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Deforestation and Agricultural Expansion Processes in Gunung Palung National Park, West Kalimantan, Indonesia

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Abstract

Gunung Palung National Park (GPNP) represents the biodiversity of tropical forests remain in Kalimantan Island. However, the natural ecosystem has been threatened by human impact. This study aimed (1) to identify the deforestation process inside the national park by imagery analysis of Landsat TM (1992), Landsat ETM+ (1999), and SPOT5 (2004), and (2) to find the driving forces behind agricultural expansions. The results showed that forest cover of GPNP decreased by 18.7% (equal with 18,675) at an average rate of 1.6% per year from 1992 to 2004. Land use changes by illegal logging were accelerated after decentralization (1,064 ha in 1992-1999 to 3,781 ha in 1999-2004). In the other side, increase of mix garden/bush area inside GPNP was relatively constant (4,555 ha in 1992-1999 to 9,040 ha in 1999-2004). Results also showed tendency on increasing areas for dry-rice cultivation and rubber plantation (averagely 2.0 ha per household). The study also revealed that secondary forest has constantly decreased in GPNP annually. Family size and income were considered as important factors that were driving forces of deforestation. To this, zoning system of the national park by clear participatory demarcation and application of effective buffer-zone support programs were recommended.

Keywords: deforestation, agricultural expansion, national park, imagery analysis, zoning system

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Introduction

Indonesia lost the 1.8 million ha area of forests from 2000 to 2005 (FAO 2006). Even if current policy reforms function successfully, it is obvious that Indonesia is in transition from a forest-rich country to a forest-poor country, following the path of Thailand and the Philippines. Along with forests loss, Indonesia also lost its biodiversity, wood supply, income, and various ecosystem services (FWI/GFW 2002). Logging, either legal or illegal, agricultural expansions, mining, and anthropogenic factors are mainly responsible behind the rapid changes of the forest cover in Indonesia.

The rate of deforestation has drastically increased from 0.8 million/year in 1993 (Revilla 1993), 1.2 million ha/year in 1996 (MoF/FAO 1996), 1.7 million ha/year between 1984 and 1997 (World Bank 2000), to above 2 million ha/year (FWI/GFW 2002). Though FWI/GFW (2002) also stated that no accurate estimation were available for shifting cultivators might be responsible for about 20% of total forest loss. This can be translated to clearance of about 4 million ha during the period from 1985 to 1997. From the estimation by region, forest-rich Kalimantan lost the largest area and forest-poor East Timor lost the largest ratio from 1985 to 1997 (Table 1).

Deforestation has also occurred in protected areas, including national parks. Act Number 5 of 1990 (Conservation of Living Resources and Their Ecosystems) stated that a national park is a nature conservation area to provide a variety of indigenous and/or introduced plants and animals for research, science, education, breeding enhancement, culture, recreation, and tourism purposes. Protected areas are established to limit the extent of land use conversions within delineated areas that are often located in hotspots of biodiversity and assumed to be large enough areas to protect endangered species. Article 5 also stated that conservation of living resources and their ecosystems shall be involved through protection of life support systems, preservation of plant and animal species diversity and their ecosystems, and sustainable utilization of living resources and their ecosystems. Due to this article statement, any and all persons are prohibited to do activities which were inconsistent with the function of utilization and other zones of the national park.

However, the simple delineation of park boundaries itself is insufficient to guarantee the preservation of ecosystems (Verburg *et al*. 2006). Agricultural expansion, land encroachment and illegal logging often occurred irrespective of park boundaries. A law enforcement approach for controlling park boundaries has proven to be difficult in low-income countries due to the large areas involved, difficult terrains and weak institutions (Baret *et al*. 2001).

One of the purposes in establishing the protected area was to compromise with the need of human welfare. But, on

the contrary, the areas are degraded or converted into different land use. In order to understand the process better, this study was directed to examine the land cover change and to identify the driving forces of farmers that related to agricultural expansion inside the national park.

Method

Imagery data processing and preparation The imagery datasets were Landsat Thematic Mapper (TM) satellite imagery (September 9, 1992), Landsat Enhanced Thematic Mapper Plus (ETM+) satellite imagery (September 5, 1999), and Geo-referenced SPOT5 imagery with three bands panchromatic of path 121/row 61 (August 29, 2004). The Landsat imagery was obtained from Tropical Rainforest Information Center, Michigan State University. The Geo-referenced SPOT5 imagery was available as digital data by courtesy of Illegal Logging Response Center Project-European Union, in cooperation with Indonesian Ministry of Forestry.

Non remotely-sensed data were also used in this study. GPS points (simultaneously taken with pictures of areas appearances) were collected in 2005 and in August 2007, both from the ground and aerial survey, by simply-powered hang glider and then digitized. These points were used to validate the classification results. The vector data of GPNP boundaries were obtained from Indonesia Ministry of Forestry (MoF). Geometric correction was undertaken to avoid geometric distortions, by establishing the relationship between the image coordinate system and the geographic coordinate system through calibration data of the sensor, measured data of position and altitude, ground control points, and atmospheric conditions. In this study, Universal Transverse Mercator (UTM) coordinate system, Zone 48 South was used. The Landsat imagery was geometrically corrected using geo-referenced SPOT5 imagery, which was corrected by ground control points from topographic base maps and GPS points. The SPOT5 imagery contains cloud cover less than 10%.

Land cover classification was performed by supervised classification method. A maximum likelihood classification, the most common supervised classification method was applied on time series imagery datasets to obtain spatial information. In order to edit the map, visual interpretation was also performed.

Household survey Preliminary information about villages adjacent to the national park was collected from GPNP Office in March 2007. Four conspicuous villages, in the sense of encroachment, were purposively selected from the 17 villages surrounding the GPNP. During preliminary survey, it was disclosed that 160 households who carried out encroachment were identified from key informants and also observation during preliminary research. Among the 160 households who involved in encroachment inside GPNP, 41 households were randomly selected for interview and household survey.

Analysis In this study, analysis of both the remotely-sensed data and socio-economic data were performed to assess the spatial and temporal changes in deforestation of GPNP from 1992-2004. The spatial analysis indicated the deforestation trend and patterns, while the household surveys described the socio-economic characteristics of farmers surrounding the GPNP and driving forces of deforestation in GPNP.

Deforestation Trends and Pattern in GPNP

Land cover changes in GPNP Illegal logging and encroachment for agricultural expansion increased after economic crisis and decentralization in 1999.

Table 1 Forest cover changes in Indonesia (1985-1997)

Island	Forest cover (ha)		Forest change (ha)	Annual change rate (%)
	1985	1997	1985-1997	
Sumatra	22,938,825	16,430,300	-6,508,525	-2.15
Java	1,274,600	1,869,675	595,075	3.60
Bali	96,450	76,700	-19,750	-1.50
Nusa Tenggara	686,775	450,450	-236,325	-2.60
East Timor	374,400	9,850	-364,550	-7.46
Kalimantan	39,644,025	29,637,475	-10,006,550	-1.92
Sulawesi	11,192,950	7,950,900	-3,242,050	-2.23
Maluku	5,790,800	5,820,975	30,175	0.07
Irian Jaya	35,192,725	33,382,475	-1,810,250	-0.38
Total	117,191,550	95,628,800	-21,562,750	-1.38

Source: FWI/GFW (2002)

Both of them have caused the deforestation process in GPNP. In order to analyze the deforestation process in GPNP, following classification of land cover was applied: 1) forest, 2) illegal logging area, 3) mix garden/bush, 4) open land, 5) grass/shrub 6) settlement, and 7) no data. Forest consisted of lowland forest, swamp forest, peat-swamp forest and mountainous forest ecosystems. Illegal logging area consisted of the area under or after illegal logging. Mix garden/bush consisted of fruits garden, rubber plantation, and bush fallows. Open land consisted of the area that was opened by slash and burn agriculture. The areas of rice cultivation, *alang-alang* (*Imperata cylindrica*) and wetland grasses were classified as grass/shrub. Through the ground surveys, it revealed that mix gardens and rubber plantations were located in the fringes of the national park.

The location of open land was dynamically changed over time and relatively constantly from 1992 to 2004. Land cover maps of GPNP from 1992 to 2004 visually indicated the process of deforestation took place inside GPNP. There were several centers of agricultural expansion, western and northern projections and eastern boundary. Illegal logging activities were not distinguished in 1992 but expanded over lowland forests in 2004. Of the 99,820 ha of the study area, 93,980 ha was covered by forests in 1992. The extent of mix garden/bush increased from 2,636 ha (2.6%) in 1992 to 4,555 ha (4.6%) in 1999 and 9,040 ha (9.1%) in 2004. Likewise, the coverage of grass/shrub increased from 2,356 ha (2.4%) in 1992 to 3,186 ha (3.2%) in 1999 and 4,132 ha (4.1%) in 2004. The area affected by illegal logging was increased from 1,064 ha (1.1%) in 1999 to 3,781 ha (3.8%) in 2004 (Table 2).

Most of the mix garden/bush and grass/shrub coverage consist of agricultural expansions inside the park. In the western part, most of people carried out mix garden agriculture, consist of *durian*, other fruits, and cultivated rice for subsistence purpose. The similar trend occurred also in the southern part; but the difference is the farmers started to plant rubber first. However, in the northern part, majority of the farmers cultivated rice and other perennial crops for their subsistence purposes. Majority of the people involved in illegal logging activity to increase their income on the unfertile land (peat-swamp and swamp) in this area. Agricultural expansion, especially for rubber garden were also obvious on the eastern part of national park, where the S village is located and was selected as the study site (Empirical evidence 1999-2006). However, based on interview with key informants in March 2007, rubber was introduced in this village in the 1930s before establishment of the national park.

Forest fires during El Niño period in 1997/1998 also evoked forest loss and turned the area into grass/shrub. It mostly occurred in the northern part of GPNP. During the field survey, less agricultural area was found in this area. As this area is mostly swampy, it is supposed that the majority of fires in the northern part broke out naturally. Contrary forest fires in western, southern, and eastern part were suspected as a result of slash and burn. Almost of all farmers surrounding GPNP open the land inside the park area by slash and burn at the end of the dry season (August-September). The change of forestland to non-forestland had significantly increased during 1999-2004.

During 1992-1999, GPNP lost 3,686 ha of forests at the rate of 0.6% annually. The rate increased dramatically during 1999-2004 and the national park lost 9,148 ha of forest land at the rate of 2.0% annually. Overall, the GPNL lost 12,384 ha of forest land from 1992 to 2004 at the rate of 1.6% annually (Table 3).

Table 2 Land cover changes in GPNP

Class	1992		1999		2004	
	ha	%	ha	%	ha	%
Forest	93,980	94.1	90,293	90.5	81,145	81.3
Illegal logging area	0.0	0.0	1,064	1.1	3,781	3.8
Mix garden/bush	2,636	2.6	4,555	4.6	9,040	9.1
Openland	848	0.8	722	0.7	804	0.8
Grass/shrub	2,356	2.4	3,186	3.2	4,132	4.1
Settlement	0.0	0.0	0.0	0.0	47	0.0
No data	0.0	0.0	0.0	0.0	871	0.9
Total	99,820	100.0	99,820	100.0	99,820	100.0

Table 3 Annual rate of deforestation in GPNP Year 1992-2004

Class	Area (ha)		Change 1992-1999 (%)		Area (ha)	Change 1999-2004 (%)	
	1992	1999	Cumulative	Annual	2004	Cumulative	Annual
Forest	93,980	90,293	-3.6	-0.514	81,145	-9.15	-1.83

Land cover change patterns by post classification procedures Forest conversion in GPNP was occurred since before 1992. Using post classification analysis, it was revealed that during 1992-1999, the forest was decreasing but 90,293 ha still remained in 1999. This change was caused by illegal logging (1,063 ha), appearance of mix garden/ bush (1,430 ha), open land (205 ha), and grass/shrub (989 ha). Both illegal logging and mix garden/bush classes, where agricultural expansion was counted in, showed a remarkable increase (Table 4).

During the period of 1999-2004, the forest area continuously decreased, and shrinkaged into 80,175 ha in 2004. These changes were illegal logging areas (3,726 ha), mix garden/bush areas (4,501 ha), open lands (198 ha), grass/ shrub areas (1,235 ha), and settlements (47 ha). As many as 264 ha of open lands were converted into grass/shrub areas, including rice cultivation areas. Table 5 showed that there were 1,191 ha of land cover changed from grass/shrub areas to mix garden/bush ones. Obviously, from the field observation, many rice-cultivation areas especially dry-rice ones were converted into rubber plantation within 5 years. Beside these, there were 871 ha with category of 'no data'.

Generally, land cover was changed in GPNP annually. During the 1992-1999, the two largest changes were the increment of illegal logging area by 1.1% and mix garden/ bush by 2.0%. These lands cover changes contributed to the forest loss by 3.9%. On the other hand, during 1999-2004, illegal logging areas were increased by 3.0% and mix garden/bush areas were by 5.0% which contributed to the forest loss by 10.1%.

The spatial analysis results showed that the annual rate of deforestation in GPNP during 1992-1999 was 1,6% and it was dramatically increased during 1999-2004 by 2.0% annually. The trend of deforestation in GPNP indicated the difference of condition before and after decentralization period. More specifically, the deforestation had rapidly increased after decentralization and economic crisis periods. During these periods, law enforcement remained a big challenge. Moreover, poor data availability of remotely-sensed-data had put some constraints.

The Socio Economic Characteristics of The Encroachers

Family-size and labor The family size was categorized into three groups: small (1-3 persons), middle (4-6), and large (>6). The household numbers of each category were: 13 (31.7%), 27 (65.9%), and 1 (2.4%) respectively. The average of family size was 4 for each household.

Most of households opened new land by their own labor. Lack of labor force in the family become the limiting factor of agricultural expansion. When a household had insufficient labor force to open larger area, "cooperative effort" (*jejurukan*) could be employed. This is a reciprocal exchange of labor force among households, which can be assumed as one of the reasons why there is no correlation between labor force and the area of encroached land.Therefore, it can be concluded that the number of labor force in a household does not influence the extent of encroached land, but the number of family member in a household does.

During 2000-2005, the growth rate in Sei Laur Subdistrict was 5.33% with population density of 10 persons per km^2 (BPS Kabupaten Ketapang 2006). Eighty three percent of respondents (household heads) were native people of this village, while just 17% were migration people from outside. Consequently by marriage, less number of family members were not native people.

Education The assumption of land encroachment for agricultural expansion was also depended on the education level due to environmental and conservation understanding of farmers. According to Schultz (1964), knowledge and technological development were the main source of agricultural change that enables tmore production with the same resources. For the study, the education level was categorized by the number of schooling years, namely: no school, 1-4 years, and 5-7 years.

From the field survey, the education level of respondents was low. There were no household heads whofinished the junior high school (SMP). Only 24% of respondents

Table 4 Land cover change patterns by class in GPNP Year 1992-1999

	Class	1999 (ha)					
		Forest	Illegal logging area	Mix garden/ bush	Open land	Grass/shrub	Total
1992 (ha)	Forest	90,293	1,063	1,430	205	989	93,980
	Mix garden/bush	0	0	1,702	259	675	2,636
	Open land	0	0	237	140	471	848
	Grass/shrub	0	0	1,188	118	1,050	2,356
	Total	90,293	1,063	4,557	722	3,185	99,820

Table 5 Land cover changes pattern by class in GPNP Year 1999-2004

Class Name		2004 (ha)							
		Forest	Illegal logging area	Mix garden/ bush	Open land	Grass/ shrub	Settlement	No Data	Total
1999 (ha)	No Data		0	26	3	17	0	(46)	0
	Forest	80,175	3,726	4,501	198	1,235	37	421	90,293
	Illegal logging area	970	1	77	3	13	0	0	1,064
	Mix garden/ bush	0	35	2,981	225	928	3	383	4,555
	Open land	0	0	264	162	255	4	37	722
	Grass/shrub	0	19	1,191	213	1,684	3	76	3,186
	Total	81,145	3,781	9,040	804	4,132	47	871	99,820

passed 5-7 years of schooling and most ofrespondents (66%) did not go to school. There was no school building for junior high school in this village. Only elementary school (SD) was available. Analysis showed that there was no significant correlation bet-ween education level and the extent of encroached land, because the maximum of schooling years was 7 years. It means that there was no household head who finished the junior high school. Most of households obtained traditionally the simple technology for agricultural purposes, mainly from experiences with their families and communities.

Household income Rubber is the dominating income source of the total income (79%), because rubber has become the main agricultural crop in the village with high price. Percentage income of rice crop was 11% and off-farm was 10%. The major off-farm income sources were trading, mainly rubber dealers, and employment in the oil-palm company nearby village. On the other words, 90% household income was originated from the land cultivating. Furthermore, the size of the encroached farmland was varied. There was no significant correlation between household income and the encroached land (R^2= 0,11).

The farmers' income from agriculture, both from rice and rubber, was calculated when the study was conducted. The price of 1 kg rice was Rp3,500, and 1 kg rubber was Rp6,000. Of the total 41 households, the average of household income during August 2007 was Rp1,252,700. The minimum income was Rp341,667 while the maximum one was Rp3,750,000. As a matter of fact, this average income was more than provincial minimum wage of West Kalimantan by Rp512,000 per month (BPS Kabupaten Ketapang 2006).

Farmers who occupied more land have no higher income, because their land was recently opened and their rubber garden was still immature to be tapped, and the pest/ disease attacked their rice fields violently. The average of rubber trees planted about 500 trees/ha. Mature rubber trees were tapped daily with average production 6 kg. Usually, the mature rubber trees will be tapped for 8-10 years after they were planted. The total of 41 respondents claimed that 95% farmers have rubber gardens

Family size and income were important factors for deciding that opening new cultivation inside GPNP is as driving forces of deforestation. The population growth has become evidence from this standpoint. Even in the sub-district level has low population density by 10 persons/km^2, the population growth rate was 5.7%. Although, farmers will not obtain any legal status of the land-title inside the national park, they still encroached the national park mostly for cultivating rice and/or planting rubber. Even though, rice cultivation has low yield crops, farmers carried out rice cultivation due to limited availability of alternative income sources in this village. In the other side, opening land was a necessity to plant rubber in order to improve their livelihood and as inheritance for their descendant. It can be concluded that agricultural expansion was one of the proximate causes of deforestation by socio-economic factors.

Land use types and allocation

Land use types Land use belongs to the households can be divided into three types, such as wet-rice (*padi sawah*), dry-rice (*padi ladang*), and rubber garden. Some farmers also have homesteads in the yard. Crops including cassava, sweet potatoes, maize, and vegetables were cultivated for self-consumption. The cultivating areas of wet-rice, dry-rice, and rubber were 22.4 ha (21%), 29.8 ha (28%), and 54.0 ha (51%), respectively.

The difference between wet and dry-rice fields is based on the location and system. Wet-rice fields were located in lowland area (*payak*), while dry-rice fields were located in upland area (*natai*). Wet-rice was cultivated by raising seedling first for about 3 months before planting (*nandur*)

using a digging stick (*nugal*).

Planting rice is the main reason to open the land. Permanent agriculture with irrigated rice fields were not found in this village. Agriculture was done using traditional cultivating system. And the average of rice output every field (1.5 ha) was very low, approximately 200 *gantang* (equal to 600 kg) or 400 kg/ha. The low yield can be regarded as the result of the poor technology and soil quality in the area, no input in cultivation, as well as pest problems. From these reasons, there was no farmer who cultivated wet-rice only.

Farmers cultivated rice for their subsistence, and rubber for daily living costs and other needs. From these reasons, almost all of the farmers combined dry and/or wet rice with rubber (Figure 1). It was observed that 39 out of 41 households had rubber garden which was traditionally planted inside of national park.

Cultivation system Traditionally rice cultivation is usually started from the beginning of dry season (May) by clearing the bush and secondary forest. By the end of July, the fields have been completely cleared. The climax of land-clearing is burning which is usually carried out in the end of dry season (August). Then, planting period will be started at the beginning of rainy season (last September-October). Planting must begin immediately, before the ash bed is blown or leached away and the heavy rain comes. In this period, farmers plant the rubber seedling before they plant rice between the rubber trees rows. Weeding is a part of maintenance activities. This activity is carried out since the grasses and other weeds grow in their field. At last, when paddy is almost in ripe, most of family members stay in the fields temporarily to guard their paddy until harvesting time come. Farmers harvest the paddy on March.

All of respondents answered that the rubber gardens were always originated from dry-rice fields. Dry-rice fields are more beneficial, because all of the areas are clean from weed, moreover it will be easier to plant rubber. Wet-rice usually need longer period to be harvested and it is planted relatively near from the farmers' houses (maximum 1.5 km).

Land use changes The condition of land is the governing factor to open the land for cultivation. Slope areas in the upland are the first choice. After the first yield of dry-rice, farmers let the rubber, which were planted that simultaneously with rice grows. Then, the rubber that substitutes dry-rice cultivation will be maintained. They open bush and secondary forest for same purpose.

Total of encroached land for agricultural purpose was 83.8 hectares. The maximum extent of land encroachment was 5.5 hectares, however encroachment was 2.0 ha. The 160 households encroached 326.4 hectares of forest land in this village. The distance which ranges from 0.1 km to 7 km also governed the encroachment, The study revealed that secondary forest had constantly decreased in GPNP annually. Angelsen and Kaimowitz (2001) also claimed that farmers cultivate more land if it is profitable. If agriculture and forest were still the only possible land uses, forest cover would decline.

Challenging deforestation problem in GPNP Tropical deforestation is the major issue in the world. International parties are paying attention and giving support to alleviate the worsening situation. Indonesian Ministry of Forestry and international parties has initiated forest rehabilitation program and actions to counter the increasing rate of deforestation in Indonesia. Unfortunately, even annual rate of deforestation in GPNP was higher than that of Indonesia, the rehabilitation and reforestation program conducted by GPNP Office could cover only 2 ha per year (GPNP Office, 2006). According to this, the main problem is how the protection efforts of GPNP can be balance, between demands for ecological and economic benefits, especially for community that supported by legal actions.

Based on Act Number 5 of 1990 Article 33 Paragraph 1, any and all persons are prohibited to do activities which may modify the natural integrity of the national park's core zone. Hence, conflicts of interest between people surrounding the national park will become a never ending problem. In conservation side, the management of GPNP expects to

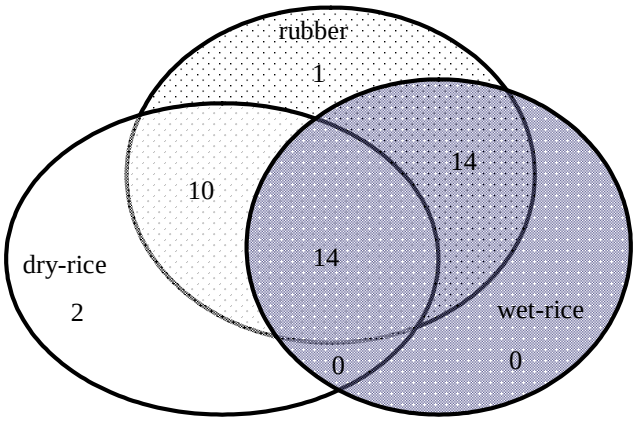

Figure 1 Combination of land use types from 41 households.

while dry-rice was cultivated by planting grain directly us protect this park by sustainable utilization for community development. On the other hand, people surrounding GPNP have limited opportunities in alternative income sources. In the policy level, law enforcement particularly effective implementation of decentralization and the economical problem solution of local farmers are prerequisites for sustainable management of GPNP.

Many efforts had been applied to increase the income of local farmers including development of buffer zones in coordination with local government. However, the Indonesia MoF through the management of GPNP must pay more attention on how to create an effective community development programs. To arrest the further agricultural expansion, both mix garden and rubber, zoning system of the national park should be planned, arranged, and demarcated by participatory mapping and communal and customary agreement are essential. To avoid conflicts of interest with people surrounding the national park, the government should allocate the cultivated area into special utilization zone of national park. Finally, community development and conservation programs must be performed effectively.

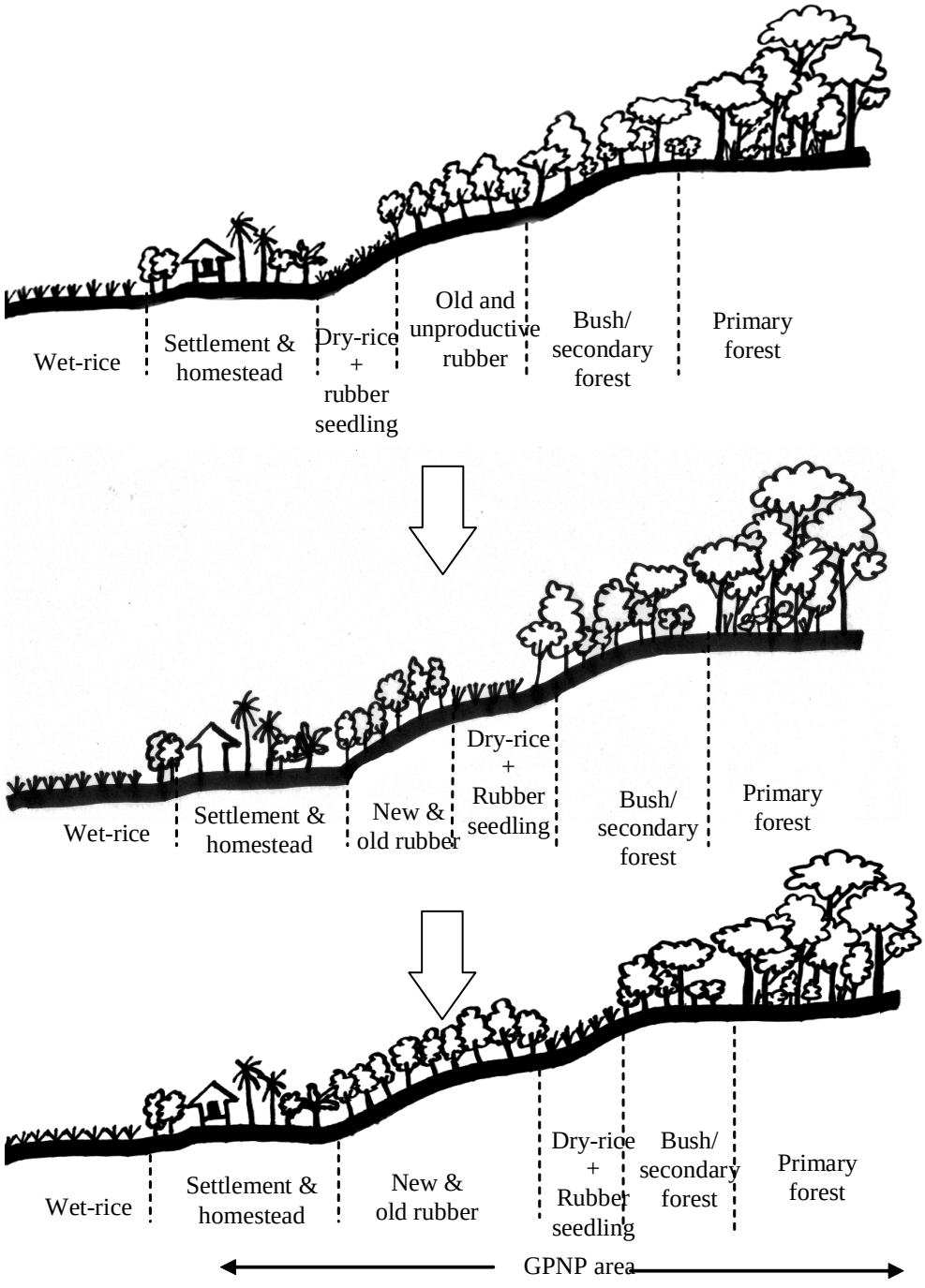

Figure 2 Land use change pattern in W settlement.

Conclusion

Deforestation processs in Gunung Palung National Park was mostly caused by agricultural expansion asproximate cause. It was related with socio-economic-cultural condition of the GPNP surrounding people. The higher income society has more cultivating area than the lower one. A very long time occupation of cultivating area in this region will be a problem of national park management. The longer occupation means the more population, and the more population means the faster agricultural expansion. So that is why, it should be found the solution, win-win solution. And one thing should be reminded that the surrounding people did agricultural expansion and planted not native plant but rubber.

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