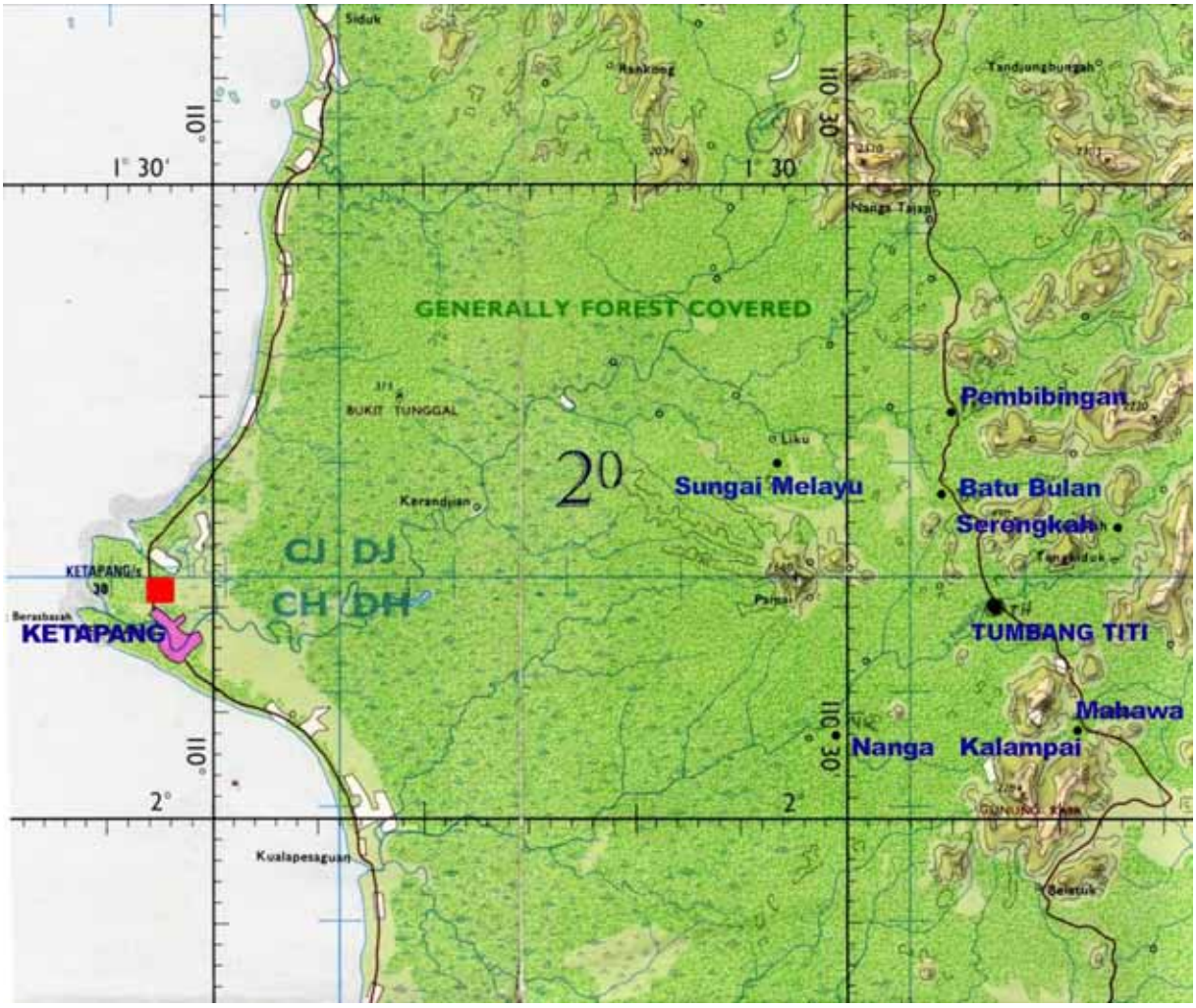


Figure 2-2 Locations and landmarks in study site

The second sub-site, called Mahawa, is located in the southern part of the study area, and covers a total area of around 36,400 ha. It includes two villages: Mahawa and Tumbang Titi. Mahawa village occupies an area of 30,700 ha and is inhabited by indigenous Dayak people, of the Pesaguan and Suku Jelai ethnic groups. However, around 15,700 ha, or 51 % of this area is covered by the grass species *Imperata cylindrica*, indicative of highly degraded land. The total number of households in this village was 672 in 1999. Tumbang Titi village is the capital of the Tumbang Titi sub-district. The total area is only around 5,000 ha but around 830 households live there. Around 1,100 ha, or 22 % of this village area is covered by *Imperata* grassland. The ethnic majority is indigenous Dayak, and a small proportion of the population

is Chinese, Batak, Javanese, Sundanese or Melayu. An industrial timber plantation HTI PT Tawang Maju was established in 1994 in the southern part of this sub-site, with an 11,000 ha concession area.

The third sub-site, Sei Melayu is located in the northwestern part of the study site and has a total area of around 79,000 ha. Four indigenous villages, 14 transmigration settlement villages, and 3 oil palm plantations occupy this sub-site. In the 1960s, most of the area was already covered by *Imperata* grassland. Prior to 1979, all these areas were under the control of indigenous Dayak people, who practiced shifting cultivation. Then in 1994, some of the *Imperata* grasslands were converted to transmigration settlements and oil palm plantations. Between 1994 and 2000, 14 transmigration villages were established. Now, around 7,021 transmigrants work in smallholder oil palm plantations under the NES (Nucleus Estate Smallholder) system. Three oil palm plantation companies have been established since 1991: PT Duta Sarana Nabati (PT DSN) which owns 14,300 ha, PT Subur Ladang Andalan (PT SLA) with 10,001 ha, and PT Bangun Maya Indah (PT BMI) with 10,018 ha.

Starting in 1997, gold mining activities by local people have significantly increased mostly in the 12,800 ha Nanga Kelampai village in the third sub-site. Here, gold mining activities have destroyed almost all of the smallholder rubber plantations, while also causing widespread land degradation (see Figure 2-3).

Figure 2-3 Landscape Level Sketch map of Tumbang Titi site

Sketch Map of Tumbang Titi Site

Ketapang District, West Kalimantan Province, Indonesia

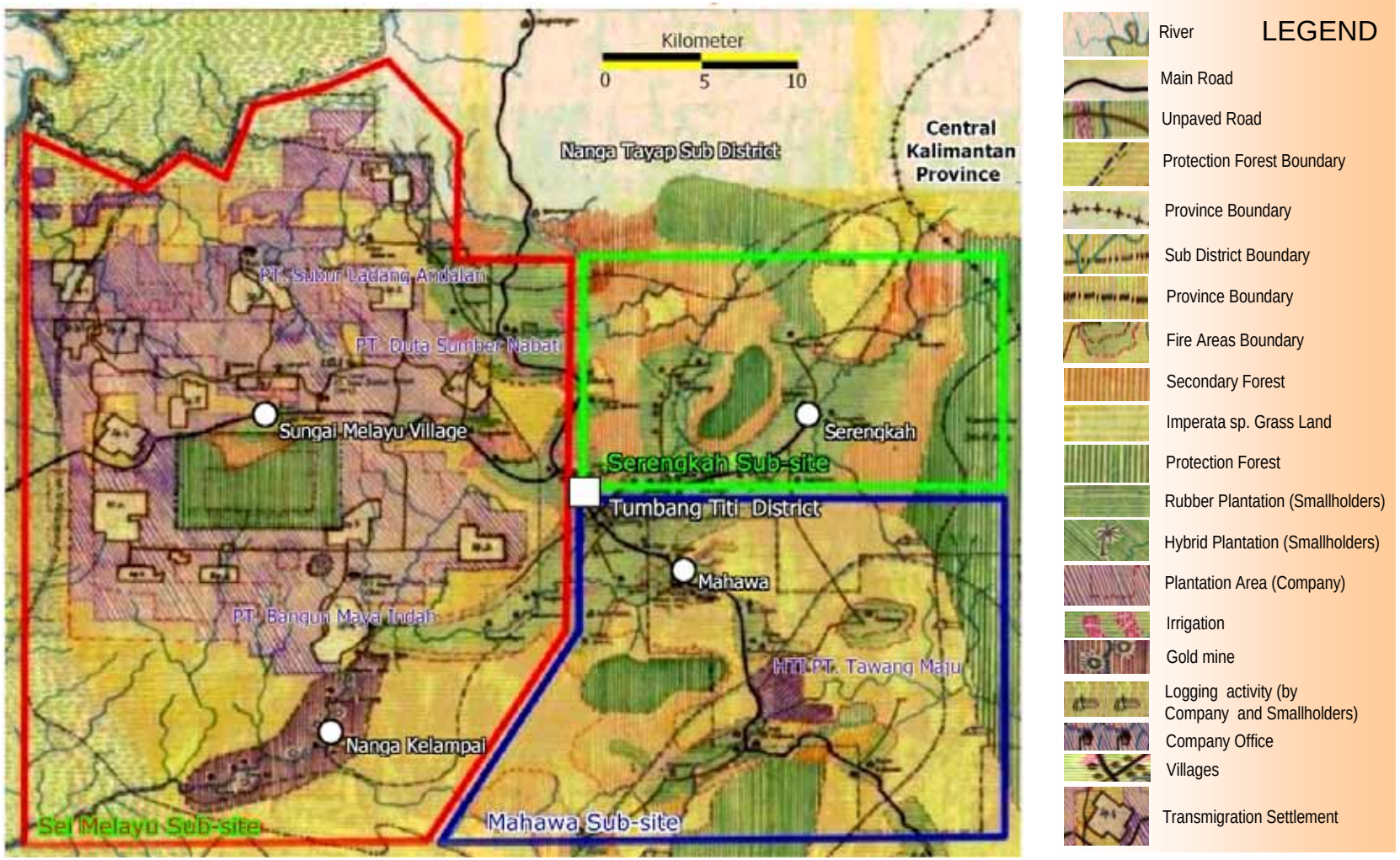


Figure 2-3 Landscape level sketch map of Tumbang Titi site.

3. METHODOLOGY

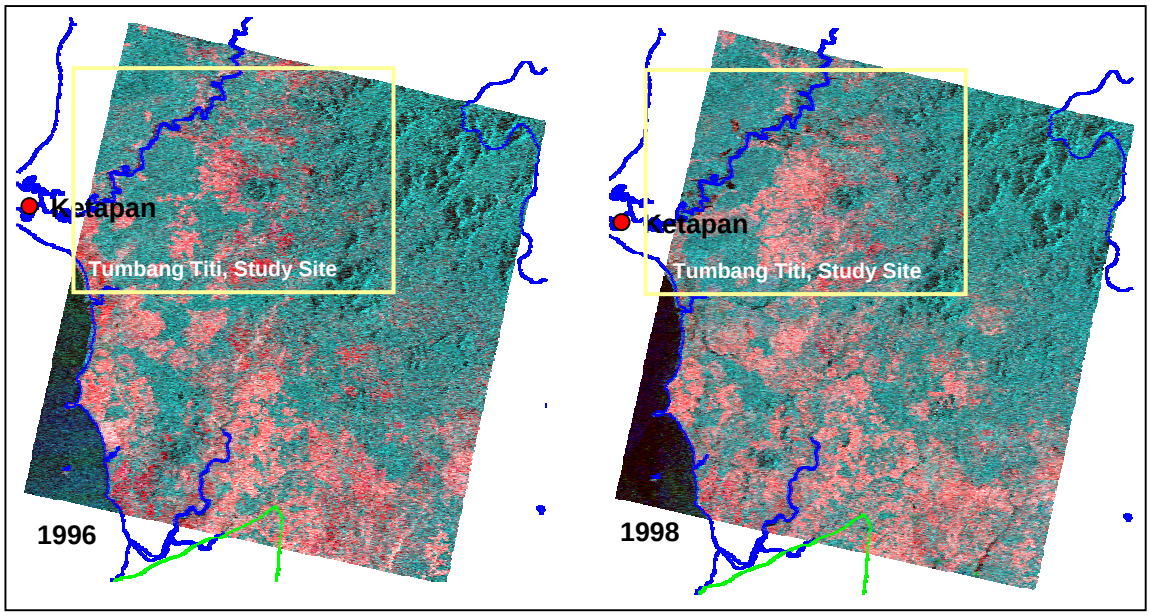
3.1 Socio-economic Study Methods

In collaboration with a local environmental NGO (Yayasan Dian Tama), sketch mapping at landscape level and rural appraisal was conducted between May and July 2000. The sketch map was developed based on a Ketapang District topography map with a scale of 1:100,000, an administration map with a scale of 1:200,000, and the Tumbang Titi sub-District situation map with a scale of 1:100,000. Subsequently, formal and informal community leaders, community members, logging companies and local government officers were interviewed, and several field visits for additional information were made. Information obtained through interviews included the history of the plantations and villages, the history of land clearing and planting, land clearing techniques, fire history, demography, land use, agricultural activities, and land tenure conflicts. The information provided through these interviews was added onto the existing base maps, and checked during the field visits.

3.2 Remote Sensing and GIS

3.2.1 Landsat TM and SAR image level

Information about land cover and land cover changes in the Ketapang area was derived from a combination of Landsat Thematic Mapper (TM) 1989, and ERS Synthetic Aperture Radar (SAR) 1996 and 1998 satellite imagery. Since this area of Indonesia is often covered with clouds and haze, SAR was used for assessing land cover prior to and after the fires. The SAR imagery covers an area of approximately 100 km by 100 km covering 1 million hectares. The SAR sensor is carried on-board the ERS-1 and ERS-2 satellites. Since radar sensors supply their own cloud penetrating electromagnetic energy, they are useful for obtaining information that cannot be gathered by optical sensors relying on emitted or reflected energy. While fire scars, forests, and agricultural areas are visually distinguishable on the radar image, the radar was not as useful for delineating the borders between different types of forest. Distinguishing between natural forest, other forest, or burn scars with standing trees was difficult. Figure 3-2 shows the Coherence Product images acquired in 1996 and 1998. In general, red and pink areas are more open while blue and gray areas are forested.



Note: Red and pink colors represent openings and gray-blue areas are mostly forested.

Figure 3-1 SAR Coherence Products showing the changes in the Tumbang Titi study site between 1996 and 1998.

Cover Category	Description
1. Cloud/shadow	Clouds and cloud shadows removed from all images
2. Water	Lakes, reservoirs, wide river bodies
3. Agriculture/bare/other	Crops, bare ground, grassy areas, villages
4. Other forest	Partially logged areas, regrowth, plantations, agroforestry
5. Natural forest	Forests not burned, harvested, or visibly disturbed by humans
6. Burn scars	Burned areas evident from satellite imagery

Table 3-1 Cover categories mapped for each of the three dates of satellite imagery.

The Image were classified into six land cover categories (see Table 3-1). Once the land cover maps were finalized, overlay analysis techniques using a GIS were applied to determine 1) land cover changes between 1989, 1996 and 1998; and 2) relationships these changes had to the burn scars in 1998. These maps provide insight into the progression of changes in and around the Ketapang site.

3.2.2 Derivation of fire hot spots

We used fire hotspot data recorded by the EU project based in South Sumatera for the years 1992 and 1993. For the years 1997-1999, we used reliable data available for the area from the Japanese International Cooperation Agency (JICA) – MOFEC Fire Protection and Management project based in Bogor, West Java.

4. RESULTS

4.1 Fires

4.1.1 Landscape level

Table 4-1 shows the field-based estimation of burnt areas by vegetation type in each of the sub-sites. The total burnt area in 1997 in this site was almost 47,500 ha, 29 % of the total area. Most of the burnt area was located in the Mahawa (43 %) and the Sei Melayu (49 %) sub-sites. *Imperata* grassland accounted for most (65 %) of the area burnt, followed by primary forest (10 %), and secondary forest (10 %). Small proportions of smallholder rubber (6 %) and oil palm (9 %) plantations were also burned in 1997.

Vegetation of burned area		**Sub-Site**						**Total**	
		Serengkah		**Mahawa**		**Sei-Melayu**			
		(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Primary Forest		2,200	59	1,000	5	1,700	7	**4,900**	**10**
Secondary Forest (scrub-bushes)		1,200	32	700	3	2,650	11	**4,550**	**10**
Imperata grassland		0	0	17,000	83	13,800	60	**30,800**	**65**
Smallholder Rubber Plantation		350	9	1,800	9	650	3	**2,800**	**6**
Oil palm plantation		0	0	0	0	4,380	19	**4,380**	**9**
Total	(ha)	**3,750**	**100**	**20,500**	**100**	**23,180**	**100**	**47,430**	**100**
	(%)	**8**		**43**		**49**		**100**	

Note:
a. Analysis from various sources that are Sub-district Agricultural Service Tumbang Titi, District Plantation Service Ketapang, Provincial Forest Service Ketapang, Ministry of Forestry's provincial office West Kalimantan, Oil Palm Company and Community Participatory.
b. *Imperata* grassland area is estimated by deducted areas of different types of land cover to total size.

Table 4-1 Field-based estimation of burnt area in 1997 by vegetation type and sub-site

Fire occurrence in this study site appears to be significantly correlated with the distribution of *Imperata* grassland, as around 86 % of these grasslands burned in 1997, while the proportion of other vegetation burned was less than 20 % (see Table 4-2). *Imperata* grasslands are very vulnerable to fire. According to Friday *et al*. (1999), *Imperata* often takes over when forests are disturbed by logging, shifting agriculture, or burning. Its seeds are easily transported by wind and it is able to grow on wet or dry, fertile or infertile soils. Once established, the grass is very flammable. Even three days without rain can dry out the grass enough to carry a fire, burning both the grass and nearby forest vegetation. To prevent the spread of *Imperata* and to make the land more economically productive, rehabilitation should be considered. The rehabilitation of *Imperata* could reduce the fire problem in the future, although it should be realized that fire is often used in the process of *Imperata* rehabilitation.

Land cover	**Total land cover of study site (ha)**	**Percentage of area burned**
Primary Forest	31,599	16
Secondary Forest (scrub)	31,260	15
Imperata Grassland	36,022	86
Smallholder Rubber Plantation	33,617	8
Oil Palm Plantation	31,124	14
Wet Rice Field	1,546	0
Gold Mining	117	0
Total	**165,285**	**29**

Note:
a. Analysis from various sources that are Sub-district Agricultural Service Tumbang Titi, District Plantation Service Ketapang, Provincial Forest Service Ketapang, Ministry of Forestry's provincial office West Kalimantan, Oil Palm Company and Community Participatory.
b. *Imperata* grassland area is estimated by deducted areas of different types of land cover to total size.

Table 4-2 Area burned in relation to land cover type in 1997

4.1.2 Imperata and its vulnerability to fire

In 1996, around 30,600 ha of land in the study site was covered by *Imperata* (see Figure 4-1). The sub-site Mahawa has the largest area of *Imperata*, i.e. 55 %, followed by sub-site Sei Melayu (45 %). The Serengkah sub-site has almost no *Imperata*. Fire often occurs in these *Imperata* areas during the dry season, and in 1997 almost all *Imperata* burned. After the 1997 fires, the area of *Imperata* increased by 16 % to 35,500 ha in 1998 (see Table 4-3). It is expected that, if fires are frequent, *Imperata* will gradually become more dominant.

Imperata grassland in this study site indicates the unsustainability of the shifting cultivation practiced here. The traditional shifting cultivation with long fallow periods is sustainable only when land is abundant. However, when population pressure increases and land becomes scarce, the fallow periods tend to become too short for sustainable food crop production. If shifting cultivation continues with the shorter fallow periods, soil fertility declines, leading to declining productivity.

Period	**Sub-site**			**Total**
	Serengkah	Mahawa	Sei Melayu	
1996	0	16,800	13,800	**30,600**
1998	0	19,300	16,100	**35,400**

Source: Bureau of Statistic Tumbang Titi Sub-district (1999) and participatory survey (2000)

Table 4-3 Area (ha) in *Imperata* grassland before and after the 1997 fires in 3 sub-sites

Figure 4-1 *Imperata* grasslands near Mahawa village.

The absence of *Imperata* in the Serengkah sub-site is yet unexplained. The area is hilly and still covered by local protection forest (29 %). Moreover, the incentive to protect forest is high, because of strong customary laws (*adat*) in this area and active collection of honey from the forest. However, more in-depth study is needed to find out why Mahawa and Sei Melayu have large areas of *Imperata* grassland, while these are absent in the Serengkah sub-site. Answering the question is important as it relates to reducing the fire problem. In addition, the social, institutional and policy constraints in rehabilitation of *Imperata* on this site need to be determined to provide guidelines to policy makers for reducing the fire problem.

4.1.3 Alternative land-use on Imperata grasslands

MacKinnon *et al*. (1996) mention that in Kalimantan areas characterized by *Imperata cylindrica* or other invasive grasses are expanding rapidly with forest depletion, and then decreasing with conversion to more successful forms of land management. Rehabilitation of these grasslands is critical for reducing the pressure on remaining forest and making the land more productive. According to Friday *et al.* (1999), *Imperata* grassland rehabilitation depends on fire control. The rehabilitation of *Imperata* grassland through the establishment of oil palm, industrial timber, or smallholder rubber plantations could help prevent fires in the long

term. In the short term, however, fire is often used in land preparation for establishing those land use types on *Imperata* grassland.

In our study site, there are four different types of *Imperata* grassland use: through the establishment of oil palm and industrial timber plantations, transmigration settlements and smallholder rubber plantations. These different approaches will be discussed in more detail below.

Three oil palm plantations (PT Subur Ladang Andalan (PT SLA), PT Duta Sumber Nabati (PT DSN), and PT Bangun Maya Indah (PT BMI)) were establihed in the third sub-site, Sei Melayu in 1991. The oil palm plantations are established under a NES system (Nucleus Estate Smallholder Scheme), integrated with transmigration settlement development, and the company was supposed to establish two types of oil palm plantation: nucleus and plasma. Nucleus is the area of oil palm owned by the company, while plasma is the oil palm area allocated to smallholders under a credit scheme. Of the total oil palm plantation that has been established from 1991 to 1999, more than 60 % was smallholder plantation or plasma.

PT DSN obtained 27,250 ha of land in period 1991 and by 1999, established oil palm on 52 % of their total concession. PT SLA holds 22,000 ha of land and planted 45% of the area from 1991 to 1997. Similarly, PT BMI owns 27,500 ha of land and has established oil palm on 36 % of the total area. Table 4-4 shows the planting areas by year in the three oil palm plantations. Most of oil palm (91 % of the area) was planted between 1991 and 1996. In 1997, according to the District Plantation Service Ketapang (1999), around 4,400 ha of young oil palm (1–2 years old), or 12 % of the total plantation area in these companies burned. Fire escaped from *Imperata* burning around the plantation, however, most of the oil palm trees survived (see Figure 4-2)

Years of planting	PT Subur Ladang Andalan		PT Bangun Maya Indah		PT Duta Sumber Nabati		Total area (ha)	Percentage of total plasma
	Total (ha)	Plasma (%)	Total (ha)	Plasma (%)	Total (ha)	Plasma (%)		
91/92	2,354	82	2,350	81	3,688	88	**8,392**	84
92/93	1,399	75	1,496	78	1,960	83	**4,855**	79
93/94	2,231	37	2,449	36	2,930	48	**7,610**	41
94/95	2,346	53	1,746	53	3,392	86	**7,484**	68
95/96	641	54	1,140	64	1,172	85	**2,953**	70
96/97	393	62	837	51	370	95	**1,600**	64
97/98	637	59	0	0	788	98	**1,425**	80
98/99	0	0	0	0	0	0	**0**	0
	10,001	60	**10,018**	60	**14,300**	79	**34,319**	68

Source: Oil Palm Companies and District Plantation Service Ketapang, South Kalimantan (1999)

Table 4-4 Total area planted by the 3 oil palm plantation companies in the Sei Melayu sub-site

Figure 4-2 Damaged young oil palm at PT Duta Sumber Nabati as a results of uncontrolled burning of *Imperata* grassland.

The establishment of oil palm plantations in this site is integrated with the establishment of transmigration settlement. From 1991 to 1997, about 7,000 transmigrants participated in oil palm plantation establishment, under establishment the Nucleus Estate Smallholder scheme (NES) (Table 4-5). The majority of transmigrants were ethnic Javanese (80 %) and the rest were local people (mostly Dayak) who lived around the plantation. By the end of 1999, around 23,320 ha of smallholder oil palm or plasma had been established.

Company Estate	Number of households per period						Total
	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	
PT SLA	500	483	298	514	66	100	**1,961**
PT BMI	500	440	440	560	0	0	**1,940**
PT DSN	0	0	1,390	112	917	701	**3,120**
Total (HH)	**1,000**	**923**	**2,128**	**1,186**	**983**	**801**	**7,021**

Source: Oil Palm Companies and District Plantation Service Ketapang, South Kalimantan (1999)

Table 4-5 Realization of transmigrants placement under the NES system by 3 oil palm plantation companies at Sei Melayu sub-site, 1991-1999

The industrial timber plantation (HTI) PT Tawang Maju owns 11,000 ha area of forestry concession in the Mahawa sub-site. From 1994 to 1999, PT Tawang Maju established their timber plantation on *Imperata* grassland and in secondary forest. The firm planted acacia (*Acacia mangium*) and sungkai (*Peronema canescens*). The area planted, however, is very small, i.e. only 350 ha or 3 % of the total concession area (see Table 4-6). Uncontrolled fires in 1997 destroyed almost all the planted trees, and it is roughly estimated that only 20 ha of the acacia remained after the fire. PT Tawang Maju subsequently stopped maintaining this plantation (see Figure 4-3).

It seems that the HTI did not succeed in building a strong partnership with the communities around the concession. The development, protection and maintenance of the forest plantation were directly under the company's responsibility, and communities around the plantation were only hired as temporary workers. Therefore there was little incentive for the communities to protect and maintain the tree plantation. This approach is different from the NES system in the oil palm plantation, where the company provides the communities with a financial stake in the plantation thereby potentially securing co-management of the plantation by the community.

Due to failure of the timber plantation, PT Tawang Maju now plans to convert the industrial timber tree concession to an oil palm plantation. They argue that acacia and sungkai trees do not grow well in this area, while they are also vulnerable to fire. Therefore, in July 2000, the firm proposed to establish an oil palm plantation under the KKPA system (Cooperative Plasma Scheme) together with the Mahawa communities of the Punuk, Petebang, Rengas and Beringin sub-villages. However, the land conversion has not yet been legally approved.

Period	Area cleared	Area Planted	
		acacia	sungkai
1994/1995	130	50	0
1995/1996	110	0	0
1996/1997	110	50	250
1997/1998	100	0	0
1998/1999	0	0	0
Total	450	100	250

Source: Report and plan planning in HTI PT Tawang Maju maps

Table 4-6 Land clearing and planting of acacia and *sungkai* by HTI PT Tawang Maju (in hectares)

Figure 4-3 *Acacia mangi*um trees that survived the 1997 fire in PT Tawang Maju

4.1.4 Fire Information from Hot-spots

Of the 1,896 hot spots detected in 1992-1993 and 1997-1999, 75% were detected in 1997. Table 4-7 shows the hot-spot densities in the study site and Kalimantan Province in the 1992-1999 period. The Tumbang Titi study site has a very high fire density (42) compared to that of other sites investigated in the research program (1.5 in Danau Sentarum and 24.3 in Sangau) (Dennis *et.al*, 2000 and Meyer *et.al,* 2000), and compared to West Kalimantan province in most years.

Year	1992	1993	1997	1998	1999
Study site	3.7	1.9	42	4.8	4.1
West Kalimantan	0.9	0.3	6.2	1.2	4.0
Ratio study site to West Kalimantan	4.1	6.3	6.8	4.0	1.0

Table 4-7 Fire hot-spot densities over time in the Tumbang Titi study area

Hot spots were concentrated in the wetland areas near the coast. Unfortunately, this area was not included in the socio-economic survey. The socio-economic survey was located in the eastern part of the wet land area with land cover dominated by *Imperata* grassland. Figure 4-4 shows the overlay of hot spots and landscape mapping. Many of the hot-spots in the landscape level study site were located in the Mahawa and the Sei Melayu sub sites which have large area of *Imperata* grassland. Few hot-spots were detected in the Serengkah sub-site, which has limited *Imperata* grassland cover.

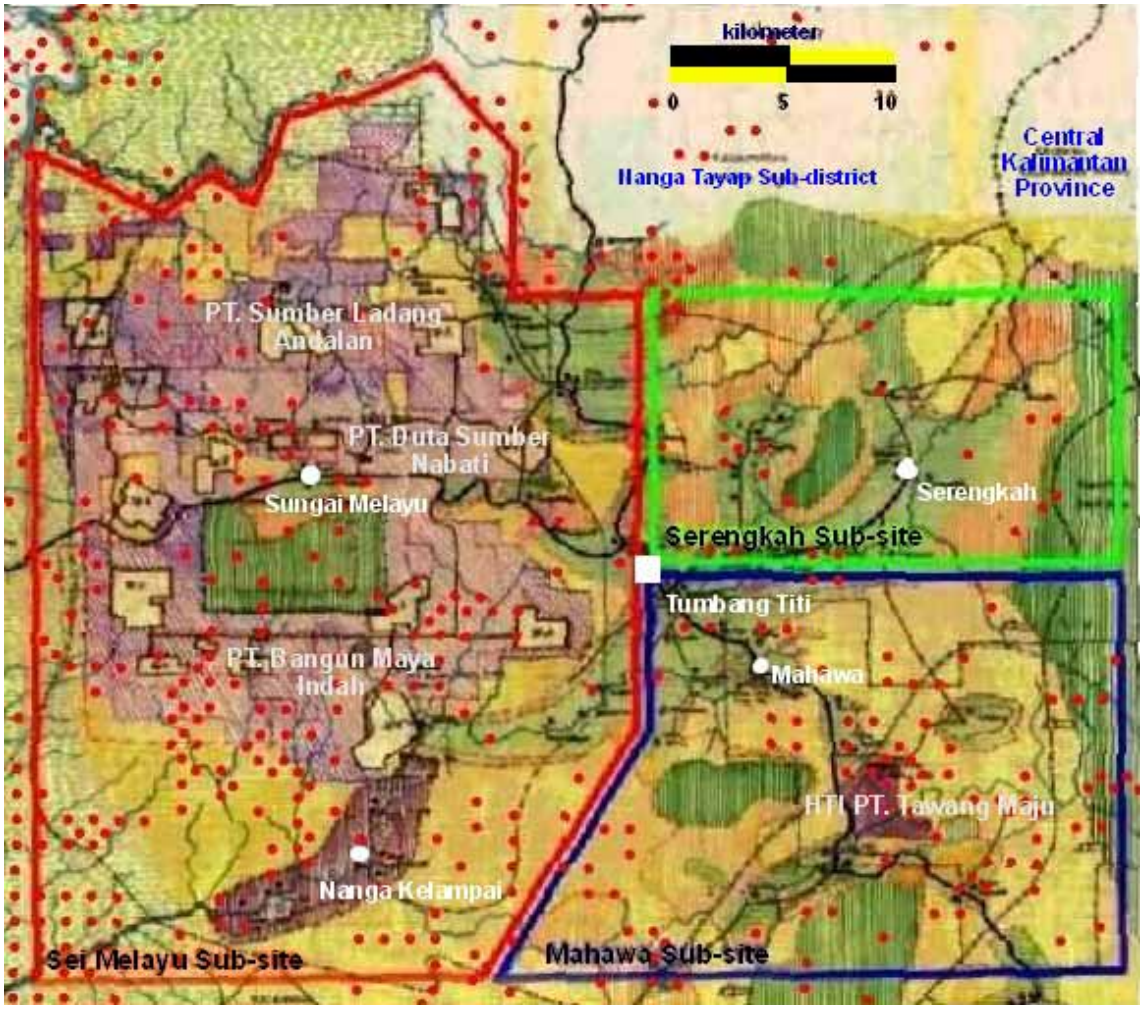


Figure 4-4 Tumbang Titi site and the 1997 hot-spots distribution

4.2 Land Cover/Use Changes

4.2.1 Land Degradation: The expansion of Imperata grasslands

The research indicates that there are three main forces behind the initial land degradation from forest to grassland on this site: shifting cultivation, illegal logging activity and gold mining activity. Shifting cultivation seems to be a major factor in land cover degradation. For a long time, indigenous Dayak communities in West Kalimantan, including those on this study site, have practiced shifting cultivation on hilly areas. When land is abundant and population density is low, a shifting cultivation system with long fallow periods is sustainable. However, when land is scarce and population densities are high, fallow periods tend to become shorter, leading to reduced soil fertility, and often to invasion of grasses.

On the other hand, hills are also used for agroforest systems, with crops such as jungle rubber, edible fruits such as *durian* (*Durio zibethinus*), or *kempas* trees (*Koompassia excelsa*) for honey production. This system is generally considered more sustainable than degraded shifting cultivation systems, because of its longer fallow periods and associated higher biodiversity. Rubber is reasonably profitable (Suyanto *et al.*, In press), however, Table 4-8 shows that the area of smallholder rubber gardens in 1997 was less than the *Imperata* grassland area on this site. It is suspected that there are some barriers for farmers to rehabilitate *Imperata* grassland for more economic and sustainable land uses. Further study in this site should investigate the constraints limiting the rehabilitation of *Imperata* grassland, including technical, social, economic and institutional factors.

Land use/cover		**Sub-Site**						**Total**	
		Serengkah		**Mahawa**		**Sei-Melayu**			
		(ha)	**(%)**	**(ha)**	**(%)**	**(ha)**	**(%)**	**(ha)**	**(%)**
Primary Forest		23,209	46	5,090	14	3,300	4	**31,599**	**19**
Secondary Forest (scrub-bushes)		11,891	24	5,200	14	14,169	18	**31,260**	**19**
Imperata Grassland		0	0	19,262	53	16,760	21	**36,022**	**22**
Smallholder Rubber Plantation		14,440	29	6,293	17	12,884	16	**33,617**	**20**
Oil Palm Plantation		0	0	0	0	31,124	39	**31,124**	**19**
Wet Rice Field		441	1	555	2	550	1	**1,546**	**1**
Gold Mining		0	0	0	0	117	0	**117**	**0**
Total	**(ha)**	**49,981**	**100**	**36,400**	**100**	**78,904**	**100**	**165,285**	**100**
	(%)	**30**		**22**		**48**		**100**	

Note:
a. Analysis from various sources that are Sub-district Agricultural Service Tumbang Titi, District

Plantation Service Ketapang, Provincial Forest Service Ketapang, Ministry of Forestry's provincial office West Kalimantan, Oil Palm Company and Community Participatory.

b. *Imperata* grassland area is estimated by deducted areas of different types of land cover to total size.

Table 4-8 Area in different land cover type in 1997

The second factor in land cover degradation is informal logging (see Figure 4-5). Dayak communities have traditionally logged *bulian* trees (*Eusideroxylon zwagerii*) in the hill areas for their house construction. *Bulian* is an important tree species in Kalimantan, known for the hardness of its wood. Since 1960, logging of *bulian* timber in Sei Melayu and Mahawa has increased in response growing to demand for this timber, especially for export to Japan and Korea. During the 1980s, *bulian* trees all but disappeared in Sei Melayu and Mahawa. As a result of this logging, the forest canopy has become fragmented, eventually leading to areas being mostly covered by scrub or *Imperata* grassland.

Figure 4-5 Illegal logging activities and short-rotation shifting cultivation leading to land degradation

The third major factor in land cover degradation is gold mining. Since 1997, gold mining activities have increased in the Sei Melayu sub-site. Just prior to this, gold prices increased from Rp. 24,000 (US$ 10) per gram in 1996 to Rp. 125,000 (US$ 52) per gram in 1997,

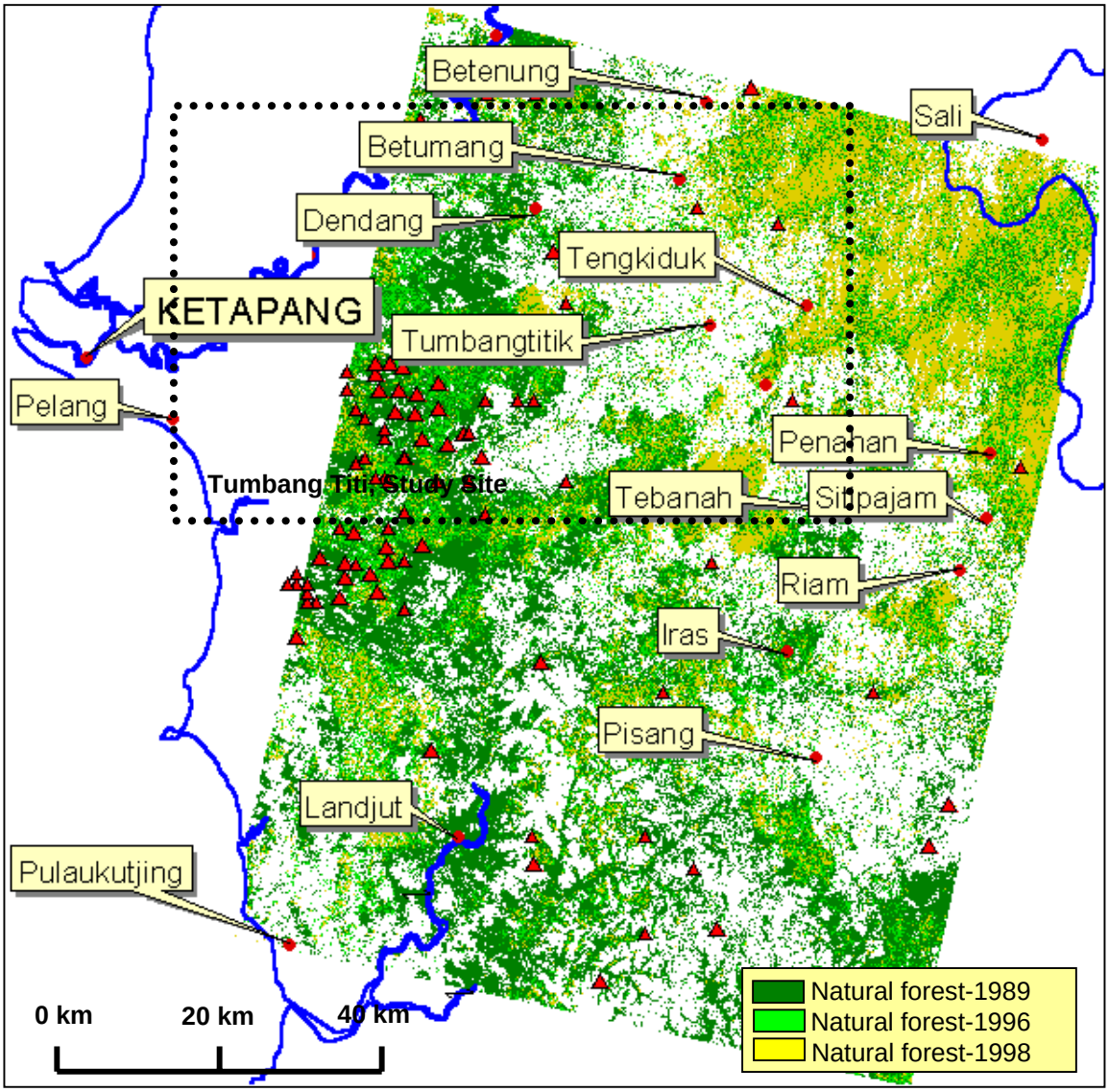
equaling a 420 % increase in price. Now, in the Sei Melayu sub-site, most Nanga Kelampai communities explore and mine the land for gold, including their own rubber gardens. The gold mining activities had also spread into the State-owned Inhutani II forest concession and transmigration areas. In 1998, the Government tried to stop this by pointing out the illegality of gold mining, but the communities argued that their activities were legal. In 1998, they had obtained official permission from the Directorate General for General Mining of Ketapang District for a Local Community Mining Area (*Wilayah Pertambangan Rakyat*).

Gold exploration involves the use of high-pressure water that washes out the soil containing the gold ore. One machine is operated by 6–8 people, and until early 1998, one such team could approximately get 20 grams of gold per week. In 2000, however, this had declined to only 5–10 grams per week. As people search ever harder for gold, this uncontrolled process leaves depression holes throughout the landscape, while waters become polluted with mercury. In late 2000, the mining area was ca. 400 hectare and is still expected to increase (see Figure 4-6).

Figure 4-6 Rubber forests in Nanga Kelampai damaged by open gold mining activities

4.2.2 Landsat TM and SAR Image level

For the change detection portion of the image-wide area, a common area of the imagery was subset that covered as much of the 1989 Landsat TM and SAR Coherence Products as possible. Unfortunately, this did not cover the entire Tumbang Titi study area but did cover many of the AVHRR "hot spots" in the area (see Figure 4-7).



Yellow areas are natural forest that remained in 1998 after the fires. Light and dark green show where natural forest occurred in 1992 and 1986 respectively.

Figure 4-7 Changes in natural forest for the common area between 1989 Landsat TM and SAR Coherence Products from 1996 and 1998.

Discussions on land cover changes will be limited to deforestation and how it relates to fire. The period of change discussed is from 1989 to 1998, or approximately nine years. Figure 4-7 is a composite map showing the progression of deforestation derived from the three dates of satellite imagery discussed earlier: 1989, 1996, and 1998. Areas mapped as natural forest in

1998 are shown as yellow. Areas mapped as natural forest in 1996 are shown as light green and include the yellow. Finally, areas mapped as natural forest in 1989 are shown as dark green and include those areas shown as light green as well as yellow.

Land cover overtime is shown in Table 4-9. Natural forest decreased from 54 percent of the total image area in 1989 to around 15 percent in 1998, of amounting to an average annual decrease of around four percent. Since the SAR Coherence Products may not be accurate for mapping burn scars, we cannot attribute a particular percentage of deforestation to fire.

Land cover	1989		1996		1998	
	ha	% cover	ha	% cover	ha	% cover
Clouds	45,819	5	45,819	5	45,819	5
Water	5,869	1	6,338	1	5,975	1
Agriculture	173,457	20	210,332	24	204,561	23
Other forest	173,167	20	401,309	46	460,048	53
Natural forest	473,304	54	207,817	24	127,335	15
Burn scar	0	0	0	0	27,878	3
Total	**871,616**	**100**	**871,616**	**100**	**871,616**	**100**

Table 4-9 Land cover changes occurring in the TM image-wide area surrounding the Ketapang site between 1986 and 1998.

Figure 4-8 shows graphically the changes taking place in the study site. Note that as the occurrence of natural forest has decreased, the occurrence of other forest and agriculture has increased.

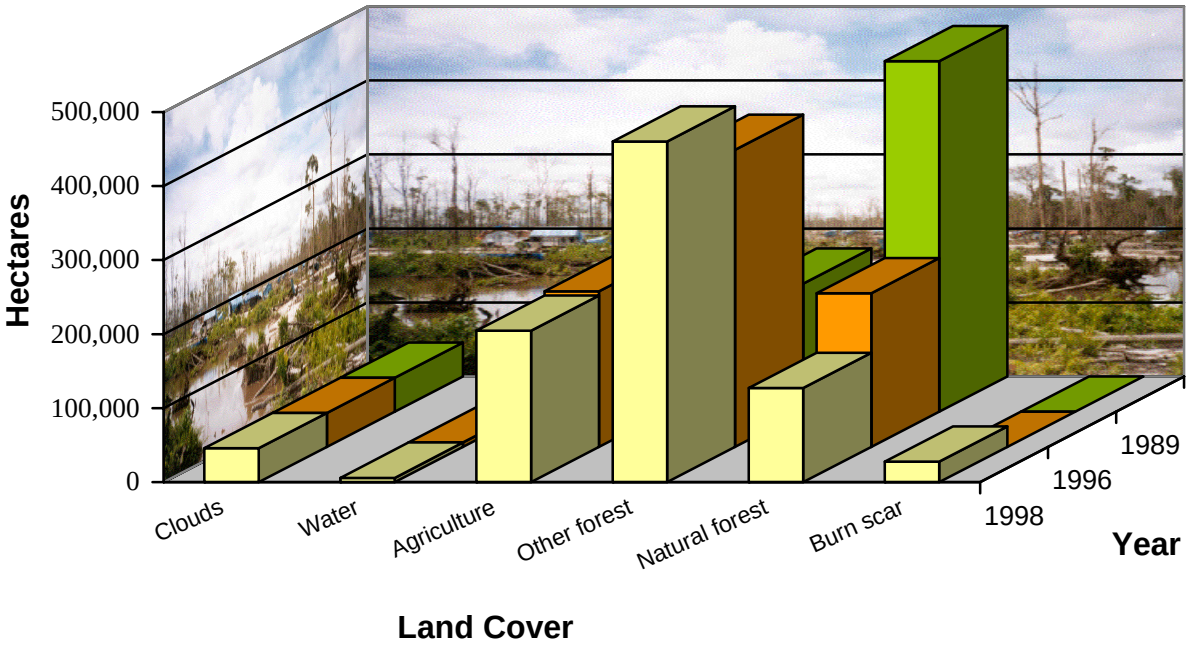


Figure 4-8 Graphic portrayal of land cover changes occurring in the combined Landsat TM–SAR coherence image area surrounding the Tumbang Tit site between 1986 and 1998.

5. UNDERLYING CAUSES

This study revealed a positive correlation between the area of *Imperata* grassland and burnt areas on this site. This indicates that *Imperata* grasslands are prone to fire. A large fire started accidentally on this site in 1997, and rapidly got out control and escaped into *Imperata* grassland. In 1997, around 86 % (31,000 ha) of the *Imperata* grasslands in the site were burned. The main source of fire came from shifting cultivation and illegal logging activities.

The large area of *Imperata* grasslands indicates a high rate of land degradation on this site. Unsustainable shifting cultivation and illegal logging activity seem to be the major causes of this degradation. The rehabilitation of *Imperata* grassland into more economic and relatively more sustainable land use by both large and smallholders is still sub-optimal. Improvement of *Imperata* rehabilitation programs involving oil palm and timber plantation establishment could reduce the fire and smoke problem in the long term. In the short term, however, fire is still used in the required land clearing activities for such programs.

6. POLICY IMPLICATIONS

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

A. Rehabilitate *Imperata* grasslands for more economic and sustainable land use.

B. Identify technical, social, economic and institutional constraints to the rehabilitation of *Imperata* grasslands and remove the barrier.

C. Provide incentives for rehabilitation of *Imperata* grasslands and ensure strong participation by local communities for successful rehabilitation of *Imperata*.

D. Provide technical assistance by improving the agricultural extension system, and provide good quality planting material to improve rubber productivity.

E. Priority development of small or large scale plantations in *Imperata* grasslands with incentives for all of the land's stakeholders.

F. Initiate research on identification of timber species suitable for rehabilitating *Imperata* grassland and integrated with community development. For example, CIFOR in collaboration with NGO (Yayasan Dian Tama) has been carrying out a community development project through rehabilitation of *Imperata* grassland using Trees: a model approach growing *Vitex pubescens* for charcoal production in Tumbang Titi, Ketapang District, West Kalimantan.

G. Reduce gold mining activities

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