Indonesia (Republic of)

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Location and area

Indonesia is an island republic and largest nation of South East Asia, stretching across some 5,000 km and with a north-south spread of about 2,000 km. The republic shares the island of Borneo with Malaysia and Brunei Darussalam; Indonesian Borneo, equivalent to about 75 per cent of the island, is called Kalimantan. The western half of New Guinea is the Indonesian province of Irian Jaya (formerly West Irian); the eastern half is part of Papua New Guinea. The marine frontiers of Indonesia include the South China Sea, the Celebes Sea, and the Pacific Ocean to the north, and the Indian Ocean to the south and west. Indonesia has a land area of 1,904,443 km^2. (Microsoft Encarta Encyclopedia 2002). According to Geoanalytics (www.geoanalytics.com/bims/bims.htm) the land area of Indonesia comprises 1,919,663 km^2.

Topography

Indonesia comprises 13,677 islands on both sides of the equator, 6,000 of which are inhabited.
Kalimantan and Irian Jaya, together with Sumatra (also called Sumatera), Java (Jawa), and Celebes (Sulawesi) are the largest islands and, together with the insular provinces of Kalimantan and Irian Jaya, account for about 95 per cent of its land area. The smaller islands, including Madura, Timor, Lombok, Sumbawa, Flores, and Bali predominantly form part of island groups. The Moluccas (Maluku) and the Lesser Sunda Islands (Nusatenggara) are the largest island groups.
The Java, Flores, and Banda seas divide the major islands of Indonesia into two unequal strings. The comparatively long, narrow islands of Sumatra, Java, Timor (in the Nusatenggara group), and others lie to the south; Borneo, Celebes, the Moluccas, and New Guinea lie to the north. A chain of volcanic mountains rising to heights of more than 3,500 m extends west to east through the southern islands, from Sumatra to Timor. The highest points of the chain are Kerinci (3,800 m) on Sumatra, and Semeru (3,676 m) on Java. Each of the major northern islands has a central mountain mass, surrounded by coastal plains. Puncak Jaya (5,030 m), in the Sudirman Range of Irian Jaya, is Indonesia's highest peak. The most extensive lowland areas are in Sumatra, Java, Borneo, and Irian Jaya.
Volcanic ash and lava have enriched the soil in many areas, and there is a strong correlation between agricultural development, population density, and the location of volcanoes. Java has the greatest concentration of recently active volcanoes (22), and some of the richest soils and highest population densities in Indonesia. (Microsoft Encarta Encyclopedia 2002).

Climate

Indonesia's climate is tropical, with two monsoon seasons—a wet season from November to March and a dry season from June to October. The weather is more moderate between monsoons. The northern islands have only slight differences in precipitation during the wet and dry seasons; the southern islands east of Java have more sharply defined dry seasons, which increase in length with proximity to Australia. Humidity is generally high, averaging about 80 per cent yearly; the daily temperature range (20° - 32° C at Jakarta) varies little from winter to summer. Rainfall in the lowlands averages about 1,800 to 3,200 mm annually; in some mountain regions it reaches over 6,000 mm. (Microsoft Encarta Encyclopedia 2002).

Land use

Indonesia has the world's largest tropical forest reserves outside the Amazon. Forests still cover about two thirds of the total land area, especially in Borneo, Sumatra, and eastern Indonesia. Almost all forestland is owned by the state. Logging has been intensive in some areas, notably Kalamantan. Timber is now Indonesia's largest single export, after oil and natural gas; the country is the world's top exporter of plywood.

About 17 per cent of Indonesia is under cultivation. Intensive cultivation, especially of wetland rice, is largely restricted to Java, Bali, Lombok, and certain areas of Celebes and Sumatra. In most of Sumatra and the outlying islands cultivation is extensive and either for subsistence or plantation-based cash crops; almost 50 per cent of the plantation area is on Sumatra (Microsoft Encarta Encyclopedia 2002).

Wetlands

Extensive natural wetlands are found in the low-lying alluvial plains and basins, flat-bottomed valleys, and grassy savannahs. Mangrove estuaries are extensive in Sumatra, Kalimantan, and Irian Jaya. In addition, Indonesia contains some of the largest artificial wetlands in the world, including millions of hectares of rice paddies and nearly 2000 km^2 of fishponds.
The freshwater swamp area "originally" (= before the influence of humans) covered 108,329 km^2 against a current area of 40,492 km^2, mangroves originally covered 53,711 km^2 against currently 24,237 km^2, whereas peat swamp forests originally covered 196,123 km^2 against currently 106,136 km^2 (www.geoanalytics.com/bims/bims.htm).

Wetlands data are readily accessible at the offices of both PHPA and Wetlands International. There is a fully computerized Indonesian Wetland Database, developed by Wetlands International - Indonesia Program (WI/IP) and operated at its offices in Bogor and Jakarta (Baer 2001).

Peatlands

Already Anderson (1794) mentioned the presence of peat on Sumatra (Wichmann 1909). Peatlands in Djambi (Sumatra) were described by G.C. Groote in 1820 (Wichmann 1909).

Potonié (1907) "Von den in den Tropen vorkommenden Sumpfwäldern, Sumpfgebüschen wissen wir daher noch nicht viel." (vgl. auch Warming 1902. Ökologische Pflanzengeographie. Berlin 2e Aufl. p 176).

Schwaner (1852-1854) was the first to point at the large extent of peatlands in the southern and eastern part of the island of Borneo. W.J.M. Michielsen found peatlands along the Sampit- and Katingan Rivers (Wichmann 1909).

In 1891 the Dutch botanist G.H. Koorders discovered a peatland with more than 6 m thick organic deposits in the eastern part of Sumatra at the left (northern bank) of the Kampar River that he estimated to be over 800 km^2 large (Potonié 1907).

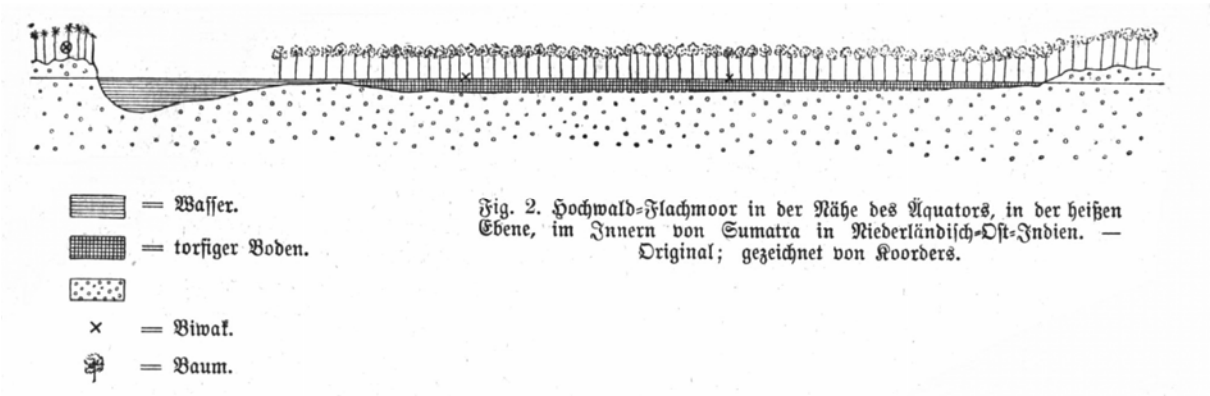

Fig. 2. Hochwald-Flachmoor in der Nähe des Äquators, in der heißen Ebene, im Innern von Sumatra in Niederländisch-Oſt-Indien. — Original; gezeichnet von Koorders.

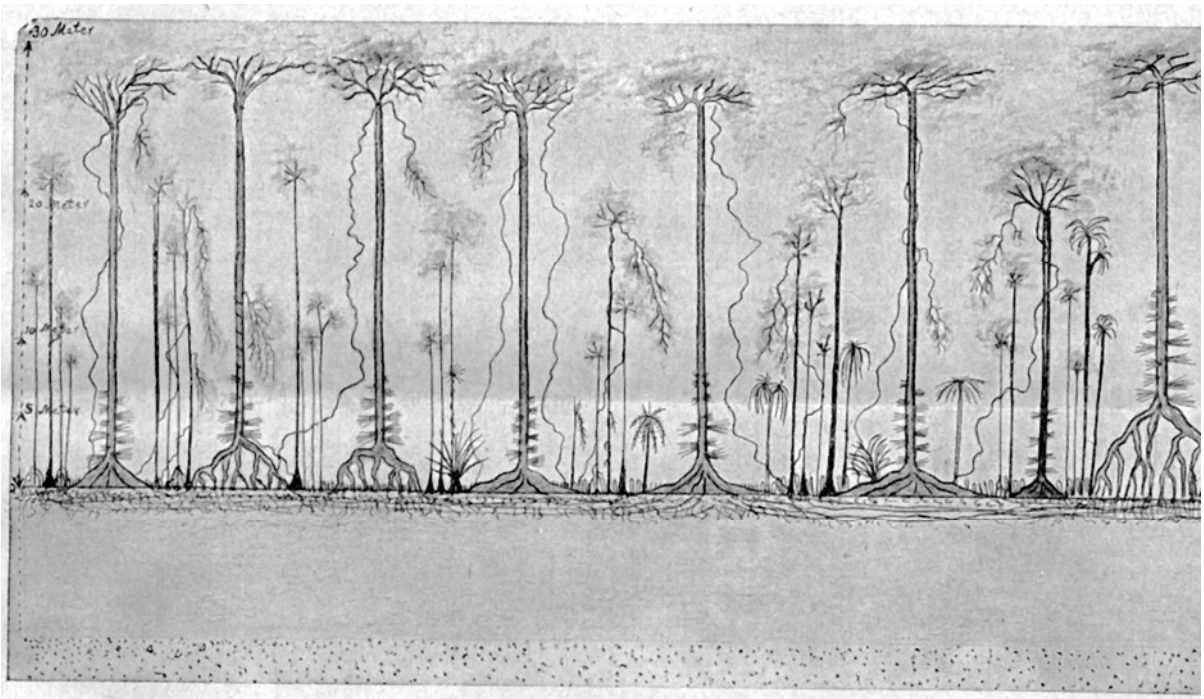

Fig. 3. Teil der Fig. 2 etwas ſtärker vergrößert zur Charakteriſierung der Vegetationstypen des Moores in der Nähe von Biwak 20/21 III 1891. — Original; gezeichnet von Koorders.

Peatlands along the Kapuwas River were discovered by Molengraaff (XX.A.F.) and near the Kenepai River by I.F. Teysmann. Molengraaff also discovered a bog peatland in the Madi mountains in Babas Hantu.

Wichmann (1909) presents an overview of the peatlands of Java, Sumatra (incl. the island of Bengkalis), Kalimantan, and New Guinea. He described especially large extents of peatlands along the northeast coast of Sumatra. In the southwestern and southern parts of the island of New Guinea peatlands were found by J.W. van Nouhuys. In the latter area O.F. Heldring measured a peatland area in the vicinity of Merauke of 2,240 km^2 (Wichmann 1909).
Also Van Heurn (1923) shortly described the peatlands of eastern Sumatra.

Schophuys (1936) described and mapped the peatlands of the Barito catchment in Southeastern Kalimantan. He found approximately 2,000 km^2 of forested peatlands and distinguished:

1. Ombrogenous virgin forested peatlands, especially in the western and northern part of the Barito basin
2. Anthropogenically disturbed forested peatlands, among others near Batumandi and along the Ulin hills east of Banjarmasin
3. Recently deforested peatlands, a.o. between Mahang and the Sungaibuluh road, where severe oxidation of peat is taken place
4. Peatlands of open lakes
5. reed (*Phragmites karka*) peatlands, a.o. in the open areas east of the Barito and the Negara
6. galam (*Melaleuca*) peatlands, mostly on the border of the peatland and tidal area.

According to Rieley et al. (1996b) there are two major types of "peatland" in Indonesia:

- Ombrogenous "peat swamps" that are only fed by aerial deposition with peat up to a considerable thickness and
- Topogenous "freshwater swamps" that are flooded by river water in the wet season with only a shallow layer of organic material (< 30 cm).

This division eventually goes back to Polak (1933a, b, 1941) who mentions the former type for the coastal plains of Sumatra, Borneo, and "probably New Guinea", whereas the latter type is said to occur in the plains of Java and Sumatra and in the mountains of Java, Celebes, and Buru (Moluccas). In contrast to Rieley et al. (1996b), however, Polak (1933a) also describes topogenous peatlands with thick peat layers, including the "pajas" on Sumatra and the "rawahs" on Java, with up to >6 m of peat (cf. Polak 1949, 1951). Deatiled descriptions of the forested peatlands on Borneo are presented by Anderson (19xx, xxx) and Bruenig (1990).

Data on the distribution of "peatlands" in Indonesia are highly variable, due to the different criteria used, which are often not explicitly stated (Radjagukguk 1985, Rosmarkam 1992, Rieley et al. 1996b).

Goldberg (1919) estimates the "peatland" area for the "Dutch-Indian Archipelago" on 10,000 km^2.
Moore & Bellamy (1974) present an area of only 7,000 km^2 but do not explain how they reached that figure.

Euroconsult (1983, cf. 1984) arrives at a peatland area for Indonesia of 88,105 km^2 but only includes the peat resources with > 2 m peat (including peat mixed with other soil types) (cf. Prasodjo & Mukarwoto 1997).

Polak (1952) estimated the total area of "peatlands" in Indonesia "roughly" on 163,498.65 km^2 and presented a first map of the distribution of peatlands. She also mentioned that "more than 1/6 of the large island of Sumatra is covered with such deposits". Andriesse (1974) comes to an area of 165,000 km^2, a figure that is also used by Shell International (1982). This area apparently refers to the area with a peat thickness > 1m (Bord na Mona 1985, Prasodjo & Mukarwoto 1997). The criterium "peat thickness > 1m" is of importance for agricultural inventories, as peatlands with more than 1m of peat, with > 65 % organic material, are generally regarded as unsuitable for agriculture (Radjagukguk 1985, cf. Diemont et al. 1992, who consider deep peats > 2m as unsuitable for agriculture).
The latter figure of 165,000 km^2 is similar to the 170,000 km^2 of Katili (1983), which is said to be composed of 67,810 km^2 on Sumatra, 64,690 km^2 in Kalimantan, 36,250 km^2 in Irian Jaya, and 250 km^2 on Java (totalling 169,000 km^2, which gives the "round" sum of 17 million

ha). Schneider (1980) uses the figure of 170,000 km^2 for the “peatland” area, Bord na Mona (1985) for the “peat deposits”, and Andriesse (1988) for the extent of organic soils. Nugroho et al. (1997), referring to Nugroho et al. (1992) mention an Indonesian “peatland” area of 156,000 km^2.

On the basis of aerial photographs, satellite imagery, and information on land use, RePPProt (1990) estimated the total extent of “peatland” in Indonesia on 200,728 km^2 (Rieley et al. 1996b), but no information is given on the thickness of the peat layer. Diemont et al. (1992) mention a “peatland” area of 200 000 km^2 and define peat as a “soil layer of waterlogged organic debris with variable organic matter and nutrient content”. Safford & Maltby (1998) estimate the “original peat swamp forest” area on 200,000 km^2.

Based on Driessen et al. (1979), Kivinen & Pakarinen (1980, 1981) mention a peatland area (> 30 cm peat) for Indonesia of 260,000 km^2, a figure also used by Markov et al. (1988) for both the area of „peat resources“ (peat thickness not mentioned) and for the peatland area (> 30 cm peat).
According to Kivinen & Pakarinen (1981), who again base on Driessen et al. (1979), 263,000 km^2 is covered by peatland in Indonesia (excluding New Guinea). This figure is quoted by Shrier (1985) for the „mire area“ of Indonesia. Schneider & Schneider (1990) and Pfadenhauer et al. (1993) again use the figure of 263,000 km^2 for peatlands, whereas Setiadi (1992) uses the somewhat smaller figure of 262,000 km^2 for the “total peatland area”.

Anonim. (1969) reported an area of 270,000 km^2. Also Prasodjo & Mukarwoto (1997) estimate the “peatland” area to be 270,000 km^2, while referring to the 88,000 km^2 with a peat layer of > 2m, and the 165,000 km^2 with a peat layer > 1m. * table 1, S.282: list of surveyed peat resources in Indonesia: peat thickness in each location: > 1m! surveyed area: total: 365,050 ha.) According to Radjagukguk (1985) the latter criterium (> 1m of peat) would, however, lead to a figure of 260,000 – 270,000 km^2.

Based on data of Pusat Penelitian Tanah (1981), Pamungkas & Soepardi 1997 mention a total peatland area of 270,630 km^2.

Other authors combine these figures into a range, often without acknowledging that they refer to different inventory criteria. Sugandhy (1997), referring to Radjagukguk (1992), mentions an extent of Indonesian “peatlands” of 165,000 - 270,000 km^2. Rieley et al. 1996b, who refers to the same source (Radjagukguk 1992), gives an estimate of the “area of peat” of 160,000 – 270,000 km², Rieley et al. (1996a) presents the extent of “peat swamps” in Indonesia in a range of 170,000 - 270,000 km^2, whereas Rieley (1997) presents the same numbers for the “undisturbed peatland” area.
According to the interpreted World Soil Map (Van Engelen & Huting 2002) 200,887 km^2 of histosols exist in Indonesia and 101,031 km^2 of gley soils.

Also with respect to the distribution of peatlands over the various islands large differences exist, even if the total areas for Indonesia arrive at similar figures (see table 1).

Table 1: Distribution of “peatlands” over the various regions of Indonesia (in km^2)

	Katili 1983	Radjagukguk 1992 / Sugandhy 1997	RePPProt 1990 / Rieley et al. 1996b / Radjagukguk 1997 *)	Safford & Maltby 1998	Rieley et al. 1996b (pre-development area	Rieley et al. 1996b (area remaining)	Pusat Penelitian Tanah 1981 / Pamungkas & Soepardi 1997
Sumatra	67,810	46,000	82,525	71,600	72,800	46,130	88,750
Kalimantan	64,690	35,000	67,876	43,400	44,310	35,130	65,230
Irian Jaya	36,250	87,000	46,242	84,000	89,100	87,530	108,750
Moluccas **)			972	1,000	480	420	5,250
Sulawesi			3,115		440	340	2,400
Java	250						250
Total	169,000	168,000	200,728	200,000	206,950	169,550	270,630

*) peat thickness = 0.4 m?; as the total figure of 200,728 km^2 according to Radjagukguk (1997) only concerns 89% of the peatland area, the total area would be 225,537 km^2

**) sometimes only Halmahera & Seram

Fig. 1: Peatland forests in Indonesia (after Bruenig 1990) Black: areas with continuous tracts. + : regions with scattered occurrences.

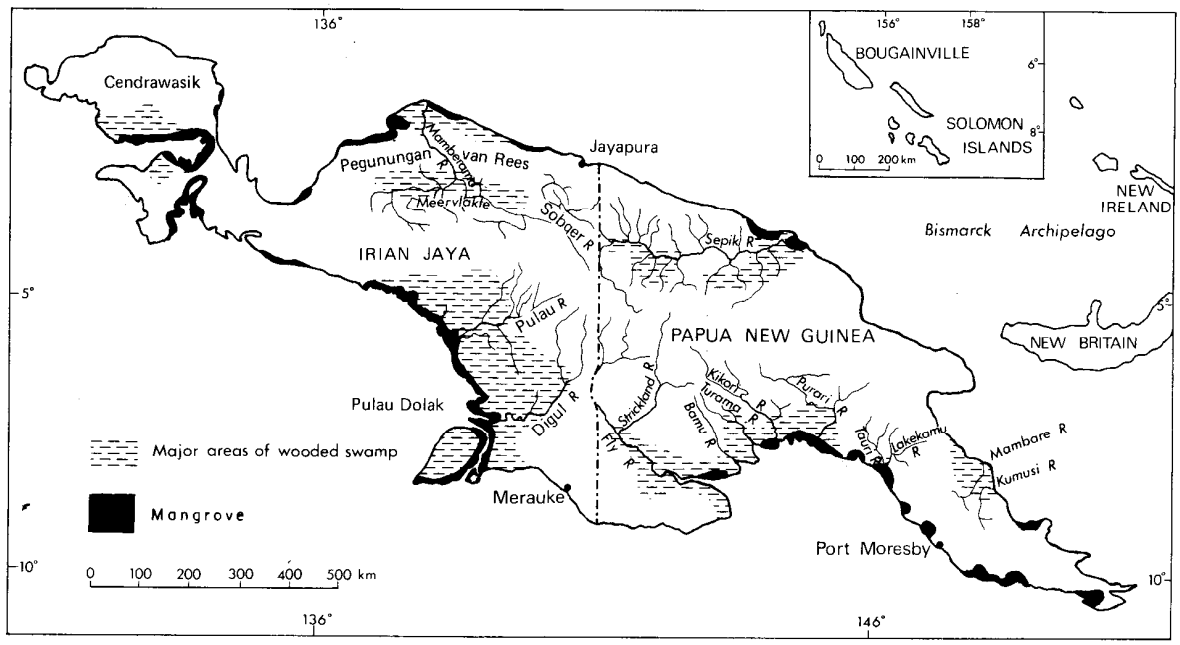

Fig. 2: Major areas of wooded freshwater swamp and mangrove in New Guinea. (After Paijmans 1990).

In West Irian the main areas of wooded freshwater swamps are the deltas of the Pulau (Eilanden) and Digul (Digoel) rivers, de plains around the bay south of Cendrawasik (Vogelkop), and those of the lower Mamberamo River, and the Meervlakte, a hugh structural depression between the central range and the Pegunungan van Rees Mountains to the north (Paijmans 1990, see Fig. 2). Their soils vary from silts and clays to layers of peat that in places is over 2 m thick. Peat soils and peaty soils are also present under coniferous swamp forests above 2000 m (Paijmans 1990).

Mire and peatland losses

Indonesia had 3,000 km^2 of ex-mangrove land put into shrimp production by 1991, with around 10,000 km^2 more of mangrove area planned for conversion to shrimp ponds. Java alone had lost 70% of its mangroves, Sulawesi 49%, and Sumatra 36% (www.earthisland.org/map/mngec.htm#Status). Since the mid 1980‘s the 29,000 km^2 of mangroves in Irian Jaya have come increasingly under threat from large-scale development schemes and unsustainable commercial exploitation of natural resources (logging, mining, oil exploration, trawl fisheries...) (Erftemeijer et al. 2000).
According to Sjarkowi (1997) of the 30,000 km^2 of coastal wetlands and the 20,000 km^2 of undeveloped forest land of South Sumatra Province, only 3,000 km^2 is in a virgin state.

Spontaneous peat swamp colonization began already around 1900 in Sumatra (Scholz 1988). According to Wichmann (1909) many peatlands in Java and Sumatra had already been reclaimed to rice, sugar and tobacco fields and could not be recognized anymore as peatlands. Van Heurn (1923) illustrated peatlands reclaimed to palm plantages near Kampungmesjid in eastern Sumatra.
Schophuys (1936) reports that since 1922 approximately 800 km^2 of deep peatlands east of Banjarmasin (SE Kalimantan) had been reclaimed for agriculture. The more nutrient rich topogenous peatlands were interesting for agriculture. Polak (1933b) mentioned that most

peatlands on Java were already reclaimed (cf. Polak 1949), which had led to a decrease in the thickness of the peat.
The acid peatland swamps were generally considered ill suited to agricultural use (Driessen & Soepraptohardjo 1974, Manshard & Morgan 1988). The absence, however, of competing land use claims and their suitability for a combination of tidally irrigated wet-rice cultivation and coconut planting made the coastal wetlands into a focal area for transmigration (Polak 1941, Scholz 1988).

to be followed by larger scale systems in South and Central Kalimantan in the 1950s and 1960s (Brookfield et al. 1995).

In the 1960s, Indonesia was confronted by a serious shortage of rice, making the country the world's largest rice importer. The tidal swamps were looked to for a ready solution and a national program started in 1968. With tremendous inputs of capital and machinery large sections of the lowland swamps were turned into farmland for wet-rice cultivation (Scholz 1988). By the late 1970s more than 8,000 km^2 of coastal wetlands in Indonesia had been opened up for rice production, principally in Kalimantan and Sumatra.
The early transmigrants who settled on ombrogenous inland peat were advised to burn the peat and use the ash to ameliorate their crop land (Sobar 1979, cited in Pamungkas & Soepardi 1997). Indonesian self-sufficiency in rice was reached in the mid 1980s (Brookfield et al. 1995, Fox 1993).
Maltby et al (1996) detail losses of pristine peat swamps in Indonesia, due to drainage for agriculture and forest clearance, to 5,310 km^2. Rieley et al. (1996b, 1997) estimate that 20% of the swamp forests have been „lost" by drainage and settlement (see tables xxx and xxx). Safford & Maltby (1998), referring to Dwiyono & Rachman (1996), estimate that 37,200 km^2 (18%) of the peat swamp forests have been "developed": 37% of the area present in Sumatra, 20% in Kalimantan, 25% in Sulawesi, 20% in Maluku, and 2% in Irian Java of peatland area. „This could mean 5 million ha of peat swamp are converted."
According to Diemont et al. (1992), 33,000 km^2 of wetlands on mineral soils and on shallow peat have been converted to agricultural use, and another 55,810 km^2 of shallow peat soils are considered as potentially suitable for agriculture. According to Parish (2002) more than 30,000 km^2 of "peatland" has been put into agricultural use. Chew (2003) gives an area of approximately 25,000 km^2 of "peat swamp forest" having been converted to oil palm estate in Indonesia since 1911.

Table xxx: The extent of "peat swamp forest" in Indonesia and their land use[*)] in km^2 (after RePPProt 1990, in Rieley et al. 1996b and Rieley et al. 1997).

Land use (km^2)	Sumatra	Kalimantan	Irian Jaya	Sulawesi	Halmahera & Seram	Total	
						km^2	%
Unclassified	36,372	3,723	3,146	n.a.	n.a.	76,743	38
Unlimited production	29,501	3,123	18,927	611	121	52,282	26
Production & conservation	8,225	19,941	9,983	825	471	39,443	20
Nature conservation	4,773	2,469	6,463	n.a.	49	13,753	7
Limited production	1,993	4,114	5,308	778	242	12,433	6

Protected forest	1,663	1,004	2,417	901	91	6,075	3
Total	82,525	67,876	46,242	3,115	972	200,728	100

*) The data for peat swamp forests and the distinction between some land use categories are unclear. The area drained for agriculture is assumed to have been "lost" (see next table)

Table xxx: Estimated area of "peatland" which has been converted to other land uses (after Rieley et al. 1996b, Rieley et al. 1997)

region	Pre-development area	Area remaining	%
Sumatra	72,800	46,130	63
Kalimantan	44,130	35,130	80
Irian Jaya	89,100	8,7,530	98
Halmahera & Seram	480	420	88
Sulawesi	440	340	77
totals	206,950	169,550	82

The increase in rice yield in the existing sawahs, however, levelled off in the following years. Furthermore the best sawah lands in Java were gradually lost to rapid industrialisation and urbanisation (Notohadiprawiro 1998). Since 1993 the country again had to import rice in increasing quantities (to over 3 million tonnes in 1998). In order to restore Indonesia to self-sufficiency in rice production, President Suharto decided to compensate for the lost rice land by claiming an equivalent area in Central Kalimantan (Rieley 1999b). By presidential decree of 1995 a "mega-project" to develop one million hectares of peatland for food crop production in Central Kalimantan was initiated, aimed at the production of two million tons of rice per year.
The total area of the mega-project was 14,571 km^2 ha of which peat swamps occupied 9,191 km^2 ha, comprising 41 % of the total peat swamps in Central Kalimantan (Notohadiprawiro 1998). The project involve the wholesale destruction of forest in order to clear the area for agriculture and commercial plantations of palm oil, rubber, and timber (Rieley 1999a). Approximately 5,000 km^2 of primary peat swamp forests were felled (Rieley et al. 2000). The biomass residues from these and similar land-clearings in recently drained peat swamps in Sumatra and Kalimantan provided the fuel for immense, uncontrollable fires in 1997 and, to a smaller extent, in consecutive years. Liew et al. (1999) in mapping areas affected by the forest fires in South Kalimantan found a total of 5,520 km^2 ha of land had been burnt in 1997 out of the 36,000 km^2 area surveyed. According to Page et al. (2000) 7,500 km^2 of peat and swamp forest in Kalimantan were damaged by the fire. Much of the surficially drained peat that was supposed to support crops burned away (Murdiyarso & Lebel 1998, Jaya et al. 2000).

Table 1: Peatland distribution in Indonesia by region

No	**Region**	**Original size (ha)**	**Remaining (ha)** [1]	**Protected (ha)**
1	Sumatera	7,282,000	4,613,000	341,000
2	Kalimantan	4,413,000	3,531,000	257,000
3	Sulawesi	44,000	34,000	-
4	Maluku	48,000	42,000	1,000
5	Irian Jaya	8,910,000	8,753,000	1,882,000
	Total	**20,697,000**	**16,973,000**	**2,481,000**

1 As of 1987 [Source: Silvius *et al*, 1987]. It is estimated that up to 3 million ha of peat has been converted or destroyed between 1987 to 2000.

Sewandono (1937, 1938) describes how people on the east coast of Sumatra have occupied the peatlands with a peat thickness of only some dm for agricultural purposes. Where the peat is deeper, only rubber and pineapple can be planted. He also noted a decreased quality of the wood going deeper into the mires.

Table 2: Estimated extent of spatial damage of peat and swamp forest by fire in 1997/98 (ha)

Region	**Area damaged (ha)**
Sumatra	308,000
Kalimantan	750,000
Irian Jaya	400,000
TOTAL	1,458,000

[Source: BAPPENAS Final report on Planning and Drought Management in Indonesia, 1999]

Hope, G.S. and J. Tulip. 1994. A long vegetation history from lowland Irian Jaya, Indonesia. Palaeogeography, Palaeoclimatology, Palaeoecology 109: 385-398.
"mire": Open sedgeland of Lepironia articulata and Marchaerina rubiginosa with occasional orchids and Utricularia caerulea.
10 m of largely lake sediments covering 60.000 y, 780 m, 6 km north of Lake Sentani

Still to be checked:

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Further I: Table 3, S. 47. Locations and areas of deep peat (> 2 m) in several provinces of Indonesia
Further II: Table 4, S. 48. Deep peat resources in Indonesia (10^3 ha)