

Agents of Deforestation in Sumatra: The big, the small, and the unaccounted (miscounted)
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Alternatives to Slash-and-Burn Programme, Nairobi, Kenya, 2002

The high rate of deforestation in Indonesia (estimates ranging between 1.0 and 1.5 million ha lost per annum in the 1990s) has attracted international environmental concern as scientists further demonstrate the relationship between tropical forests and global climate change, biodiversity, and other ecosystem services. In an endeavor to better understand the problem, several studies have aimed to account for the major actors of forest conversion—from smallholder farmers to large scale plantations to government sponsored settlement schemes—and to assess each group's relative impact over time and space (Kartodihardjo and Supriyono 2000; Sunderlin and Resosudarmo 1996; Dick 1991; Holmes 2000). Unfortunately, although there exists a large volume of literature documenting land use cover and forest conversion in Indonesia, the majority of the data within these documents is either unreliable or extremely difficult to interpret. It has therefore been very difficult to place accurate numbers on the various agents responsible for the change.

This note examines the existing literature on Indonesian deforestation, focusing in particular on the island of Sumatra, where the highest national rates of deforestation have been recorded, and where two key ASB benchmark sites are located (in the provinces of Jambi and Lampung). The review uses as a base a spatial analysis performed by Danan Hadi (199?) of ICRAF Southeast Asia that calculates the areas of large projects in Sumatra, based on MoFEC and MoT maps from various years. The review also draws consistently from two key documents that provide what are (in the author's view) the most comprehensive overviews of the situation to date. John Dick's paper (1991) is based on reports by the Regional Physical Planning Program for Transmigration (RePPPProT) which were compiled between 1984 and 1989, and which are considered to be the first relatively reliable and comprehensive biophysical data sets compiled for Indonesia. A review by Derek Holmes' (2000) compares the 1980s RePPPProT data with more recent data put together by the Badan Planologi of the MoFEC using satellite imagery dating from 1996-1998.

Although it is not possible to assign a definitive estimate to the share of deforestation attributable to the various agents of conversion, three broad conclusions can be inferred from an overview of the literature. Namely, 1) large scale estates account for approximately one-quarter of total deforestation in Sumatra, 2) smallholder activity appears to account for a roughly equal share of Sumatran deforestation, though the available statistics skew this overall percentage downwards, and 3) a significant portion of Sumatran deforestation remains largely unexplained (though plausible explanations are suggested and presented below), and will require further study and analysis.

Dick reported in 1991 that despite the quality of the RePPPProT data, it was impossible to identify the role of smallholders in deforestation with any precision. He concluded, "In the final analysis, the existing data on land use change is so inconsistent, so conflicting and of such poor quality that it probably does not allow reliable estimation of rates of deforestation. RePPPProT provides a good base from which to measure future change but not much insight on past rates of change (i.e. what was there before and how long ago?). It is imperative that an

updated inventory of land use/land condition be carried out to RePPP standards within the next four to five years. Until such reliable, “time-series” information is available, all estimates of deforestation in Indonesia will be nothing more than semi-educated guesses.” (Dick, p.32) Ten years later, Holmes was able to put together such a time-series study with the use of new satellite imagery ranging from 1996-1998 compiled by MoFEC. Although he arrives at a similar conclusion as did Dick with regards to the reliability and interpretability of the existing data, he was able to produce more empirical estimates about the causes of deforestation by province (Sumatra, Kalimantan, and Sulawesi), including some rough numbers for the amount of forest conversion by large scale operators and for smallholders over the past twelve years (1985-1997).

Using Hadi’s spatial analysis as a base and Holmes’ analytical framework as a guide, this review attempts to break down Sumatran deforestation by its various agents, accounting for the inconsistencies that arise during the course of such an exercise. Where relevant, it compares existing data from reliable sources (primarily Hadi and Holmes) in order to strengthen the conclusions.

Large-Scale Operations

Timber and tree crop estates

Of the approximately 19 million hectares of forest lost in the three outer islands between 1985 and 1997, 10% are attributable to timber plantations (HTI), whereas another 13% can be attributed to tree crop estates (HGU)¹ (Holmes 2000). The same figures for Sumatra indicate that the combined impact of HTI and HGU on the island’s total deforestation (8.32 million ha) has been significantly greater, together accounting for 32 percent. The majority of this difference can be attributed to the development of corporate oil palm plantations on several Sumatran provinces (see next paragraph).

Table 1: Forest loss, large-scale timber estates and tree crops estates

	Forest loss b/w 1985- 1997 (Holmes)		HTI, realized b/w 1989 and 1999 (Holmes, MoFEC, updated from SPH 97/98)	HTI, allocated (Holmes) (96/97, stati stik hutan tanaman industri)	HTI, allocated (Hadi) From 1996 maps, MoFEC	Oilpalm area developed b/w 1985- 1997 (Holmes)	Oilpalm Area, 1998 (Holmes, from DG Estates)	Tree crop estates (HGU), or “kebun”, (Hadi)
Aceh	579,656		81,799	376,564	372,144	173,713	206,405	186,324
N. Sumatra	1,212,264		100,190	486,640	562,759	225,471	612,617	69,221
W. Sumatra	572,780		11,371	0	12,319	133,392	137,952	102,286
Riau	1,819,109		291,859	684,312	678,512	566,372	606,165	1,168,470
Jambi	1,156,447		98,740	189,941	166,336	235,559	236,059	264,695
S. Sumatra	2,350,840		252,832	590,069	576,983	302,994	309,761	35,337
Bengkulu	270,297		2,290	5,000	8,230	57,006	57,006	37,205
Lampung	359,243		54,385	282,835	29,215	56,940	74,530	82,113
SUMATRA	8,320,636 (100%)		893,463 (11%)	2,615,361 (31%)	2,406,498	1,751,447 (21%)	2,240,495	1,945,651
Outer Islands	19,063,828 (100%)		1,935,179 (10%)	5,952,232 (31%)	-----	2,401,149 (13%)	2,904,497	-----

¹ Holmes’ estimates for HGU are based exclusively on oil palm plantations data, the primary large scale estate crop in Sumatra. These numbers are therefore a lower bound on estimates of total large scale estate crop development.

A few points are worth noting from Table 1. First, the numbers in Holmes' summary of HTI/HGU activity over a 12 year period (1985-1997) are fairly congruent with those provided by Hadi for *total* HTI/HGU in 1996. This result supports the hypothesis that the majority of large-scale timber and tree-crop estates development has taken place in recent decades. Oil palm plantations in particular have increased nationally from 106,000 ha in 1967 to 2.5 million ha in 1997, an average yearly growth rate of 10.6%. The majority of these plantations are located in 6 provinces, all of which, except one (W. Kalimantan), are in Sumatra (N. Sumatra, S. Sumatra, Riau, Jambi, and Aceh) (Casson 1999). Area for oil palm plantations on Sumatra accounted for 76% of all oil palm development in Indonesia (2,200,000 ha out of an approximate 3,000,000 ha) (DG of Estates, in Holmes). Combining this oil palm development with HTI, the corporate development of plantation estates emerges as the single largest accelerating agent of deforestation in the 1990s.

A second point worth noting is that although approximately 2.5 million hectares of forest had been allocated for timber plantations in Sumatra by 1996, the actual amount realized to 1998 was only roughly one-third of the amount officially allocated. To what extent this 1.7 million ha of "unrealized" HTI land remains forested cannot be determined with precision from the data. However, given the discrepancies between the number of registered HTI developments and the far greater overall timber supply in Sumatra (Brown 1999, from Holmes), it is speculated that a significant portion of this "unrealized" land has already been cleared by large investors for the sole purpose of harvesting timber, and is currently lying idle without any intention of further development. Holmes suggests that an equally extensive area of licensed oil palm estates may have been cleared for timber, and subsequently left undeveloped. It is reasonable to conclude from this information that the overall contribution of large-scale HTI and HGU development to deforestation over the past twelve years has been even greater than the 32% suggested in the table.

Transmigration and PIR/NES schemes²

After 1979, smallholder estates expanded with a government initiative (supported by the World Bank) of the PIR/NES schemes (*Perkebunan Inti Rakyat* or Nucleus Estate and Smallholder scheme). Under PIR/NES, private developers prepared plots of land for smallholders located in the area. After several years, this land was transferred to the smallholders (called Plasma), who managed the estate under the supervision of the private developer. The developer, in turn, was required to purchase the oil palm product from the smallholders (Casson 1999).

At approximately the same time the PIR/NES schemes began, the government-sponsored Transmigration program had begun a fundamental switch away from the development of settlements characterized by subsistence crops and towards the development of smallholder tree crop estates. The majority of the transmigration sector (often in coordination with the PIR/NES schemes) thus became largely subsumed by the "smallholder estates" sector as officially recorded by the DG of Estates. (However, as will be discussed below, the "smallholder estates"

² Upon first glance, one might be tempted to classify deforestation caused by transmigrants and PIR/NES schemes as smallholder activity. However, both categories are orchestrated (if not entirely driven) by large-scale government development projects and/or are directly supervised by private investors who exert priority control over these developments. For this reason, these categories are more accurately classified as large-scale operations along with HTI and HGU.

sector as recorded in official statistics does not reflect the true amount of smallholder land dedicated to tree crops in Indonesia.)

Table 2 lists the recorded, “official” total area of smallholder estate crops developed between 1984 and 1997, as reported by the DG of Estates. It is implied from these numbers that the development of smallholder estates has accounted for approximately 20% of Sumatran deforestation over the past twelve years, roughly equivalent to the percentage attributed to large-scale private developers. The close comparison of these numbers with the numbers compiled by Hadi for total cumulative transmigration area in 1997 are expected, given the aforementioned overlap of the transmigration schemes with smallholder tree crop projects beginning in the 1980s.

Table 2: Smallholder estate crops area v. Transmigration area

	Forest loss b/w 1985-1997 (Holmes)	Smallholder estate crops (developd b/w 1984-97) (Holmes)	Transmigration, 1997 (Hadi)
Aceh	579,656	153,857	142,623
N. Sumatra	1,212,264	136,994	51,601
W. Sumatra	572,780	87,317	87,455
Riau	1,819,109	441,759	375,626
Jambi	1,156,447	255,680	364,085
S. Sumatra	2,350,840	323,227	447,956
Bengkulu	270,297	67,675	115,009
Lampung	359,243	128,141	177,704
SUMATRA	8,320,636 (100%)	1,594,650 (19%)	1,762,059

As mentioned previously, the amount of land recorded as “smallholder estates” does not accurately account for smallholders outside of these large-scale projects. There exists a much larger area of land under the management of independent smallholders that is dedicated to tree crops, especially rubber, that does not appear in official statistics. “Small investors” (to be discussed later) also are thought to contribute a significant portion to this smallholder estate category. The fundamental problem in accounting for the true area of estate crops under smallholder control is spurred by the biased opinion of the Indonesian government (and many development agencies) regarding smallholders’ ability to develop profitable tree-based systems without government guidance and planning (Tomich 1991).

Smallholder activity:

Dick concluded in 1991 that “of all forms of deforestation, the most difficult to assess accurately is that resulting from individual peasant farmers.” Holmes arrived at the same conclusion in 2000, asserting that while “the big estates are certainly the most conspicuous agent [of deforestation],... it is very difficult to assess the role played by the more insidious small farmer.” There is still little available data to record the activity of smallholder farmers not included under some type of government scheme. Past attempts at assigning a share of deforestation to smallholders involved looking at numbers of “shifting cultivators”. Using this definition, the World Bank arrived at the conclusion that by 1990, 14 million hectares of land had been converted by shifting cultivators in Indonesia as a whole (in Sunderlin 1996). Ingram

et al. (1989) did a similar study by province for the 1980s that estimated an approximately 3.4 million ha as converted by shifting cultivators in Sumatra during that decade (see table 3).

However, the term “shifting cultivator” has been consistently criticized as being both misleading and inaccurate as a category of smallholder activity. This is particularly true in the case of Sumatra, where the “textbook” version of traditional shifting cultivation is reported to have all but disappeared (Tomich and van Noordwijk 1995). Moreover, most reports of “shifting cultivation” as smallholder conversion has failed to distinguish between traditional shifting cultivation and the much more damaging effects of spontaneous migration, which have been blamed for the majority of smallholder forest conversion (Sunderlin 1996; Dick 1991).

Holmes uses the term “pioneer farmer” (as a replacement for the antiquated and often misleading term of shifting cultivator) to categorize a predominant agent of smallholder deforestation. Pioneer farmers include spontaneous migrants as well as farmers who have been displaced by large estates. It is thought by some that these farmers usually engage in unsustainable methods of primarily arable cropping on marginal lands, and that most of them lack the resources required to plant tree crops on their cleared land. However, the planting of seedling rubber (after an initial upland rice crop) is purported to be a common practice of these pioneer farmers. Holmes estimates pioneer farmers’ contribution to forest clearance for Sumatra at 1,257,236 ha between 1985-1997, accounting for 15% of total deforestation.

Table 3: Estimates of smallholder activity

	Forest loss b/w 1985-1997 (Holmes)	Estimated clearance by pioneer farmers (1984-97) (Holmes, table 6, based on many assumptions)	Estimated area under shifting cultivation (table 6.0.1, from 80s data, FAO/MoFEC)
Aceh	579,656	66,701	69,500
N. Sumatra	1,212,264	142,847	386,200
W. Sumatra	572,780	176,714	121,800
Riau	1,819,109	139,657	490,500
Jambi	1,156,447	94,163	200,500
S. Sumatra	2,350,840	273,966	1,456,700
Bengkulu	270,297	57,100	214,500
Lampung	359,243	306,088	488,900
SUMATRA	8,320,636 (100%)	1,257,236 (15%)	3,428,600

Residual causes of deforestation:

As stated at the beginning of this review, whereas a significant portion of Indonesian deforestation can be attributed to large-scale operations and smallholder activity, there remains a significant deforestation residual that is for the most part unexplained. The following section attempts to assign some loose numbers to this unaccounted-for remainder, distinguishing between “large” and “small” operations where possible.

Forest fires:

The droughts of 1997/1998, spurred by El Niño weather patterns and the suspension of the regular monsoon rains, contributed to a series of forest fires and a resulting annual forest loss higher than any known annual total in SE Asian forest history. The area of lowland forest “damaged” as a consequence of these forest fires in Sumatra was 691,000 ha (Fortech 1999, in Holmes). If it is assumed that half of this forest damage was mapped as forest loss, the resulting figure for Sumatra is 345,500 ha of lowland forest, or approximately 4% of total forest converted between 1985-1987.

Whether these fires were primarily a result of natural causes or human induced activity, or a combination of both, is difficult to say with much confidence. In the past, smallholders practicing slash-and-burn farming received much of the blame for runaway forest fires on the island. However, this blame is now being spread to large-scale developers as well, who use fire to clear large areas of land for (legal and illegal) logging. Case studies conducted by the ICRAF-Southeast Asia team on the provinces of Lampung, Jambi, and South Sumatra (Suyanto 199#?) provide additional evidence that the underlying cause of forest fires on Sumatra is a combination of smallholder activity and large scale developments (both private and government sponsored). In both cases, it is noted that these fires often result from land tenure conflicts between local communities and large plantations, a problem exacerbated by the lack of a transparent legal system to address land claims, land ownership, and communal rights.

Regardless of whether it is small or large scale activities that are behind the Indonesian fires, forest loss from fires will continue to be a significant problem in the future as long as fire persists as the cheapest form of land clearing available to farmers. The trend of increasing frequency and severity of El Nino events and their associated climatic shocks will only intensify this problem in years to come.

Small Investors:

Holmes attributes a significant amount of recent deforestation to the “small investor”, who he describes as an urban businessman or government employee who purchases rural land and invests in tree crops in order to diversify his/her collection of assets. The small investor hires labor to clear and manage tree crops on this land (usually rubber, cocoa, coffee or cinnamon as opposed to oil palm, unless processing facilities are easily accessible/available). It is believed that many of these small investors do not have formal license to this land and thus are not listed in government statistics for forest conversion. Holmes attributes 10% of total forest conversion in Indonesia to the small investor (though he gives little explanation for how he arrives at this statistic).

Encroachment on protected forest:

A significant portion of deforestation is caused by illegal encroachment on “protected” forest land (Protection and Conservation Forest combined). Looking at Badan Planologi 1999 data to assess forest cover within former TGHK forest status boundaries, it appears that only 70% of protected forest in Sumatra still maintains forest cover. In South Sumatra and Lampung,

these figures were 47% and 52%, respectively (from Holmes, table 4). The encroachment on protected areas is most likely a combination of pioneer farmers, shifting cultivators (minimal), and the small investor activity described above. However, there is evidence that the area of large-scale timber and tree crop plantation development often encroaches on protected areas as well. For example, Bukit Tigapuluh National Park (127,698 ha) in the Jambi and Riau provinces has been threatened by the PT Sumatra Makmur Lestari (8,000 ha) and the PT Arvena Sepakat (5,450 ha) large-scale plantations. A similar situation is occurring in Lampung, where the Inti Rakyat Blambangan plantation encroaches on nearby protection forest (Kartodihardjo and Supriono 2000).

Another problem which may contribute to further encroachment onto protected areas in the future is the government allocation of Conversion Forest in amounts that exceed the total hectares of this type of forest currently available. As a consequence, concessionaires may increasingly turn to protected areas (in addition to production forest areas) for development (see Kartodihardjo and Supriono 2000).

Clear-cutting of large-scale concessions:

As suggested previously by the discrepancy between the overall supply of the Indonesian timber industry and the amount of realized HTI, several large areas officially licensed for conversion to tree crops or timber estates have most likely been clear-cut for the sole purpose of supplying the plywood and pulp mills. As cited in Holmes, it is estimated that up to half of cleared land that is nominally under concession is currently lying idle, and that this undeveloped land accounts for several million hectares of forest loss in recent decades (indeed, the action of clear-felling for timber supply has been singled out as the largest agent of deforestation in Indonesia).

Conclusions:

There are too many holes and inconsistencies in the present data to distinguish with any precision the impacts of the various actors, large and small, on deforestation in Sumatra. However, analysis of recent spatial analyses combined with a review of the literature indicates that both large-scale developments and smallholder activities have been important agents of deforestation, and that neither group can be dismissed. Summarizing the key, distinguishable causes of deforestation over the past 12 years bears the following:

- Timber estates (HTI)—10%
- Tree crop estates (HGU)—20%
- Pioneer farmers—15%
- Small investor—10%³
- Forest fires—4%

As the numbers suggest, large and small scale activities combined are responsible for approximately half of total deforestation (55%) in Sumatra; the other half remains largely unexplained. Accounting for large scale HTI and HGU projects is a fairly straight-forward

³ From percentage used by Holmes for all outer islands

exercise based on existing statistics, confirmed in this review by a comparison between Hadi's analyses and the data compiled by Holmes. Accounting for smallholders involves a lot more guesswork. A proper analysis of smallholder activity on deforestation therefore requires more detailed (and more accurate) studies on this topic. Such studies are needed not only to fill gaps in the data for those groups of smallholders largely "left out" of the statistics (i.e. small investors, independent smallholders, spontaneous migrants), but also to clarify the often ambiguous meaning of already available statistics. For example, the numbers for smallholder treecrop estates tell nothing about how much of this activity is undertaken by individual smallholders v. small investors v. smallholders participating in large government projects (i.e. transmigration, PIR/NES schemes).

While an in-depth policy analysis is beyond the scope of this paper, it would be remiss not to mention the very important link between the problem of deforestation in Sumatra and the Indonesian policy environment. As a blaring example, the fact that the amount of forest under application for conversion exceeds the amount of this type of forest currently available in Sumatra screams for policy reform. There is a clear and urgent need for a re-evaluation and re-classification of forest status in Indonesia, one that takes into account the current state of emergency regarding Sumatra's fast-disappearing natural resource base.

There is a long list of other potential policy reforms that could make a significant impact on the deforestation problem; these reforms may be direct (i.e. government patrolling of Protection Forest boundaries) or indirect (i.e. the establishment of secure land tenure to promote long-term investment in land). However, no policy will be effective unless it is based upon an accurate understanding of the problem, and, as indicated by lack of data for many smallholder groups and by the large unaccounted-for deforestation residual, the problem is far from understood. A more comprehensive grasp of the situation arrived at through further research is needed to ensure that policies are directed at the correct target.

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Annex 1. **Land Use Change in Sumatra: large v. small** (A review of the literature)

Data—1990 to present:

1) Data on forest type and forest use

- a. Forest status, forest cover, and forest use (table 3); Forest cover within forest status boundaries (table 4); Data on land use and allocations (timber estates and mainly oil palm estates) (table 5); Results of forest conversion, development of cleared land by large investors (HTI + HGU) and smallholder estate crops (table 6). [*Derek Holmes, Consultant to the WB, "Deforestation in Indonesia: A Review of the Situation in Sumatra, Kalimantan, and Sulawesi," 17 Jan 2000 (draft)*]
- b. Data by forest type (1998). [*MoFEC, DG of Forest Utilization, "Forest Utilization Statistical Yearbook" (1998)*]
- c. Changes in area of conversion forest (1981-1997) and tree crop plantations to be developed in this conversion forest area. [*CIFOR Occasional Paper 26 (Kartodihardjo and Supriono), "Impact of Sectoral Development on Natural Forest Conversion and Degradation: Timber and Tree Crop Plantations"*]
- d. Forest function and land cover class (1996). [*MoFEC/FAO, "Natural Forest Inventory of Indonesia, Final Forest Resources Statistics Report" (1996)*]
- e. Data on forest concession estates. [*BPS, "Statistics of Forest Concession and Estates and Area by Island in 1995"*]
- f. "Land Uses by Large Projects (forest concessions, industrial timber estates, tree crop estates, and transmigration projects) in Sumatra", [*HPH data from MoF maps (1996) and transmigration data from MoT maps (1997).*]

2) Agricultural data/ land use data

- a. Agricultural Use of Total Arable Land (1992). [*Pierre van der Eng, "Agricultural Practices and Soil During the 19th and 20th Centuries", 1992 (data taken from Luas Lahan Menurut Penggunaannya di Jawa-di Luar Jawa)*]
- b. Land Use Type (1995). [*BPS, "Natural Resource Statistics of Indonesia" (1996)*]
- c. Oil palm area by producer category (smallholder, government estate, private estate) in 1996. [*CIFOR Occasional Paper 18, "Tree Planting in Indonesia: Trends, Impacts, and Directions"(data taken from DG of Estates, 1996)*]
- d. Expansion of palm tree plantations, 1991-1997; Oil palm area by producer category (smallholder, government estate, private estate) in 1997 (from DG of Estates, 1998); Forest land (by forest type) converted to plantations, 1982-1999. [*Anne Carson (CIFOR), "The Hesitant Boom: Indonesia's Oil Palm Sub-Sector in an Era of Economic Crisis and Political Change" (1999)*]

Data—1980's

1) Data on forest type and forest use

- a. Total forest area according to various sources; Forest land area by forest use type (TGHK), 1988; Area of operating/non-operating concessions (1970-1989); Timber estate plantations (HTI) area (1984-1988); Total area of estate crops plantations (1970, 1975, 1980-1987); Area under shifting cultivation and number of shifting cultivators; Area under shifting cultivation by forest type (1985-89); Total number of concessions (1970, 1976, 1980-89). [*MoFEC/FAO, "Statistical Information Related to the Indonesian Forestry Sector", Jakarta, 1989*]

2) Agricultural data/ land use data

- a. Land use type (1984); Forest function areas by land use; Revised forest category by land use type. [*RePPProT, "Review of Phase I Results, Sumatra", Volume One, Main Report, Aug 1988*]
- b. Land use by province, 1989. [*"Development Study on Coastal Roads on the Eastern Coast of Sumatra", data from Central Bureau of Stats, "Land Area by Utilization for Outside of Java, 1989*]
- c. Land use by province, 1982-1983. [*RePPProT data*]
- d. Area of perennial crops by smallholder and estates; Harvested area of annual dryland crops. [*Ulrich Scholz, "The Natural Regions of Sumatra", Volume I (based on maps from Volume II)*]

3) Useful maps?

- a. ICRAF Jambi maps ['86, '88, '92 vegetation maps, roads and land use, concession areas, forest type, land use of forest category]
- b. ORSTOM maps [Agricultural Settlement and Deforestation, Development of Recent Settlements, Constraints on and Evolution of Land Use, Farming Systems and Land Use]

Data—late 1800's-mid 1900's

1) Agricultural/plantation crop statistics (acreage, production)

- a. Rubber production (for all Indonesia), 1908-1940, specified for estates v. smallholders [*P. Creutzberg, "Changing Economy in Indonesia: Vol 1: Inonesia's export crops 1816-1940"*]
- b. Acreage of Peasant Rubber Culture in E. Sumatra, 1941; Expansion of the Rubber Culture in E. Sumatra, 1900-1932; Rubber exports from E. Sumatra (plantation v. peasant rubber), 1922-1939; Acreage of oil palm culture and exports from E. Sumatra and Aceh, 1916-1938; Expansion of tea culture in E. Sumatra, 1915-1932; Percentage of Indonesians engaged in the agricultural and non-agricultural sectors in regions of Sumatra in 1930. [*Thee Kian-wie, "Plantation Agriculture and Export Growth: an economic history of E. Sumatra, 1863-1912"*]
- c. Hectareage of smallholder rubber in 1939-41. [*Kenneth Thomas, "Smallholder Rubber in Indonesia", data from Smallholders Rubber Dept., from Rubber Restriction Census*]
- d. Production of timber, 1925-1941; Production of firewood, 1925-1941. [*"Changing Economy in Indonesia, vol 16"*]
- e. Area/production of tea, Sumatran estates, 1900-1940; Hectares of oil palm on east coast of Sumatra, 1911-1924; Production of oil palm for processing in Sumatra, 1935-1940; Coffee Production from Sumatran estates, 1873-1922; Tobacco Production on Sumatran Estates, 1860-1940; Tobacco area of Sumatran estates, 1920-1940. [*P. Creutzberg, "Changing Economy in Indonesia: Vol 1: Inonesia's export crops 1816-1940"*]

2) Useful maps

- a. Sumatra vegetation maps, 1938
- b. ORSTOM map, Human settlement and Land Use in 1920-1930