BIOPHYSICAL PROPERTIES OF THE CONSERVATION AND SUSTAINABLE MANAGEMENT OF BELOWGROUND BIODIVERSITY (CSM-BGBD) PROJECT SITES IN INDONESIA

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Introduction

The Conservation and Sustainable Management Belowground Biodiversity (CSM-BGBD) Project in Indonesia will be conducted in three benchmark areas in Sumatra Island. Two benchmarks, Sumber Jaya benchmark (SJ) and Pakuan Ratu benchmark (PR) are located in Lampung Province, while the other benchmark will be located in Jambi Province (Figure 1). The Jambi benchmark also consisted of two sites, Rantau Pandan and Muara Kuamang. The benchmark areas represent the ecological zone of Sumatra Island, which consisted of mountainous, piedmont, peneplain and swampy areas. Sumber Jaya is located in the mountainous areas, while Rantau Pandan in the piedmont areas, both Muara Kuamang and Pakuan Ratu are located in peneplain region.

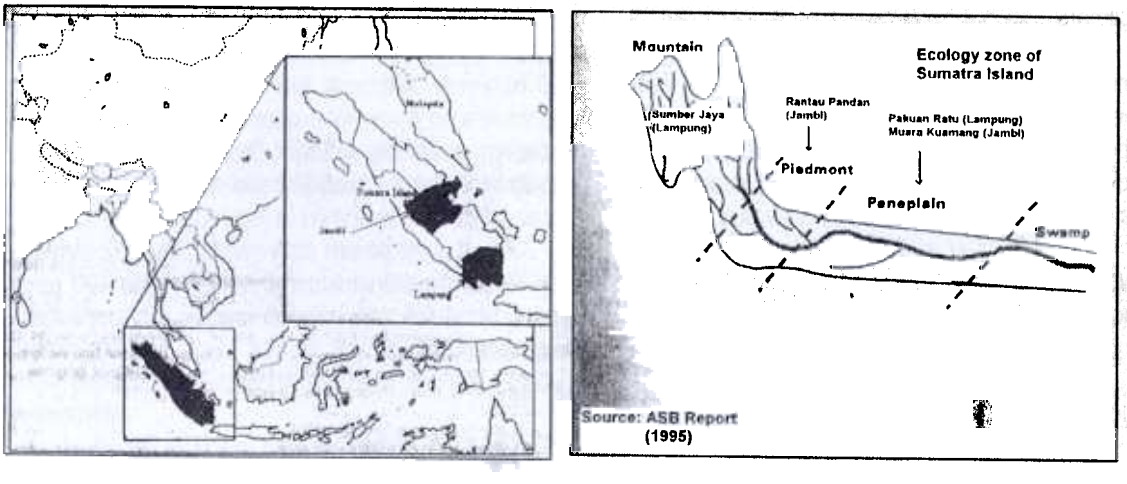

Figure 1. Location map of Sumatra Island, Lampung and Jambi (A) and position of the benchmark areas from the ecological zone view point of Sumatra Island (B).

In addition to this, Lampung Province represents the areas with high population density and high - pressure on natural resources, in contrast with Jambi Province, which represents low population density. Population cencus in 2000 showed that the population of Lampung was 6.7 million while Jambi had 2.4 millions population. Lampung province has the highest population density in Sumatra Island, 191 population per km^2, while Jambi has the lowest population density, 45 population per km^2 (BPS, 2003).

Lampung Benchmarks

Sumber Jaya area is located in western part of Lampung Province, while Pakuan Ratu is in northern part. Both areas are situated in Tulang Bawang watershed, in which Sumber Jaya area is located in the headwater of the watershed while Pakuan Ratu is in the middle of the watershed.

Sumber Jaya Window

Topography and geology

The altitude ranges from 725 m asl to 1718 m asl. Several mountains occurred in this area with the elevations of 1394 m (Bukit Rigis), 1034 m (Bukit Baringin), 1703 m (Bukit Balirang) and 1718 m (Mt. Sekincau). About 85% of this area is mountainous; gentle to moderately steep slopes are found in interhill miniplains (3 - 30%), however, the slopes are mostly moderately steep to abrupt (16 - >45%).

According to the Amin *et al.* (1994), the research site is situated in Recent Volcanic Formation (Qhvs). This formation is located in the middle part of Barisan Zone, and its materials were derived from Rindingan Mount in the Holocene age. The materials of the formation consist of andesitic to basaltic breccia, lava, and tuff. Underlying the above materials which are located in the southern part of the research area is the Rigis Hill, in which its materials were derived from older materials from Hulusimpang Formation (Tomh). These materials were accumulated in the Tertiary period during the late of Oligocene to earliest Miocene epoch, and consist of andesitic to basaltic rocks. In the middle of Miocene, these materials (Tomh) were intruded by granitic rocks (Tmgr) and were exposed in the southern part of the Rigis Hill.

Climate

Analysis of the data from 1974 - 1998 showed that the average annual rainfall ranged from 2426 mm to 3366 mm, with average rainfall of 2500 - 2600 mm/year. Although there is no sharp distinction between the wet and dry seasons, the rain is mostly concentrated from November to May. In dry season, the mean monthly rainfall is still above 100 mm. The climate condition at Pajar Bulan station shows the following data. The relative humidity is around 87%, with its maximum value 99%; the average temperature is around 22°C, with the minimum value of 14.2 °C. The rainfall pattern is shown in Figure2.

Afandi *et al.* (2002a) reported that from 1995 - 2000, the maximum daily rainfall was 82 mm/day, which concentrated in two hours, occurring in January 1998, while the maximum intensity was 120 mm/h occurring in March 1999. Afandi *et al.* (2002a) also reported that the daily rainfall was usually occurred in intermittent pattern, hence in one day there would be several rainfalls.

Soil

The recconaisace soil map of the areas (Soil Survey Staff, 1998) showed the soils are dominated by Dystropepts and Humitropepts (Hikmatullah *et al.*, 1990). Detail observation also showed that the soils were Destrudepts (Afandi *et al.*, 2002c). Afandi *et al.* (2002c) reported that although the soils in this research area were formed by recent volcanic materials, the result of mineral analysis showed that the soils contain low weatherable minerals (<10 %) which are almost the same as *ultimate soils* (Oxisols), and the weatherable mineral in the sub surface horizon was less than 1%. Lumbanraja *et al.* (1999) reported that the soils were mostly heavy clayey containing more than 30% clay; the major clay mineral species was tubular halloysite (7 A) with accompanying vermiculite - chlorite intergrades, quartz, cristobalite, and some iron oxide minerals.

Land use

Based on satellite imagery, Dinata (2002) reported that the land use in Sumber Jaya in 2000 consisted of: residential areas (2.2%), paddy rice (3.3%), coffee plantation in various management (70.8%), grass (9.1%), cleared land (1.2%), shrubs (1.0%) and dense forest (12.5%). Syam *et al.* (1997) reported that in 1970 the forest occupied 57.38% of that area and became 21.39% in 1990; on the other hand, the monoculture plantation (coffee plantation) increased from 0% in 1970 to 41.77% in 1990.

On field level observation, Afandi *et al.* (2002b) reported that there were many shrubs areas which grew along the river areas ("riparian"), which effectively prevented soil loss. Afandi *et al.* (2002a) also reported that although the farmer applied "clean - weeded" management in coffee areas, the soil loss based on plot scale measurement was very low, with the maximum of 22.7 t/ha.

Pakuan Ratu benchmark

Research on BGBD Project in the middle area of Tulang Bawang Watershed will be located around Way Kiri River with longitudes between 104°50′ - 105°00′ (East) and 4°25′ - 4°30′ (South).

Topography and geology

The main landform of the Pakuan Ratu benchmark area is acid tuff plain with undulating (3 – 8%) to rolling (8 – 16%) slope classes, and 25 – 100 m a.s.l altitude. Alluvial landform occupies a small part of this area, particularly along meandering belt.

According to Gafoer *et al.* (1993), the most part of the Pakuan Ratu area is located in the Kasai Formation (QTk), and the small part is in the Recent Alluvium (Qa). The Kasai Formation, which was previously named the Upper part of Palembang Zone (Bemmelen, 1949), consists of conglomerate and quartz sandstone, tuffaceous clay stone containing silicified wood with pumiceous tuff and lignite intercalations. Aggradation processes, which began in the early Tertiary Period until the early Quarternary Period filled the geosynclinal of Sumatra by sedimentary rock materials (Palembang zone) and formed widespread of peneplain in South Sumatra. The upper part of Palembang zone or Kasai Formation (± 150 m thick) was deposited overlying the Muaraenim Formation (Tmpm) during Pliocene Epoch (late Tertiary) until Pleistocene Epoch (early Quarternary). The Recent Alluvium, which was accumulated in the Holocene Epoch, consists of boulder, gravel, sand, silt, mud, and clay. Those materials can be found along meandering belt of Way Besai River. Both of the two Formations belong to acid rock materials.

Climate

Rachman *et al.* (1997) reported that the annual rainfall was around 2500 mm/year with average annual temperature of about 26.8°C. The rainfall pattern in this area is shown in Figure2.

Soil

According to the Land Unit and Soil Map of the Baturaja Sheet 1:250.000 (Hikmatullah *et al.*, 1990), there are several classes of soils (Great Soil Group Category, based on USDA, 1987) in the Pakuan Ratu benchmark area. Soils in the acid tuff plain were dominated by *Hapludox* and *Dystropepts*, while soils in the floodplain of meandering river (alluvial landform) are dominated by *Tropaquepts, Dystropepts*, and *Fluvaquents.*

Land use

Several land use types could be found in the Pakuan Ratu benchmark area in later years, such as secondary forest, fresh water swamp forest, riparian forest, mixed perennial crops, shrub and bush, upland crops, and grassland. There are some big private and national estate plantations, such as sugarcane plantation, oil palm plantation, pineapple plantation, and rubber plantation.

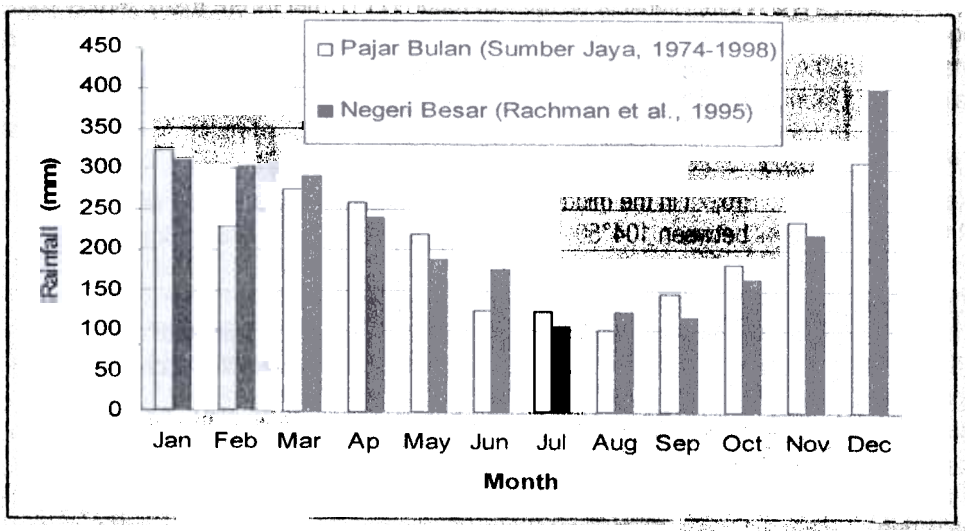

Figure 2. Rainfall pattern in Sumber Jaya and Pakuan Ratu.

Jambi Benchmarks

Rantau Pandan Window

The location of Rantau Pandan window area is in the latitude of 101°45' - 102°00'E and 1°37' - 1°44'S. This area represents the piedmont zone ranging from 100 to 500 m a.s.l. The upper part of this benchmark area is part of the Kerinci Seblat National Park (KSNP). Rantau Pandan benchmark area has a fairly stable population, without much inflow of migrants, and its land use is dominated by agroforests mainly jungle rubber with recent increases in share of Cinnamomum or Cassiavera.

Topography and geology

According to van Noordwijk *et al.* (1995), there were two types of landform in Rantau Pandan benchmark area, i.e. 1) floodplain, along the Bungo river and 2) hilly area, well - drained soils formed on granite and colluvial materials.

Geological map of Painan Quadrangle (Rosidi *et al.*, 1976) show that the Rantau Pandan benchmark area belongs to the Pelepat and the Granite Formations. The Pelepat Formation consists of andesitic lava, while the Granite Formation consists of pegmatite.

Climate

Climate data for the nearest three stations are shown in Table 1. The nearest climate data available are for relatively low elevation stations, so they may a bit underestimate rain fall and overestimate temperature for the higher parts of the benchmark area. Annual rainfall ranges from about 2898 to 3146 mm. According to the rainfall classification of Schmidt and Ferguson, this benchmark area is in class A, with 12 months of more than 100 mm rainfall. Based on the classification of agroclimatic zone (Oldeman, 1975), this benchmark area belongs to agroclimatic zone B1, because it has 7 - 9 wet months (>200 mm rainfall) and less than 2 dry months (<100 mm rainfall). The average of air temperature ranges from 27.1°C in July to 30.4°C in September.

Biophysical Properties of the Location Sites

Table 1. Climate data for the Rantau Pandan benchmark area (Rachman *et al.*,1997)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Rainfall (mm)													
Tanah Tumbuh*	339	273	230	353	171	109	115	181	191	217	336	411	2926
Rantau Panjang*	302	234	234	317	236	147	121	209	165	269	280	343	2898
Bangko*	313	268	268	299	245	142	147	206	170	297	345	389	46
Temp. (°C)													
Average	29.1	28.6	28.6	29.1	28.7	29.4	27.1	29.4	30.4	28.9	28.8	29.0	28.9
Stand. Dev.	0.30	0.30	0.30	0.15	0.60	0.40	0.20	0.10	0.05	0.10	0.05	0.25	0.23
Max	33.5	32.5	32.1	32.9	32.5	32.8	28.1	32.7	34.8	33.9	33.2	32.9	32.6
Min	24.6	24.8	25.0	25.3	24.9	25.9	26.0	26.0	25.9	23.8	24.3	25.1	25.1
ETP (mm)	112	123		34	120	117	114	127	127	117	97	124	450
Radiation (MJ $m^{-2}day^{1}$)													
Average	15.2	15.6	16.(		14.3	13.6	13.9	4.7	15.5	15.8	15.2	15.(	15.0

*Climate Station

Soil

Tropofluvents were found in the floodplain along the Bungo river with slope of less than 1% and contributed 12% of the whole area. Three types of soils in the sub group category occupied 88% of the whole area and distributed in five land units, and they were found in the hilly area of this benchmark. Those soils are *Oxic Dystropepts*, *Typic Dystropepts*, and *Lithic Dystropepts*. Soil solum varies between shallow and very deep. *Lithic Dystropepts* represent soils with shallow soil solum, while *Oxic and Typic Dystropepts* represent soils with deep to very deep soil solum. All of soils in the benchmark area have low base saturation (<50%) in all subhorizons between depths of 25 cm and 100 cm, or between 25 cm and a lithic contact. CEC of soils are generally low, particularly in the *Oxic Dystropepts* that have CEC clay of less than 24 cmol(+) kg^{-1}. Soil with low CEC clay shows the domination of kaolinite in the clay fraction.

Land use and farming systems

van Noordwijk *et al.* (1995) had identified ten kinds of land uses found in this benchmark area ie: 1) natural forest, 2) community - based forest management, 3) commercial logging, 4) rubber agroforests, 5) rubber agroforests with clonal planting material, 6) rubber monoculture, 7) oil palm monoculture, 8) upland rice/bush fallow rotation, 9) cassava/Imperata rotation, and 10) wetland rice fields.

Muara Kuamang Window

Geographically, the Muara Kuamang window area is sited in the latitude between 102°10' - 102°20'E and 1°30' - 1°40'S. This area represents the peneplain zone of Sumatra. There are several streams as the tributaries of Batanghari river i.e. Bungo Tebo river, B. Senamat river, B. Pelepat river, and Kuamang river. Kuamang village is in the sub - district of Pelepat and represents the local farmers (Jambi ethnic group).

Geology

Rachman *et al.*(1997) reported that there were two kinds of landform found in this benchmark area, i.e. floodplain along the streams and rivers and undulating to rolling peneplain. According to Geological Map of Sumatera 1:2,500,000 (Rosman and Dai, 1979), this windows area is located in the recent volcanic rock materials. Geological Map of Muarabungo Quadrangle (Simanjuntak *et al.*, 1991) gives information in more detail. This area particularly consists of the Kasai Formation (QTk) and Muaraenim Formation (Tmpm). Rock materials in the Kasai Formation were accumulated from the late Tertiary period (pliocene epoch) until early Quarternary period (plistocene epoch), and consist of conglomerate, quartz sandstone, tuffaceous

claystone, and massive acid pumiceous tuffs. Muaraenim Formation was accumulated in the Tertiary period (from the miocene until the pliocene epoch), and consists of claystone, silstone, tuffaceous sandstone as well as coral intercalation.

Climate

The climate data from the nearest three stations (Muara Bungo, Kuamang Kuning, and Muara Tebo) show clear difference of annual rainfall, particularly between Muara Tebo (2149 mm/year) and the two others (2982 mm/year in Muara Bungo and 3012 mm/year in Kuamang Kuning). According to the rainfall classification of Schmidt and Ferguson, this benchmark area is in class A, with 11 - 12 months of more than 60 mm rainfall. This benchmark area belongs to agroclimatic zone B1 - C1 according to the classification of agroclimatic zone (Oldeman, 1975), because it has 5 - 9 wet months (>200 mm rainfall) and 2 or less dry months (<100 mm rainfall). The average of air temperature ranges from 25.6°C in January to 26,3°C in May, June, and October.

Soil

Tropofluvents was found in the flood plain, and Typic Kandiudox was found in the peneplain.

Land use and farming systems

van Noordwijk *et al.* (1995) reported that there is no primary forest left in this area, as all forest has been logged. The dominant land use in this area is secondary forest/bush and agroforestry in which rubber is the dominant crop. The other land uses found in this area are wetland rice field/cultivation, annual crops, secondary forest (jungle rubber), garden of perennial crops, and oil palm plantation.

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