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# Carbon Storage in the Northern Sebangau Area between Tangkiling and Kasongan, Central Kalimantan

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## ABSTRACT

Tropical Peatland has been accumulated between the Rivers Rungan and Katingan in Central Kalimantan during the last 10,000 years. Since the 1980s peatland and Peat Swamp Forest (PSF) is being cleared for the construction of the Kalimantan highway between the rivers Rungan (at Tangkiling) and Katingan (at Kasongan). Before then access to that area of peatland was only possible by boat (Sieffermann et al. 1988, Rieley and Page 1997, Rieley et al. 2001, Boehm et al. 2005). Since then land development projects have taken place in form of human settlements, agricultural activities and plantations, which have greatly increased the risk of peatland fires during the dry season. In 1997 and 2002 El Niño prolonged the dry season considerably increasing the risk of fire. With the help of Remote Sensing and a Geographical Information System (GIS) an exact survey is possible, providing information as to the changes in the landscapes and the condition of the environment and an integrated planning and management program can be achieved.
To understand better the situation of that area peat drillings parallel to the Kalimantan highway along the transect Tangkiling and Kasongan have been done in 2006. Results of these peat measurements showed a peat depth up to 8.10 m. The estimation of stored peat volume and carbon for the northern Sebangau Catchment and Palangka Raya between Katingan and Rungan rivers up to the border of the heath forest is 7.1x10exp9 m³ (res. 5.93x10exp9 m³) peat volume. The content of carbon in 1 cubic meter of peat has been measured to be 154.3kg. We found a stored Carbon value of 0.92 to 1.1x10exp9 tons for this area. The pH-values of water were very acidic and three soil samples showed a very low nutritional value. It will be necessary to rehabilitate this fragile peatland ecosystem.

To measure the topography of the peat land under the PSF it is proposed to use a high-resolution Airborne Laser-Scanner (ALS). With this device the z-range resolution (height) measurement can be increased to a value better than 0.15m. This laser-scanner can measure the height of the PSF at the canopy area with the first echo and the peat surface and peat dome with the last echo. Tree height of the PSF can be obtained by subtracting the two echoes and the bio-mass by multiplication height x area. With the additional peat depth drillings, this method will evaluate the amount of stored Carbon in peatland better than the presently used methodology. High quality hydrological models can be analysed with this method and thus offer a better understanding of peatlands (Boehm 2006). Laser-scanner technology has come out of the research phase and is now fully mature.

# INTRODUCTION

## Geographic location of the research site

Tangkiling District is located to the North of Palangka Raya in Central Kalimantan and has 7 unusual granite hills in the normally flat topography lowland peat land with high annual precipitation. Tangkiling village is located 34 km from Palangka Raya, the provincial capital, on the Kalimantan highway to Sampit. Approx. 45 km away from Tangkiling (79 km from Palangka Raya) is the village Kasongan on the Katingan River. Between the two rivers a huge amount of peat has been accumulated up to more then 8m deep. In order to estimate the stored carbon and to measure the precise water shed of the peat dome, peat drillings were carried out in spring 2006 every 500m along the highway and 200m from the road. This research area is approx. the northern part of the so called Sebangau Peatland Catchment up to the heath forest.
Landsat ETM images 118-61 acquired on 30 June 1991 and 14 Jan/15 Feb 2003 were compared by using detailed analysis of the region around the Tangkiling granite hills, the black water river Rungan and Kasongan on river Katingan. These images show major changes in this large remnant of tropical peatland due to high rates of deforestation and fires in 1997 and 2002 (Boehm et al. 1995 and 2000). The 1991 Landsat image shows very clearly in different green colours the different PSF and peat lands (Figure 5). With the peat drillings we analysed the types of PSF and the peat thickness. The ground survey confirmed the areas of tall and medium PSFs. Also the peat volume and carbon was estimated in this area. We also used Shuttle Radar .... (SRTM)-Data with the Digital Elevation Model (DEM) information acquired in Feb. 2000. With the new highway built in the 1980s many people were able to enter the previously inaccessible interior of this peat land landscape, exploit residual timber resources, mostly on an illegal basis, and use fire as the most economical method of land clearance. It is going to be important to restore this fragile flat tropical peatland in the future.

# METHODOLOGY

## Peat Drilling and Carbon estimation

We used the normal peat drilling equipment and two Global Positioning Sensors (GPS) and a compass (Figures 1 – 4). Along the transect Kasongan at km79 with the Katingan River to Tangkiling at km34.5 with the Rungan river we drilled every 500m parallel to the Kalimantan highway at 200m distance peat holes to find the peat thickness. Peat samples from 0 - 20 cm depth and the mineral soil below the peat were taken for pH, C and nutrient analysis to the Analytical Laboratory at Palangka Raya University. Water samples from the seven small rivers which cross the transect were also brought to the laboratory for pH analysis (Table 1). Nutrient analysis for the mineral soil was carried out on three samples near Tangkiling area (Table 2) for Rungan Sari and Transmigration area km38. Table 3 contains the 91 peat drillings with peat depth, vegetation, the location and the mineral below the peat.
C analysis was carried out on 22 samples and bulk density analysis on 12 samples (Table 4). pH value of the mineral soil below the peat was analysed for 21 samples (Table 5) along the transect (Hardjowigeno 1993 and Sulistiyanto 2004). We estimated two peat area types in the GIS (type1, brown, with 5 to 6m peat depth and type2, yellow, with 2.5m to 3m depth) in order to calculate the peat volume and the stored carbon between the Rivers Rungan and Katingan.

The method used for peat and mineral soil analysis can be seen in the table below:

| No | Parameter | Method |
|---|---|---|
| 1 | Peat, mineral soil, and water pH | pH meter |
| 2 | C-organic | Loss on ignition |
| 3 | Bulk Density | Ring sample |
| 4 | N total | Kejhdahl method |
| 5 | Available P | P-Bray 1 |
| 6 | K, Ca, Mg, and Na exchangeable | Ammonium Acetate pH 4.8 |
| 7 | C E C (Cation Exchange Capacity) | Ammonium Acetate pH 4.8 |
| 8 | Texture | Pipette method |

## Data Processing

### *Land cover classes with peat land and PSF types:*

Basic image processing was done using the Remote Sensing Software ENVI4.2. Raw image files were imported into ENVI and bands 5, 4 and 3 were selected to produce a colour RGB image. This band combination proved to be the best in this tropical region. It allowed separating more than 20 vegetation and land use classes. With a Global Positioning Sensor (GPS) points were collected during peat drillings using the waypoint mode of the GPS. With the Geographic Information System (GIS) software ArcView3.3 the peat drilling locations were superimposed to the LANDSAT images from 1991 and 2003 (Boehm *et al.,* 1995, Boehm & Siegert, 2000, Boehm et al. 2003, 2004, Boehm 2004 and 2006). The analysis was made by visual interpretation in the images. Maps were prepared for an area of 29 x 46 km² between Kasongan and Tangkiling using the Satellite images from 30. June 1991 and 15. Feb. 2003 (Figures 5 and 6) with classified areas of PSF types. We used for the estimation of stored peat volume and carbon for the northern area of Sebangau Catchment and Palangka Raya between rivers Katingan and Rungan up to the border of the heath forest the LANDSAT image from 1991, with the different visible colours for PSF types (Figure 5 and 13).

### *ERS and SRTM-DEM elevation data with existing vegetation types:*

Additionally we used multi-temporal Radar ERS data from 1996 and 1997 to see the opening process of the PSF (Figure 7) compared to the Landsat image from 1991 (Figure 5).
To get information about the elevation along the transect we used the SRTM DEM data from February 2000. Different heights of elevation lines were analysed in ArcView in combination with the peat drillings (Figures 8 and 9) and shown by different colours. Cross-sections along the transect were prepared for the highway without PSF and to the north parallel to the transect with PSF (Figure 11 and 12).

## RESULTS AND DISCUSSION

Table 1 shows the pH-value from the seven small black water rivers crossing the Kalimantan highway ranging from 3.41 to 4.74 with the average of 3.7. There is one pH-value from a small river at km36.2 showing a pH-value higher than 4.0 with a value of 4.74. This river comes from the Tangkiling hills and flows mainly over a mineral soil area. The pH-values of the other six rivers were analysed between 3.41 and 3.73. These rivers come directly from peat land area. These pH-values are higher than Sulistiyanto's results. Sulistiyanto (2004) reported that the water running off the Sebangau area range from 3.04 to 3.18. The pH-value usually indicates where the water comes from.

Table 2 present the results of the nutrient analisis for three soil samples under very shallow peat land (7cm deep / km36.5) and two samples with no peat but only quartz sand, RS1 (km36) at Rungan Sari and km38 at the transmigration area. Table 2 shows that almost all macro nutrients in that area have very low values (K, Ca, Mg and Na) with exception of P which has a low value, based on criteria from the Bogor Soil Research Institute (PPT, 1983, cited by Hardjowigeno, 1993). The macro nutrient cation exchange capacity (CEC) was very low too. Based on these results of nutrient analysis, we can conclude that the fertility condition of the soil at that area is low.

Table 3 shows the variation of peat depth and mineral soil below the peat from Kasongan to Tangkiling transect. Very shallow peat can be found from km79 to km77.5 and in several locations there is no peat at all. There is deep peat from km77 to km76.5. This area is near to the black water river at km 76.8. Between km76 and km64, there is fluctuation in peat depth from 0 cm (no peat) to 170 cm peat depth.
The dome shape is between km63.5 and km47. The thickness of peat increases gradually from km62.5 to km54 with the thickest peat depth at km53.5 with 810cm depth. At this location the peat dome has it`s maximum. After km53.5 the thickness of peat decreases gradually until km47.5 with only 5cm depth. From km47 to km34.5, the thickness of peat is very shallow and

several drilling holes had no peat at all, except at km40.5 and km40. On the river side the soil under the peat is sandier and under the rivers themselves are partly clay.
Shallow peat with sand below can be seen in Figure 10.
There is a variation on mineral soils types below the peat along the transect Kasongan to Tangkiling. Most of the mineral soil below the peat was sand (quartz sand) and hardpan, only a few places had clay. Table 5 shows that there is a variation on mineral soil pH-values below the peat from 3.32 to 4.97 with the average of 4.01. According to Soil Research Institute (PPT, 1983 cited by Hardjowigeno, 1993) the state of mineral soil below the peat is very acid.

The peat itself has in average a bulk density of 0.275 g/cm³ (from 12 samples 0 – 20 cm peat depth (Table 4)). The average of C organic content is 56.1% (from 22 samples from 0 – 20 cm peat depth (Table 4)). From the data above we can calculate that the peat weight in 1 $m^3$ = volume x bulk density = 1,000,000 cm³ x 0.275 g/cm³ = 275 kg.
The amount of C in 1 $m^3$ peat = 0.561 x 275 kg = 154.3 kg.
With the help of the SRTM-DEM information we analysed the transect cross-section (Figure 11). The peat land without trees has in average on the river side an altitude of 22m to 25m and at the peat dome of approx. 40m. That means a soil-peat-accumulation between the shore of the rivers and the peat dome is approx. 15m to 18m. Since the 1980s the PSF along the highway has been logged. The primary PSF in Figures 8 and 9 have a canopy top of up to 60m. That means that the tall PSF in this area is between 20m and 25m high. The height of the trees was confirmed with 24m by ground measurements.
The amount of stored peat volume and carbon can be estimated for the northern area of Sebangau Catchment and Palangka Raya between rivers Katingan and Rungan up to the border of the heath forest in the following calculation:
5m to 6m in average x450x10exp6 m² = 2.25 to 2.7x10exp9 m³ big peat area and 2.5m to 3m average x 1473x10exp6 m² = 3.68 to 4.42x10exp9 m³ medium peat area.
The sum is for the northern Sebangau Catchment **5.93 to 7.1x10exp9 m³ peat volume.** One m³ peat contains for this peat land 154.3kg Carbon. So we find a stored **Carbon value of 0.92 to 1.1x10exp9 tons** for this area. This is in line with the calculations of Page et al. 2002 for a bigger area in Kalimantan and Indonesia.

## CONCLUSION

This paper provides information on peat thickness, type of mineral soil below peat including pH-values, the chemicals characteristic of quartz sand along a transect Kasongan to Tangkiling. The amount of C in 1 $m^3$ peat was analysed to be 154.3 kg which is 56.1% of the peat weight of 275kg.
Calculation was estimated on the amount of stored peat volume and carbon in the northern area of Sebangau Catchment between Kasongan and Tangkiling using peat measurements and GIS technology. We found a stored carbon value of approx. 1x10exp9 tons in the northern Sebangau Catchment.
Due to the mineral soil below the peat being mainly quartz sand of low fertility, this area is of doubtful utility for agriculture or for plantations.
Future work could be carried out on that area with more peat drillings spread over the area of interest to get more accurate results of the peat volume and the amount of carbon.

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Figure 1: Kalimantan highway with km stones

Figure 2: Two Garmin GPS and a compass

Figure 3: Peat drilling in cleared PSF parallel to the Kalimantan highway with peat driller

Figure 4: Peat drilling equipment

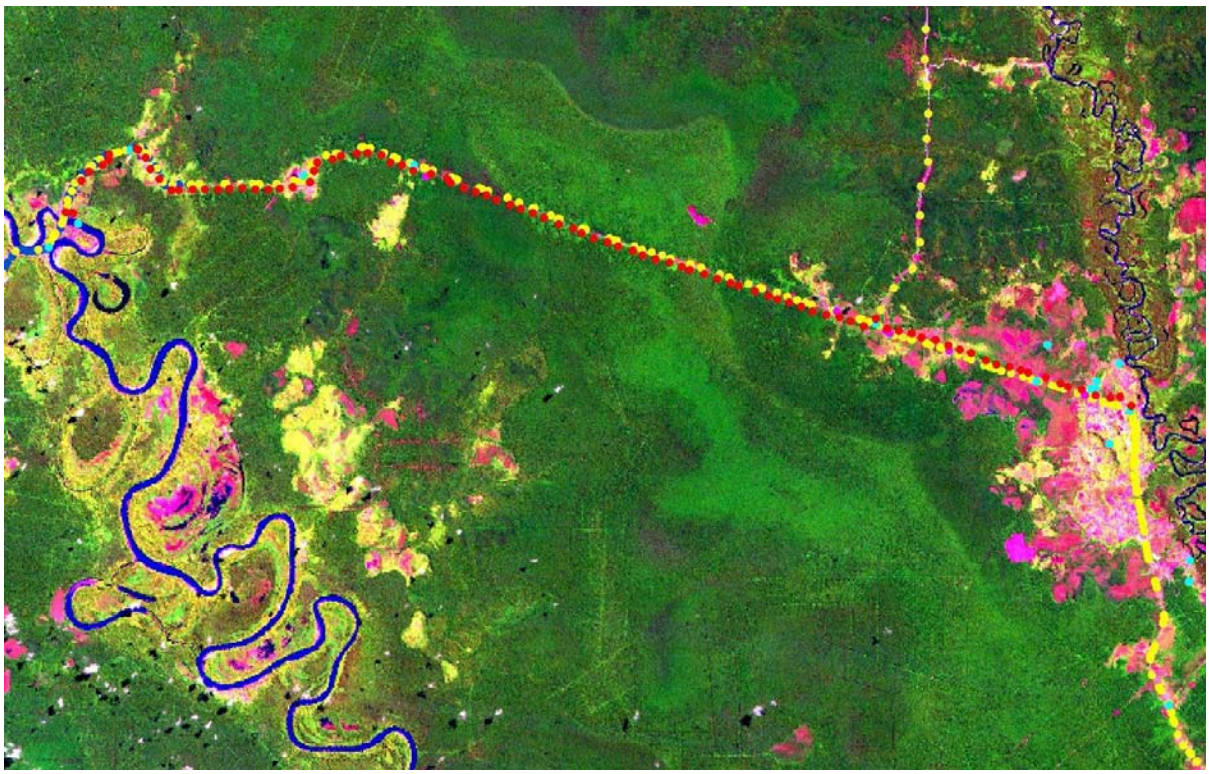

Figure 5: Landsat image RGB=543 acquired on 30.06.1991. On the left side is the Katingan river and on the right side the Rungan river. North is always up. The different green colours in the map show different PSF types. Yellow is the track on the Kalimantan highway (transect) and red are the 91 peat drillings 200m from the highway every 500m. Turquoises are the Peat Rivers.

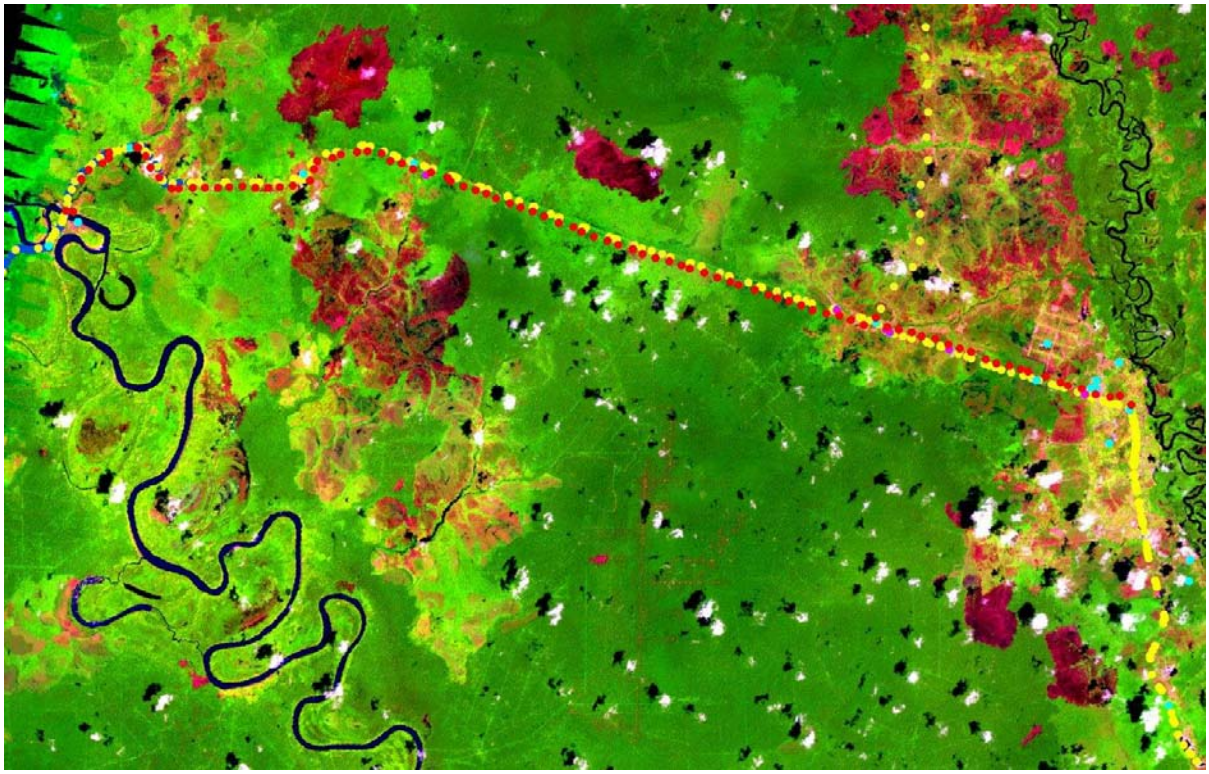

Figure 6: Landsat image RGB=543 acquired on 15.02.2003. Different green colours (dark) show different PSF types, red colours show cleared peat land and the fires from 2002. Yellow is the track on the Kalimantan highway and red are the 91 peat drillings 200m from the highway every 500m.

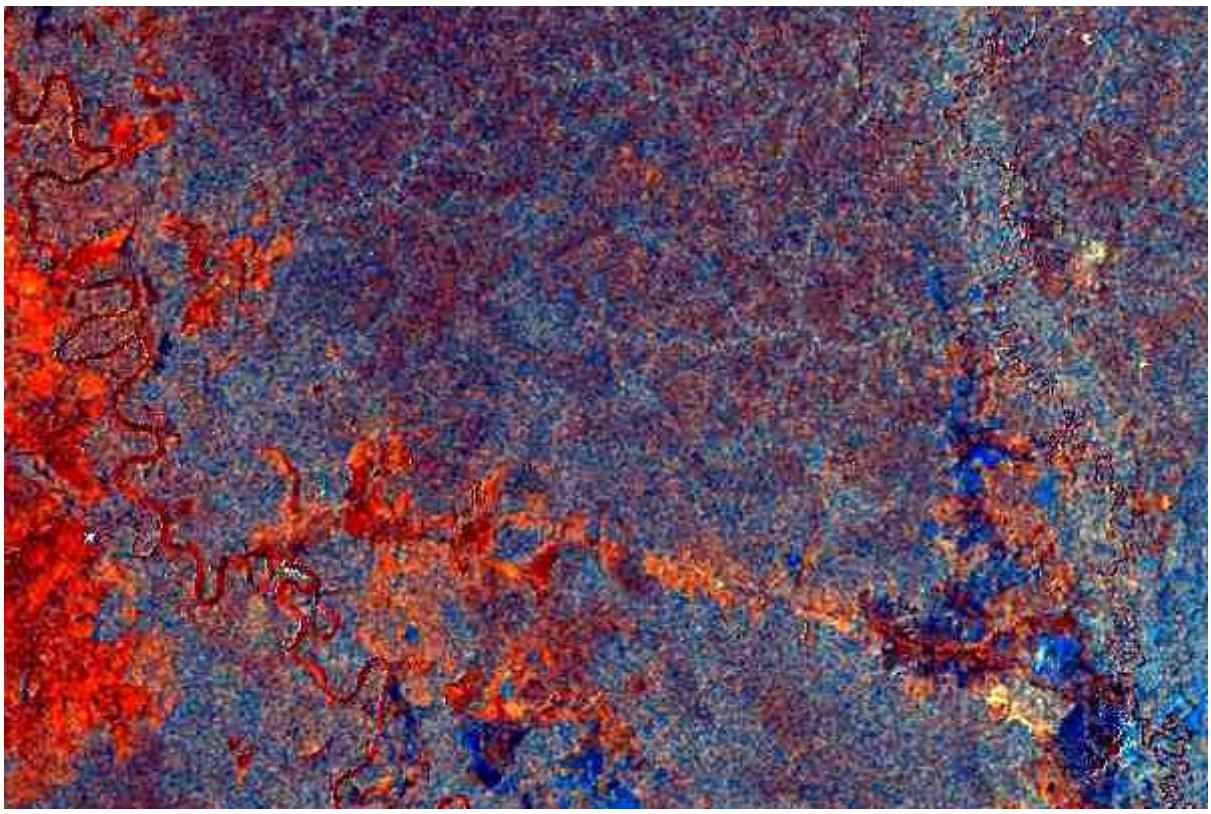

Figure 7: ERS-Radar images acquired 1996 and 1997 show superimposed multi-temporal coloured Radar-images, which indicates in reddish colours the cleared PSF.

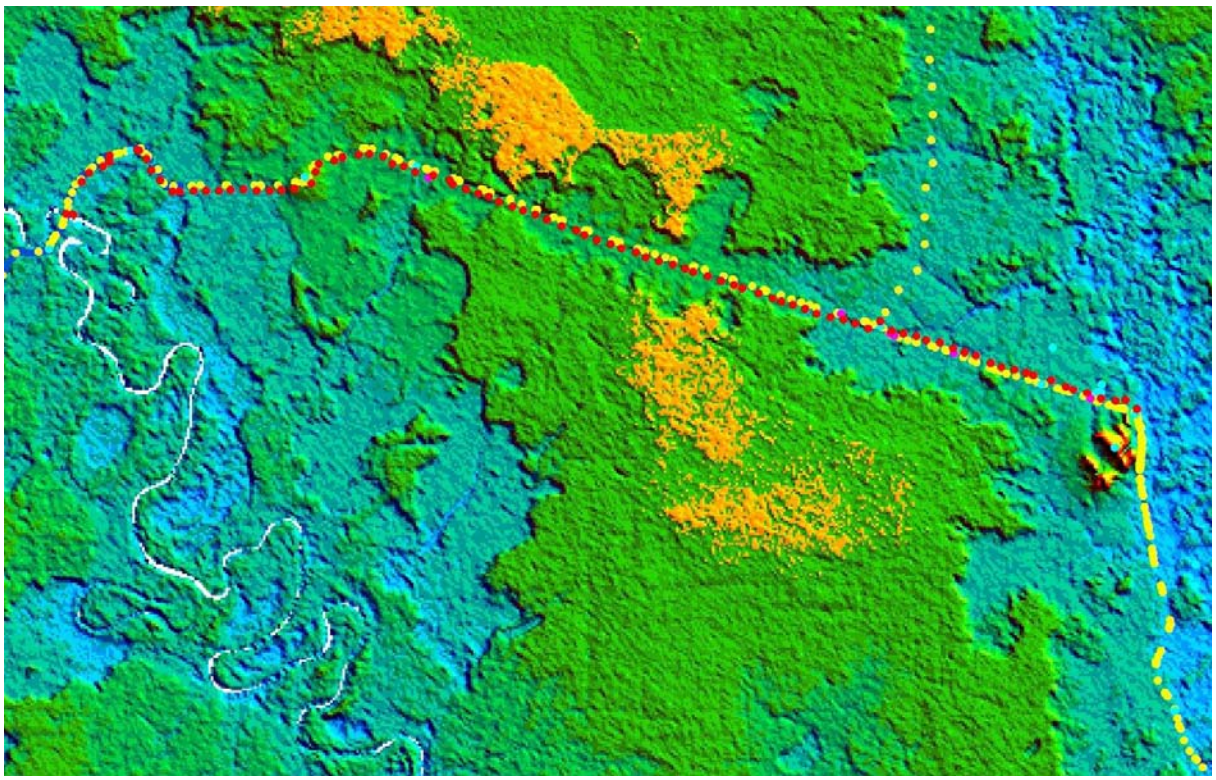

Figure 8: SRTM DEM-Image from Feb. 2000. The elevation is shown in colours. The brown (very high trees) and green colours includes the canopy of the PSF. Cleared peat land is lower, especially along the highway with yellow track points. River Katingan left, Rungan right and the Tangkiling hills can be identified. The peat drilling locations are marked by the red points parallel to the Kalimantan highway.

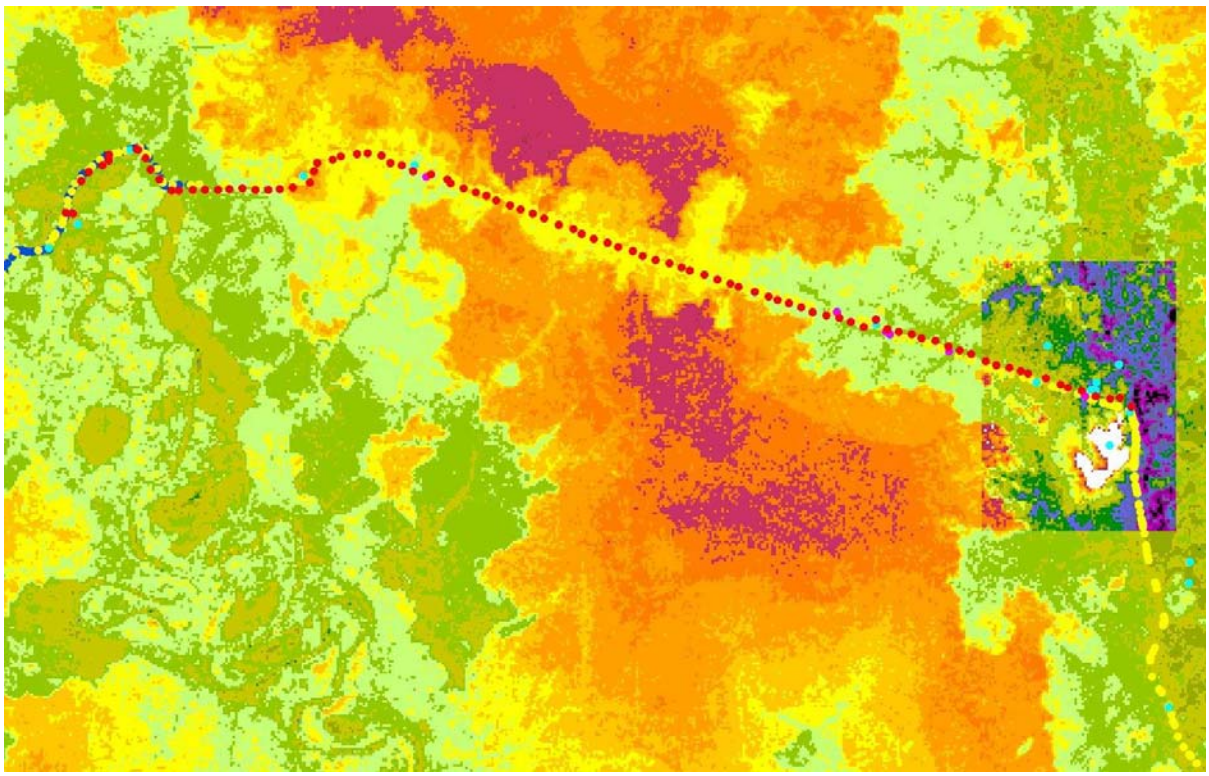

Figure 9: SRTM DEM-Image from Feb. 2000. The elevation is shown in different colours which includes the canopy of the PSF. The elevation resolution is higher along the Kalimantan highway. The peat dome can be seen in yellow colours. The Tangkiling hills are white, saturated.

Figure 10: Shallow peat layer and sandy soil below, so called podzol. Secondary growths of bushes are seen in the rear.

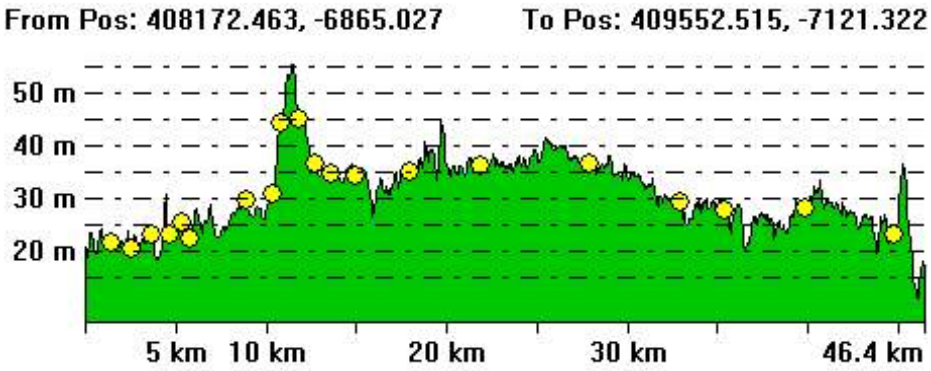

Figure 11: Cross-section derived from the SRTM-data along the Kalimantan highway from Kasongan left to Tangkiling right. The peak at approx. 11km indicate the holy granite stones at Tjilik Riwut with Dayak Kaharingan shrine. The max. peat dome is at 25.5km from Kasongan.

Figure 12: Cross-section derived from the SRTM-data along the PSF several km north of the Kalimantan highway

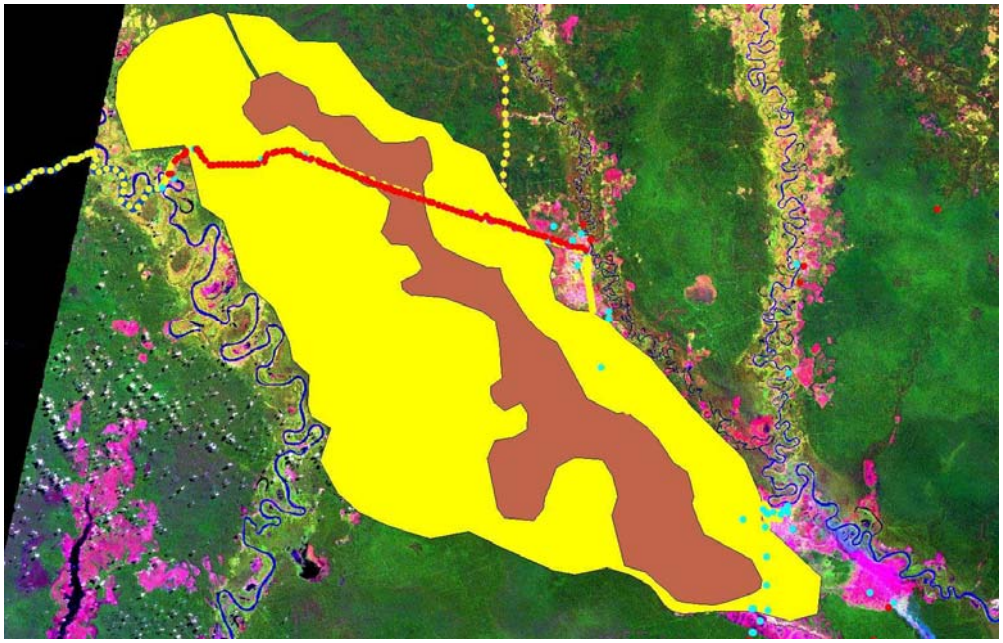
Figure 13: Estimated area of stored peat volume and carbon for the northern area of Sebangau Catchment and Palangka Raya between rivers Katingan and Rungan up to the border of the heath forest analysed in the Landsat image from 1991 with two types of peat thickness (brown 5 to 6m and yellow 2.5 to 3m)

| No. | Sample Code | pH Value | Coordinate | | Direction Water flow |
|---|---|---|---|---|---|
| | | | S | E | |
| 1 | Km 36.2 | 4.74 | 1.97131$^{o}$ | 113.74219$^{o}$ | North |
| 2 | Km 41.8 | 3.73 | 1.95528$^{o}$ | 113.69439$^{o}$ | North |
| 3 | Km 44.3 | 3.41 | 1.94933$^{o}$ | 113.67356$^{o}$ | North |
| 4 | Km 44.5 | 3.42 | 1.94842$^{o}$ | 113.67208$^{o}$ | North |
| 5 | Km 46.5 | 3.45 | 1.94150$^{o}$ | 113.65489$^{o}$ | South |
| 6 | Km 64.1 | 3.60 | 1.89403$^{o}$ | 113.51069$^{o}$ | South |
| 7 | Km 76.8 | 3.70 | 1.88439$^{o}$ | 113.40887$^{0}$ | South |

Table 1: The seven small black water rivers crossing the Kalimantan Highway. pH-average is 3.7. The small river No1 gets water partly from the Tangkiling hills and partly from the peat land.

| No. | Sample Code | Parameter | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | pH H2O (1 : 2,5) | N-Total ( % ) | P-Bray I (ppm) | K-exch | Ca-exch | Mg-exch | Na-exch | Fe-exch | Al-exch | H-exch | CEC |
| | | | | | (me/100g) | | | | | | | |
| 1 | Rungan Sari1 KM | 4.38 | 0.71 | 10.04 | 0.05 | 0.35 | 0.09 | 0.02 | 0.20 | 0.28 | 0.003 | 2.91 |
| 2 | 36.5(RS2) | 4.65 | 0.31 | 12.02 | 0.06 | 0.52 | 0.07 | 0.03 | 0.16 | 0.40 | 0.002 | 6.01 |
| 3 | TRANSMIGR. | 4.52 | 0.12 | 24.53 | 0.10 | 1.21 | 0.30 | 0.03 | 0.22 | 0.52 | 0.004 | 6.41 |

| No. | Sample Code | Parameter | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | C-Org (%) | BS (%) | Texture (%) Sand | Silt | Clay | Coordinates | |
| 1 | Rungan Sari1 KM | 0.949 | 17.50 | 92.54 | 1.76 | 5.70 | S = 1.96344° | E = 113.74581° |
| 2 | 36.5(RS2) | 1.536 | 11.45 | 90.30 | 2.91 | 6.79 | S = 1.96917° | E = 113.74094° |
| 3 | TRANSMIGR. | 2.07 | 25.68 | 88.12 | 5.13 | 6.75 | S = 1 95303° | E = 113 72772° |

Table 2: Results of analysed nutrients for three samples under shallow peat land. Explanation: K-exch = K exchangeable etc, BS = Base Saturation, CEC = Cation Exchange Capacity

| **No** | **Location** | **Brief description of location** | **Position (GPS)** | **Peat depth (cm)** | **Mineral below peat** |
|---|---|---|---|---|---|
| 0 | Kasongan Bridge | Near river | S: 01$^{o}$ 54' 24.22'' E:113$^{o}$23'02.9'' | 0 | Clay |
| 1 | Kasongan Bridg 200 m south | Near river | S: 01$^{o}$ 54' 25.5'' E:113$^{0}$23'12.1'' | 0 | Clay |
| 2 | KM 79 200 m south | Agriculture land | S: 01$^{o}$ 53' 44'' E:113$^{0}$23'22.5'' | 25 cm | Clay |
| 3 | KM 78.5 200 m south | Agriculture land | S: 01$^{o}$ 53' 32,9'' E:113$^{0}$23'31,8'' | 30 cm | Clay |
| 4 | KM 78 200 m south | Agriculture land | S: 01$^{o}$ 53' 24.4'' E:113$^{0}$23'49.2'' | 0 cm | Clay |
| 5 | KM 77.5 200 m south | (back yard of new hotel) | S: 01$^{o}$ 53' 18.1'' E:113$^{0}$23'57.7'' | 10 cm | Clay |
| 6 | KM 77 200 m south | Near black water river | S: 01$^{o}$ 53' 11.4'' E:113$^{0}$23'57.7'' | 170 cm | Sand |
| - | KM 76.8 | Black water River ( direction of water flow – South) | S: 01$^{o}$ 53' 03.8'' E:113$^{0}$24'23.8'' | | |

| | | | | | |
|---|---|---|---|---|---|
| 7 | KM 76.5<br>200 m south | Near black water river | S: 01° 53'04.9''<br>E:113°24'34.7'' | 210 cm | Sand |
| 8 | KM 76<br>200 m south | bush | S: 01° 53' 14.8'<br>E:113°24'43.1'' | 0 cm | Sandy |
| 9 | KM 75.5<br>200 m south | bush | S: 01° 53' 29.2''<br>E:113°24'50.2'' | 0 cm | Sandy |
| 10 | KM 75<br>200 m south | bush | S: 01° 53' 41.6''<br>E:113°25'01.4'' | 0 cm | Sandy |
| 11 | KM 74.5<br>200 m south | Forest | S: 01° 53' 55.9''<br>E:113°25'16.4'' | 380 cm | Clayey |
| 12 | KM 74<br>200 m south | bush | S: 01° 53' 56''<br>E:113°25'26.2'' | 0 cm | Sandy |
| 13 | KM 73.5<br>200 m south | Agriculture land | S: 01° 53' 55.5''<br>E:113°25'43.4'' | 0 cm | Sandy |
| 14 | KM 73<br>200 m south | Forest | S: 01° 53'54.8''<br>E:113°25'58.7'' | Litter 5 cm | Clayey |
| 15 | KM 72.5<br>200 m south | forest | S: 01° 53' 54.8''<br>E:113°26'15.0'' | Litter 7 cm | Sandy |
| 16 | KM 72<br>200 m south | forest | S: 01° 53' 54.5''<br>E:113°26'29.6'' | 48 cm | Clayey |
| 17 | KM 71.5<br>200 m south | forest | S: 01° 53' 53.6''<br>E:113°26'45.6'' | 99 cm | Clayey |
| 18 | KM 71<br>200 m south | forest | S: 01° 53' 55.4''<br>E:113°27'02.0'' | 140 cm | Clayey |
| 19 | KM 70.5<br>200 m south | bush | S: 01° 53' 54.9''<br>E:113°27'18.7'' | 150 cm | Clayey |
| 20 | KM 70<br>200 m south | bush | S: 01° 53' 53.7''<br>E:113°27'33.1'' | 35 cm | Sandy |
| 21 | KM 69.5<br>200 m south | bush | S: 01° 53' 52.1''<br>E:113°27'49.2'' | 0 cm | Sandy |
| 22 | KM 69<br>200 m south | bush | S: 01° 53' 45.5''<br>E:113°28'11.7'' | 0 cm | Sandy |
| 23 | KM 68.5<br>200 m south | bush | S: 01° 53' 31.6''<br>E:113°25'16.9'' | 0 cm | Sandy |
| 24 | KM 68<br>200 m south | bush | S: 01° 53'21.6''<br>E:113°28'20.4'' | 0 cm | Sandy |
| 25 | KM 67.5<br>200 m south | forest | S: 01° 53' 17.3''<br>E:113°28'39.9'' | 40 cm | Sandy |
| 26 | KM 67<br>200 m south | forest | S: 01° 53' 12.6''<br>E:113°28'50.1'' | 75 cm | Clayey |
| 27 | KM 66.5<br>200 m south | bush | S: 01° 53' 10.2''<br>E:113°29'10.7'' | 100 cm | Hardpan |
| 28 | KM 66<br>200 m south | forest | S: 01° 53' 08.8'<br>E:113°29'24.8'' | 114 cm | Clayey |
| 29 | KM 65.5<br>200 m south | forest | S: 01° 53' 11.8''<br>E:113°29'41.8'' | 170 cm | Hardpan |
| 30 | KM 65<br>200 m south | forest | S: 01° 53' 21.2''<br>E:113°29'52.6'' | 50 cm | Hardpan |
| 31 | KM 64.5<br>200 m south | forest | S: 01° 53' 24.8''<br>E:113° 30'07.0'' | 20 cm | Hardpan |
| 32 | KM 64<br>200 m south | bush | S: 01° 53' 31.9''<br>E:113° 30°22.3'' | 0 cm | Sandy |
| 33 | KM 63.5<br>200 m south | forest | S: 01° 53' 36.1''<br>E:113°30'44.5'' | 5 cm Litter | Sandy |
| 34 | KM 63<br>200 m south | Forest | No signal | 120 cm | Clayey |
| 35 | KM 62.5 | forest | S: 01° 53' 46.9'' | 40 cm | Hardpan |

| | | | | | |
|---|---|---|---|---|---|
| | 200 m south | | E:113$^0$ 31’09.2’’ | | |
| 36 | KM 62<br>200 m south | forest | S: 01$^o$ 53’ 53.1’’<br>E:113$^0$31’25.7’’ | 45 cm | Hardpan |
| 37 | KM 61.5<br>200 m south | forest | S: 01$^o$ 53’ 58.1’’<br>E:113$^0$31’41.3’’ | 230 cm | Hardpan |
| 38 | KM 61<br>200 m south | forest | S: 01$^o$ 54’ 02.1’<br>E:113$^0$31’54.3’’ | 310 cm | Hardpan |
| 39 | KM 60.5<br>200 m south | forest | S: 01$^o$ 54’ 08.5’’<br>E:113$^0$ 32’07.1’’ | 410 cm | Hardpan |
| 40 | KM 60<br>200 m south | forest | S: 01$^o$ 54’ 14.9’’<br>E:113$^0$32’24.7’’ | 320 cm | Hardpan |
| 41 | KM 59.5<br>200 m south | Forest | S: 01$^o$ 54’ 20.2’’<br>E:113$^0$32’37.7’’ | 410 cm | Hardpan |
| 42 | KM 59<br>200 m south | forest | S: 01$^o$ 54’ 25.1’’<br>E:113$^0$32’53.1’’ | 455 cm | Hardpan |
| 43 | KM 58.5<br>200 m south | forest | S: 01$^o$ 54’ 31.5’’<br>E:113$^0$ 33’07.6’’ | 437 cm | Hardpan |
| 44 | KM 58<br>200 m south | Forest | S: 01$^o$ 54’39.7’’<br>E:113$^0$33’25.7’’ | 330 cm | Hardpan |
| 45 | KM 57.5<br>200 m south | forest | S: 01$^o$ 54’ 44.8’’<br>E:113$^0$33’44.2’’ | 482 cm | Hardpan |
| 46 | KM 57<br>200 m south | forest | S: 01$^o$ 54’ 50.3’’<br>E:113$^0$33’54.9’’ | 420 cm | Hardpan |
| 47 | KM 56.5<br>200 m south | forest | S: 01$^o$ 54’ 56.8’’<br>E:113$^0$34’10.2’’ | 420 cm | Hardpan |
| 48 | KM 56<br>200 m south | forest | S: 01$^o$ 55’ 02.2’<br>E:113$^0$34’27.4’’ | 314 cm | Hardpan |
| 49 | KM 55.5<br>200 M south | forest | S: 01$^o$ 55’ 07.6’<br>E:113$^0$34’41.5’’ | 363 cm | Hardpan |
| 50 | KM 55<br>200 m south | forest | S: 01$^o$ 55’ 12.1’’<br>E:113$^0$ 34’59.1’’ | 542 cm | Hardpan |
| 51 | KM 54.5<br>200 m south | forest | S: 01$^o$ 55’ 18.7’’<br>E:113$^0$35’11.8’’ | 580 cm | Hardpan |
| 52 | KM 54<br>200 m south | forest | S: 01$^o$ 55’ 23.9’’<br>E:113$^0$35’28.7’’ | 710 cm | Hardpan |
| 53 | KM 53.5<br>200 m south | forest | S: 01$^o$ 55’ 28.1’’<br>E:113$^0$35’45.9’’ | 810 cm | Hardpan |
| 54 | KM 53<br>200 m south | forest | S: 01$^o$ 55’ 32.5’’<br>E:113$^0$ 36’00.9’’ | 570 cm | Hardpan |
| 55 | KM 52.5<br>200 m south | forest | S: 01$^o$ 55’36.5’’<br>E:113$^0$36’11.3’’ | 610 cm | Hardpan |
| 56 | KM 52<br>200 m south | forest | S: 01$^o$ 55’ 42.1’’<br>E:113$^0$36’29.9’’ | 395 cm | Hardpan |
| 57 | KM 51.5<br>200 m south | forest | S: 01$^o$ 55’48.1’’<br>E:113$^0$36’46.7’’ | 360 cm | Hardpan |
| 58 | KM 51<br>200 m south | forest | S: 01$^o$ 55’ 53.5’’<br>E:113$^0$37’02.7’’ | 305 cm | Hardpan |
| 59 | KM 50.5<br>200 m south | forest | S: 01$^o$ 55’ 57.2’’<br>E:113$^0$37’13.5’’ | 260 cm | Hardpan |
| 60 | KM 50<br>200 m south | forest | S: 01$^o$ 56’ 03.8’’<br>E:113$^0$37’33.9’’ | 205 cm | Hardpan |

| | | | | | |
|---|---|---|---|---|---|
| 61 | KM 49.5<br>200 m south | forest | S: 01° 56' 09.7''<br>E:113°37'50.8'' | 190 cm | Hardpan |
| 62 | KM 49<br>200 m south | forest | S: 01° 56' 13.7''<br>E:113° 38'02.8'' | 170 cm | Hardpan |
| 63 | KM 48.5<br>200 m south | forest | S: 01° 56' 18.4''<br>E:113°38' 17.3'' | 47 cm | Sand |
| 64 | KM 48<br>200 m south | forest | S: 01° 56' 23.7''<br>E:113°38' 32.9'' | 65 cm | Sand |
| 65 | KM 47.5<br>200 m south | forest | S: 01° 56' 29.5''<br>E:113° 38' 47.3'' | 5 cm | Sand |
| 66 | KM 47<br>200 m south | bush | S: 01° 56' 33.8''<br>E:113°39' 04.7'' | 0 cm | Sand |
| 67 | KM 46.5<br>200 m south | bush | S: 01° 56' 36.5''<br>E:113° 39' 20.3'' | 0 cm | Sand |
| 68 | KM 46<br>200 m south | bush | S: 01° 56' 42.2''<br>E:113°39' 35.5'' | 0 cm | Sand |
| 69 | KM 45.5<br>200 m south | bush | S: 01° 56' 47.5''<br>E:113°39' 51.6'' | 0 cm | Sand |
| 70 | KM 45<br>200 m south | bush | S: 01° 56' 39.2''<br>E:113°40' 07.1'' | 0 cm | Sand |
| 71 | KM 44.5<br>200 m North | Forest | S: 01° 56' 51.3'<br>E:113°40'21.3'' | 0 cm | Sand |
| 72 | KM 44<br>200 m North | Bush | S: 01° 56' 54.0'<br>E:113°40'35.6'' | 0 cm | Sand |
| 73 | KM 43.5<br>200 m North | Bush | S: 01° 56' 57.6'<br>E:113°40'52.0'' | 0 cm | Sand |
| 74 | KM 43<br>200 m North | Bush | S: 01° 57' 02.0'<br>E:113°41'04.3'' | 0 cm | Sand |
| 75 | KM 42.5<br>200 m North | Bush | S: 01° 57' 05.8'<br>E:113°41'21.8'' | 5 cm | Sand |
| 76 | KM 42<br>200 m North | | S: 01° 57' 12.7'<br>E:113°41'38.1'' | 2 cm | Sand |
| 77 | KM 41.5<br>200 m North | Bush | S: 01° 57' 18.3'<br>E:113°41'53.5'' | 0 cm | Sand |
| 78 | KM 41<br>200 m North | Bush | S: 01° 57' 22.4'<br>E:113°42'07.4'' | 3 cm (litter) | Sand |
| 79 | KM 40.5<br>200 m North | Forest | S: 01° 57' 30.9'<br>E:113°42'25.6'' | 200 cm | Clayey |
| 80 | KM 40<br>200 m North | Forest | S: 01° 57' 35.8'<br>E:113°42'39.3'' | 190 cm | Sand |
| 81 | KM 39.5<br>200 m North | Forest | S: 01° 57' 39.7'<br>E:113°42'56.0'' | 30 cm | Sand |
| 82 | KM 39<br>200 m North | Bush | S: 01° 57' 43.8'<br>E:113°43'09.7'' | 5 cm | Sand |
| 83 | KM 38.5<br>200 m North | Bush | S: 01° 57' 46.6'<br>E:113°43'19.6'' | 10 cm | Sand |
| 84 | KM 38<br>200 m North | Bush - Transmigration | S: 01° 57' 52.5'<br>E:113°43'41.6'' | 5 cm | Sand |
| 85 | KM 37.5<br>200 m North | Bush | S: 01° 58' 00.6'<br>E:113°44'00.1'' | 5 cm | Sand |
| 86 | KM 37<br>200 m North | Bush | S: 01° 58' 05.1'<br>E:113°44'09.8'' | 2 cm | Sand |
| 87 | KM 36.5 | Bush | S: 01° 58' 09.0' | 7 cm | Sand |

| | | | | | |
|---|---|---|---|---|---|
| | 200 m North | | E:113$^0$44'27.4'' | | |
| 88 | KM 36<br>200 m North | Rungan sari | Rungan Sari | - | Sand |
| 89 | KM 35.5<br>200 m North | Bush | S: 01$^o$ 58' 20.0'<br>E:113$^0$45'02.8'' | 2 cm | Sand |
| 90 | KM .35<br>200 m North | Agriculture land | S: 01$^o$ 58' 18.7'<br>E:113$^0$45'16.0'' | 0 cm | Clay |
| 91 | KM 34.5<br>200 m North | Agriculture land | S: 01$^o$ 58' 29.6'<br>E:113$^0$45'30.1'' | 0 cm | Clay |

Table 3: Measurements of peat depth along the Kalimantan highway Kasongan to Tangkiling between the rivers Katingan and Rungan. At km 53.5 the peat depth is 8.10m.

| No. | Place of sample | Parameter | |
|---|---|---|---|
| | | Bulk Density ( g/cm3 ) | C - Organic (%) |
| 1 | Km 40 U | 0.33 | 57.13 |
| 2 | Km 49 | 0.26 | 57.26 |
| 3 | Km 50 | - | 57.48 |
| 4 | Km 51 | 0.26 | 56.50 |
| 5 | Km 52 | - | 57.34 |
| 6 | Km 53 | 0.30 | 57.23 |
| 7 | Km 54 | - | 56.16 |
| 8 | Km 55 | 0.31 | 57.21 |
| 9 | Km 56 | - | 57.54 |
| 10 | Km 57 | 0.29 | 56.91 |
| 11 | Km 58 | - | 56.92 |
| 12 | Km 59 | 0.23 | 56.79 |
| 13 | Km 60 | - | 56.85 |
| 14 | Km 61 | 0.25 | 53.87 |
| 15 | Km 62 | - | 54.06 |
| 16 | Km 63 | 0.28 | 57.13 |
| 17 | Km 65 | 0.27 | 54.47 |
| 18 | Km 66 | - | 55.34 |
| 19 | Km 67 | 0.26 | 56.44 |
| 20 | Km 70 | - | 55.29 |
| 21 | Km 71 | 0.26 | 55.13 |
| 22 | Km 72 | - | 50.77 |

Table 4: Bulk density and C-organic content of peat at 0-20 cm deep in certain places along transect Kasongan to Tangkiling

| No. | Place of sample | Parameter |
|---|---|---|
| | | pH $H_2O$ ( 1 : 2,5 ) |
| 1 | Km 40 U | 3.83 |
| 2 | Km 49 | 3.90 |
| 3 | Km 50 | 4.43 |
| 4 | Km 51 | - |
| 5 | Km 52 | 3.98 |
| 6 | Km 53 | - |
| 7 | Km 54 | 3.88 |
| 8 | Km 55 | 4.04 |
| 9 | Km 56 | 3.32 |
| 10 | Km 57 | 3.99 |
| 11 | Km 58 | 3.98 |
| 12 | Km 59 | 4.97 |
| 13 | Km 60 | 3.38 |
| 14 | Km 61 | 3.73 |
| 15 | Km 62 | 4.49 |
| 16 | Km 63 | 3.58 |
| 17 | Km 65 | 3.55 |
| 18 | Km 66 | 4.16 |
| 19 | Km 67 | 3.56 |
| 20 | Km 70 | 4.40 |
| 21 | Km 71 | 4.28 |
| 22 | Km 72 | 4.42 |
| 23 | Km 77 | 4.37 |

Table 5: The pH-value of mineral soil below peat at certain places along transect Kasongan and Tangkiling. The average of pH-value is 4.01.

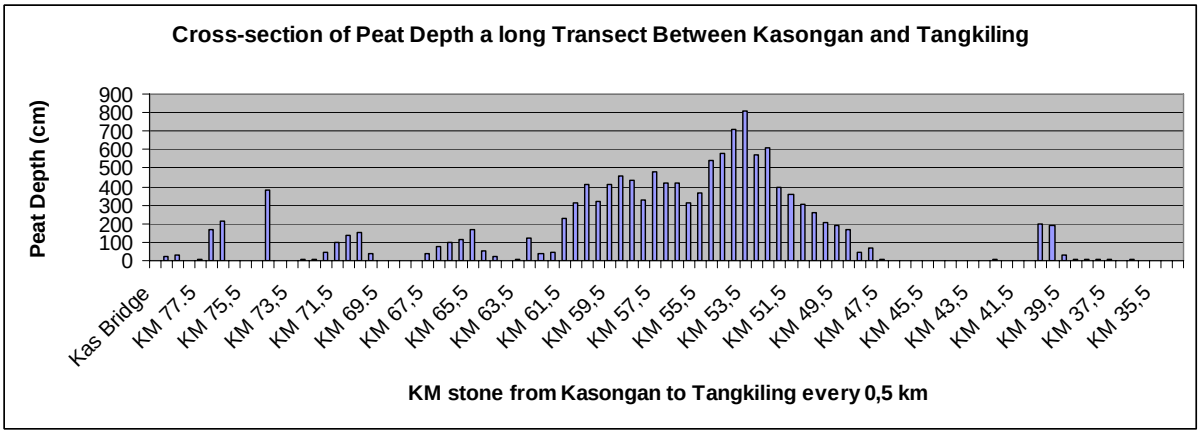


Figure 14: Peat depth taken along the transect from Table 3