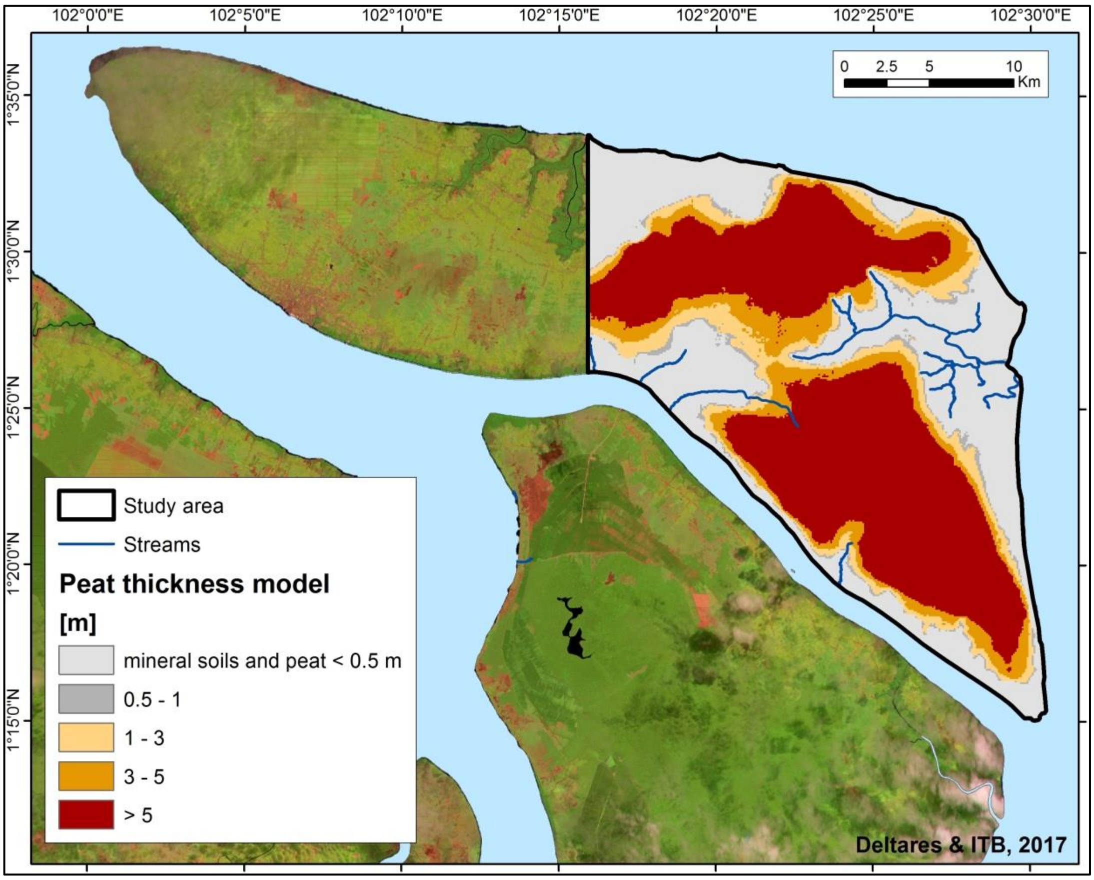
Peatland mapping for Bengkalis Island, Riau, using limited LiDAR data and peat thickness field measurements



Submission by Deltares and ITB (Team Deltares)

to

Indonesian Peat Prize

Indonesian Peat Prize - Solution Development Phase

Final Report, June 2017

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Vernimmen R, Hooijer A, Akmalia R, Mulyadi D, Syahrozi O, Anugrah I, Visser M, Yuherdha A, Andreas H, 2017. Peatland mapping for Bengkalis Island, Riau, using limited LiDAR data and peat thickness field measurements. Team Deltares report to the Indonesian Peat Prize - Solution Development Phase.

Abstract

For a study area of 54,133 ha in Bengkalis (Riau Province), a peat extent and peat thickness (PT) model is created at 100 m spatial resolution from limited LiDAR data (30.2 % area coverage) and field PT measurements collected for the study area (n=274). A high R^2 of 0.84 was found between surface elevation and PT, confirming that the peat bottom is relatively flat and close to Sea level as is often the case in coastal peatlands, as peat development started from river floodplains and mangroves some 5,000 years ago. A surface elevation DTM was created from the LiDAR data, and PT measurements were subtracted to derive a peat bottom (PB) elevation surface model applying three different methods. PT models are determined as the difference between DTM and PB models. The three PT models are all in close agreement (R^2 0.93 to 0.94) with independent validation data collected for the study (n=73). For the simplest peat thickness map, assuming a flat peat bottom near Sea level, the map is accurate within 0.5 m for 52.1 % of the validation data and for 79.5 % within 1 m. It was found that peat covers 65.6 % of the area, with 83.0 % of peat being deeper than 3 m. The peat bottom is below 0 m and 2 m +MSL in 56.6 % and 94.7 % of the area respectively, most of the area is therefore at high risk of future flooding if drainage and peat loss continue. It is demonstrated that the LiDAR data can also be used to determine canal water table depth (CWD) below the land surface, which provides useful data for water management; it is found that CWD in the study area is more than 0.5 m below the peat surface along 84.1 % of canals during the LiDAR survey in the wet season, and would be expected to be >1 m in the dry season, which helps explain the high fire risk in the area. Total cost of LiDAR and field data collection and analysis for the study is 35,622 US$, or 1.00 US$ per ha of peatland area (0.66 US$ per ha of study area).

Summary

In this report, the application of the method for peatland mapping as applied by Deltares and ITB to a study area in Bengkalis is submitted to the IPP (Indonesia Peat Prize) organization. The method builds on past work by Deltares in research and advisory projects that required peat mapping in Indonesia (since 2007), with the aim of not only yielding a sufficiently accurate result but also of doing this quickly and economically. In our experience, this requires three main elements:

- the use of elevation models (DTMs), applying LiDAR data where possible,
- peat thickness (PT) field surveys that are limited in scope where possible but meet the highest quality standards,
- and an understanding of peatland genesis and morphology that allows insightful interpretation of the data.

Airborne LiDAR data provides the fastest and most accurate way to creating DTMs over large areas, while also providing useful information on vegetation and canal water depth. In our experience however, LiDAR data can often not economically be collected at full coverage as this would cost tens of millions of dollars if applied to all peatland in Indonesia (maybe hundreds of millions if repeat measurements are required for monitoring, as we propose) and years of data collection and processing. Both the funding and the time required are likely not available, as peatland degradation proceeds year by year and peatland related policies evolve rapidly. Therefore in our projects we apply a method that allows generation of elevation models from LiDAR data collected along 'flight strips' that cover 10 % to 30 % of the area, and manual support of interpolation, as explained in Section 2.1.4. This results in a reduction of cost and data collection time by a factor 3 to 10. As the IPP study area was found to be unusually complex in morphology, with small irregular peat domes with steep surface slopes, a relatively high LiDAR coverage of 30.2 % was applied in this case.

LiDAR data following this method has in 2015, 2016 and 2017 been collected over most of East Sumatra lowland and parts of West Kalimantan lowland (Section 1.2; Figure 1), resulting in coverage of 1.8 Mha of LiDAR data over a total of 26,300 km of flight lines. Most of this coverage is over lowland peatland. The resulting DTMs will be available in the public domain for further use in mapping initiatives.

To minimize cost and effort peat surveys in the field were optimized by conducting them [a] along transects perpendicular to coast and streams and going up the peat slopes (Figure 4), [b] starting transects at the expected peat extent boundary mapped visually from satellite data (Figure 21) and [c] ending surveys where PT was found to exceed 7 m (Figure 5). Measurement quality was assured by having the peat/mineral interface in augers photographed at all locations (time and location verified) and having multiple replicates for averaging and error rejection. A total of 274 average measurements were collected of which 219 had peat over 0.5 m in depth. Two-thirds of these measurements (n=146) were used for PT map creation, and one-third (n=73) for map validation. The field survey report and SOP are presented in Annex 1 and 2.

Peat extent was delineated from Landsat satellite images, visually tracing features that are typical of peat (forest type, drainage patterns), and applying peat thickness measurements for validation and refinement. It was found that the two data sources are in close agreement.

A third data source for peat extent delineation, the DTM, was not applied in this case for lack of time, but was also found to be in good agreement.

A very close relation (R^2=0.84) was found between PT measurements and LiDAR based DTM, consistent with the common finding that the peat bottom in coastal peatlands is usually quite flat and uniform and confirming that PT models can often be derived from the DTM if some information is available on peat bottom elevation and shape from limited field measurements.

PT models were derived by subtracting peat bottom (PB) models from the DTM (Section 3.6). The first method ('Method 1') of PB model creation was to interpolate a surface model between measurement points and contours that were manually drawn. Method 2 assumes a flat horizontal PB surface determined from the average of available data. Method 3 applies a regression equation between DTM and available PT data. It is found that the PT models derived from all three PT definition methods match the validation PT data closely with R^2 values of 0.94, 0.93 and 0.93 respectively for Methods 1, 2 and 3 (Figure 23, Figure 24). This is because the study area has a large range in surface elevation and peat thickness values while the PB is relatively smooth and horizontal, near Mean Sea Level (Figure 12), as we often find to be the case in coastal lowland peatlands in Indonesian. In many areas, especially large uniform peat domes where peat thickness data are scarce and hard to obtain, Methods 2 or 3 will therefore suffice. It should be noted however that there are exceptions, with some peatlands having shallower peat and irregular peat bottoms; in such areas a greater amount of field surveys will be needed and the peat bottom can only be determined from Method 1 if maximum accuracy is required.

For the simplest peat thickness map (Method 2), assuming a flat peat bottom near Sea level, the map is accurate within 0.5 m for 52.1 % of the validation data and for 79.5 % within 1 m. The maps of Method 1 and 3 are accurate within 0.5 m for 39.7 % and 50.7 % of the validation data, respectively, while within 1 m for 63.0 % and 79.5 % respectively (Table 3).

Applying Method 1, 2 and 3, peat covers 65.6 %, 72.1 % and 71.8 % respectively of the Bengkalis study area, while PT exceeds 3 m over 83.0 %, 78.8 % and 78.6 % respectively (excluding areas that have no peat). PT exceeds 5 m over 65.3 %, 58.9 % and 59.4 % respectively (Table 4).

The DTM resulting from LiDAR data shows that 29.0 % of the study area (including mineral soil areas) is now below 2 m +MSL and 60.7 % below 6 m + MSL. It is therefore a rather low-lying area, with the lowest areas already being prone to flooding. In future, if peat continues to be lost (following drainage) and Sea level rises, almost the entire area will be severely flood prone or may even be lost to the Sea permanently after peat is fully removed, with only 5.3 % of the mineral substrate topography below peat in the study area being above 2 m +MSL (Figure 26) and as much as 56.6 % being below current Mean Sea Level (according to Method 1).

We discuss that, where the peat bottom is below permanent water level, the bottom peat will never be available for oxidation (Section 4.2, Figure 28). In such areas, it may be considered whether it is necessary to know the exact peat thickness at great accuracy. We therefore advise to adjust the accuracy requirement for peat thickness mapping according to peat thickness and likely position of the peat bottom. Field efforts may be reduced in large inaccessible peatland areas where peat is clearly very deep; we often find a peat thickness

of 5 to 7 m to be a good cut-off point. In our experience this can greatly reduce the time and effort required for peat mapping as efforts can be focused on those areas where questions are greatest.

It is demonstrated that canal water table depth (CWD) relative to the surrounding land surface can be mapped from LiDAR. In the two day measurement period (6-7 November 2016), CWD in LiDAR strip coverage over peat in the study area is in the ranges of 0-0.5 m, 0.5-1 m and >1 m below the peat surface in 15.9 %, 42.6 % and 41.5 % of cases respectively. We propose that regular repeat LiDAR surveys over selected flight lines can offer a robust monitoring mechanism alongside ground measurements.

The cost of peatland mapping over the Bengkalis Island study area of 54,133 ha has been 16,500 US$ for collecting LiDAR data (excluding mobilization costs) and 7,248 US$ for field surveys. The cost of data processing, analysis and reporting is hard to determine as this will be much reduced when applying this method at the large scale, but we estimate this to equal 50% of the cost of data collection (LiDAR + field) in a normal assignment (without the scientific analyses and cross checks applied in this study for IPP). The total cost of mapping of the study area is therefore 35,622 US$, or 0.66 US$ per hectare (1.00 US$ per hectare of actual peatland).

1 Introduction

1.1 The need for improved peat maps for Indonesia

It is well documented that Indonesia has extensive peatland cover, especially in the coastal lowlands of Sumatra, Kalimantan and Papua. Peat maps for some areas have existed for more than 100 years, and the first comprehensive and consistent nationwide map was produced by the Regional Physical Planning Programme for Transmigration (RePPProT) project (RePPProT, 1990). A map by Puslitanak (Ministry of Agriculture) was published by Wetlands International in 2003-2006 (Wahyunto *et al.*, 2003, 2004, 2006), followed by a derived map published in 2011 by BBSDLP (Ministry of Agriculture; Ritung *et al.*, 2011).

An assessment of the accuracy of the latter 2 maps (Puslitanak and BBSDLP), funded by Netherlands Government, was published by Deltares in 2013 (Hooijer and Vernimmen, 2013). It was found that while peat thickness information provided by existing maps is very poor, peat extent is actually quite well known, actually no worse than in other regions with major peatland extent including Russia and Canada. The location of all large peat areas in Sumatra and Kalimantan is indicated on existing maps, but questions do exist on exact boundaries, both of the peat and of deep peat. The 3 m peat thickness boundary, that has legal implications, is especially poorly known.

The existence of fairly accurate maps of peat extent, by international standards, presents an advantage to efforts to better map peat thickness. Existing peat boundaries can be used as a starting point for map improvement.

When improving peatland maps for Indonesia, it is important to understand priorities and deal with highest priorities first. The first priority is to generate maps that allow land use zoning at the landscape scale, distinguishing agri/silivicultural production areas (plantations and smallholders) and conservation/restoration areas for natural peat swamp forest. These maps will also support redesign of water management systems at the landscape (meso-) scale. This needs to be done very rapidly in support of current Government initiatives to reduce fire risk and carbon emissions, yet it does not require the highest level of detail and accuracy that may take years to achieve. After the initial overall mapping for zoning purposes is done, it is possible to create more detailed maps where needed for detailed planning and design purposes. By creating separate products that are ‘fit for purpose’, rather than aiming to achieve perfection in a first product, the process can be speeded up and resources can be applied where they are most needed to meet priorities.

1.2 Background to Deltares peatland mapping method

Deltares, with partners, has been involved in large scale peat mapping in SE Asia since 2007, starting with the mapping of the Ex Mega Rice Project (EMRP) area in the CKPP project (2005-2008), with Wetlands International, which relied mostly on field surveys along 1,350 km of transects (Silvius *et al.*, 2007). It was found that field surveys alone are not the most suitable approach to peatland mapping because of the vast scale and poor accessibility of the areas involved, difficulties in making field teams follow strict protocol

under difficult conditions, and high financial and time requirements. Mapping results based on field surveys alone are often poor in our experience.

Since 2007, Deltares has been pioneering the use of LiDAR data in peat mapping. In the KFCP project (2010-2014) full LiDAR coverage over much of the EMRP area was collected at very considerable cost and time investment. It was then found that for most purposes, including peat mapping and water management, such full coverage data is neither affordable nor required. Instead, it is possible to collect data along parallel flight lines and create elevation models and derived models though interpolation. A first application of this method in 2014, with Wetlands International and UGM, has been for the Kampar Peninsula in Sumatra (Hooijer *et al.*, 2015b).

LiDAR data has in 2015, 2016 and 2017 been collected over most of East Sumatra lowland and parts of West Kalimantan lowland (Figure 1), following the 'strip' method described in this report, mostly funded by APP (over its *Acacia* plantations and surrounding landscapes) and by UKCCU (over much of South Sumatra) with other organizations funding smaller areas of specific interest. First data over these areas was collected in April-May 2015[1], and a second round of data collection was done in October 2016 - March 2017. By mid-2017 this has resulted in coverage of 1.8 Mha of LiDAR data over a total of 26,300 km of flight lines. Most of this coverage is over lowland peatland.

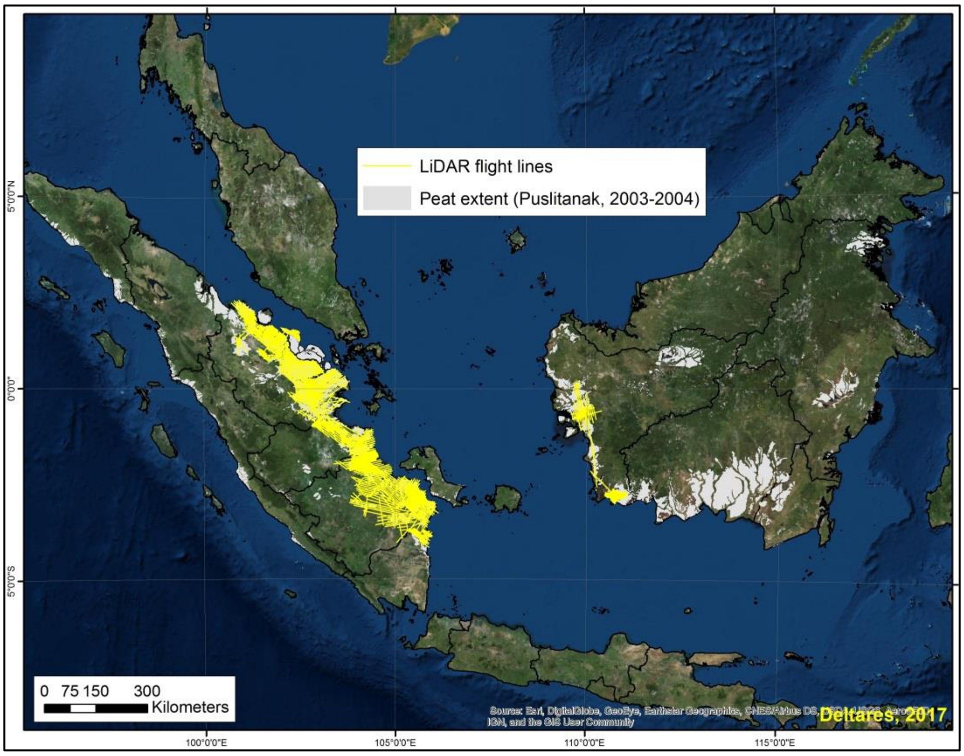

Figure 1 LiDAR flight line coverage over East Sumatra and West Kalimantan lowland acquired from April-May 2015 and October 2016 – March 2017.

[1] https://www.deltares.nl/en/projects/lidar-data-large-scale-peatland-management-flood-risk-assessment/

By not collecting LiDAR data full coverage, but over large areas allowing highly competitive tendering by multiple different provider companies, the cost of LiDAR data collection is reduced by over 10 times compared to full coverage data over small areas.

The method applied in this IPP submission and in ongoing projects is an iterative process. The first stage is rapid data collection and rapid production of maps with relatively limited data. The resulting maps are considered sufficiently accurate for most purposes in most areas, but not for all purposes in all areas. The second stage focusses on refining the results for areas of specific interest. In several smaller areas, LiDAR data are now collected at full coverage to answer specific client questions.

Through this two-stage approach, obtaining a big picture first and generating a spatial framework in which to later place detailed studies where 'fit for purpose', major reductions in time and resource requirements can be achieved compared to an approach that requires uniform high data coverage in all areas even if the result far exceeds the 'fit for purpose' requirement.

The LiDAR data are used in generation of DTMs, that are applied in lowland flood risk assessments and peat thickness mapping, as well as assessments of subsidence and canal water depth (from repeated data collection) and vegetation characteristics and used as base models for drainage and irrigation design (from DTMs). Of particular interest is that some of the data over peatland was collected over the same strips before and after the 2015 fires, allowing accurate assessment of fire impacts including loss of peat and carbon.

Accounting for all land that is within 2.5 km from a LiDAR strip, peatland coverage suffices to produce peat thickness models over some ~5.1 Mha of peatland. Most of these peat thickness models equal or surpass the accuracy achieved over the Bengkalis study area. In some areas however, peat thickness mapping is complicated by irregularities in the peat bottom or sudden changes in peat surface elevation; in such areas, additional LIDAR and/or field data can be collected later to refine models.

The resulting DTMs will be available in the public domain for further use in mapping initiatives. We invite others to use this framework as a starting point for further improvement of maps, collecting additional data (LiDAR and field) where necessary.

1.3 Using a LiDAR based DTM for peat thickness mapping

The fundamental assumption of the LiDAR-based peat mapping method applied by Deltares and ITB is that the bottom of the peat deposit, i.e. the top of the underlying mineral soil (usually clay or sand), is relatively flat compared to the top of the peat deposit. We have found this to be the case in many other coastal peat locations in Indonesia, which is explained by the peat having formed on top of a mostly flat terrain of floodplains and mangroves, starting some 5,000 years ago. However the assumption does not hold for inland peat deposits (so-called valley peat) where the peat has often formed on top of a pre-existing landscape.

1.4 Study area

The study area is located on the Eastern part of Bengkalis island (Riau Province) and covers an area of 54,133 ha (Figure 3).

It should be noted that the peat dome morphology in the study area appears quite different from the peat landscapes commonly seen along Indonesia’s coastlines. Severe coastal erosion has occurred in past decades, possibly centuries (Sutikno *et al.*, 2017), and this has resulted in near-coast peat slopes that often exceed 5 m per km, sometimes even over 10 m km^{-1} (Supardi *et al.*, 1993; Figure 2). This is far steeper than peat surface slopes commonly found in Indonesia, that are often below 1 m km^{-1} and rarely above 2 m km^{-1}. Moreover, the peat domes of Bengkalis Island are small and narrow, less than 10 km across while peat domes of more than 20 km across are common. Some caution is therefore needed when interpreting the performance of peat thickness mapping methods as applied to this rather unrepresentative area. It is our experience that some methods, including the one applied by the Deltares+ITB team, will perform better in peat landscapes that have larger domes with smoother and more regular surface morphology.

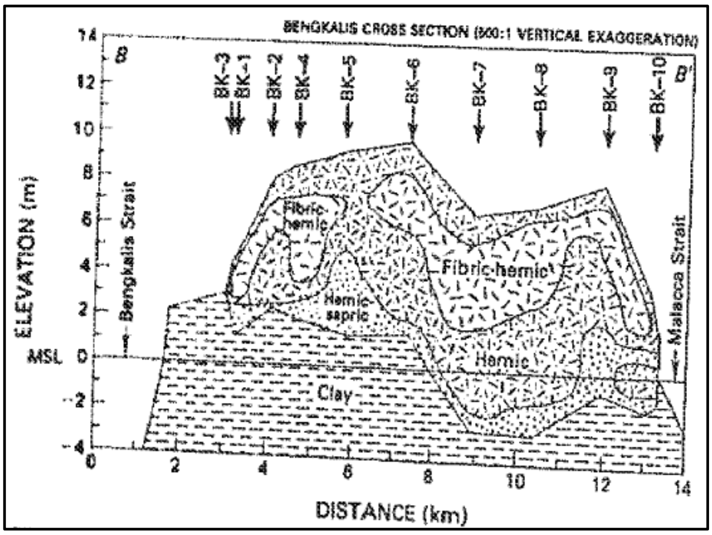

Figure 2 Cross section through Bengkalis Island showing extremely steep peat surface slopes (Supardi *et al.*, 1993). This cross section is to the West of the IPP study area.

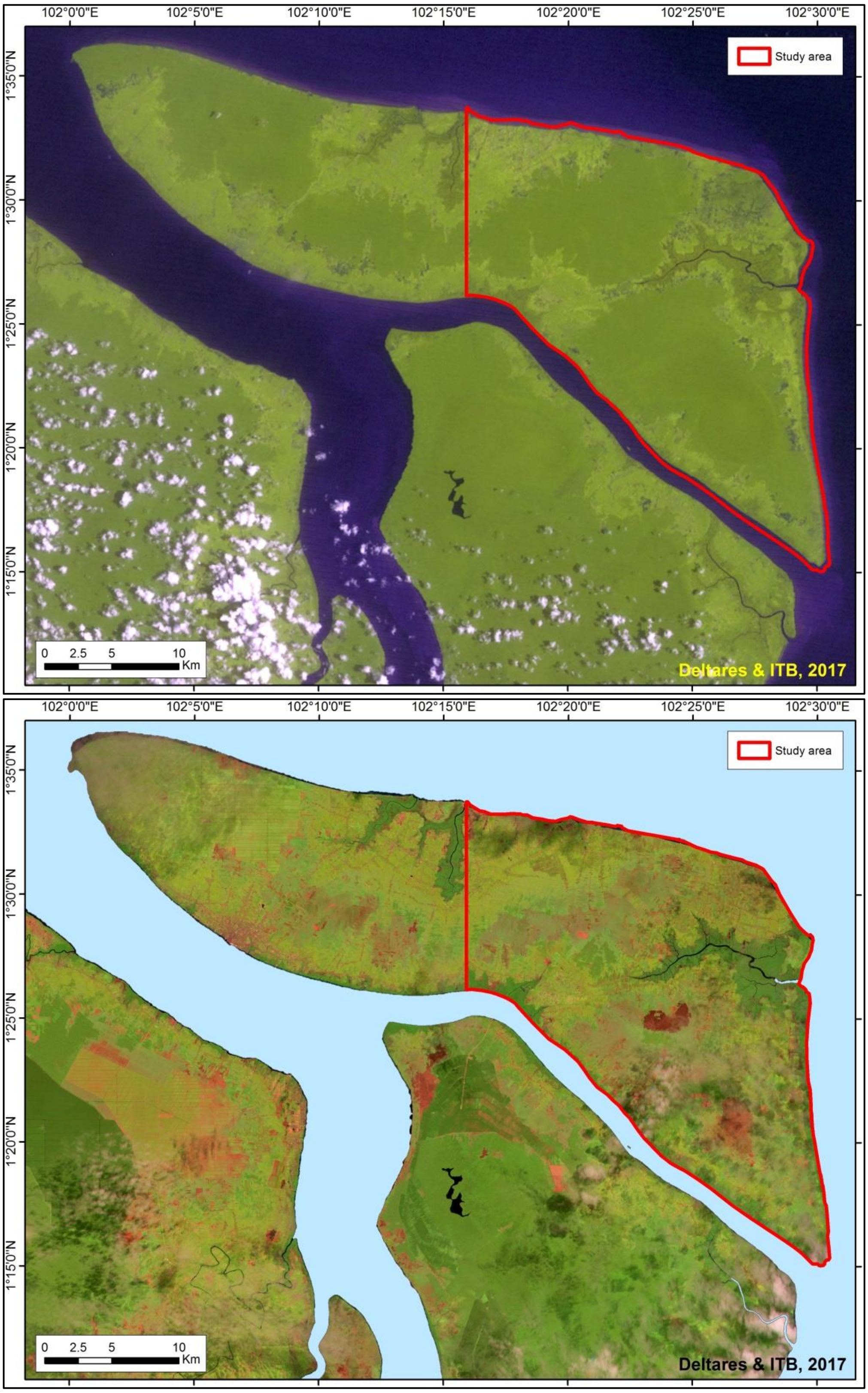

Figure 3 Study area on Bengkalis Island (Riau Province, Sumatra Island). In the background a RGB composite (TOP) Landsat-1 image of 5 October 1972 (spectral bands 6-7-5) and (BOTTOM) Sentinel-2 image of 4 August 2016 (spectral bands 11-8-5).

1.5 This report

This report consists of 2 parts. The main report is in the format of a scientific paper, aiming to be concise and relatively brief. The Annexes provide a detailed report of the peat thickness field survey carried out during this study including the SOP used and provides the resulting field data.

2 Methods and materials

2.1 LiDAR data and DTM generation

2.1.1 LiDAR data collection partner

The company contracted to collect LiDAR data (PT. Surtech) was selected in a competitive bidding process to which four companies were invited, on the basis of quality of proposal, proven experience and cost. The work was offered as part of a much larger package of LiDAR data collection over Sumatra and Kalimantan, allowing bidders to lower cost and increase efficiency as a function of scale of data collection.

2.1.2 LiDAR data collection design

Peat extent was first visually identified from Landsat images, showing drainage and vegetation patterns that in our experience are likely to indicate peat, as well as from existing peat maps. LiDAR flight lines were then designed to cross peat boundaries and coast lines at perpendicular angles (Figure 4) to extract the maximum of information from a minimum of coverage and cost. As these are unusually small peat domes (between 16,000 – 20,000 ha) with complex morphology and unusually steep peat surface slopes, strips were placed 2.5 km apart[2] where the presence of peat was expected.

LiDAR data over the study area were collected in two days (6 – 7 November 2016). Overall LiDAR coverage over the study area is 164 km^2 or 30.2 % of the study area. Cost of LiDAR data collection over the project area was 16,500 $US (excluding mobilization costs) at a unit cost of 1.00 US$/ha.

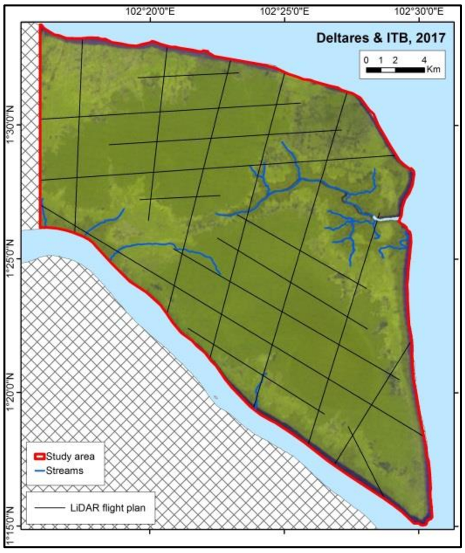

Figure 4 LiDAR flight plan over IPP study area as designed using existing peat extent maps, historical Landsat imagery (using vegetation patterns indicating presence of peat) and location of rivers and coast. In the background the RGB composite Landsat-1 image of 5 October 1972 (spectral bands 6-7-5) used. LiDAR flight line spacing is mostly at 2.5 km in this study.

[2] In other areas with larger and simpler peat domes, LiDAR strip intervals of 5 km suffice in our experience, for peatland mapping at the landscape scale.

2.1.3 LiDAR data filtering

LiDAR data were filtered applying algorithms developed by Deltares, removing vegetation signal to create a layer that presents the soil surface. In the same process, open water surfaces were also identified. The applied filtering methods will be published in coming months.

2.1.4 Creating a DTM from LiDAR data along strips

Contour lines of soil surface elevation at 1 m intervals were drawn manually between filtered LiDAR strips. A recent (August 2016) composite Sentinel-2 image was used to extract further information on likely peat dome morphology, guiding the location of contour lines in some locations. A DTM (Digital Terrain Model i.e. surface elevation model) was created by Inverse Distance interpolation between LiDAR strip data and contour lines.

2.1.5 Identifying likely peat domes

Likely peat domes were identified visually from the DTM.

2.2 Field data collection of peat thickness

A detailed report on the peat survey and budget is included in Annex 1.

2.2.1 Field survey design

Survey transects were designed to cross peat domes at perpendicular angles to extract the maximum of information from a minimum of data points. Transects started where no peat was expected to be found and along easy access points such as roads or canals, and extended up the domes to where peat was expected to be deep according to the DTM (Figure 5). Going up the dome, measurements were taken at 500 m intervals and were ended as soon as peat deeper than 7 m was found, to avoid spending much effort surveying large areas of very deep peat. In Figure 6 the survey design is presented.

The peat thickness field survey was conducted in the period 16 March to 20 April 2017, by 2 field teams working in parallel supervised by 2 experts from ITB. Total cost of the survey was 11,259 $US (however only two-thirds of this cost was for data used for map creation, the remainder for validation data; see below). In total, peat thickness was measured at 284 locations, 274 locations within the study area of which 221 (80.7 %) had peat (defined as an organic soil horizon of over 50 cm).

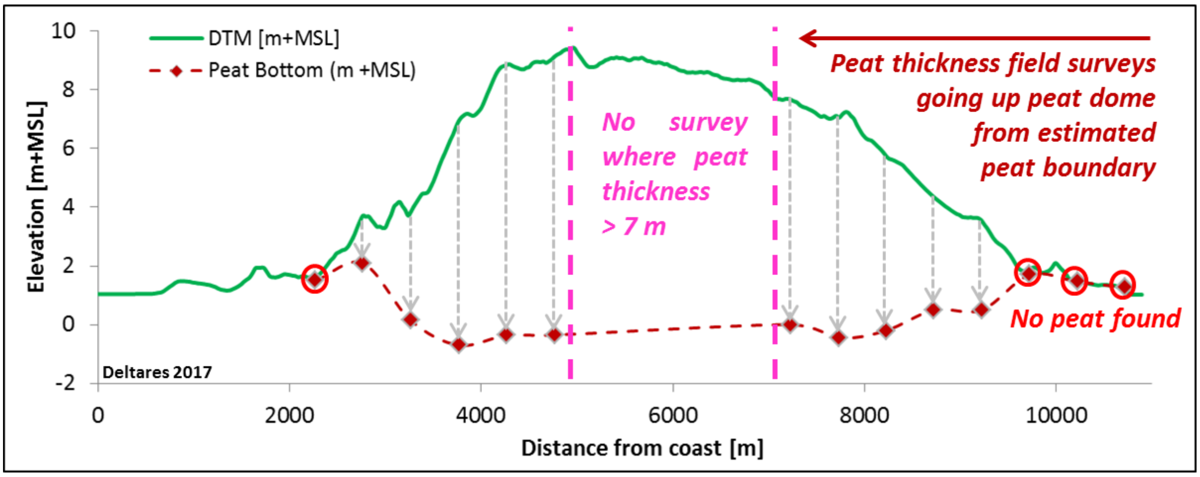

Figure 5 Schematic set-up of an effective and cost-efficient peat thickness survey. Surveys are planned perpendicular to coastlines and river as much as possible, which often matched the steepest slope of the peat dome. To reduce the number of sampling points in areas without peat, surveys start at a 'likely peat boundary' that is identified from satellite images. To reduce the number of measurements in areas where very deep peat is known to be present without further survey, surveys along transects end when a certain peat thickness limit is reached (in this case 7 m as these peat domes are small and steep, but sometimes a 5 m limit can be applied). By planning surveys in this manner, it is estimated that the number of survey locations can be reduced by over 50 % in many areas.

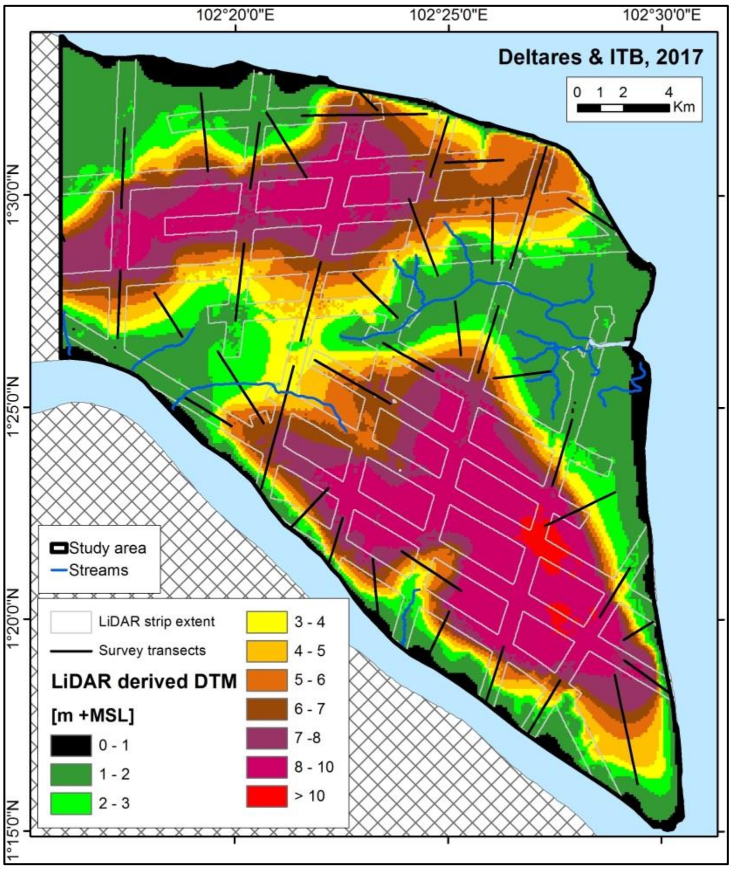

Figure 6 Peat thickness survey design along 44 transects, starting at areas where no peat was expected going perpendicular up the dome. In the background DTM generated from the LiDAR strip data (Figure 8).

2.2.2 Survey protocol

The peat thickness field survey was carried out following a field protocol (SOP; Annex 2). Peat thickness was measured using an Edelman type auger. At the first stage of the survey three replicate measurements were taken at every sample location, at 1 m apart, to be able to investigate variation and error sources; this was later reduced to 2 measurements when differences between replicate results were found to be small. The peat thickness measurement used for analysis was the average of the replicate measurements.

Vegetation cover and land use was documented at each survey location and photographed in four directions. The mineral subsoil that was trapped in the auger was photographed as well as evidence that the peat bottom had been reached.

2.2.3 Analysis of errors within peat thickness measurements

The quality of peat thickness data collected was analyzed by determining the correlation between the first and second measurement at every location.

2.3 Comparing LiDAR DTM and peat thickness measurements

The surface elevation above Mean Sea Level was derived from the LiDAR derived DTM, for all peat thickness measurement locations. DTM values were then plotted against peat thickness measurements and the regression determined. This was done for all data combined as well as separately for the 2 peat domes distinguished in the study area, and also separately for locations that are covered by LiDAR data strips and locations that are away from LiDAR data strips. The coefficient of determination (R^2) was calculated as a measure of how well peat surface elevation can be used as a proxy for peat thickness.

2.4 Creating a peat bottom elevation model

As input to the peat thickness model, and to gain understanding of the future flood risk in a scenario where all peat is removed from the area due to oxidation and fires (both inevitable consequences of peatland drainage), a model was constructed of the elevation of the peat bottom, i.e. the top of the mineral substrate below the peat, relative to Mean Sea Level and tidal range. Three types of peat bottom models were constructed. The first method creates a non-uniform peat bottom layer from subtracting actual field peat thickness measurements and the LiDAR based DTM (Figure 12); contour lines are added manually between measurements and a peat bottom map is created by inverse distance interpolation between points and lines (the likely maximum peat extent boundary (Section 2.6) is applied as ‘no peat’, i.e. mineral soil with or without an organic top soil horizon of less than or equal to 0.5 m). The second method applies a constant horizontal peat bottom elevation surface near Mean Sea Level based on the average peat bottom elevation determined from peat thickness measurement locations. The third method applies a linear regression relationship between peat surface elevation and peat thickness measurements.

The peat thickness data used to create peat bottom maps consists of two-thirds of peat thickness field measurements collected by the Deltares+ITB team, as shown in Figure 13. The remaining one-third was used for validation. The validation data transects were selected

at random, evenly distributed through the study area without considering values or impact on map results.

2.5 Creating a peat thickness model

Peat thickness models were created using the LiDAR based peat surface DTM (Section 2.1) and the peat bottom maps (Section 2.4). Peat thickness is determined as the difference between peat surface and peat bottom as illustrated in Figure 7.

As three peat bottom maps were created, this results in three peat thickness maps.

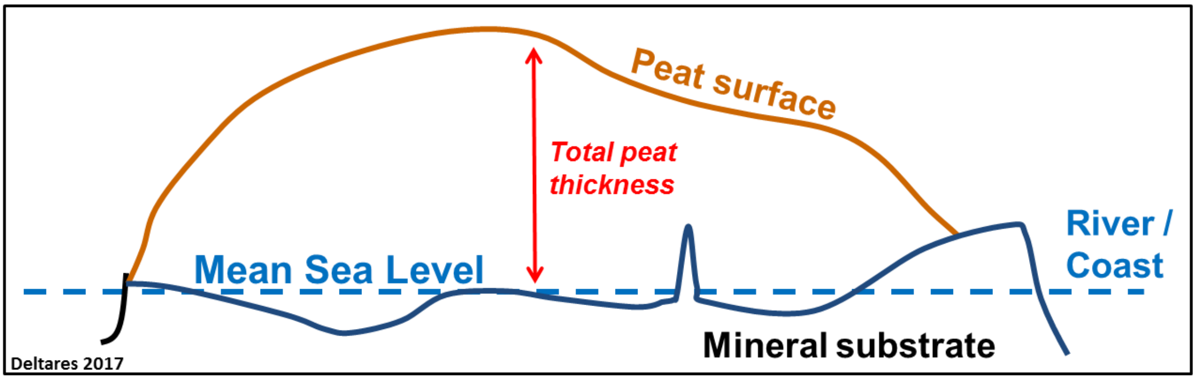

Figure 7 Illustration of how peat thickness is determined as the difference from the peat surface and depth of the peat bottom (interface with the mineral substrate).

2.6 Mapping peat extent

Peat extent was mapped through visual interpretation of a 1972 composite Landsat-1 image (i.e. when the area was still largely forested and peat extent can be discerned from vegetation patterns) combined with location of 'no peat' measurements carried out during the survey (Section 2.2).

A third potential data source for peat extent delineation, the LiDAR derived DTM, was not applied in this case, but was also found to be in good agreement.

2.7 Assessment of future flood risk

In the absence of accurate and recent water level data for the area, and in the limited scope of this assignment, it is not possible to produce a detailed flood risk assessment here. This will be done when this study is published. However, it is possible to predict how much of the area would be flooded in future if peat surface subsidence and Sea Level Rise continue. The principles applied have been published before, detailed descriptions can be found in Hooijer *et al.* (2015ab).

A future flood risk level of at least 2 m +MSL is assumed, based on a Sea Level Rise by around 1 m in the next 100 years (the 'middle' scenario according to most projections) and a tidal range of around 2 m as is common along the Sumatra coast.

2.8 Measuring canal water table depth from LiDAR data

Canal water levels are determined in LiDAR data, where floating matter and surface ripples occur. Average ground surface level is determined from the DTM on both sides of the canal. The canal water depth is determined as the difference between water level and ground level. This method can be applied to canals in any land type, it is not limited to peat areas. The method is being applied over most lowland in East Sumatra at present, and will be published in a scientific paper in the near future.

3 Results and Discussion

3.1 LiDAR data and DTM generation

The DTM that was generated from filtered LiDAR data and contour lines (Figure 8) shows two distinct peat domes separated by streams that flow East and West. These domes are named Dome 1 and Dome 2 for the Southern and Northern domes respectively (Figure 8). Dome 2 extends into the Western part of Bengkalis Island, outside of the study area.

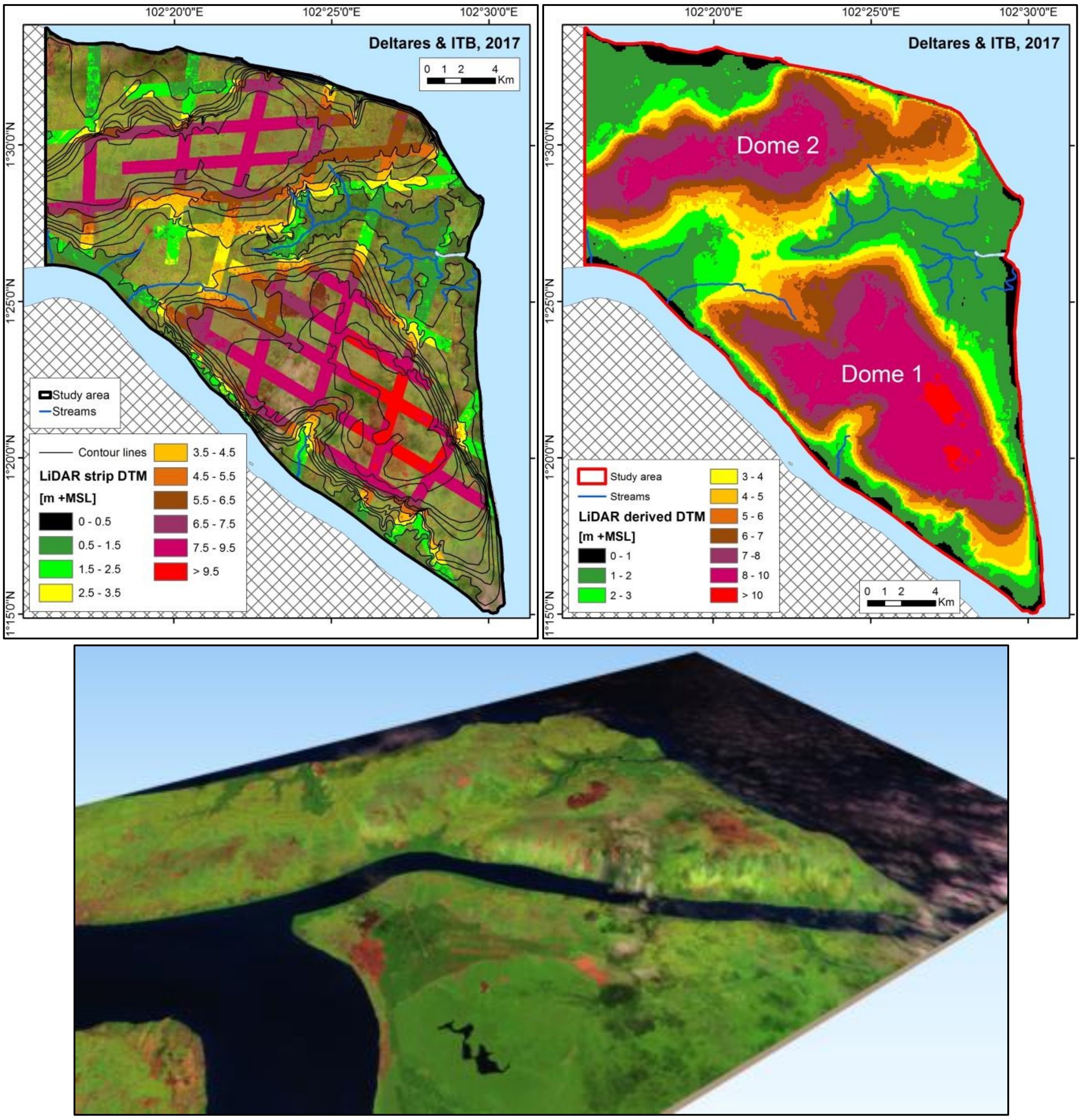

Figure 8 (TOP LEFT) LiDAR strip + manually drawn contour lines and (TOP RIGHT) LiDAR derived DTM (100 m spatial resolution) for the study area (interpolated using LIDAR strip and contour lines) showing 2 distinct peat domes (Dome 1 and Dome 2). (BOTTOM) a 3D representation of the DTM with a Sentinel-2 composite image of 6 August 2016 superposed on it.

The average elevation of the LiDAR strip data after filtering (removal of vegetation signal) was 5.50 m +MSL with a standard deviation of 2.80 m. Figure 9 presents the elevation distribution in the study area determined from the LiDAR DTM shown in Figure 8. The DTM derived from the filtered LiDAR data and contour lines shows that 157 km^2 or 29.0 % of the study area surface is below 2 m above MSL, and 213 km^2 or 39.3 % is more than 6 m above MSL. In Dome 1, these numbers are 126 km^2 and 65.0 %; in Dome 2 they are 84 km^2 and 52.0 % (Table 1).

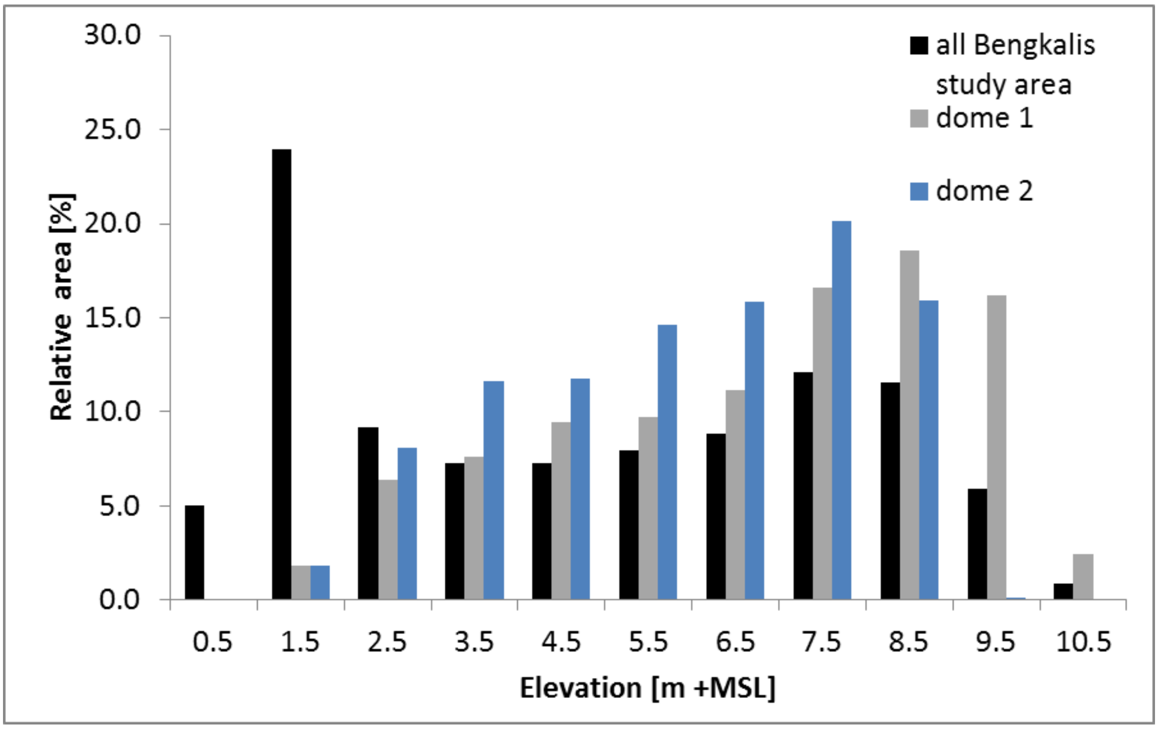

Figure 9 Relative distribution of surface elevation in the LiDAR-derived DTM, for the whole study area, as well as for the 2 peat domes (using the extent derived from peat thickness model (method 1), Figure 22).

Table 1 Elevation characteristics of LiDAR-derived DTM for the whole study area, as well as for the 2 peat domes (using the extent derived from peat thickness model (method 1), Figure 22).

Elevation characteristics	Whole study area	Peat dome 1	Peat dome 2
Area [ha]	54107	19405	16109
Mean [m]	4.74	6.77	5.86
% <2 m	29.0	1.9	1.8
% <3 m	38.2	8.2	9.9
% <4 m	45.5	15.8	21.6
% <6 m	60.7	35.0	48.0
% <8 m	81.6	62.8	84.0
% <10 m	99.1	97.6	100.0
% <12 m	100.0	100.0	100.0

3.2 Peat thickness field data

Of the 284 survey locations, 274 locations were within the study area (Figure 10). Of these 274 locations, 221 (80.7%) found the presence of peat i.e. an organic top soil horizon of over 0.5 m thickness. For 2 of these locations the mineral subsoil was not reached since not sufficient extensions were brought to the field. These locations were not re-surveyed at a later time and are removed from further calculations (see also Annex 1). Of the remaining 219 locations, 95.0% found a peat thickness of over 1 m and 77.6% over 3 m. Average peat thickness of the 219 locations is 4.79 m with a standard deviation of 2.17 m (Table 2).

The fit between first and second replicates in each measurement is very good with an R^2 of 0.99 and an average absolute difference of 0.05 m (Figure 11), indicating that the quality of peat thickness measurements collected in this survey is high.

Figure 10 Peat thickness measurements in the study area as surveyed between 16 March to 20 April 2017. Also shown is the extent of the LiDAR strip data (Figure 8).

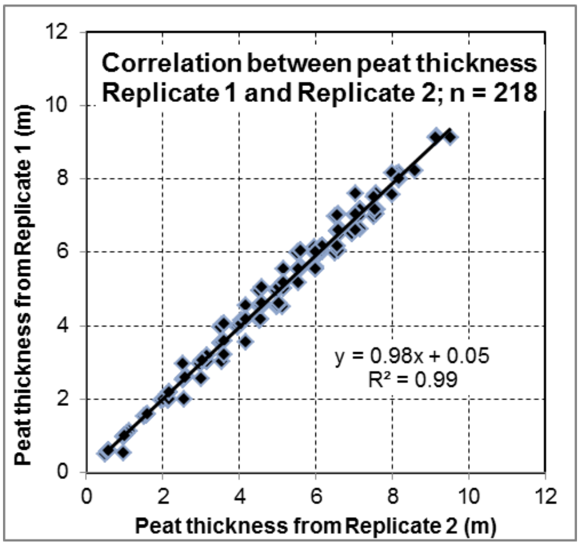

Figure 11 First and second replicate peat thickness field measurements plotted against each other (n = 218).

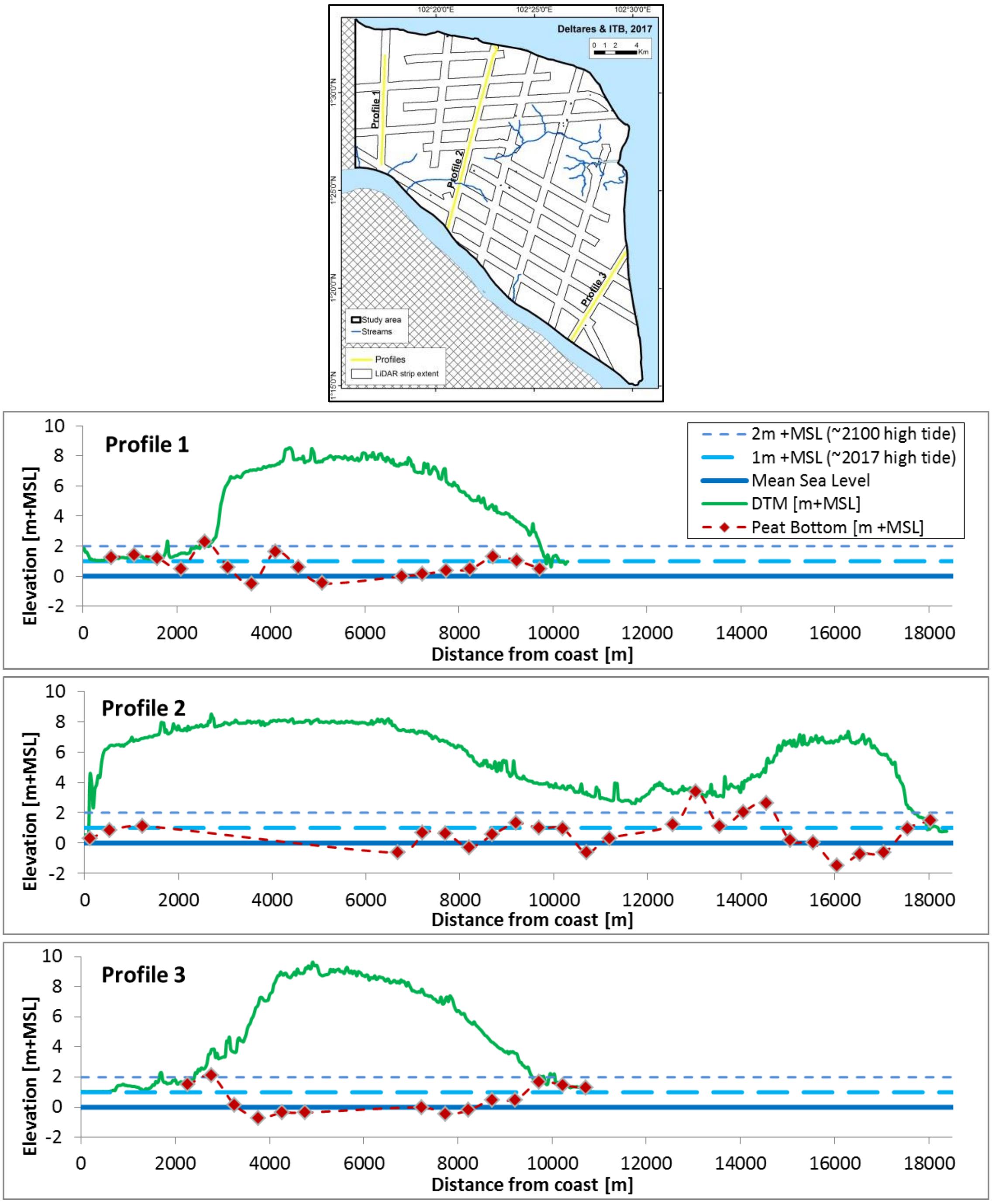

Figure 12 Three cross sections over the two Bengkalis Island peat domes along LiDAR flight lines, showing LiDAR derived surface elevation (DTM) and the peat bottom as derived from field measurements. The North side is on the left in all profiles. Mean Sea level and estimated likely High Tide levels are also shown. *Note:*

- *Peat surface slopes are unusually steep near the coast, to even over 10 metres per kilometre whereas slopes over 2 m / km are generally rare in intact peatlands.*
- *The peat bottom (i.e. the top of the mineral substrate) is quite flat with variations mostly limited to within 2 metres.*
- *The peat bottom is usually around Mean Sea level, and nearly always below the estimated 2100 High Tide level of 2 m +MSL below which drainage will probably not be possible in the longer term.*

3.3 LiDAR DTM compared with peat thickness measurements

A very close fit was found between surface elevation above Mean Sea Level as derived from the LiDAR DTM (Figure 8) and peat thickness measurements (Figure 10), with an R^2 value of 0.84 for all data combined if 'no peat' measurements are excluded (Figure 14). This confirms that the peat bottom is relatively flat, as found in most coastal peatlands in Indonesia, and that a surface DTM can be used for peat thickness mapping.

The fit is somewhat better for locations where LiDAR data are available ('on the LiDAR strip') with an R^2 of 0.86, than for locations where the DTM is interpolated between LiDAR strips ('off the LiDAR strip') with an R^2 of 0.79 (Figure 15). This confirms that the interpolated DTM is somewhat less accurate than the DTM derived directly from LiDAR filtering, as expected, and that this has some impact on the accuracy of the peat thickness model. However, the relatively small difference in accuracy also provides further proof that the relation between the LiDAR DTM and peat thickness measurements is very strong, and also that peat thickness measurements are indeed very accurate, as the relation is affected directly and plausibly by relatively small variations in the accuracy of the DTM alone.

The peat thickness range, and the fit with the peat surface DTM, of measurements that were used for model creation (Figure 13) was almost identical to that of measurements that were used for validation, as is shown in Figure 16.

Figure 13 Distinction between peat thickness measurements in the study area (Figure 10) used further in peat thickness model creation (black dots) and as used for validation. Also shown is the extent of the LiDAR strip data (Figure 8).

Finally it was investigated whether the relation between peat thickness and peat surface DTM was fundamentally different between the two domes, as they have somewhat different settings in the landscape. The number of peat thickness measurements in Dome 1 and Dome 2 is similar, at 108 and 111 respectively. It was found that, despite these differences, the peat thickness distribution and also the underlying relation between peat thickness and DTM was nearly identical for the two domes (Figure 17). Average and maximum peat thickness from field measurements are 5.08 / 9.33 m and 4.51 / 8.09 m respectively (Table 2).

It is thus shown, in Figure 14 to Figure 17, that peat thickness field measurements match the peat surface DTM very well, regardless of how the peat thickness dataset is cut up in subsets. This confirms that the DTM should allow generation of an accurate peat thickness model.

Table 2 Peat thickness (PT) measurement statistics. PB = Peat bottom.

Peat thickness class	All			Dome 1			Dome 2			Creation of PT map			Validation		
	n	[%]	[%] (excl. no peat)	n	[%]	[%] (excl. no peat)	n	[%]	[%] (excl. no peat)	n	[%]	[%] (excl. no peat)	n	[%]	[%] (excl. no peat)
no peat	53	19.3	n.a.	30	21.6	n.a.	23	17.0	n.a.	28	16.1	n.a.	25	25.5	n.a.
0.5 - 1 m	11	4.0	5.0	6	4.3	5.5	5	3.7	4.5	8	4.6	5.5	3	3.1	4.1
1 - 2 m	17	6.2	7.7	9	6.5	8.3	8	5.9	7.1	14	8.0	9.6	3	3.1	4.1
2 - 3 m	21	7.7	9.5	10	7.2	9.2	11	8.1	9.8	12	6.9	8.2	9	9.2	12.3
3 - 5 m	57	20.8	25.8	21	15.1	19.3	36	26.7	32.1	36	20.7	24.7	21	21.4	28.8
5 - 8 m	102	37.2	46.2	53	38.1	48.6	49	36.3	43.8	69	39.7	47.3	32	32.7	43.8
>8 m	13	4.7	5.9	10	7.2	9.2	3	2.2	2.7	7	4.0	4.8	5	5.1	6.8
total #	**274**	**100**	**100**	**139**	**100**	**100**	**135**	**100**	**100**	**174**	**100**	**100**	**98**	**100**	**100**
avg. PT (excl. no peat) [m]	4.79			5.08			4.51			4.69			5.00		
std. PT (excl. no peat) [m]	2.17			2.34			1.96			2.20			2.12		
max. PT [m]	9.33			9.33			8.09			9.33			9.17		
avg. PB (excl. no peat) [m +MSL]	0.65			0.46			0.83			0.61			0.71		
std. PB (excl. no peat) [m +MSL]	0.88			0.94			0.79			0.91			0.82		
min. PB [m +MSL]	-1.67			-1.67			-0.83			-1.29			-1.67		
max. PB [m +MSL]	3.12			3.06			3.12			3.12			2.94		

Total for class 'All', 'Dome 1' and 'Dome 2' include 2 measurements for which no exact peat thickness measurement was available, see also Annex 1

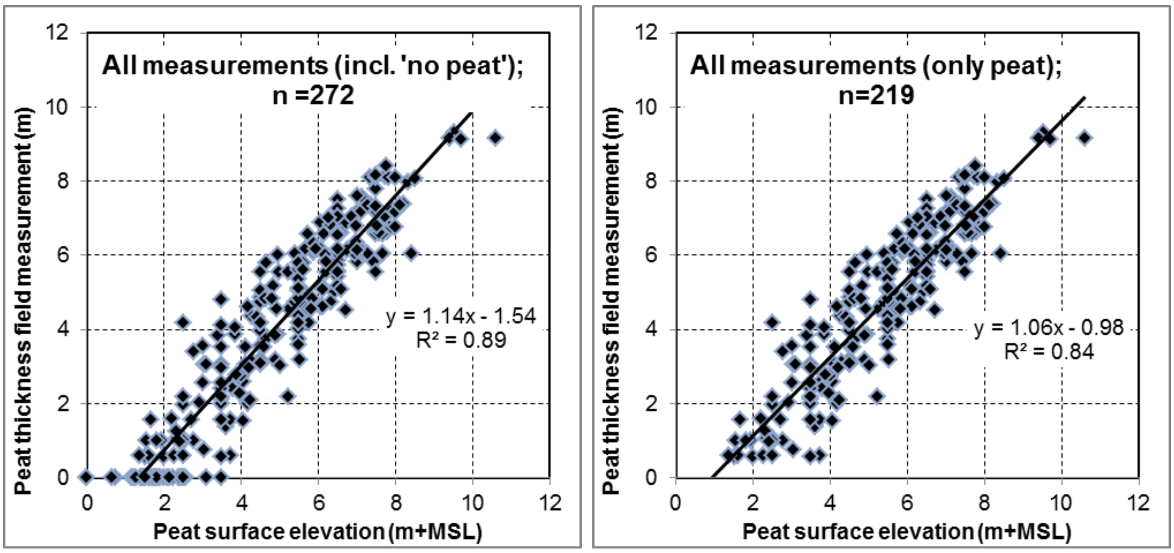

Figure 14 Peat thickness measurements plotted against elevation as determined from LiDAR DTM. (LEFT) including all (incl. 'no peat') measurements, (RIGHT) including only peat measurements.

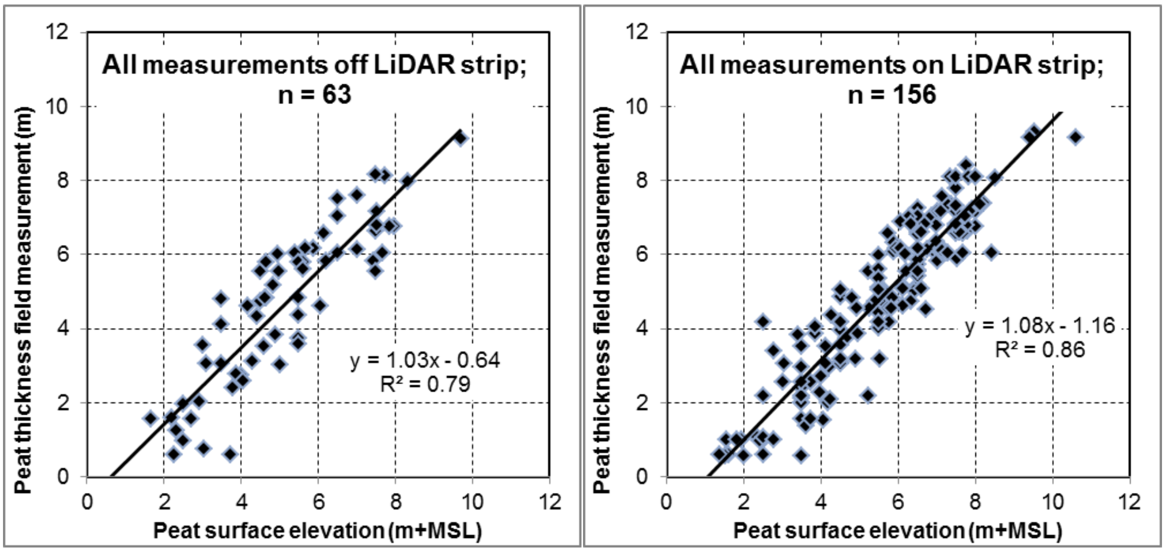

Figure 15 Peat thickness measurements (LEFT) 'on the LiDAR strip' and (RIGHT) 'off the LiDAR strip' plotted against elevation as determined from LiDAR DTM.

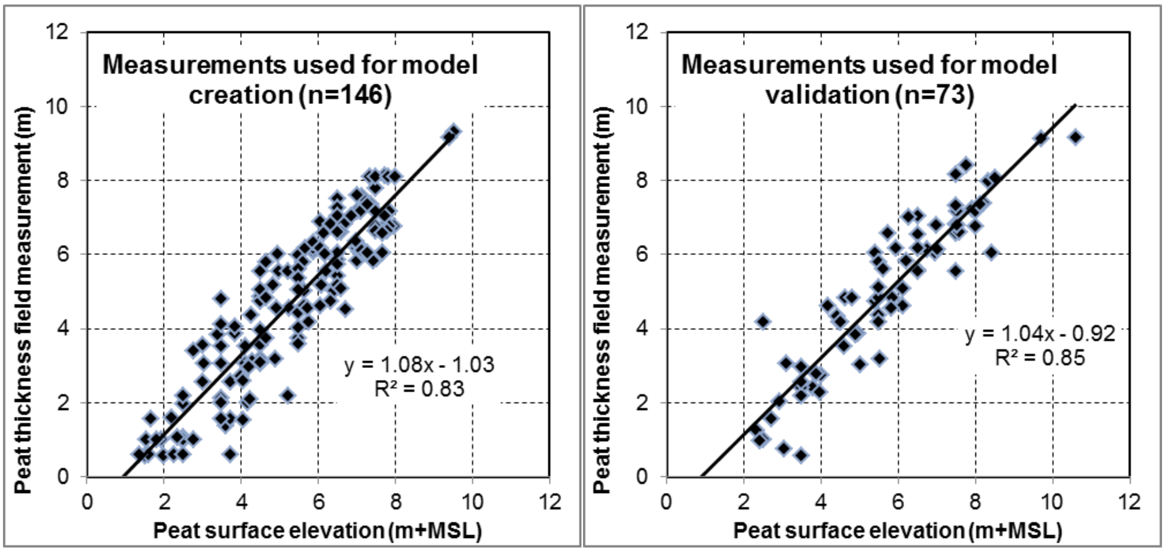

Figure 16 Peat thickness measurements used to create the peat thickness model (LEFT), and those used to validate the model (RIGHT) plotted against elevation as determined from LiDAR DTM.

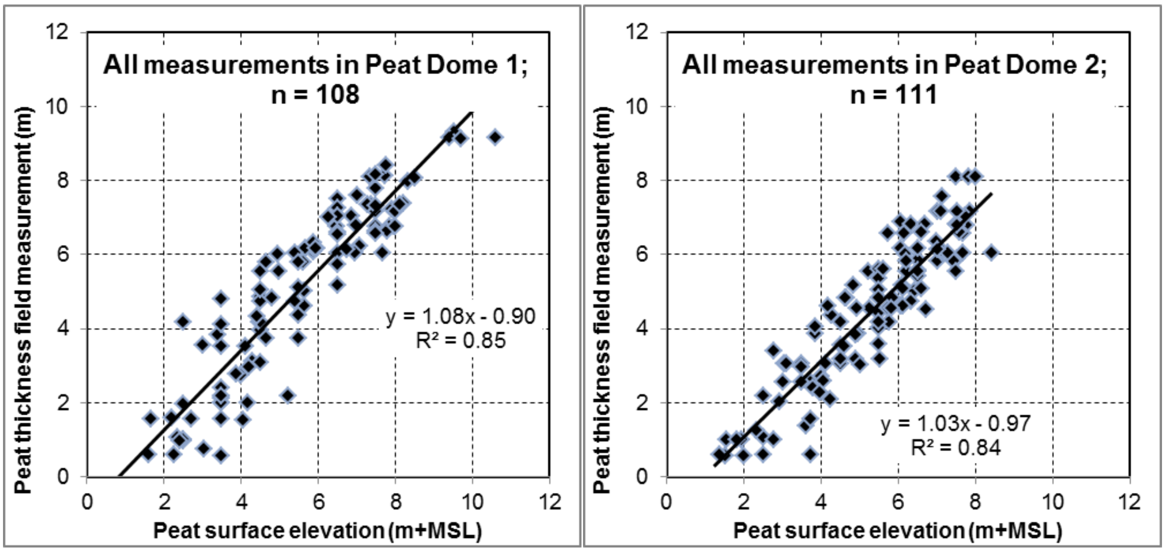

Figure 17 Peat thickness measurements in the two domes that occur in the study area (see Figure 8) plotted against elevation as determined from LiDAR DTM.

3.4 Peat bottom elevation model

From Figure 12 it is evident that the peat bottom is quite smooth in most of the area and near Mean Sea Level, with variations mostly within 1 plus or minus 1 metre +MSL.

This uniform peat bottom elevation is expected given the peat formation history in this area, with peat formation starting some 5,000 years ago on a relatively flat pre-existing landscape of coastal river floodplains and mangroves (Cameron *et al.*, 1989). In fact, this principle of the peat bottom being more or less horizontal and near Mean Sea Level has in the past been used to determine surface elevation above Sea level from peat thickness measurements, even for Padang Island that is next to Bengkalis and shares the same development history (van Doorn, 1959; Figure 18). In the case of some other older publications that show greater variation in peat bottom elevation, such as Supardi *et al.* (1993) for Bengkalis Island (although that still shows limited variations with plus and minus 2 metres +MSL; Figure 18), we suspect that this is partly due to the lack of an accurate surface elevation model (land based peat elevation surveys as applied in that study are notoriously inaccurate and often wrong by several metres in our experience, especially in forested areas).

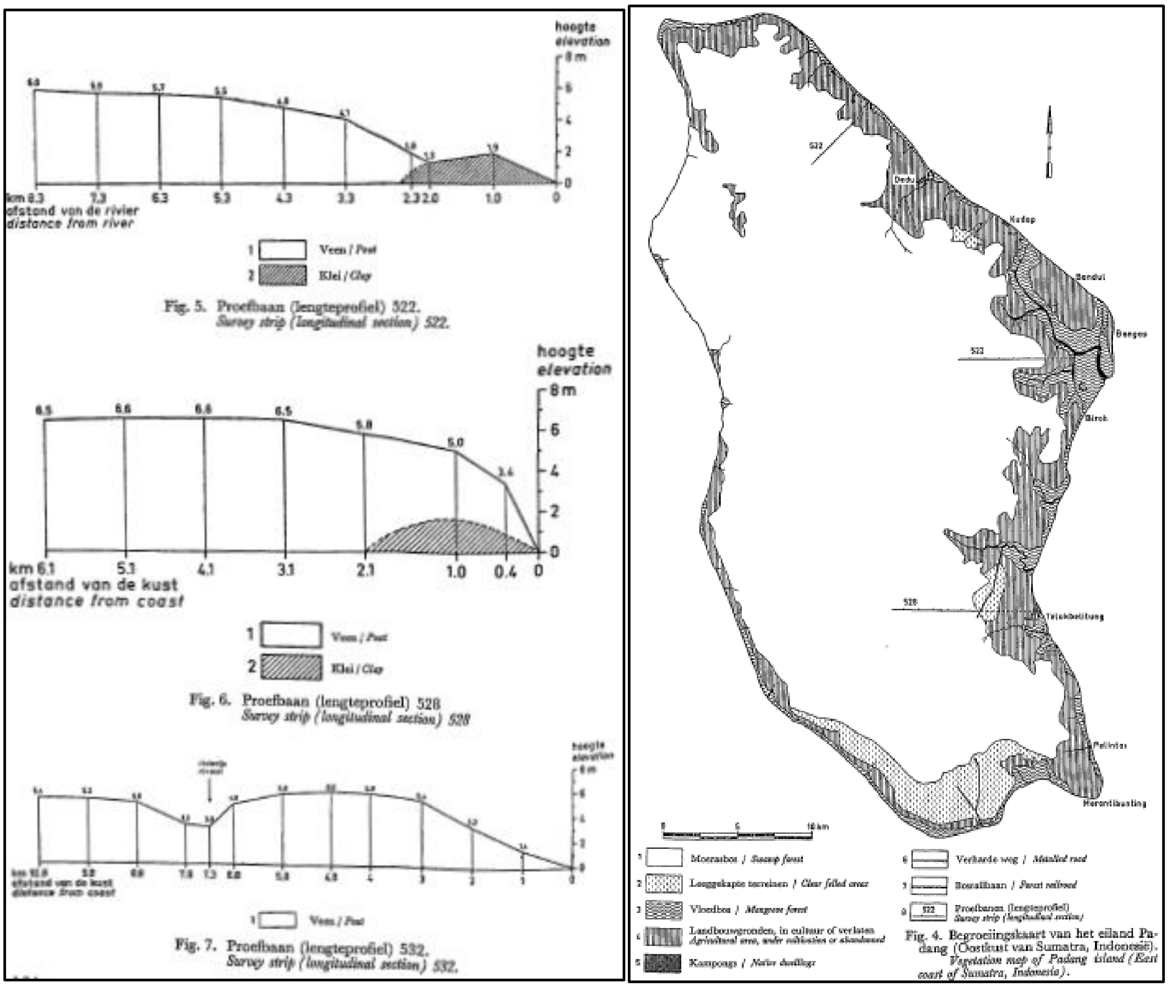

Figure 18 Cross sections through coastal peatland on Pulau Padang, adjoining Bengkalis Island, as published by van Doorn in 1959. This study applied the principle that the peat bottom in such areas is relatively flat compared to the peat surface.

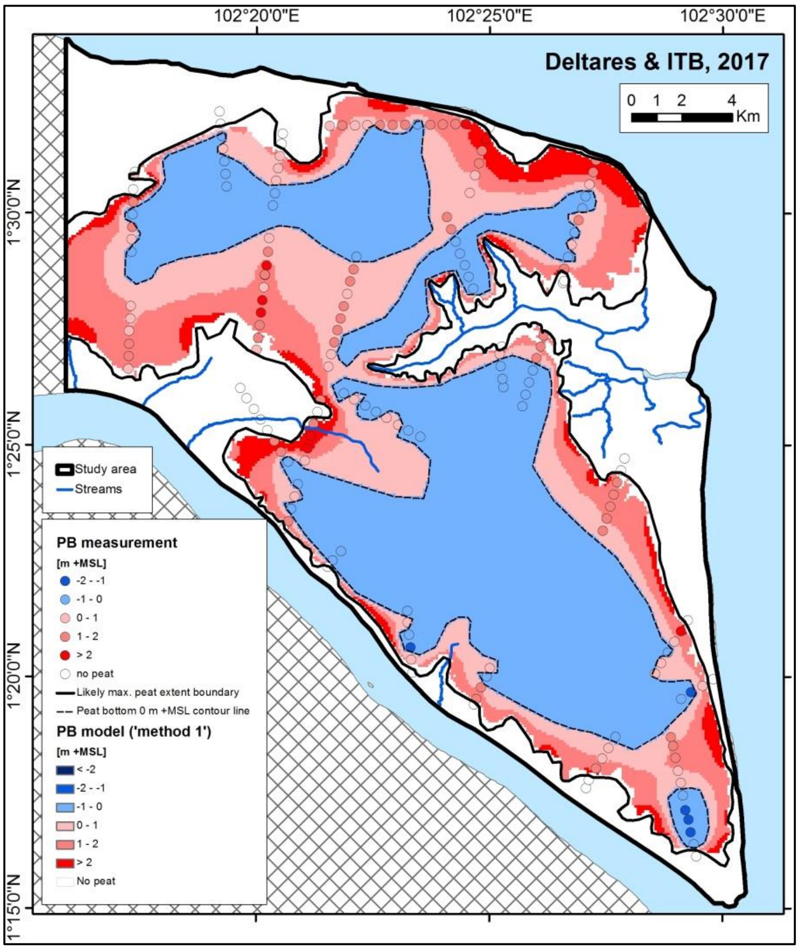

Figure 19 Peat bottom model as derived from subtracting actual field peat thickness measurements (Figure 13; black dots) and the LiDAR based DTM (Figure 8); the 0 m +MSL contour lines are added manually between measurements. The peat bottom map is created through inverse distance interpolation between peat bottom measurements, the 0 m +MSL contour lines and the likely maximum peat extent boundary.

Of course, in some areas the peat bottom elevation is actually more variable. This can be explained by the existence of a pre-existing landscape with greater morphology around early Holocene river channels and estuaries, and hills. It is also found in a few areas along the Sumatra coastline that the peat bottom has been moved up or down by tectonics, sometimes by several metres. However, whether the peat bottom is uniform and near Sea level can be determined from a relatively limited number of field measurements, and the mapping approach can be adjusted accordingly.

In Figure 19 the peat bottom model is shown resulting from the interpolation between peat thickness measurements subtracted from the LiDAR derived DTM, manual drawn peat bottom contour lines and the likely maximum peat extent boundary. It should be noted that the peat bottom model shown in Figure 19 already accounts for the ‘no peat’ area as shown in Figure 22 resulting from the difference between the LiDAR derived DTM and the ‘full’ peat bottom model.

Overall peat bottom elevation above MSL is 0.50 m with a standard deviation of 0.77 m, as determined from the full peat bottom model (Figure 19). The peat bottom is below MSL over 30.7% of the peat area, and below 1 +MSL (estimated high tide level) over 50.1% of the area.

The peat bottom in the nearby area of Kampar Peninsula is also near MSL but somewhat lower than in the Bengkalis study area, more often below Sea level than above it (Figure 20).

We conclude that the peat bottom elevation is in many coastal peatland areas in Indonesia sufficiently uniform to allow creation of a peat thickness map from a DTM even if only few peat thickness measurements would be available, applying only an estimate of uniform peat bottom elevation based on scarce data.

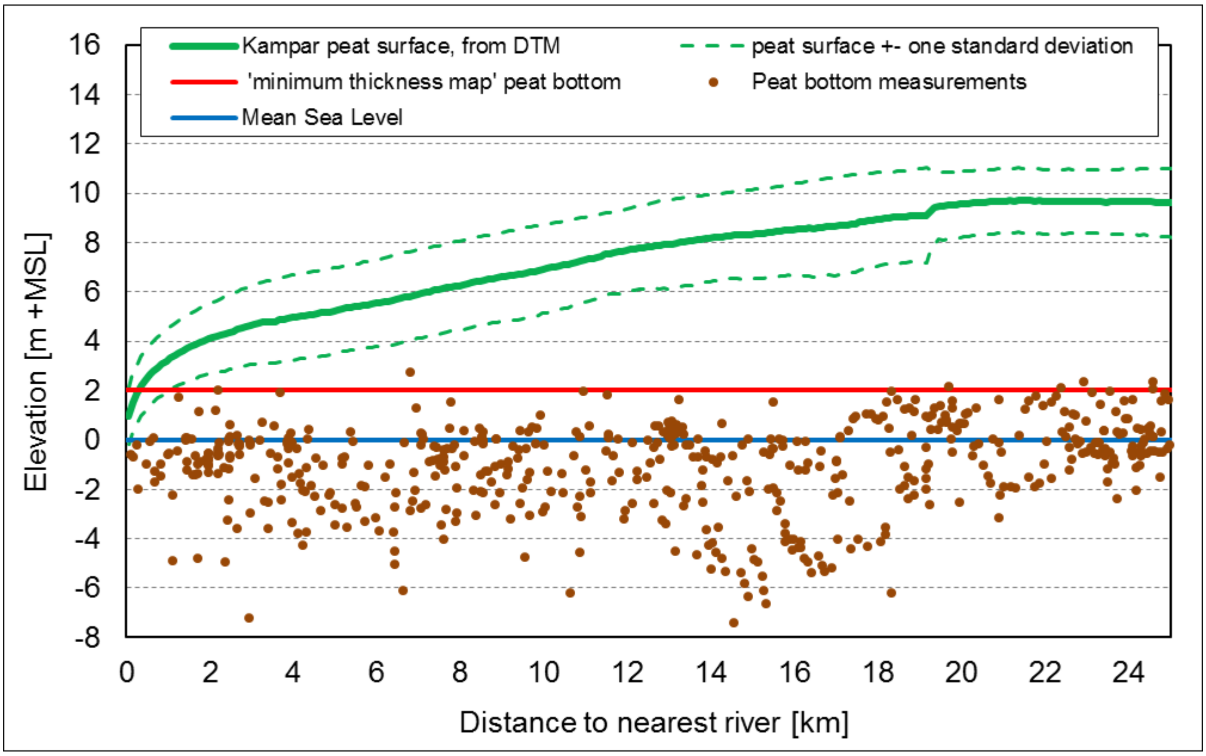

Figure 20 Virtual cross section through the Kampar Peninsula (KP) peatland, near the Bengkalis study area, in Riau (from Hooijer *et al.*, 2015b). The cross section presents the average of all peat bottom (from field surveys) and surface elevation (from LiDAR DTM) points on the KP. The peat bottom here is usually near Mean Sea Level, but more commonly below it than above it. Note that the peat thickness measurements available for the Kampar Peninsula are from several sources, some with unclear survey protocols and no metadata. Such data must be considered with caution, and may explain part of the large variation in peat bottom elevation seen in this graph.

3.5 Peat extent

The likely maximum peat extent boundary was mapped through visual interpretation of a composite Landsat-1 image of 5 October 1972 (i.e. when the area was still forested and peat extent can be discerned from vegetation patterns; Figure 21) combined with the location of 53 ‘no peat’ measurements found during the 2017 peat thickness survey (Section 3.2).

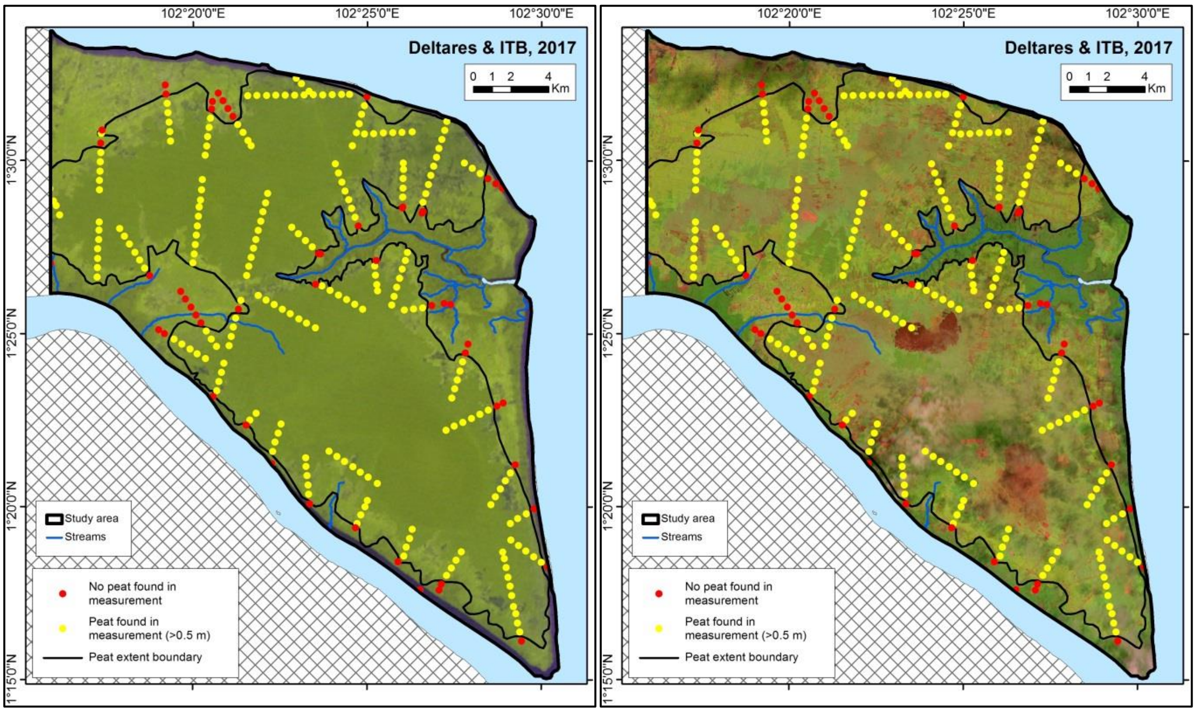

Figure 21 Likely maximum peat extent boundary in the study area delineated based on visual interpretation of (TOP) background RGB composite (spectral bands 6-7-5) Landsat-1 image of 5 October 1972 and peat thickness measurements (yellow and red dots). For comparison the likely maximum peat extent boundary is also shown on (BOTTOM) Sentinel-2 background RGB image of 4 August 2016 (spectral bands 11-8-5). Note that nearly all peat was still forested in 1972.

3.6 Peat thickness and extent models

The first peat thickness model created (Figure 22), utilizing both LiDAR based DTM and field measurements of peat thickness collected in this study and applying the likely maximum peat extent boundary (Figure 21), has an average peat thickness of 5.96 m with a standard deviation of 2.60 m. Validation of this model with the one-third of data that were not used in model creation yielded an average absolute error of 0.62 m with a standard deviation of 0.73 m (Table 3).

The second peat thickness and extent model (Figure 22), applying a constant peat bottom elevation (Table 2) and the likely maximum peat extent boundary (Figure 21), has an average peat thickness of 5.44 m with a standard deviation of 2.38 m. Validation of this model with the one-third of data that were not used in the first peat thickness model creation yielded an average absolute error of 0.48 m with a standard deviation of 0.53 m and for the

two-third of data used to create the model these values were 0.65 m and 0.53 m, respectively (Table 3).

A third peat thickness and extent model (Figure 22) was created by applying the regression equation between the LiDAR derived DTM and peat thickness measurements used to create the first peat thickness model (Figure 16) and the likely maximum peat extent boundary (Figure 21), has an average peat thickness of 5.55 m with a standard deviation of 2.55 m. Validation of this model with the one-third of data that were not used in the first peat thickness model creation yielded an average absolute error of 0.49 m with a standard deviation of 0.53 m and for the two-third of data used to create the model these values were 0.65 m and 0.51 m, respectively (Table 3).

Table 3 Statistics of modeled peat thickness (PT) compared with peat thickness measurements for the three peat thickness models. PB = Peat bottom.

	PT models		
	'method 1'	'method 2'	'method 3'
only 'no peat'			
avg. PB [m]	0.50	0.63	0.54
std. PB [m]	0.77	0.00	0.19
avg. PT [m]	5.96	5.44	5.55
std. PT [m]	2.60	2.38	2.55
comparison with validation data (without 'no peat' measurements)			
n	73	73	73
avg. abs. error	0.84	0.64	0.65
std.	0.73	0.52	0.52
measurements within 0.5 m [%]	39.7	52.1	50.7
measurements within 1 m [%]	63.0	79.5	79.5
comparison with all field data (without 'no peat' measurements)			
n	219	219	219
measurements within 0.5 m [%]	79.5	38.4	36.1
measurements within 1 m [%]	87.7	74.0	74.0

The three approaches yield somewhat different results, with the outcome of the first method deemed to be somewhat more accurate with an R^2 against field measurements of 0.94 which is slightly higher than the other two model results (0.93), and with an intercept through '0' (Figure 23). However, it should be noted that the peat bottom in most of the area is below 1 m +MSL and therefore below the flood limit. In other words: even as peat continues to disappear after drainage, the peat bottom in most of the area can never be at the land surface, as the land will be flooded before the mineral substrate can be exposed. It is therefore questionable whether knowing the exact peat thickness, i.e. the exact position of the peat bottom below the flood limit, always warrants much extra effort and investment in field surveys.

The results of the different DTM based peat thickness mapping methods (Figure 22) are quite similar. This is because the variation in peat bottom elevation is much less (in the order of 10-20 %) than that in peat surface elevation. Therefore, the peat surface shape dominates the peat thickness model whatever approach is taken to mapping the peat bottom elevation.

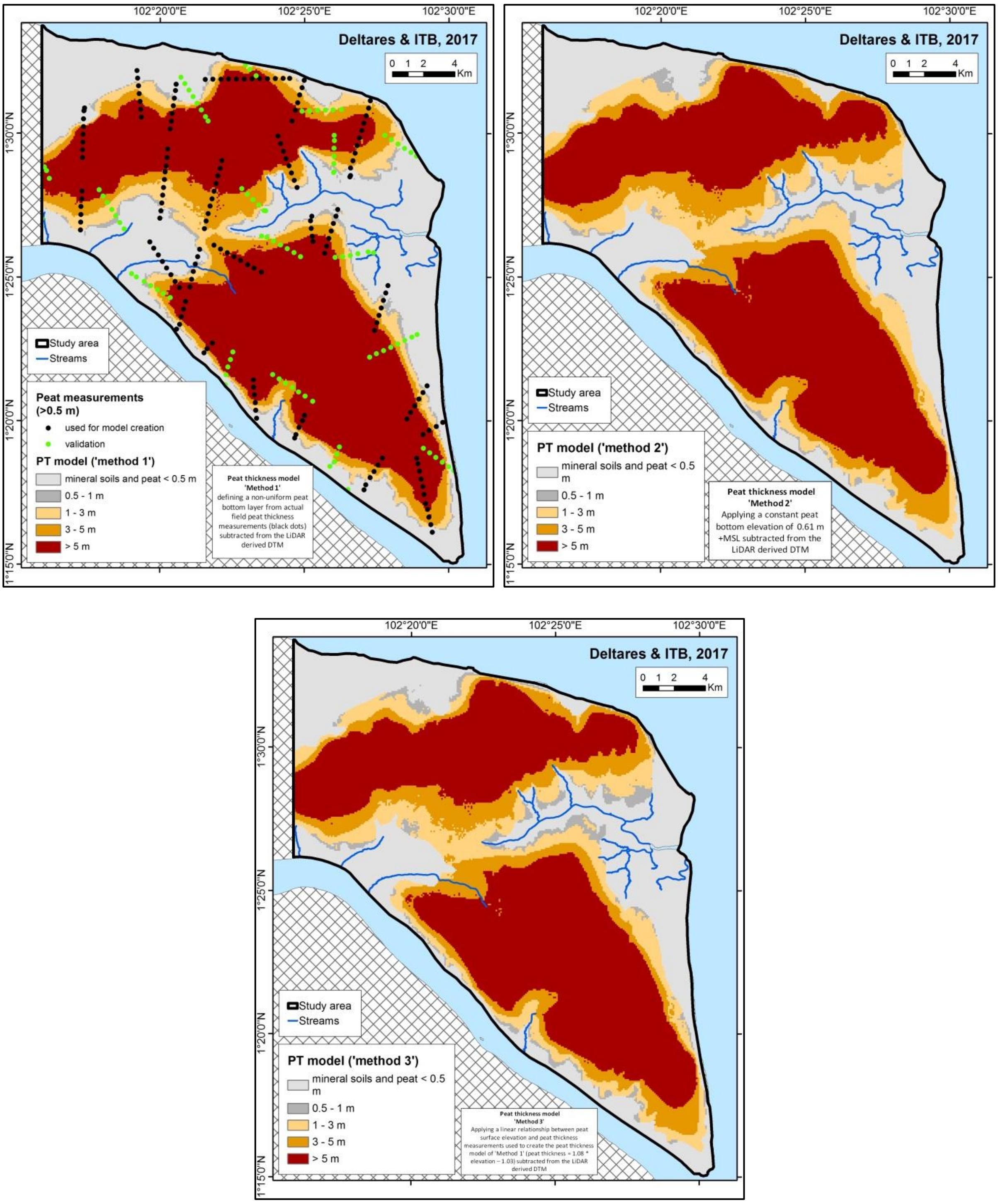

Figure 22 Peat thickness models as derived from LiDAR based DTM (100 m spatial resolution), applying three different methods:

- Method 1: Defining a non-uniform peat bottom layer from actual field peat thickness measurements measurements (black dots).
- Method 2: Applying a constant peat bottom elevation of 0.61 m +MSL (Table 2).
- Method 3: Applying a linear relationship between peat surface elevation and peat thickness measurements used to create the first peat thickness model (peat thickness = 1.08 * elevation – 1.03) (Figure 16).

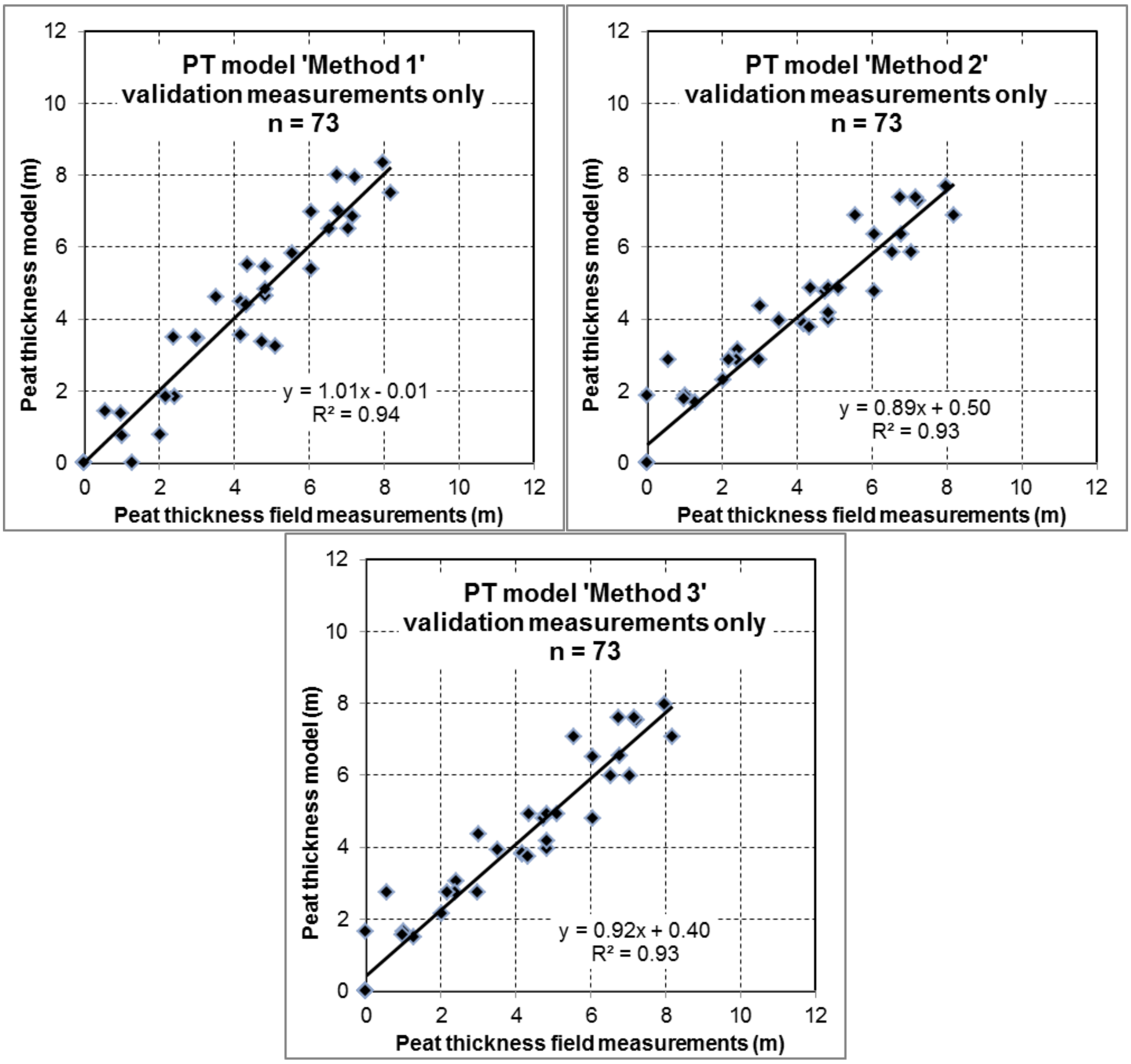

Figure 23 Modelled peat thickness plotted against peat thickness measurements (the 'validation' dataset (Figure 13) for the 3 different peat thickness models.

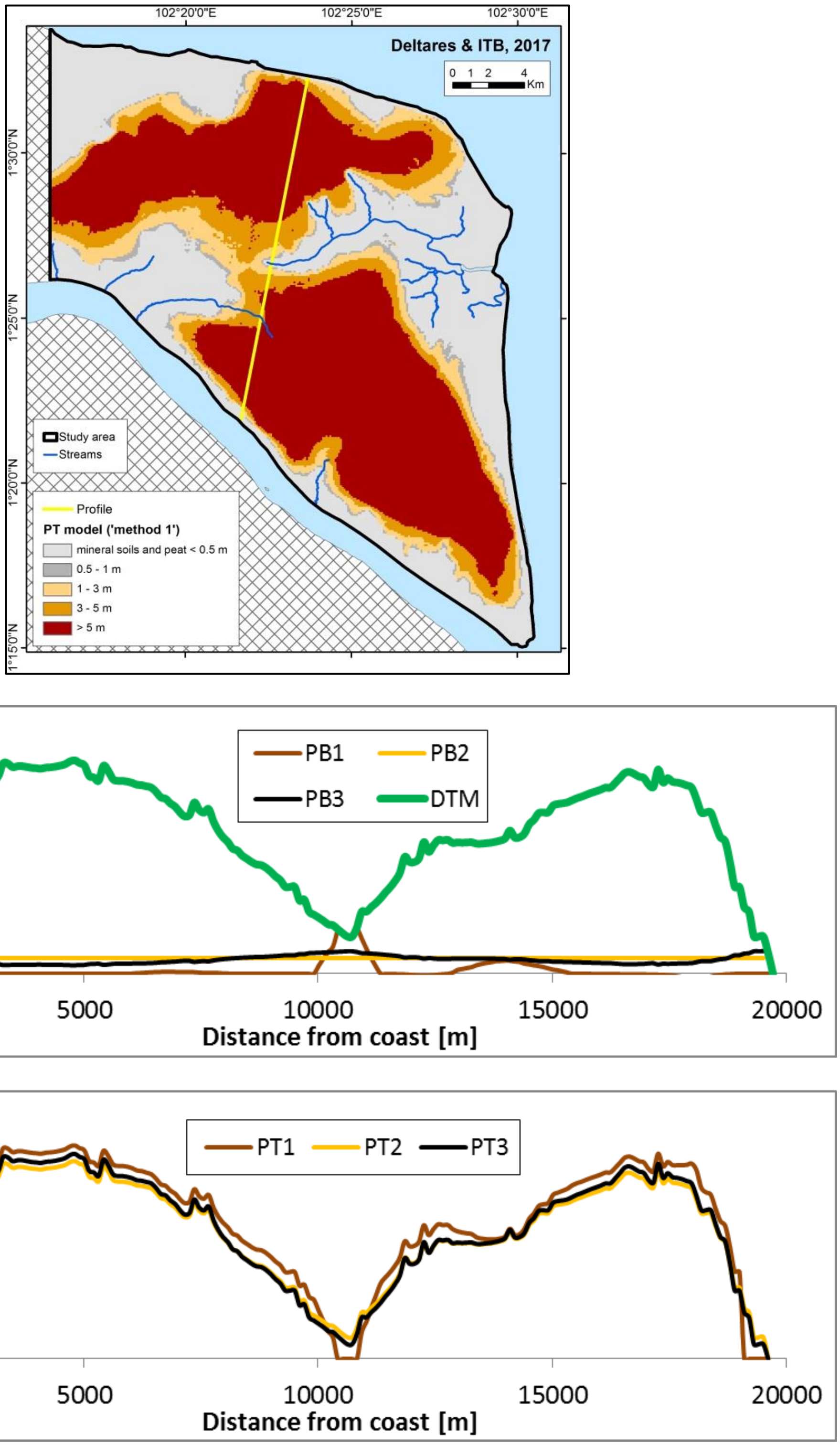

Figure 24 Cross section through the two Bengkalis peat domes showing LiDAR based peat surface elevation (DTM), peat thickness and peat bottom elevation according to 3 peat models. For methods see caption in Figure 22.

The peat thickness area distribution for each of the 5 classes of the peat thickness models (Figure 22) is provided in Table 4 and shows that peat covers 65.6 % of the study area, with

83.0 % of peat being deeper than 3 m according to peat thickness model using method 1. These values are 72.1 % and 78.8 % for method 2 and 71.8 % and 78.6 % for method 3, respectively.

Table 4 Peat thickness area (ha) distribution for the three different peat thickness models (Figure 22).

Peat thickness class	Method 1			Method 2			Method 3		
	[ha]	[%]	[%] (excl. 'no peat')	[ha]	[%]	[%] (excl. 'no peat')	[ha]	[%]	[%] (excl. 'no peat')
no peat	18600	34.4	-	15089	27.9	-	15256	28.2	-
0.5 - 1 m	1264	2.3	3.6	1160	2.1	3.0	1702	3.1	4.4
1 - 3 m	4780	8.8	13.5	7122	13.2	18.3	6603	12.2	17.0
3 - 5 m	6280	11.6	17.7	7765	14.4	19.9	7470	13.8	19.2
>5 m	23183	42.8	65.3	22971	42.5	58.9	23076	42.6	59.4
Total	54107	100	100	54107	100	100	54107	100	100

3.7 Comparing DTM based peat thickness maps with existing maps

Three widely known peat extent maps exist for Indonesia, namely RePPProT (1990), Puslitanak (published by Wetlands International, Wahyunto *et al.*, 2003) and BBSDLP (Ritung *et al.*, 2011). For the Bengkalis study area these maps are shown in Figure 25.

The three existing models all show two distinct domes, as was also found in this study. The 2003 and 2011 maps present the same peat extent, that is far larger than the extent in the 1990 map and also substantially larger than the extent found in this study. However, the extent of the deepest peat in the 2003 and 2011 maps (2-4 m and >3 m respectively) is far less than what was found in this study, less than half of the >3 m area (Table 5). It is clear that the peat extent and thickness map presented by Deltares and ITB is a large improvement on existing maps.

Table 5 Areas of 'deepest' peat as determined from different peat thickness maps: (1) Puslitanak (Wahyunto et al., 2003), (2) BBSDLP (Ritung et al., 2011) and (3) this study (Table 3).

Source	Peat thickness class	Area [ha]
Puslitanak (2003)	2-4 m	16323
BBSDLP (2011)	> 3 m	5233
This study (method 1)	> 3 m	29463

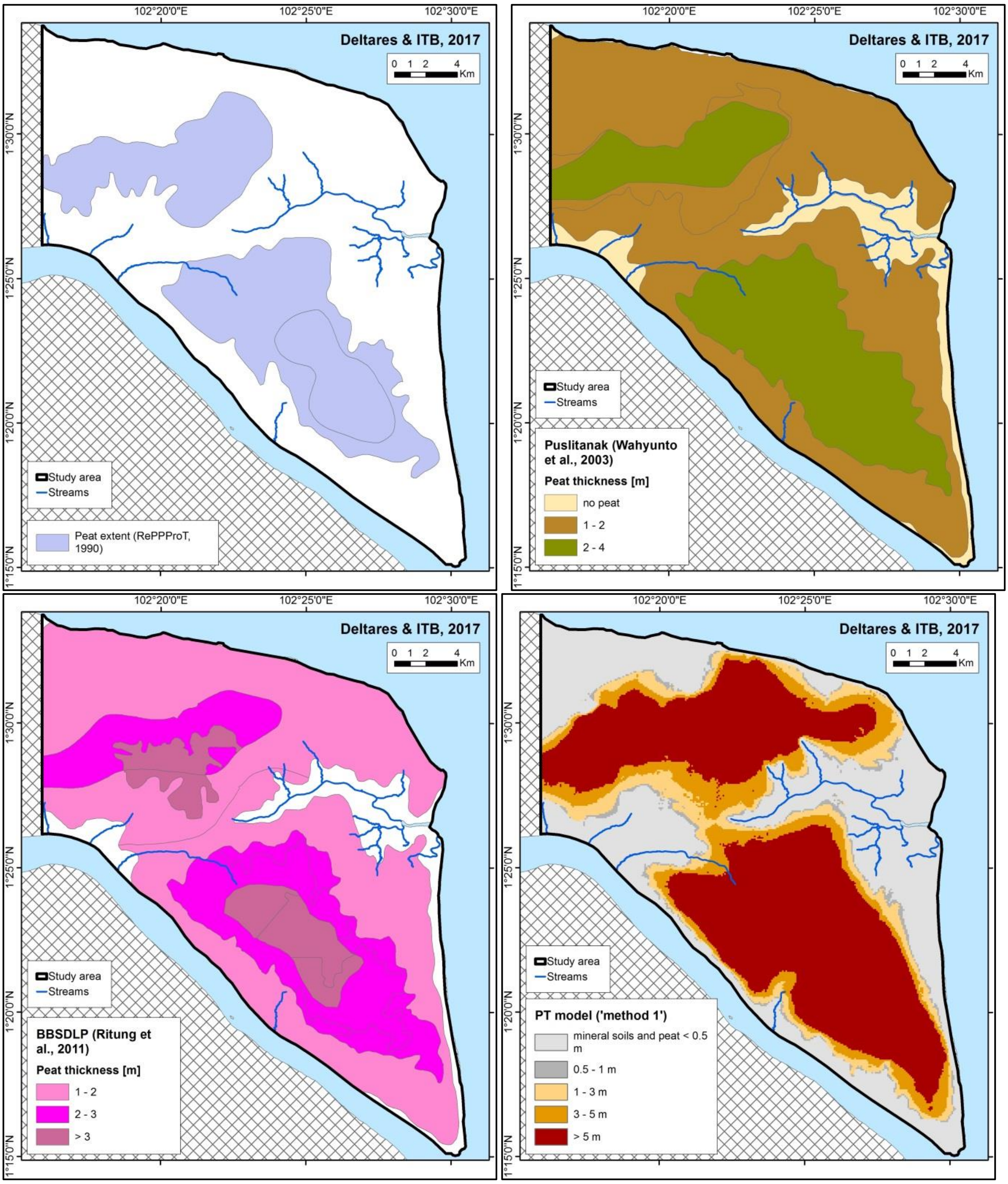

Figure 25 Three existing peat extent (and thickness for Puslitanak and BBSDLP) maps for the Bengkalis study area. (TOP LEFT) RePPProT (1990), (TOF RIGHT) Puslitanak (Wahyunto *et al.*, 2003) and (BOTTOM LEFT) BBSDLP (Ritung *et al.*, 2011). For comparison also PT model 1 (Figure 22) is also shown (BOTTOM RIGHT).

3.8 Future flood risk

The DTM resulting from LiDAR data shows that 29.0 % of the study area (including mineral soil areas) is currently (2017) below 2 m +MSL. In future, if peat continues to be lost (following drainage) and Sea level rises, almost the entire area will be severely flood prone or may even be lost to the Sea permanently after peat is fully removed, with only 5.3 % of the mineral substrate topography below peat in the study area being above 2 m +MSL (Figure 26) and as much as 56.6 % being below current Mean Sea Level. The land use in the area is too fragmented and uncertain to assign fixed subsidence rates to drainage regimes, but in case of a subsidence rate around 3.5 cm yr^{-1} as applied in other studies, most of this development could take place within 100 years.

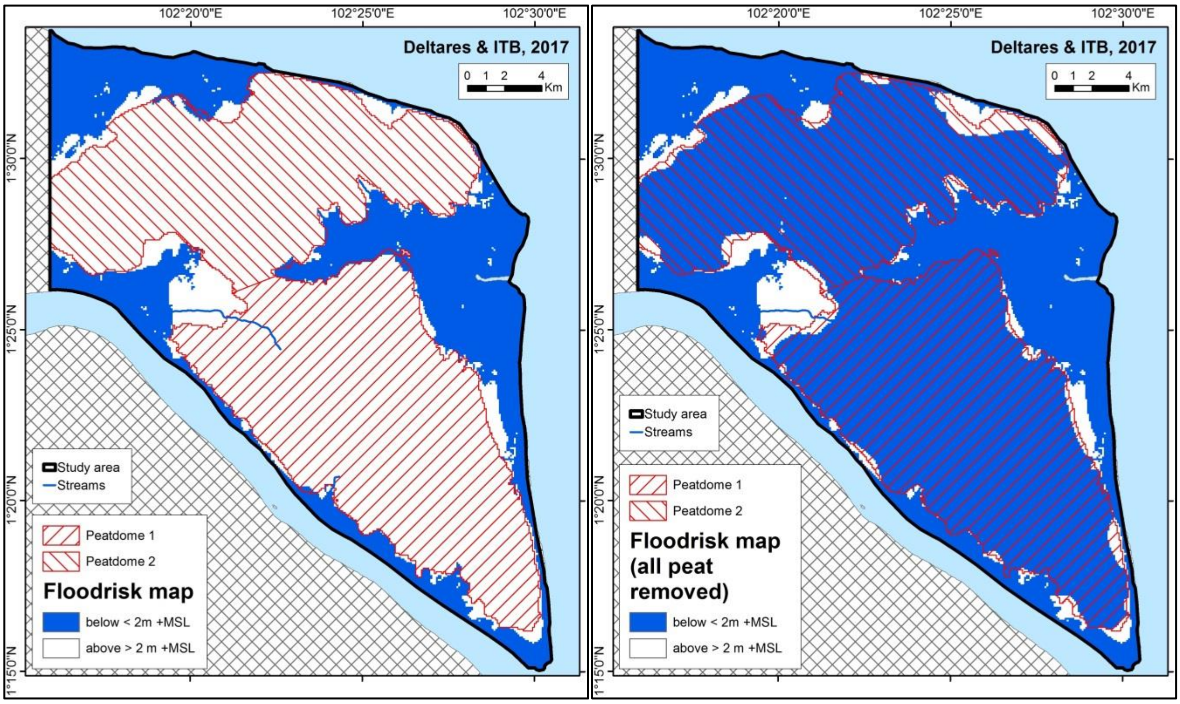

Figure 26 Land surface below 2 m +MSL in 2017 (LEFT), as determined from the LiDAR based DTM, and (RIGHT) after removal of all peat following drainage.

3.9 Measuring canal water table depth from LiDAR data

From Figure 27 it is clear that canal water table depth (CWD) relative to the surrounding land surface, as mapped using LiDAR, does not yield random results but rather consistent and plausible CWD values over long stretches of canals. In the two day measurement period (6-7 November 2016), CWD in LiDAR strip coverage over peat in the study area is in the ranges of 0-0.5 m, 0.5-1 m and >1 m below the peat surface in 15.9 %, 42.6 % and 41.5 % of cases respectively. The relative abundance of lower water table depths, in a period that was relatively ‘wet’ with high rainfall and therefore high water tables, indicates that major improvements in water management are required. Canal water tables will drop by 0.5 to 1 m in the dry season, in a normal year, so will be below 1 m in nearly all peatland canals in the study area for part of the year. As long as water levels remain this low, fire risk will be high.

It should be noted that, in intensively drained areas, ground water depths can be easily estimated from CWD, as water tables in deep peat are relatively uniform due to the very high hydraulic conductivity of fibric and hemic tropical peat (usually > 10 m/day).

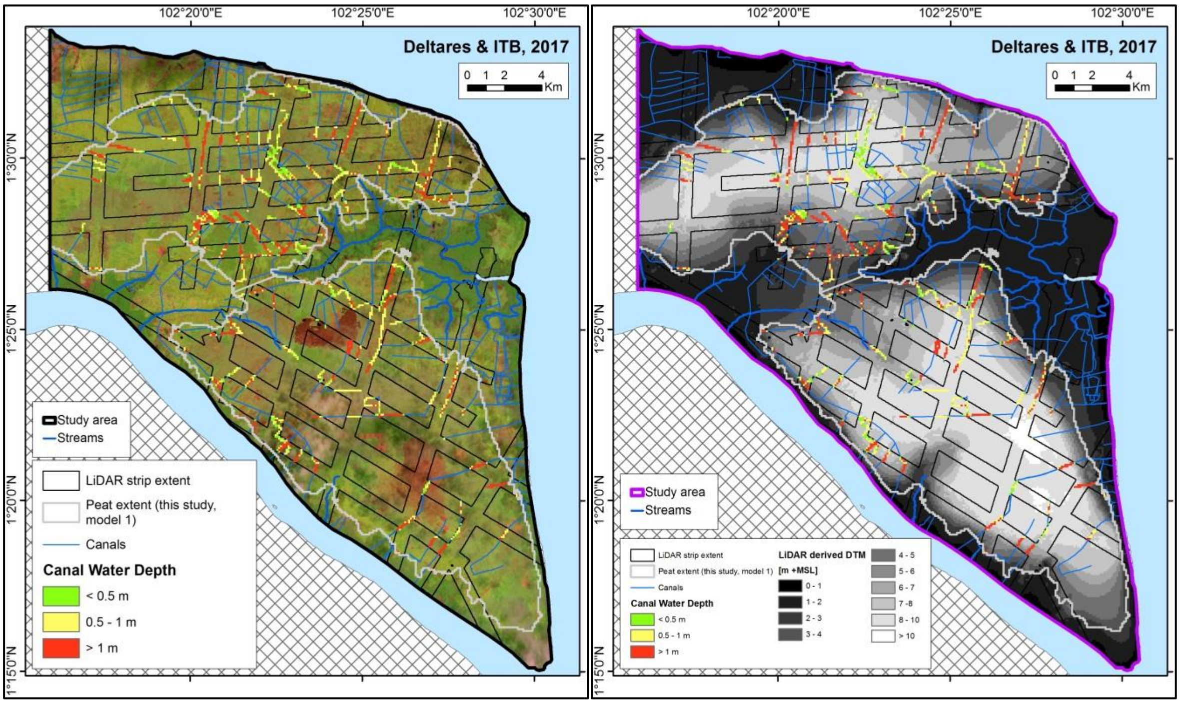

Figure 27 Canal water depth below the surrounding land surface on peatland, for 6-7 November 2016, as determined from LiDAR data.

4 Conclusions and recommendations

The Bengkalis peat mapping activity presented here has taken some 9 months altogether, from first planning (starting in September 2016) to completion. Most of this time, from September 2016 to February 2017, was required for preparation and execution of airborne LiDAR data collection at a cost of 16,500 US$ (excluding mobilization). The collection of 284 field measurements of peat thickness took 5 weeks with 2 teams (excluding 2 weeks of preparation) at a cost of 11,259 US$ (when accounting for the fact that only two-third of the measurements were used to create the peat thickness map this is 7,248 US$).

Total survey cost to create the peat thickness map presented in this study is 23,748 US$ or 0.67 US$ per hectare of peat. This cost can be lowered further for future mapping in areas where LiDAR data and/or field peat thickness are already available (as is increasingly the case). The cost of data processing, analysis and reporting is hard to determine as this will be much reduced when applying this method at the large scale, but we estimate this to be equal to 50% of the cost of data collection (LiDAR + field). The total cost of mapping of the study area is therefore 35,622 US$, or 0.66 US$ per hectare (1.00 US$ per hectare of actual peatland) (Table 6).

Table 6 Overview of mapping costs for the Bengkalis study area.

Description	USD
LiDAR survey (excl. mobilization costs)	16500
Field survey	7248
Subtotal	**23748**
Data processing, analysis, reporting (est. 50% of survey costs)	11874
Total	**35622**
Total (USD/ha)	0.66
Total (USD/ha peat)	1.00

4.1 Peat thickness map

The simple peat thickness map as determined from a LiDAR based elevation model alone, assuming a peat bottom at 0.61 m +MSL (Table 2), is accurate within 0.5 m for 52.1 % of 73 peat thickness field measurement points collected in this study and for 79.5 % within 1 m (Table 3). A more complex peat thickness map that utilizes not only LiDAR data but also two-thirds of the peat thickness points collected, is accurate within 0.5 m for 39.7 % of the 73 validation peat thickness field measurements and for 63.0 % within 1 m. If all 219 measurements would be used for validation this is 79.5 and 87.7 %, respectively (Table 3).

The study has demonstrated that it is possible to create peat thickness maps of sufficient detail and accuracy for purposes of land use zoning, at the landscape level, using a cost effective combination of limited LiDAR and field data. A few areas in transition zones between peat and mineral soil areas are left where it may be helpful to have more detailed peat thickness maps for the purpose of precise land use planning; such gaps are easily filled in by targeted field mapping if and where required.

We observe that the peat bottom is below 2 m +MSL for 29.0% of the study area. In addition we find that only 5.3 % of the mineral substrate topography below peat in the study area is above 2 m +MSL (Figure 29; 1,874 ha) and as much as 56.6 % is below current Mean Sea Level (20,082 ha). It is therefore evident that the mineral soil substrate in most of the area will never come to the surface even if all peat would be removed in conditions of continued drainage and fire. Peat below this flood limit can never burn or be oxidized as it will always remain inundated, and should in our view therefore not be included in calculations of future carbon emissions or total carbon stock. It may be asked what the actual requirement is for highly detailed peat thickness maps in areas where the peat bottom is below the (future) flood limit. The same question may be asked in areas of very deep peat, that will take centuries to be removed even if the bottom is above the (future) flood limit.

Our recommendation is to conduct peat thickness mapping in 2 phases, to ensure speed and cost effectiveness:

- Phase 1 consists of a rapid landscape scale assessment utilizing strip-based LiDAR and limited field surveys, as demonstrated in this study. This will provide clarity on areas of deep peat in the short term and at limited cost, and allow creation of landscape scale models of where peat protection is required. National and Provincial management plans can be developed on this basis.
- Phase 2 can zoom in on areas where the presence or thickness of peat is not sufficiently clear after Phase 1, and where detailed planning at the village or plantation level requires such information. This phase will consist mostly of detailed field investigations, for instance using a sampling grid, and may in some areas take years to complete.

The Phase 1 approach is currently being applied by Deltares for most of East Sumatra and parts of West and Central Kalimantan, following the method applied to the Bengkalis study area, with results planned to be released in the public domain by 2018. This data is available to be the basis of Phase 2 type detailed mapping by other organizations. We would recommend other organizations to also bring relevant LiDAR and peat thickness data in the public domain in support of such efforts.

4.2 Accuracy requirements for peat thickness maps

It should be considered that only part of a peat deposit may be available for oxidation including fires. Peat that is below the permanent water table will always be water saturated and can therefore never decompose or burn (although it may be eroded by waves in coastal settings). The position of the permanent water table depends on Sea / River level, which changes with Sea Level Rise, and also on distance to Sea or River as a conveyance gradient is required to remove water from the peat surface (DID, 2001; Hooijer *et al.*, 2015b). Thus, it should be considered that a substantial amount of peat may be excluded from carbon stock calculations (Figure 28), and that knowing the depth of peat below the permanent water table may be less relevant. Likewise, for land suitability assessments for agriculture, it is often not relevant to know the depth of peat below the permanent water table.

This principle may be used to reduce accuracy and intensity requirements for peat thickness surveys and mapping in peatlands where the peat bottom is known to be below the permanent water table over large areas. The reduction in effort and cost required for peatland mapping may be substantial especially in extensive, inaccessible and data scarce areas like the Kampar Peninsula in Riau (Hooijer *et al.*, 2015b) or the EMRP area in Central Kalimantan (Sumarga *et al.*, 2016).

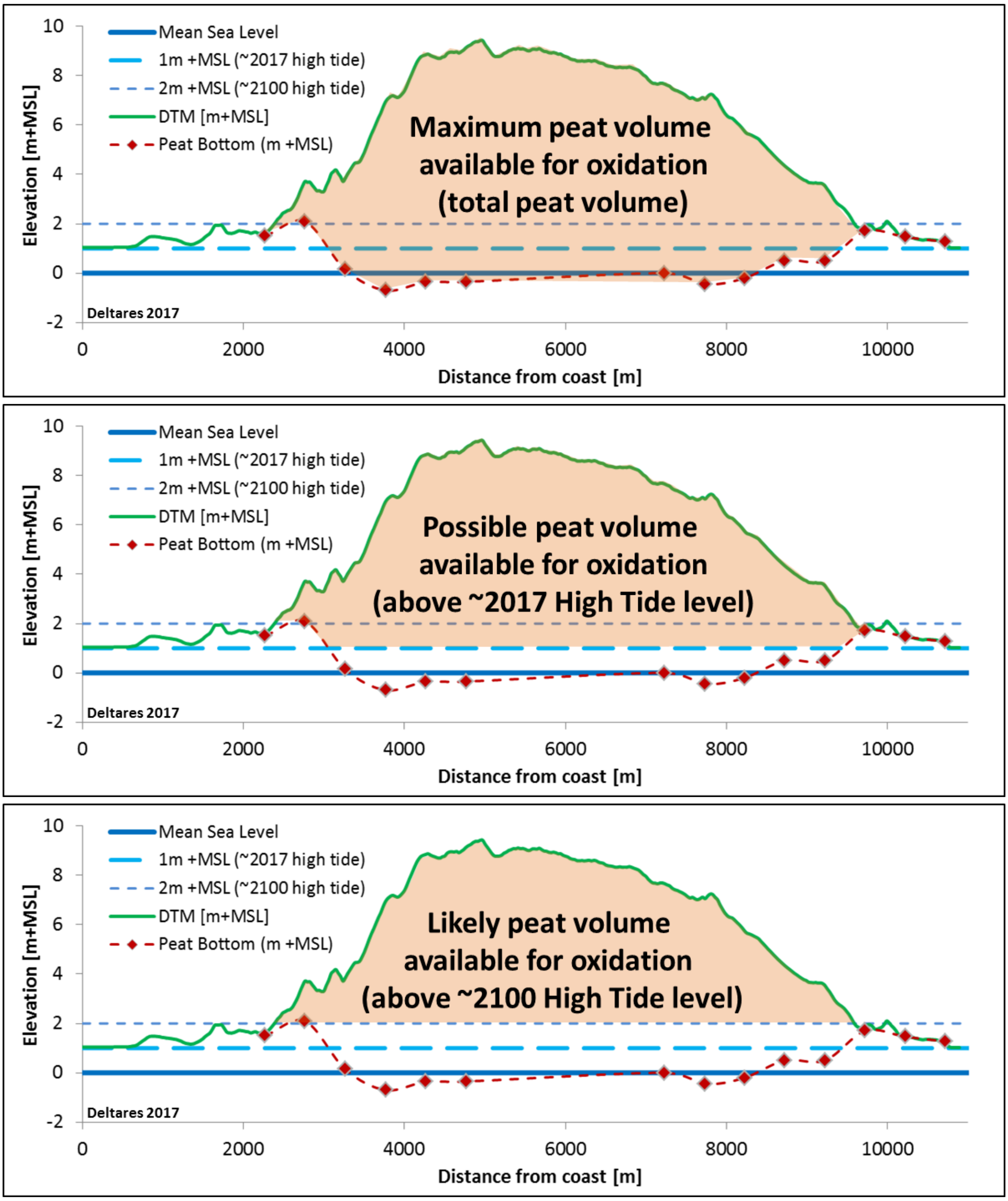

Figure 28 Schematic illustration of how only part of a peat deposit may be available for oxidation including fires.

4.3 Flood risk mapping

The results of the flood risk mapping are in agreement with those of earlier assessments of this nature (Hooijer *et al.*, 2015ab; Sumarga *et al.*, 2016) and confirm that most coastal lowland peatland in SE Asia will flood in future if peatland drainage and subsidence are allowed to continue. Ending drainage will require either full restoration to natural forest, which we would recommend especially in buffer zones around remaining areas of natural forest on peatland[3], or conversion to alternative crop species that tolerate high water levels (sometimes referred to as 'paludiculture'). If such crop species are selected from native swamp forest species and grown for timber at long rotation, this model would indeed create both economic productivity and ecological value. If a high species diversity can be achieved and crops are grown at rotations longer than 20 years, this would mean a de-facto return to the HPH model of selective timber logging that applied to most Indonesian swamp forest until the 1990s, which had been quite successful for some decades in limiting fire risk and maintaining carbon and timber resources.

4.4 Canal water table depth measurements from LiDAR

The canal water table depth measurement using LiDAR data has the potential to be applied in mapping and monitoring at the very large scale. A single measurement, while providing only a snapshot in time, does allow detection of areas with very low or high water levels that require prioritization in further assessment. If airborne LiDAR is flown multiple times over the same locations, possibly applying drones, this could contribute to water level monitoring systems. Such systems are required to allow water level targets to be met, that reduce fire risk, carbon emission, forest degradation and peat surface subsidence. While LiDAR data collection is not cheap, if applied tactically it may prove more cost effective than field monitoring. The accuracy of this method is being validated against ground measurements in other areas, results will be published; it is found to be more accurate than ground measurements in some circumstances.

5 Acknowledgements

We thank Asia Pulp and Paper for funding the data collection in the study area.

[3] It has been shown (Hooijer and Vernimmen, 2013) that nearly all remaining lowland forest in Sumatra and Kalimantan is in fact on deep peat (thickness >3 m). Protecting and expanding areas of remaining lowland forest is therefore probably the most effective way of reducing future fire risk and carbon emission in Indonesian peatland and forest.

6 References

Cameron CC, I, Esterle JS, Curtis AP, 1989. The geology, botany and chemistry of selected peat-forming environments from temperate and tropical latitudes. International Journal of Coal Geology, 12 (1989) 105-156.

DID Sarawak, 2001. Water management guidelines for agricultural development in lowland peat swamps of Sarawak (Report of the Department of Irrigation and Drainage, Sarawak, Malaysia, 78 pp.

van Doorn Z, 1959. Enkele waarnemingen aan oorspronkelijke Indonesische veenmoerassen ter vergelijking met de Hollands-Utrechtse venen (in Dutch). Some Observations on Original Peat Bogs in Indonesia for Comparison with the Holland-Utrecht Peat Area. Boor en Spade 10:156-170.

Hooijer A, Vernimmen R, 2013. Peatland maps for Indonesia. Including accuracy assessment and recommendations for improvement, elevation mapping and evaluation of future flood risk. Quick Assessment and Nationwide Screening (QANS) of Peat and Lowland Resources and Action Planning for the Implementation of a National Lowland Strategy - PVW3A10002. Agentschap NL 6201068 QANS Lowland Development, for Government of Indonesia and Partners for Water (Netherlands). https://www.deltares.nl/app/uploads/2015/03/QANS-Peat-mapping-report-final-with-cover.pdf

Hooijer A, Vernimmen R, Visser M, Mawdsley N, 2015a. Flooding projections from elevation and subsidence models for oil palm plantations in the Rajang Delta peatlands, Sarawak, Malaysia. Deltares report 1207384, 76 pp. https://www.deltares.nl/app/uploads/2015/06/Rajang-Delta-Peatland-Subsidence-Flooding-Deltares-2015.pdf

Hooijer A, Vernimmen R, Mawdsley N, Page S, Mulyadi D, Visser M, 2015b. Assessment of impacts of plantation drainage on the Kampar Peninsula peatland, Riau. Deltares Report 1207384 to Wetlands International, CLUA and Norad. https://www.deltares.nl/app/uploads/2015/12/Plantation-Impacts-Kampar-Peatland-DELTARES-2015.pdf

RePPProT, 1990. The Land Resources of Indonesia: a national overview. Government of the Republic of Indonesia: Ministry of Transmigration, Directorate General of Settlement Preparation, and BAKOSURTANAL. Land Resources Department NRI, Overseas Development Administration, Foreign and Commonwealth Office UK. Peat classification according to interpretation of databasin.org (version 2), available for download from http://databasin.org/datasets/eb74fe29b6fb49d0a6831498b0121c99, last accessed 10 February 2016.

Ritung S, Wahyunto, Nugroho K, Sukarman, Hikmatullah, Suparto, Tafakresnanto C, 2011. Peta lahan gambut Indonesia. Skala 1:250.000. Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian.

Silvius M, Hooijer A, Vernimmen R, 2007. Central Kalimantan Peatland Project CKPP; Final report of the project expansion component under CKPP Activity 8: Improved policies and coordination between government departments: Peat soil and drainage mapping for the Ex-Mega Rice Project area in Central Kalimantan Implemented by Wetlands International with Delft Hydraulics. Annex 12 - Land-based elevation surveys.

Sumarga E, Hein L, Hooijer A, Vernimmen R, 2016. Hydrological and economic effects of oil palm cultivation in Indonesian peatlands. Ecology and Society 21(2):52. http://dx.doi.org/10.5751/ES-08490-210252

Supardi, Subekty AD, Neuzil SG, 1993. General geology and peat resources of the Siak Kanan and Bengkalis Island peat deposits, Sumatra, Indonesia. In Cobb JC, Cecil CB, eds. Modern and Ancient Coal-Forming Environments. Boulder, Colorado, Geological Society of America Special Paper 286.

Sutikno S, Sandhyavitri A, Haidar M, Yamamoto K, 2017. Shoreline Change Analysis of Peat Soil Beach in Bengkalis Island Based on GIS and RS. International Journal of Engineering and Technology, Vol. 9, No. 3.

Wahyunto, Ritung S, Subagjo H, 2003. Peta luas sebaran lahan gambut dan kandungan karbon di pulau Sumatera / Map of area of peatland distribution and carbon content in Sumatera, 1990-2002. Wetlands International - Indonesia Programme and Wildlife Habitat Canada (WHC), Bogor, Indonesia.

Wahyunto, Ritung S, Subagjo H, 2004. Peta Sebaran Lahan Gambut, Luas dan Kandungan Karbon di Kalimantan / Map of Peatland Distribution Area and Carbon Content in Kalimantan, 2000-2002. Wetlands International - Indonesia Programme & Wildlife Habitat Canada (WHC), Bogor, Indonesia.

Wahyunto, Bambang Heryanto, Hasyim Bekti dan Fitri Widiastuti, 2006. Peta-Peta Sebaran Lahan Gambut, Luas dan Kandungan Karbon di Papua / Maps of Peatland Distribution, Area and Carbon Content in Papua, 2000 - 2001. Wetlands International – Indonesia Programme & Wildlife Habitat Canada (WHC).

Annex 1 – Peat thickness field survey

As part of the effort to create a peat map for the IPP test area in Eastern Bengkalis Island, a total of 44 transects with a total of 284 locations were surveyed by two separate field teams consisting of Deltares and ITB staff with support staff recruited from local communities. The survey transects covered 18 village areas and were executed in the period 16th March 2017 until 20th April 2017.

A1 Introduction

The peat thickness survey was carried out on Bengkalis Island (Figure 3). The team accessed Bengkalis, arriving at Roro port by a boat from Sei Pakning port located on mainland Riau, which takes about one hour. Sei Pakning itself was reached after 5 hours driving from Pekanbaru.

The peat thickness survey was carried out from 16th March 2017 until 20th April 2017. Prior to survey execution approval to carry out the survey was secured through a letter issued by BIG (Figure 29).

BADAN INFORMASI GEOSPASIAL
(B I G)
Jl. Raya Jakarta-Bogor KM. 46. Cibinong 16911
Telepon. (021) 875 2062-2063. Faksimile. (021) 875 2064 PO. Box. 46 CBI
Website: http://www.big.go.id

Nomor : B-3.1/DIGT/IGT/03/2017 — 3 Maret 2017
Sifat : Biasa
Lampiran : Daftar Anggota Tim
Perihal : Informasi Pelaksanaan Survei *Indonesian Peat Prize*

Kepada Yth.
1. Bupati Bengkalis
2. Kepala Badan Pembangunan Daerah Kabupaten Bengkalis
3. Kepala Badan Lingkungan Hidup Kabupaten Bengkalis
4. Camat Bengkalis
5. Camat Bantan

di tempat

Bersama ini diinformasikan bahwa Badan Informasi Geospasial (BIG) sedang melaksanakan kegiatan *Indonesian Peat Prize*, suatu kompetisi yang bertujuan untuk mengidentifikasi metode pemetaan gambut yang akurat, cepat, dan terjangkau. Pada tahapan kompetisi ini, BIG telah mengumumkan 10 tim yang maju ke Tahap 2 untuk melakukan uji coba lapangan. Lebih lanjut, BIG telah menetapkan Kawasan Hidrologis Gambut Pulau Bengkalis, Provinsi Riau sebagai lokasi uji coba Tahap 2 yang akan dilaksanakan pada kurun waktu bulan Agustus 2016 hingga Mei 2017.

Salah satu tim yaitu tim dari Deltares dan Institut Teknologi Bandung akan melaksanakan kegiatan survei pengumpulan data di Pulau Bengkalis, Kabupaten Bengkalis, Provinsi Riau. Kegiatan tersebut mencakup survei untuk permukaan tanah, pengukuran dan analisa kedalaman tanah gambut, dan identifikasi tutupan lahan terutama di lahan gambut.

Sehubungan hal tersebut, kami sampaikan informasi pendahuluan agar koordinasi yang dibutuhkan di lapangan berupa pemberian informasi kepada pihak terkait, termasuk Kepala Desa setempat di wilayah Pulau Bengkalis, atas adanya rencana kegiatan ini dapat dilakukan sebelumnya. Pelaksanaan survei lapangan tersebut akan dilaksanakan pada tanggal **6 Maret sampai 30 April 2017.**

Demikian disampaikan, atas perhatian dan bantuan Saudara/i diucapkan terima kasih.

Deputi Bidang Informasi
Geospasial Tematik,

Nurwadjedi

Tembusan:
1. Kepala Badan Informasi Geospasial;
2. Sekretaris Utama Badan Informasi Geospasial;
3. Direktur Pengendalian Kerusakan Gambut, Kementerian Lingkungan Hidup dan Kehutanan.

Lampiran Surat Nomor : B-3.1/DIGT/IGT/03/2017
Tanggal : 3 Maret 2017

DAFTAR TIM PELAKSANA SURVEI INDONESIAN PEAT PRIZE:

1. Dedi Mulyadi (Deltares)
2. Rizka Akmalia (Deltares)
3. Heri Andreas (Institut Teknologi Bandung)
4. Odie Syahrozi (Institut Teknologi Bandung)
5. Isfan Anugrah Ramadhan (Institut Teknologi Bandung)

Figure 29 Letter from BIG informing local government about the peat thickness survey carried out by Team Deltares.

A2 Reconnaissance survey

Prior to the actual field measurements, a reconnaissance survey was carried out (by Mr. Dedi Mulyadi and Mrs. Rizka Akmalia from Deltares) to determine the survey requirements. Prior to the reconnaissance survey a village map was prepared (based on 2009 village boundaries). During the 3 days reconnaissance survey (16, 22 – 23 March 2017), all villages where peat sample locations were planned were visited. During these visits the purpose of the survey and the survey locations were explained and approval was asked from the village head (Kepala Desa) to conduct the survey (see Figure 30). The official letter from BIG (Figure 29) helped to introduce the team members and explain the purpose of the survey. Somewhat surprising, none of the village heads were aware of the peat prize competition, or of other survey teams in the area. Most of the villages welcomed the team to conduct the survey after further explanation about the outcome of the survey.

Figure 30 (TOP) Village office in desa Muntai Induk visited during the reconnaissance survey. (BOTTOM) Explaining the purpose and locations of the survey, in desa Palkun.

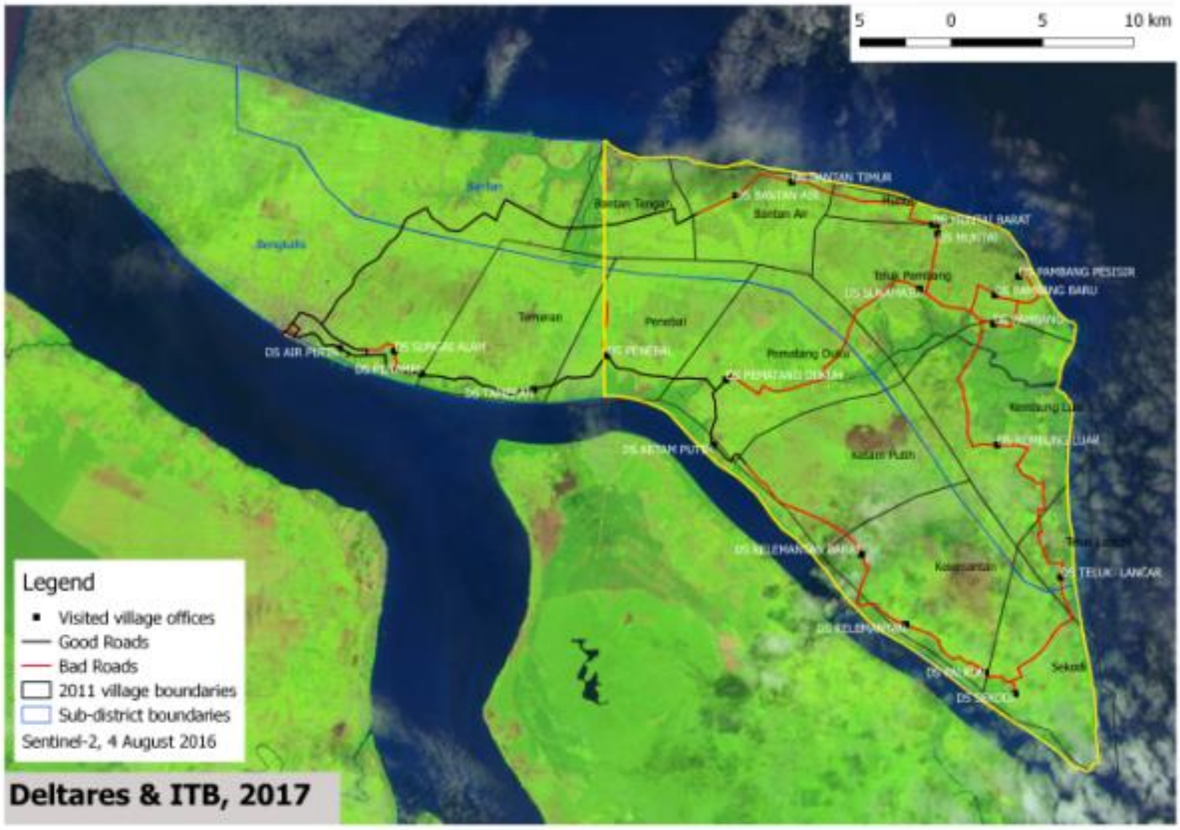

Figure 31 Village boundaries in 2011 (source: Laboratorium SIG Universitas Muhammadiyah Purwokerto) within the Bengkalis test area. In the background a RGB (spectral bands 11-8-5) composite Sentinel-2 image of 4 August 2016. Indicated as well the surveyed road condition.

It was found that the village boundaries did not always match the current location of village offices. During discussions with the village heads it was found that some of the village boundaries have been further sub-divided ("pemekaran") into new villages. In Table 7 an overview of the villages visited is provided. For new villages that were not included on the map, further discussion with village heads and other villagers were required to see how many points were actually inside the area of new villages.

Apart from obtaining approval from the village heads, meetings with local village heads also helped providing local workers to join the field team. At first, we planned to hire people from one village as permanent workers for the whole survey. However, it was impossible to have a 'fixed' team since people in several villages were very careful to welcome outside workers and insisted to include some local workers from their village instead.

Table 7 List of villages in the Bengkalis test area according to 2011 village boundary maps available to Deltares and as found in the field.

Sub-district	Villages on map	Villages in the field	Coordinate (UTM 48N)	
			X (m)	Y (m)
Bantan	Bantan Air	Bantan Air	202890	169898
		Bantan Sari	199636	168313
		Bantan Timur	205945	170630
	Bantan Tengah	Bantan Tengah	204350	171047
	Kembung Luar	Kembung Luar	217198	156233
	Muntai	Muntai Barat	213936	167802
		Muntai Induk	213853	168283
		Muntai Pesisir	n.a.	n.a.
	Teluk Lancar	Teluk Lancar	220653	148980
	Teluk Pambang	Pambang Baru	217055	164439
		Pambang Induk	216983	162848
		Pambang Pesisir	218378	165456
		Sukamaju	212937	164782
Bengkalis		(outside test area)	n.a.	n.a.
	Kelemantan	Kelemantan	212188	146402
		Kelemantan Barat	209763	150237
	Ketam Putih	Ketam Putih	201657	156200
	Pematang Duku	Pematang Duku	202322	159793
		(outside test area)	n.a.	n.a.
	Penebal	Penebal	195844	161122
	Sekodi	Sekodi	218177	142595
		Palkun	216554	143763
		(outside test area)	n.a.	n.a.
	Temeran	Temeran	191812	159274

More than 40% of the sample points were located on smallholder plantations of local villagers. Local workers and additional local workers as “pendamping” who joined the team usually were heads of sub-villages (dusun level) or villagers who really knew the area. They were usually well recognized by the other villagers and could explain to them about the survey activities. It helped the field teams to enter and get permission to carry out the work inside the smallholder plantations. Furthermore, local workers usually knew shortcuts or easier tracks to reach the sample point locations. Table 8 shows the list of contacts from every village that was surveyed.

Table 8 List of villages and names of village heads (and one Sekdes) visited during the survey.

Sub-District	Village Name	Contact Person
Bantan	**Bantan Air**	Miswan
	Bantan Sari	Marni (Sekdes)
	Bantan Timur	Miswan
	Bantan Tengah	Sutrisno
	Kembung Luar	Farzan
	Muntai Barat	Eni
	Muntai Induk	Arwin
	Pambang Baru	Nur Azikin
	Pambang Pesisir	Jamilah
	Sukamaju	Wahyudi
	Teluk Lancar	Ismail
	Pambang Induk	Basri
Bengkalis	**Kelemantan**	Nanga
	Kelemantan Barat	Bambang
	Ketam Putih	Sofyan
	Palkun	Anasri
	Pematang Duku	Zulkifli
	Penebal	Solehen
	Sekodi	Khairi
	Temeran	Sarwan

Depending on the surveyed area, different additional local workers joined the survey. In several areas where a transect crossed village boundaries, the transect was surveyed during two different days using additional local workers from the respective village. If however there were only one or two sample points located within the village, the survey for the transect was continued without hiring additional local workers from the respective village. Those locations were sampled with local workers from the neighbouring village where most of points in the same transect were located, after approval from the local village head in which the sample points were located.

One factor affecting the number of team members was the land cover and accessibility of sample point locations (illustrated in Figure 32). For areas which could not be easily reached and required 'rintisan', additional local workers were hired. A list of local field team members for each day, together with the list of names of additional local field workers from every village are provided in Table 9. In general, each of the two field teams consisted of one team leader (from ITB) and 2 to 4 local workers, supervised by Mrs. Rizka Akmalia of Deltares, who was supported by Mr. Dedi Mulyadi. The main field team (present during the whole survey) consisted of 2 team leaders from ITB (Mr. Odie Syarozie and Mr. Isfan Anugrah) and 2 local workers from Desa Penebal (Pak Udin and Pak Anto).

Figure 32 Different types of land cover needed to be crossed to reach the sample location.

Table 9 List of local field team members for each day of the survey.

Day	Date	Team 1 (Leader: Isfan Anugrah)					Team 2 (Leader: Odie Syahrozie)						Total
		Survey Location	Member1	Member2	Member3	Member4	Survey Location	Member1	Member2	Member3	Member4	Member5	Workers
Thursday	16-Mar						Reconaissance					Ade	1
Friday	17-Mar	Penebal	Norehan	-	-	-	Penebal	Agus	-	-	-	Ade	9
Saturday	18-Mar	Penebal	Anto	Amar	Rusli	Sabarudin	Penebal	Udin	Norehan	Agus	Sandi	Ade	9
Sunday	19-Mar	Penebal	Anto	Amar	Rusli	Sabarudin	Temeran	Udin	Norehan	Agus	Sandi	Ade	9
Monday	20-Mar	Penebal	Anto	Amar	Rusli	Sabarudin	Penebal	Udin	Norehan		Sandi	Ade	8
Tuesday	21-Mar	Pematang Duku	Anto	Amar	Rusli		Pematang Duku	Udin	Muh Isa	Mansur		Ade	7
Wednesday	22-Mar	Pematang Duku	Anto	Amar	Rusli		Pematang Duku, Reconai	Udin	Muh Isa	Mansur		Ade	7
Thursday	23-Mar	Pematang Duku	Anto		Norehan		Pematang Duku, Reconai	Udin				Ade	4
Friday	24-Mar	Pematang Duku	Anto	Amar	Norehan		Ketam Putih	Udin	Zaenal			Ade	6
Saturday	25-Mar	Pematang Duku	Anto	Amar	Norehan		Ketam Putih	Udin	Zaenal	Roni		Ade	7
Sunday	26-Mar	Pematang Duku	Anto	Amar	Norehan		Ketam Putih	Udin	Zaenal	Roni		Ade	7
Monday	27-Mar	Ketam Putih	Anto	Amar	Norehan		Ketam Putih	Udin	Zaenal	Roni		Ade	7
Tuesday	28-Mar	Pematang Duku	Anto	Amar	Norehan		Ketam Putih	Udin	Zaenal	Roni		Ade	7
Wednesday	29-Mar						DAY OFF, Moving to South						0
Thursday	30-Mar	Kelemantan	Anto	Wiyono			Kelemantan	Udin	Eli				4
Friday	31-Mar	Kelemantan	Anto	Atep			Palkun	Udin	Eli				4
Saturday	01-Apr	Sekodi	Anto	Nasir			Palkun	Udin	Sadri				4
Sunday	02-Apr	Sekodi	Anto	Nasir			Sekodi	Udin	Sadri				4
Monday	03-Apr	Teluk Lancar	Anto	Nasir			Teluk Lancar	Udin	Arianto				4
Tuesday	04-Apr	Kembung Luar	Anto	Majlis			Kembung Luar	Udin	Saroni				4
Wednesday	05-Apr						DAY OFF, Moving to North						0
Thursday	06-Apr						DAY OFF						0
Friday	07-Apr	Kembung Luar	Anto	Iwan			Kembung Luar	Udin	Saroni				4
Saturday	08-Apr	Kembung Luar	Anto	Supratno			Teluk Pambang	Udin	Saroni				4
Sunday	09-Apr	Teluk Pambang	Anto	Supratno			Teluk Pambang	Udin	Sapridin				4
Monday	10-Apr	Teluk Pambang	Anto	Supratno			Teluk Pambang	Udin	Sapridin				4
Tuesday	11-Apr	Sukamaju	Anto	Zamri			Muntai Induk	Udin	Ishak				4
Wednesday	12-Apr	Muntai Barat	Anto	Zamri			Muntai Induk	Udin	Nar				4
Thursday	13-Apr	Bantan Sari	Anto	Sunarto	Joko		Bantan Timur	Udin	Zaelani	Suruli			6
Friday	14-Apr	Bantan Sari	Anto	Sunarto			Bantan Timur	Udin	Zaelani				4
Saturday	15-Apr	Bantan Air	Anto	Suparno			Bantan Air	Udin	Asropin				4
Sunday	16-Apr	Penebal	Anto	Amar			Penebal	Udin	Emi				4
Monday	17-Apr	Penebal	Anto	Amar			Pematang Duku	Udin	Sunarto				4
Tuesday	18-Apr	Pematang Duku	Anto	Zul			Pematang Duku	Udin	Fikar				4
Wednesday	19-Apr	Ketam Putih	Anto	Zul			Ketam Putih	Udin	Amin				4
Thursday	20-Apr	Pematang Duku	Anto	Alin			Pematang Duku	Udin	Shadri				4

During the reconnaissance survey, road access was mapped using GPS tracking (Figure 33). Because the quality of the roads was not always good (Figure 34), some villages could not be easily reached. To reduce daily mobilization time (and increase field time) it was decided that the field teams needed to move basecamp several times. Based on road accessibility and accommodation availability, the survey area was divided into three sectors; West, South, and North (Figure 33).

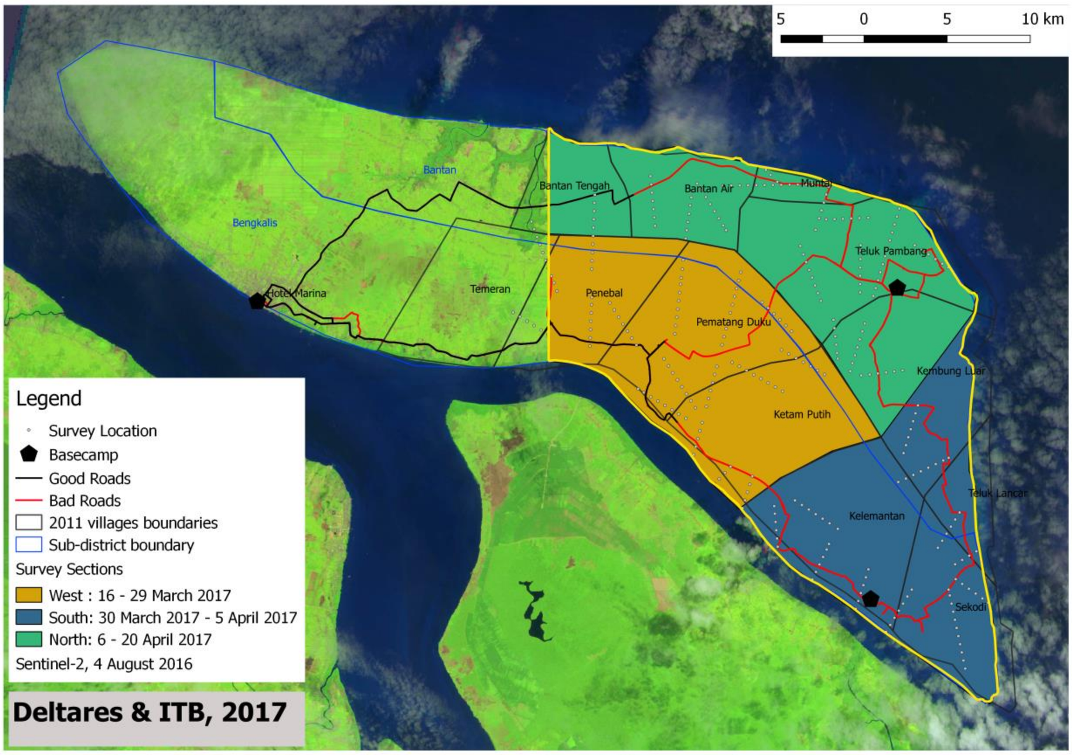

Figure 33 Area sectors ‘West’, ‘South’ and ‘North’ with basecamp and indication of road quality as surveyed on 22-23 March 2017. An illustration of ‘good’ and ‘bad’ roads is provided in Figure 34. Section boundaries were drawn based on the 2011 village boundaries (Figure 31).

Figure 34 Illustration of ‘good’ and ‘bad’ roads encountered during road reconnaissance survey from 22-23 March 2017.

Sector boundaries were drawn based on the official village boundaries. Desa Penebal and Desa Pematang Duku were grouped in the first sector ‘West’. The survey points located in the ‘West’ sector, were reached by car from the basecamp located closed to the Roro port (hotel Pantai Marina) in about 1 hour (one-way). Since roads in the ‘South’ and ‘North’ sectors were in general bad, the teams moved the basecamp to Desa Kelemantan (in South sector) and Desa Pambang Induk (in North sector). In both these sectors motorcycles (Figure 35) were used to reach sample locations.

Figure 35 Motorcycle used during the survey in 'South' and 'North' sectors.

Apart from bad road access in the ‘South’ and ‘North’ sectors finding accommodation was also an issue as this part of Bengkalis has a low population density and there are no hotels or losmens in the survey area. During the survey in the ‘South’ and ‘North’ sectors, the team stayed in local village houses (Figure 36). This was another reason why a good relationship with the local village heads was important in order to get approval to stay in the local village houses.

Figure 36 Team members staying at Desa Kelemantan Barat (‘South’ sector).

A3 Field survey

The field survey was carried out following a field protocol (SOP) using an Edelman type auger (details can be found in Annex 2). An overview of all equipment used during the survey is provided in Table 10.

Table 10 List of survey equipment.

Equipments	Specification
Auger	Edelman/Belgy type
	stainless steel
	6 cm diameter
	23 cm long
	12 x 1 m extensions
	(see Annex 2, Fig 1)
Handheld GPS	GARMIN GPSMAP 64S
	3-axis tilt-compensated compass
	sunlight readable screen
	accuracy 3-15 meters
Camera	Digital Nikon CoolPix A10
	AA battery
	16.1 MP
Measuring tape	2 m long

An Edelman type stainless steel auger was used in this survey with 12 one meter extension rods (Figure 37). Different auger types are readily available on the market in Indonesia. We chose the Edelman/Belgy type with 6 cm diameter head and 23 cm length body.

Figure 37 (LEFT) Edelman type auger heads used in this peat survey. (RIGHT) team preparing the auger at the survey location.

An additional consideration when choosing the proper auger is the type of connector used to connect separate extensions rods. At least 3 different connection types are commonly used; nut-bolt, button-hex, and C-clip (Figure 38). Using the nut-bolt type connection, the different extension rods would be securely fastened. However, the button-hex connection was preferred since this allows connecting and disconnecting parts with less hassle than the nut-bolt type.

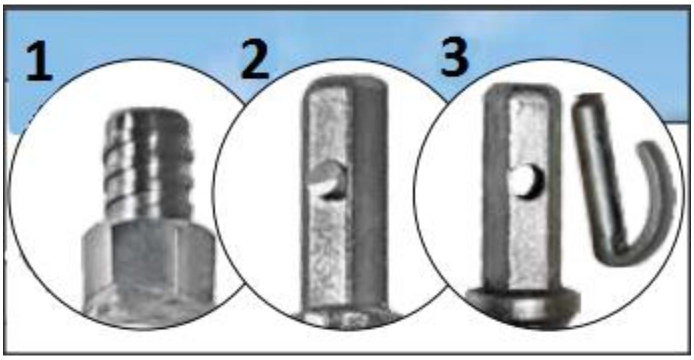

Figure 38 Different types of connector: (1) nut-bolt, (2) button-hex, (3) C-clip ((source: www.precisionagrilab.com/Documents/AMSSoilProbes.pdf).

During the first week of the survey, three auger heads were lost. The auger heads were trapped in the deep peat and could not be retrieved since the connector failed to secure the connection with the extension rods during retrieval. One more auger was lost in the second week. Following the loss of these auger heads, the auger connections were modified so auger heads have a bigger bolt and extension rods are connected using a longer hex connection (see Figure 39). In addition, in order to trap more soil, the team also decided to modify the auger head as shown in Figure 40. The modifications to the auger were carried out at a local workshop in Desa Pematang Duku (Figure 41).

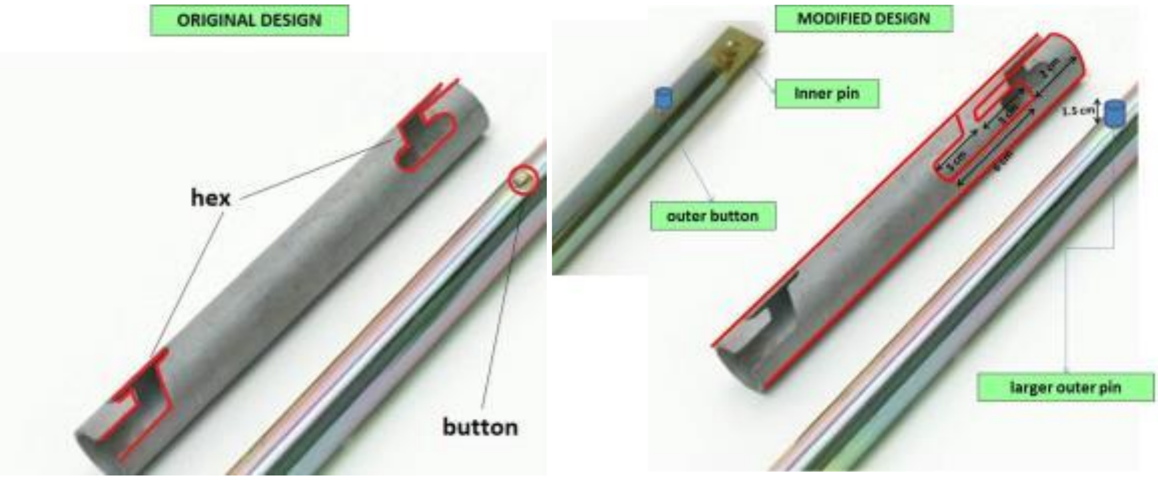

Figure 39 (LEFT) Original design (RIGHT) Modified design of connector used in the study after several auger heads were lost at the beginning of the survey.

Figure 40 (LEFT) Original Edelman type auger head used at the start of the survey and (RIGHT) Modified Edelman auger head from week 2 of the survey onwards.

Figure 41 Duplicating auger head in the local workshop.

A handheld Garmin GPSMap 64S (3 - 15 m horizontal accuracy) was used to find sample locations based on the survey map and to log geographical positions of each survey point. The team also printed out a map per village which showed survey point locations and road access.

Vegetation cover and land use was documented at each survey location and photographed in four directions (Figure 42). The augering process in the field is shown in Figure 43. Mineral subsoil that was trapped in the auger was photographed as evidence that the peat bottom had been reached (Figure 44).

Figure 42 Vegetation cover as observed in four directions at sampling location GPS-160. (LEFT) North, (RIGHT TOP) East, (LEFT BOTTOM) South and (BOTTOM RIGHT) West.

Figure 43 Augering process at the sample location.

Figure 44 Mineral soil found below the peat at (LEFT) GPS-43 and (RIGHT) point GPS-40.

At the start of the survey, the protocol dictated that at each sample location three replicate measurements should be taken. This was done to determine spatial variation in peat thickness. However, after analysing results for the first 83 sampling locations it was found that spatial variation was very low (standard deviation < 25 cm) and it was decided to reduce the number of replicates to two, to speed up the survey. Replicates were usually taken within 5 m from the first sample location in a relatively flat area. In general, one team could finish three to four point locations per day (times 2 or 3 replicate locations). Peat thickness and land cover type for each survey location is provided in Annex 3.

A4 Survey results / statistics

A total of 2.4 km (2452.7 m, including the replicates) of peat was surveyed in 32 days (5 weeks) with 2 survey teams; with an average sampling speed of 38.3 m / day / team, ranging from 5.3 – 71.6 m / day / team depending on field conditions (access, weather). In general shallow peat areas were easier to access than deeper peat areas. Figure 45 illustrates the survey progress per week.

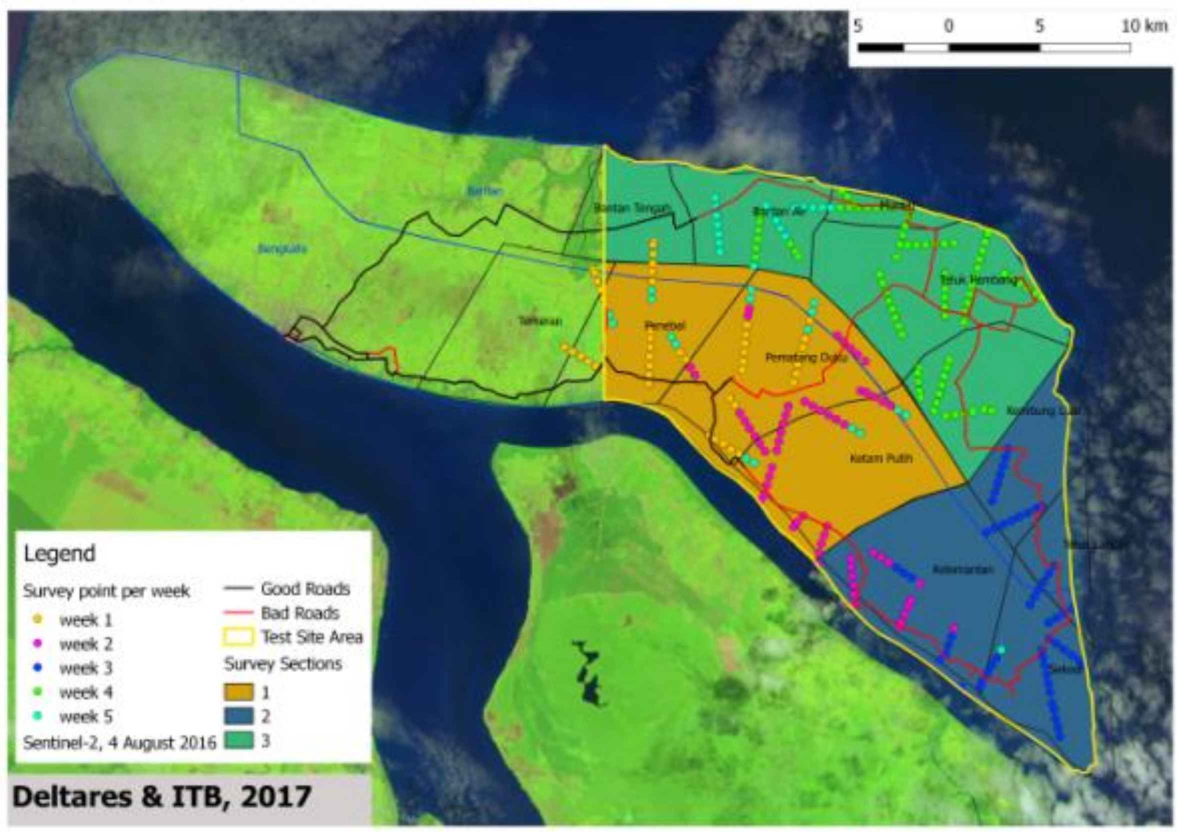

Figure 45 Survey progress per week.

Of the 284 surveyed locations, 274 locations were within the test area. Of these 274 locations, 53 locations (19.3 %) were on no peat or with an organic layer of less than 50 cm, whereas 50 locations (17.9 %) were on shallow (<3 m) peat. For 2 locations (GPS-30 and GPS-57) the mineral subsoil was not reached since not sufficient extensions were brought to the field. These locations were not re-surveyed at a later time since 7 m was almost reached at the previous survey location at 500 m distance along the same transect (6.78 m at GPS-29 and 6.79 m at GPS-56). Average peat thickness for the 219 locations with peat (>0.5 m) is 4.79 ± std. 2.17 m.

The peat thickness survey within the test area covered 10 land cover types (1) forest, (2) scrubland/bush/ferns, (3) oil palm plantation, (4) rubber plantation, (5) coconut plantation, (6) sago plantation, (7) pinang plantation, (8) mangrove, (9) settlement area and (10) sweet potato plantation (see Annex 3). The majority of the locations on peat were taken in rubber, oil palm and coconut plantations (28.4 %, 14.9 % and 14.0 % respectively) and shrubland

(33.8%), whereas only 1.8% of the survey locations (4 measurements) were located in forest. This is a representative reflection of the actual land cover in the area, that is dominated by plantations with hardly any forest left (outside mangrove).

A5 Survey costs

Total survey costs amounted Rp 152 million (USD 11,259), of which Rp 15,000,000 (9.9 %) was for mobilization costs, Rp 23,000,000 (15.1 %) for lodging, and Rp 101,000,000 (66.4 %) for the actual survey (car rental + meals + logistics + labour). Equipment cost amounted to Rp 13,000,000 (8.6 %). All expenses are as listed in Table 11. While total survey costs of this survey are 11,259 USD, the cost to collect the peat thickness measurements to create the peat thickness model is 7,248 USD, as only two-third of the peat thickness measurements were used to create the model, the remaining one-third were used to validate the model (Table 11).

Table 11 Survey cost overview. Also included the costs used to collect the peat thickness measurements to create the peat thickness model (two thirds of all measurements).

Specification	IDR (in million)	USD#	% of Total	survey cost to create map (USD)
Mobilization	15	1111	9.9	1111
Lodging	23	1704	15.1	1136
Survey costs (car rental, meals, logistics, wages)	101	7481	66.4	4988
Equipment costs	13	963	8.6	13
Total	**152**	**11259**	**100**	**7248**
#using exchange rate of 13,500 IDR/USD				

A6 Lessons learned and recommendations for future surveys

A reconnaissance survey prior to the actual peat thickness survey is recommended as it will help efficient planning of the survey. It is important to know the field conditions both in terms of technical aspects (such as soil condition, land cover) as well as practical aspects (such as road access, availability of accommodation and local workers), prior to fully mobilizing large teams. An accurate estimation of the speed and cost of work is only possible once these aspects are known.

A proper auger (incl. sufficient extension rods) does not need to be expensive. They are available on the Indonesian market for less than 5 million IDR (approx. 375 USD). A local workshop could duplicate the auger at even lower price. Existing road lines on the map did not always really exist in the field. Even when the road existed, it cannot be accessed by car. Therefore, using a motorcycle for survey is highly recommended for efficient mobilization.

Hiring local workers that knew the area well was also key to speed up the survey. Instead of following 500 m straight line to reach adjacent points, the team sometimes needed to turn around to find easiest and fastest track.

Conducting the survey in an area owned by a large company sometimes was an advantage for the team, since these areas were usually clear and no ‘rintis’ was needed while the small-holders plantations were usually full of shrubs and ‘rintis’ was still required.

Annex 2 – Standard Operating Procedure (SOP)

This SOP provides guidelines for measuring peat thickness using a manual auger.

Equipment and Materials

The following equipment should be available for measuring peat thickness in the field:

- Hand auger set (preferably with Edelman type auger, see Figure A.1)
  The Edelman auger body consists of two blades in conical shape with a screw-like shape in the bottom to help in entering and digging the soil. A broader auger body permits a good hold of soil sampling. This auger head should be connected to a handle. Extension rods for deeper digging are also necessary to be prepared.
- Analysis plan and/or detail site information
- Handheld GPS
- Measuring tape
- Pocket camera
- Hand gloves
- Stationery set

1. Procedures

1) Before start drilling in the field, a good survey plan should be made in order to identify which locations are suitable to perform the peat thickness measurement. Transects are made perpendicular from the river to the peat dome. Surveyed points should be design per 500m along each transect with 3 replicates in every point.
2) GPS is required to navigate surveyor to the sample point location.
3) Identify a suitable location for drilling; try to drill in a relatively flat area.
4) Prior to drilling, check for cables, tubes, pipes, woods, or any other obstacles.
5) If needed, clear the area of vegetation before starting the drilling. Only clear the vegetation which is hampering the drilling.
6) Connect the handle and the auger head.
7) Place the auger on the peat surface and turn the handle clockwise. The auger must be perpendicular to the peat surface around the drilling point. To avoid slippery during drilling, surveyor could wear a hand gloves (see Figure A.2)
8) The peat soil is collected gradually during drilling (every 0.5 m). it will be used for filling the gaps later, but it should be arranged to minimize the drilling hole (e.g. drilling always conducted perpendicular to the surrounding peat surface)
9) From each 50 cm drilling, withdraw the auger. Upon withdrawal, lay the auger head on the ground and check whether the mineral soil is already caught in the auger body. Try to document the soil by taking picture of the soil trapped in the auger head (see Figure A.3)
10) For deeper drilling, one or more extension rods should be used. Connect the extension rod between the auger head and the handle. Add the extension rods as needed gradually.

11) Drilling can be carried out by two persons especially when connecting or removing the extension rods, one to hold the lower part of the auger to prevent it falling into the hole, while the other releasing the top parts of auger (see Figure A.4).
12) Drilling is carried out until the auger head reaches the mineral soils underneath the peat layer (see Figure A.5)
13) Using the measurement tape, measure the mineral soil trapped in the auger for calculating the peat thickness.
14) Before removing the auger, measured the length of the auger protruding from the peat surface which is to be used in calculating peat thickness.
15) Calculate the peat thickness = the total length of auger - mineral soil layer that trapped in the auger head - the length of auger above the peat surface.
16) Record the coordinate of hole point in GPS
17) Observe the surrounding vegetation cover and land cover of the sample location. Take photograph of the sample location in 4 wind directions to document the surrounding area. Keep consistent with the pictures direction (e.g. maintain clockwise).
18) From the first replicate, pick 2 others replicate points along 5 meter radius on the west and east side.
19) Repeat the procedure for replicate 2 and replicate 3.

2. Attachments

Figure A.1 Edelman Auger set
Figure A.2 The initial stage of peat drilling
Figure A.3 Example of soil trap in the auger body
Figure A.4 The process of removing and connecting the extension rods and continue drilling
Figure A.5 The example of auger that has reached the mineral soil (clay)

Figure A.1 Edelman Auger set

Figure A.2 The initial stage of peat drilling

Figure A.3 Example of soil trap in the auger body

Figure A.4 The process of removing and connecting the extension rods and continue drilling

Figure A.5 The example of auger that has reached the mineral soil (clay).

Annex 3 – Peat thickness measurements

The detailed peat thickness field survey results are presented in following tables.

Waypoint	Date	X-UTM48N	Y-UTM48N	Peat Thickness	Mineral Soil	LULC	Location	Field Team	Remarks
GPS-160-A	17-Mar-2017	194801	161015	4.56	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-160-B	17-Mar-2017	194790	161008	4.01	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-160-C	17-Mar-2017	194796	161011	3.56	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-161-A	17-Mar-2017	194389	161267	4.56	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-161-B	17-Mar-2017	194389	161259	5.17	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-161-C	17-Mar-2017	194400	161277	5.01	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-159-A	17-Mar-2017	195215	160759	3	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-159-B	17-Mar-2017	195223	160746	3.17	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-159-C	17-Mar-2017	195219	160759	3.17	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-30-B	18-Mar-2017	198280	162709	>7.31 (clay not found)	clay	bush	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-30-C	18-Mar-2017	198271	162707	>7.31 (clay not found)	clay	bush	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-30-A	18-Mar-2017	198272	162716	>7.31 (clay not found)	clay	bush	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-29-A	18-Mar-2017	198258	162270	6.56	clay	bush in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-29-B	18-Mar-2017	198266	162274	7.01	clay	bush in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-29-C	18-Mar-2017	198248	162281	6.77	clay	bush in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-28-A	18-Mar-2017	198243	161774	6.01	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-28-B	18-Mar-2017	198254	161778	5.56	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-28-C	18-Mar-2017	198233	161789	6.01	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-24-A	18-Mar-2017	198157	159781	1.01	clay	palm	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-24-B	18-Mar-2017	198168	159778	1.01	clay	palm	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-24-C	18-Mar-2017	198150	159783	1.01	clay	palm	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-25-A	18-Mar-2017	198174	160276	2.56	clay	palm	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-25-B	18-Mar-2017	198178	160273	2.56	clay	palm	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-25-C	18-Mar-2017	198166	160280	2.56	clay	palm	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-158-A	18-Mar-2017	195684	160510	no peat	clay	pinang trees	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-158-B	18-Mar-2017	195685	160509	no peat	clay	pinang trees	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-158-C	18-Mar-2017	195690	160497	no peat	clay	pinang trees	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-26-A	18-Mar-2017	198184	160770	3.01	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-26-B	18-Mar-2017	198192	160765	3.17	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-26-C	18-Mar-2017	198190	160778	3.01	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-27-A	18-Mar-2017	198185	161283	4.56	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-27-B	18-Mar-2017	198190	161278	4.56	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-27-C	18-Mar-2017	198189	161283	4.56	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-169-A	19-Mar-2017	199882	161536	3.01	clay	bush in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-169-B	19-Mar-2017	199882	161542	3.01	clay	bush in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-169-C	19-Mar-2017	199874	161529	3.01	clay	bush in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-162-A	19-Mar-2017	193951	161540	5.56	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-162-B	19-Mar-2017	193938	161538	6.01	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-162-C	19-Mar-2017	193939	161544	6.01	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-168-A	19-Mar-2017	200166	161095	2.62	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-168-B	19-Mar-2017	200166	161086	2.62	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-168-C	19-Mar-2017	200172	161103	2.01	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-163-A	19-Mar-2017	193527	161812	6.01	clay	forest	Desa Temeran	Deltares, ITB, Desa Penebal	Replicate 1
GPS-163-B	19-Mar-2017	193518	161809	6.17	clay	forest	Desa Temeran	Deltares, ITB, Desa Penebal	Replicate 2
GPS-163-C	19-Mar-2017	193516	161812	6.17	clay	forest	Desa Temeran	Deltares, ITB, Desa Penebal	Replicate 3
CROSSCHECK 1	19-Mar-2017	195060	166063	no peat	clay	mangrove plantation	Desa Temeran	Deltares, ITB, Desa Penebal	Replicate 1/crosscheck
GPS-182-A	19-Mar-2017	195147	165886	no peat	clay	palm and pinang trees boundaries	Desa Temeran	Deltares, ITB, Desa Penebal	Replicate 1
GPS-182-B	19-Mar-2017	195141	165881	no peat	clay	palm and pinang trees boundaries	Desa Temeran	Deltares, ITB, Desa Penebal	Replicate 2
GPS-182-C	19-Mar-2017	195154	165889	no peat	clay	palm and pinang trees boundaries	Desa Temeran	Deltares, ITB, Desa Penebal	Replicate 3
GPS-181-A	19-Mar-2017	195320	165416	no peat	clay	palm and rubber plantation	Desa Temeran	Deltares, ITB, Desa Penebal	Replicate 1
GPS-181-B	19-Mar-2017	195321	165415	no peat	clay	palm and rubber plantation	Desa Temeran	Deltares, ITB, Desa Penebal	Replicate 2
GPS-181-C	19-Mar-2017	195304	165416	no peat	clay	palm and rubber plantation	Desa Temeran	Deltares, ITB, Desa Penebal	Replicate 3
GPS-178-A	19-Mar-2017	195848	163996	5.56	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-178-B	19-Mar-2017	195846	163985	5.56	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-178-C	19-Mar-2017	195848	164003	5.56	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-179-A	19-Mar-2017	195648	164478	3.56	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-179-B	19-Mar-2017	195656	164483	3.17	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-179-C	19-Mar-2017	195653	164472	3.01	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-180-A	19-Mar-2017	195484	164941	3.56	clay	rubber plantation	Desa Temeran	Deltares, ITB, Desa Penebal	Replicate 1
GPS-180-B	19-Mar-2017	195487	164942	4.01	clay	rubber plantation	Desa Temeran	Deltares, ITB, Desa Penebal	Replicate 2
GPS-180-C	19-Mar-2017	195477	164949	3.87	clay	rubber plantation	Desa Temeran	Deltares, ITB, Desa Penebal	Replicate 3
CROSSCHECK 2	20-Mar-2017	198434	167613	no peat	clay	boundary pinang trees and rubber plantation	Desa Bantan Tengah	Deltares, ITB, Desa Penebal	Replicate 1/crosscheck
GPS-298-A	20-Mar-2017	198313	165412	5.62	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-298-B	20-Mar-2017	198304	165420	6.01	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-298-C	20-Mar-2017	198325	165413	6.01	clay	ferns in rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-300-A	20-Mar-2017	198360	166413	5.56	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-300-B	20-Mar-2017	198359	166424	5.17	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-300-C	20-Mar-2017	198358	166405	5.56	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-299-A	20-Mar-2017	198330	165913	7.56	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
GPS-299-B	20-Mar-2017	198331	165917	7.56	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
GPS-299-C	20-Mar-2017	198322	165929	7.56	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 3
GPS-302-A	20-Mar-2017	198390	167439	1.01	clay	rubber plantation	Desa Bantan Tengah	Deltares, ITB, Desa Penebal	Replicate 1
GPS-302-B	20-Mar-2017	198397	167434	1.01	clay	rubber plantation	Desa Bantan Tengah	Deltares, ITB, Desa Penebal	Replicate 2
GPS-302-C	20-Mar-2017	198381	167438	1.01	clay	rubber plantation	Desa Bantan Tengah	Deltares, ITB, Desa Penebal	Replicate 3
GPS-301-A	20-Mar-2017	198366	166918	no peat	clay	yard of village house	Desa Bantan Tengah	Deltares, ITB, Desa Penebal	Replicate 1
GPS-301-B	20-Mar-2017	198354	166918	no peat	clay	yard of village house	Desa Bantan Tengah	Deltares, ITB, Desa Penebal	Replicate 2
GPS-301-C	20-Mar-2017	198370	166916	no peat	clay	yard of village house	Desa Bantan Tengah	Deltares, ITB, Desa Penebal	Replicate 3
GPS-32-A	21-Mar-2017	203331	161014	0.56	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-32-B	21-Mar-2017	203337	161015	0.56	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-32-C	21-Mar-2017	203332	161008	0.56	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-33-A	21-Mar-2017	203384	161512	1.01	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-33-B	21-Mar-2017	203380	161513	1.01	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-33-C	21-Mar-2017	203388	161514	1.17	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-34-A	21-Mar-2017	203440	162010	1.56	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-34-B	21-Mar-2017	203448	162018	1.56	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-34-C	21-Mar-2017	203439	162014	1.01	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-35-A	21-Mar-2017	203498	162502	1.56	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-35-B	21-Mar-2017	203502	162506	1.56	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-35-C	21-Mar-2017	203495	162502	1.56	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-256-A	21-Mar-2017	206361	160828	2.56	clay	bush in forest	Desa Pematang Duku	deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-256-B	21-Mar-2017	206362	160821	2.56	clay	bush in forest	Desa Pematang Duku	deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-256-C	21-Mar-2017	206354	160832	3.01	clay	bush in forest	Desa Pematang Duku	deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-254-A	21-Mar-2017	206131	159858	2.56	clay	coconut trees	Desa Pematang Duku	deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-254-B	21-Mar-2017	206134	159862	2.56	clay	coconut trees	Desa Pematang Duku	deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-254-C	21-Mar-2017	206122	159863	2.56	clay	coconut trees	Desa Pematang Duku	deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-255-A	21-Mar-2017	206239	160347	4.01	clay	ferns in rubber plantation	Desa Pematang Duku	deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-255-B	21-Mar-2017	206236	160350	3.56	clay	ferns in rubber plantation	Desa Pematang Duku	deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-255-C	21-Mar-2017	206253	160349	4.01	clay	ferns in rubber plantation	Desa Pematang Duku	deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3

Waypoint	Date	X-UTM48N	Y-UTM48N	Peat Thickness	Mineral Soil	LULC	Location	Field Team	Remarks
GPS-257-A	21-Mar-2017	206485	161312	3.01	clay	forest	Desa Pematang Duku	deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-257-B	21-Mar-2017	206482	161315	3.17	clay	forest	Desa Pematang Duku	deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-257-C	21-Mar-2017	206488	161309	3.01	clay	forest	Desa Pematang Duku	deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-31-A	21-Mar-2017	203268	160526	0.56	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-31-B	21-Mar-2017	203263	160520	0.56	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-31-C	21-Mar-2017	203273	160530	0.56	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-36-A	21-Mar-2017	203549	163012	3.56	clay	swamp	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-36-B	21-Mar-2017	203548	163016	3.56	clay	swamp	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-258-A	22-Mar-2017	206613	161774	3.01	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-258-B	22-Mar-2017	206620	161775	3.56	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-258-C	22-Mar-2017	206617	161775	3.01	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-259-A	22-Mar-2017	206738	162262	4.56	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-259-B	22-Mar-2017	206741	162268	4.17	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-259-C	22-Mar-2017	206738	162260	4.56	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-261-A	22-Mar-2017	206988	163251	6.01	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-261-B	22-Mar-2017	206988	163245	6.01	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-261-C	22-Mar-2017	206992	163253	6.17	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-37-A	22-Mar-2017	203602	163510	5.01	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-64-A	23-Mar-2017	203106	155935	4.56	clay	ferns in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-64-B	23-Mar-2017	203102	155943	4.62	clay	ferns in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-64-C	23-Mar-2017	203102	155934	5.01	clay	ferns in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 3
GPS-135-A	23-Mar-2017	202621	159013	0.5	clay	ferns in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-135-B	23-Mar-2017	202617	159010	0.5	clay	ferns in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-135-C	23-Mar-2017	202609	159001	0.5	clay	ferns in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 3
GPS-65-A	23-Mar-2017	202667	156197	0.56	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-65-B	23-Mar-2017	202670	156199	0.56	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-65-C	23-Mar-2017	202667	156187	0.56	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 3
GPS-80-A	23-Mar-2017	209956	161025	no peat	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-80-B	23-Mar-2017	209955	161021	no peat	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-80-C	23-Mar-2017	209961	161020	no peat	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 3
GPS-68-A	23-Mar-2017	201413	156977	no peat	clay	sago palm	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-68-B	23-Mar-2017	201436	156968	no peat	clay	sago palm	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-68-C	23-Mar-2017	201467	156966	no peat	clay	sago palm	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 3
GPS-66-A	23-Mar-2017	202251	156460	1.01	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-66-B	23-Mar-2017	202248	156465	1.01	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate2
GPS-66-C	23-Mar-2017	202254	156474	1.01	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 3
GPS-136-A	23-Mar-2017	202874	158595	no peat	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-136-B	23-Mar-2017	202870	158600	no peat	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-136-C	23-Mar-2017	202872	158606	no peat	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 3
GPS-165-A	23-Mar-2017	200962	159843	no peat	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-165-B	23-Mar-2017	200958	159843	no peat	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-165-C	23-Mar-2017	200974	159841	no peat	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 3
GPS-67-A	23-Mar-2017	201732	156769	no peat	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-67-B	23-Mar-2017	201757	156765	no peat	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-67-C	23-Mar-2017	201774	156748	no peat	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate3
GPS-141-A	24-Mar-2017	204242	156471	4.57	clay	bush	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-141-B	24-Mar-2017	204238	156469	4.57	clay	bush	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-141-C	24-Mar-2017	204247	156474	4.67	clay	bush	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-166-A	24-Mar-2017	200687	160255	1.13	clay	bush in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-166-B	24-Mar-2017	200682	160258	1.13	clay	bush in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-166-C	24-Mar-2017	200696	160259	1.52	clay	bush in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 3
GPS-77-A	24-Mar-2017	208883	162078	4.97	clay	coconut plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-77-B	24-Mar-2017	208882	162071	4.52	clay	coconut plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-77-C	24-Mar-2017	208883	162082	4.97	clay	coconut plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 3
GPS-76-A	24-Mar-2017	208530	162435	4.97	clay	coconut plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-76-B	24-Mar-2017	208527	162428	4.97	clay	coconut plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-76-C	24-Mar-2017	208533	162443	4.52	clay	coconut plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 3
GPS-138-A	24-Mar-2017	203425	157743	no peat	clay	ferns in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-138-B	24-Mar-2017	203426	157739	no peat	clay	ferns in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-138-C	24-Mar-2017	203426	157749	no peat	clay	ferns in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-140-A	24-Mar-2017	203974	156894	3.01	clay	ferns in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-140-B	24-Mar-2017	203982	156890	3.17	clay	ferns in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-140-C	24-Mar-2017	203966	156899	3.17	clay	ferns in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-142-A	24-Mar-2017	204518	156066	6.17	clay	palm trees	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-142-B	24-Mar-2017	204526	156065	6.17	clay	palm trees	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-142-C	24-Mar-2017	204515	156074	6.17	clay	palm trees	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-167-A	24-Mar-2017	200417	160689	1.97	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-167-B	24-Mar-2017	200427	160696	2.13	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-167-C	24-Mar-2017	200436	160683	1.97	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 3
GPS-78-A	24-Mar-2017	209252	161720	3.52	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-78-B	24-Mar-2017	209238	161728	3.52	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-78-C	24-Mar-2017	209251	161725	3.52	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 3
GPS-137-A	24-Mar-2017	203154	158168	no peat	clay	sweet potato plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-137-B	24-Mar-2017	203159	158166	no peat	clay	sweet potato plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-137-C	24-Mar-2017	203165	158162	no peat	clay	sweet potato plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-139-A	24-Mar-2017	203685	157330	no peat	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-139-B	24-Mar-2017	203688	157322	no peat	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-139-C	24-Mar-2017	203690	157340	no peat	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-120-A	24-Mar-2017	205815	158540	2.11	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-120-B	24-Mar-2017	205814	158547	2.11	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-120-C	24-Mar-2017	205817	158531	2.11	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-119-A	25-Mar-2017	205686	158054	no peat	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-119-B	25-Mar-2017	205689	158052	no peat	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-119-C	25-Mar-2017	205692	158057	no peat	clay	bush	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-118-A	25-Mar-2017	205536	157578	2.01	clay	bush along riverside	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-118-B	25-Mar-2017	205532	157582	2.01	clay	bush along riverside	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-118-C	25-Mar-2017	205535	157572	2.01	clay	bush along riverside	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-172-A	25-Mar-2017	207594	158302	4.52	clay	bush in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-172-B	25-Mar-2017	207587	158302	5.13	clay	bush in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-172-C	25-Mar-2017	207595	158304	4.97	clay	bush in rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-117-A	25-Mar-2017	205416	157105	2.01	clay	bush in sago plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-117-B	25-Mar-2017	205414	157101	2.01	clay	bush in sago plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-117-C	25-Mar-2017	205414	157113	2.01	clay	bush in sago plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-171-A	25-Mar-2017	207160	158553	3.52	clay	coconut plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-171-B	25-Mar-2017	207161	158555	3.52	clay	coconut plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-171-C	25-Mar-2017	207158	158548	3.52	clay	coconut plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
CROSSCHECK3	25-Mar-2017	210065	161010	no peat	clay	mangrove	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1/Crosscheck

Waypoint	Date	X-UTM48N	Y-UTM48N	Peat Thickness	Mineral Soil	LULC	Location	Field Team	Remarks
GPS-170-A	25-Mar-2017	206731	158798	3.52	clay	palm plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-170-B	25-Mar-2017	206728	158792	3.52	clay	palm plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-170-C	25-Mar-2017	206742	158795	3.52	clay	palm plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-79-A	25-Mar-2017	209614	161388	2.97	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-79-B	25-Mar-2017	209612	161382	2.97	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-79-C	25-Mar-2017	209618	161390	2.97	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-71-A	26-Mar-2017	210135	159301	0.97	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-71-B	26-Mar-2017	210136	159298	0.97	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-71-C	26-Mar-2017	210137	159313	0.97	clay	yard of village house	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-115-A	26-Mar-2017	205181	156115	6.17	clay	bush in forest	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-115-B	26-Mar-2017	205184	156110	6.17	clay	bush in forest	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-115-C	26-Mar-2017	205187	156108	6.17	clay	bush in forest	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-116-A	26-Mar-2017	205301	156607	2.17	clay	bush in rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-116-B	26-Mar-2017	205297	156608	2.17	clay	bush in rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-116-C	26-Mar-2017	205309	156605	2.17	clay	bush in rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
CROSSCHECK4	26-Mar-2017	204332	153410	no peat	clay	mangrove	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1/Crosscheck
CROSSCHECK5	26-Mar-2017	209795	159389	no peat	clay	mangrove	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1/Crosscheck
GPS-72-A	26-Mar-2017	210560	159057	2.52	clay	palm plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GSP-72-B	26-Mar-2017	210568	159059	2.52	clay	palm plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-72-C	26-Mar-2017	210571	159059	2.13	clay	palm plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-111-A	26-Mar-2017	204641	154213	6.01	clay	palm trees	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-111-B	26-Mar-2017	204641	154206	6.17	clay	palm trees	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-111-C	26-Mar-2017	204639	154212	6.01	clay	palm trees	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-110-A	26-Mar-2017	204533	153722	1.56	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-110-B	26-Mar-2017	204534	153724	1.56	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-110-C	26-Mar-2017	204544	153715	1.56	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-173-A	26-Mar-2017	208024	158059	5.97	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-173-B	26-Mar-2017	208031	158056	5.97	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-173-C	26-Mar-2017	208036	158056	5.97	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-73-A	26-Mar-2017	211005	158811	4.97	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-73-B	26-Mar-2017	211009	158803	4.52	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-73-C	26-Mar-2017	211011	158811	4.97	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-174-A	26-Mar-2017	208455	157815	4.97	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-174-B	26-Mar-2017	208446	157821	4.97	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-174-C	26-Mar-2017	208447	157825	5.13	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-74-A	26-Mar-2017	211449	158580	6.52	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-74-B	26-Mar-2017	211455	158578	6.62	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-74-C	26-Mar-2017	211443	158577	6.52	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-61-A	27-Mar-2017	206290	152152	4.6	clay	bush	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-61-B	27-Mar-2017	206292	152148	4.6	clay	bush	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-61-C	27-Mar-2017	206292	152159	5.05	clay	bush	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-294-A	27-Mar-2017	207512	150480	5.05	clay	bush in forest	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-294-B	27-Mar-2017	207515	150482	5.05	clay	bush in forest	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-294-C	27-Mar-2017	207512	150476	5.21	clay	bush in forest	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
CROSSCHECK6	27-Mar-2017	206095	151888	no peat	clay	mangrove	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1/Crosscheck
CROSSCHECK7	27-Mar-2017	207471	149834	no peat	clay	mangrove	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1/Crosscheck
GPS-297-A	27-Mar-2017	207951	151938	7.6	clay	palm plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-297-B	27-Mar-2017	207962	151939	7.05	clay	palm plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-297-C	27-Mar-2017	207965	151943	7.06	clay	palm plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-60-A	27-Mar-2017	206628	152513	7.6	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-60-B	27-Mar-2017	206634	152511	7.6	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-60-C	27-Mar-2017	206624	152516	7.6	clay	rubber plantation	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-296-A	27-Mar-2017	207804	151448	7.05	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-296-B	27-Mar-2017	207797	151447	6.6	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-296-C	27-Mar-2017	207801	151440	6.6	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-295-A	27-Mar-2017	207635	150976	6.05	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-295-B	27-Mar-2017	207631	150978	6.05	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-295-C	27-Mar-2017	207640	150971	6.05	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 3
GPS-113-A	28-Mar-2017	204915	155175	8.01	clay	bush in forest	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-113-B	28-Mar-2017	204917	155174	8.17	clay	bush in forest	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-112-A	28-Mar-2017	204783	154696	7.17	clay	forest	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-112-B	28-Mar-2017	204790	154700	7.56	clay	forest	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-37-A	28-Mar-2017	203597	163512	4.52	clay	shrub	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-37-B	28-Mar-2017	203596	163515	4.97	clay	shrub	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-38-A	28-Mar-2017	203666	163888	4.52	clay	shrub	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-38-B	28-Mar-2017	203654	163877	4.52	clay	shrub	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-175-A	28-Mar-2017	208902	157545	5.97	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-175-B	28-Mar-2017	208899	157541	6.52	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
GPS-240-A	30-Mar-2017	209279	149676	7.17	clay	bush	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-240-B	30-Mar-2017	209281	149679	7.17	clay	bush	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-288-A	30-Mar-2017	211327	149942	4.17	clay	bush in forest	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-288-B	30-Mar-2017	211333	149942	4.17	clay	bush in forest	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-237-A	30-Mar-2017	209422	148199	1.56	clay	ferns in sago plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-237-B	30-Mar-2017	209421	148192	1.56	clay	ferns in sago plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-287-A	30-Mar-2017	210925	150212	4.17	clay	ferns in sago plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-287-B	30-Mar-2017	210931	150210	4.56	clay	ferns in sago plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
CROSSCHECK (Between GPS244 and GPS243)	30-Mar-2017	211920	146412	no peat	clay	mangrove	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1 / Crosscheck
GPS-239-A	30-Mar-2017	209335	149186	6.17	clay	palm plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-239-B	30-Mar-2017	209342	149186	6.17	clay	palm plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-247-A	30-Mar-2017	212551	147871	6.52	clay	palm plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-247-B	30-Mar-2017	212559	147864	6.97	clay	palm plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-238-A	30-Mar-2017	209385	148682	4.56	clay	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-238-B	30-Mar-2017	209394	148686	5.01	clay	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-244-A	30-Mar-2017	211992	146630	0.97	clay	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-244-B	30-Mar-2017	212009	146630	0.97	clay	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-245-A	30-Mar-2017	212198	147087	3.97	clay	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-245-B	30-Mar-2017	212209	147088	3.52	clay	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-246-A	30-Mar-2017	212423	147533	6.52	clay	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-246-B	30-Mar-2017	212423	147525	6.97	clay	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-286-A	30-Mar-2017	210512	150487	8.17	clay	sago plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-286-B	30-Mar-2017	210516	150483	8.17	clay	sago plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-292-A	30-Mar-2017	213087	148774	7.97	clay	shrub	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-292-B	30-Mar-2017	213083	148772	>8.97 (clay not found)	clay Not Found	shrub	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-241-A	30-Mar-2017	209266	150141	7.56	clay	yard of village house	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-241-B	30-Mar-2017	209270	150139	8.01	clay	yard of village house	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-236-A	30-Mar-2017	209470	147691	no peat	clay	yard of village house	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-236-B	30-Mar-2017	209471	147684	no peat	clay	yard of village house	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2

Waypoint	Date	X-UTM48N	Y-UTM48N	Peat Thickness	Mineral Soil	LULC	Location	Field Team	Remarks
GPS-56-A	31-Mar-2017	214804	145847	6.56	clay	bush in sago plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-56-B	31-Mar-2017	214806	145840	7.01	clay	bush in sago plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
CROSSCHECK to GPS 53	31-Mar-2017	214178	144590	no peat	clay	mangrove	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1 / Crosscheck
CROSSCHECK to GPS 249	31-Mar-2017	216381	143091	no peat	clay	mangrove	Desa Palkun	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1 / Crosscheck
CROSSCHECK to GPS 248	31-Mar-2017	215345	143101	no peat	clay	mangrove	Desa Palkun	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1 / Crosscheck
GPS-57-A	31-Mar-2017	214930	146327	>9.17(clay not found)	clay Not Found	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-57-B	31-Mar-2017	214940	146331	>9.17(clay not found)	clay Not Found	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-55-A	31-Mar-2017	214626	145377	4.17	clay	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-55-B	31-Mar-2017	214620	145380	4.17	clay	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-54-A	31-Mar-2017	214488	144896	2.17	clay	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-54-B	31-Mar-2017	214481	144899	2.17	clay	rubber plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-291-A	31-Mar-2017	212602	149113	6.97	clay	shrub	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-291-B	31-Mar-2017	212594	149102	7.13	clay	shrub	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-250-A	31-Mar-2017	216492	143410	no peat	clay	shrub	Desa Palkun	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-250-B	31-Mar-2017	216491	143395	no peat	clay	shrub	Desa Palkun	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-289-A	31-Mar-2017	211773	149657	4.13	clay	shrub in sago plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-289-B	31-Mar-2017	211788	149657	4.52	clay	shrub in sago plantation	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-290-A	31-Mar-2017	212173	149378	6.13	clay	swamp	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 1
GPS-290-B	31-Mar-2017	212173	149366	5.97	clay	swamp	Desa Kelemantan	Deltares, ITB, Desa Penebal, Desa Kelemantan	Replicate 2
GPS-5-A	01-Apr-2017	220333	142206	6.01	clay	bush in forest	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-5-B	01-Apr-2017	220337	142200	6.01	clay	bush in forest	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-6-A	01-Apr-2017	220229	142796	5.56	clay	bush in forest	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-6-B	01-Apr-2017	220239	142796	6.01	clay	bush in forest	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-3-A	01-Apr-2017	220540	141325	5.56	clay	bush in sago plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-3-B	01-Apr-2017	220550	141320	5.56	clay	bush in sago plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-8-A	01-Apr-2017	220042	143771	6.62	clay	palm plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-8-B	01-Apr-2017	220042	143777	6.62	clay	palm plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-2-A	01-Apr-2017	220670	140847	3.56	clay	rubber plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-2-B	01-Apr-2017	220662	140841	3.56	clay	rubber plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-4-A	01-Apr-2017	220461	141827	5.56	clay	rubber plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-4-B	01-Apr-2017	220458	141822	6.01	clay	rubber plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-251-A	01-Apr-2017	216777	143857	2.97	clay	rubber plantation	Desa Palkun	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-251-B	01-Apr-2017	216771	143865	2.97	clay	rubber plantation	Desa Palkun	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-252-A	01-Apr-2017	217018	144267	3.97	clay	rubber plantation	Desa Palkun	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-252-B	01-Apr-2017	217012	144262	3.97	clay	rubber plantation	Desa Palkun	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-7-A	01-Apr-2017	220148	143290	5.97	clay	rubber plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-7-B	01-Apr-2017	220146	143298	6.13	clay	rubber plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-11-A	01-Apr-2017	219758	145120	6.97	clay	rubber plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-11-B	01-Apr-2017	219754	145114	6.52	clay	rubber plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-10-A	01-Apr-2017	219830	144754	6.52	clay	rubber plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-10-B	01-Apr-2017	219841	144762	6.97	clay	rubber plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-1-A	01-Apr-2017	220763	140359	no peat	clay	school yards	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-1-B	01-Apr-2017	220758	140362	no peat	clay	school yards	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-253-A	01-Apr-2017	217279	144680	5.97	clay	shrub	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-253-B	01-Apr-2017	217275	144679	5.52	clay	shrub	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-9-A	01-Apr-2017	219948	144280	5.97	clay	shrub	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-9-B	01-Apr-2017	219939	144286	6.13	clay	shrub	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-277-A	02-Apr-2017	220589	145455	7.17	clay	ferns in sago plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-277-B	02-Apr-2017	220587	145452	7.17	clay	ferns in sago plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-281-A	02-Apr-2017	222141	144311	no peat	clay	mangrove	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-281-B	02-Apr-2017	222149	144308	no peat	clay	mangrove	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-285-A	02-Apr-2017	221432	147416	no peat	clay	mangrove	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-285-B	02-Apr-2017	221435	147417	no peat	clay	mangrove	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-276-A	02-Apr-2017	220199	145746	7.17	clay	rubber plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-276-B	02-Apr-2017	220188	145756	7.62	clay	rubber plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-284-A	02-Apr-2017	221018	147151	1.97	clay	sago plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-284-B	02-Apr-2017	221014	147159	1.97	clay	sago plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-279-A	02-Apr-2017	221401	144860	6.56	clay	shrub	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-279-B	02-Apr-2017	221396	144864	6.56	clay	shrub	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-280-A	02-Apr-2017	221803	144562	4.17	clay	shrub	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-280-B	02-Apr-2017	221807	144561	4.17	clay	shrub	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-282-A	02-Apr-2017	220159	146629	8.13	clay	shrub	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-282-B	02-Apr-2017	220164	146630	8.13	clay	shrub	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-283-A	02-Apr-2017	220567	146899	7.52	clay	shrub in sago plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-283-B	02-Apr-2017	220551	146906	7.52	clay	shrub in sago plantation	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-50-A	03-Apr-2017	220163	149330	1.52	clay	coconut plantation	Desa Teluk Lancar	Deltares, ITB, Desa Penebal, Desa Teluk Lancar	Replicate 1
GPS-50-B	03-Apr-2017	220161	149336	1.52	clay	coconut plantation	Desa Teluk Lancar	Deltares, ITB, Desa Penebal, Desa Teluk Lancar	Replicate 2
GPS-51-A	03-Apr-2017	220420	149755	no peat	clay	palm plantation	Desa Teluk Lancar	Deltares, ITB, Desa Penebal, Desa Teluk Lancar	Replicate 1
GPS-51-B	03-Apr-2017	220429	149756	no peat	clay	palm plantation	Desa Teluk Lancar	Deltares, ITB, Desa Penebal, Desa Teluk Lancar	Replicate 2
GPS-48-A	03-Apr-2017	219625	148482	6.97	clay	rubber plantation	Desa Teluk Lancar	Deltares, ITB, Desa Penebal, Desa Teluk Lancar	Replicate 1
GPS-48-B	03-Apr-2017	219632	148484	7.52	clay	rubber plantation	Desa Teluk Lancar	Deltares, ITB, Desa Penebal, Desa Teluk Lancar	Replicate 2
GPS-49-A	03-Apr-2017	219900	148906	3.97	clay	rubber plantation	Desa Teluk Lancar	Deltares, ITB, Desa Penebal, Desa Teluk Lancar	Replicate 1
GPS-49-B	03-Apr-2017	219903	148899	3.52	clay	rubber plantation	Desa Teluk Lancar	Deltares, ITB, Desa Penebal, Desa Teluk Lancar	Replicate 2
GPS-46-A	03-Apr-2017	219125	147632	9.13	clay	rubber plantation	Desa Teluk Lancar	Deltares, ITB, Desa Penebal, Desa Teluk Lancar	Replicate 1
GPS-46-B	03-Apr-2017	219126	147636	9.52	clay	rubber plantation	Desa Teluk Lancar	Deltares, ITB, Desa Penebal, Desa Teluk Lancar	Replicate 2
GPS-278-A	03-Apr-2017	220985	145163	7.17	clay	shrub	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-278-B	03-Apr-2017	220984	145169	7.56	clay	shrub	Desa Sekodi	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-47-A	03-Apr-2017	219365	148061	9.17	clay	shrub	Desa Teluk Lancar	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 1
GPS-47-B	03-Apr-2017	219376	148058	9.17	clay	shrub	Desa Teluk Lancar	Deltares, ITB, Desa Penebal, Desa Sekodi	Replicate 2
GPS-43-A	04-Apr-2017	217626	155253	1.01	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-43-B	04-Apr-2017	217622	155252	1.01	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-42-A	04-Apr-2017	217482	154766	2.01	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-42-B	04-Apr-2017	217475	154768	2.01	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-40-A	04-Apr-2017	217196	153814	5.17	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-40-B	04-Apr-2017	217197	153813	5.17	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-233-A	04-Apr-2017	218988	152675	0.52	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-233-B	04-Apr-2017	218987	152683	0.97	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-39-A	04-Apr-2017	217040	153324	6.62	clay	ferns in coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-39-B	04-Apr-2017	217052	153327	6.62	clay	ferns in coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-235-A	04-Apr-2017	219777	153052	no peat	clay	mangrove	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-235-B	04-Apr-2017	219779	153049	no peat	clay	mangrove	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-231-A	04-Apr-2017	218095	152239	6.13	clay	palm plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-231-B	04-Apr-2017	218088	152233	6.13	clay	palm plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-44-A	04-Apr-2017	217771	155725	no peat	clay	rubber plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-44-B	04-Apr-2017	217770	155729	no peat	clay	rubber plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-41-A	04-Apr-2017	217338	154288	3.01	clay	rubber plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-41-B	04-Apr-2017	217339	154298	3.17	clay	rubber plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-234-A	04-Apr-2017	219448	152896	no peat	clay	rubber plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-234-B	04-Apr-2017	219443	152894	no peat	clay	rubber plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2

Waypoint	Date	X-UTM48N	Y-UTM48N	Peat Thickness	Mineral Soil	LULC	Location	Field Team	Remarks
GPS-228-A	04-Apr-2017	216737	151606	9.17	clay	shrub	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-228-B	04-Apr-2017	216734	151602	9.17	clay	shrub	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-232-A	04-Apr-2017	218532	152456	2.97	clay	shrub	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-232-B	04-Apr-2017	218538	152457	2.52	clay	shrub	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-230-A	04-Apr-2017	217635	152028	7.97	clay	shrub	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-230-B	04-Apr-2017	217633	152031	8.18	clay	shrub	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-229-A	04-Apr-2017	217177	151827	9.13	clay	shrub	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-229-B	04-Apr-2017	217173	151824	9.13	clay	shrub	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-45-A	04-Apr-2017	217915	156207	no peat	clay	yard of village house	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-45-B	04-Apr-2017	217909	156207	no peat	clay	yard of village house	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-223-A	07-Apr-2017	215006	158064	2.56	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-223-B	07-Apr-2017	215007	158074	3.01	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-214-A	07-Apr-2017	213086	159031	6.17	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-214-B	07-Apr-2017	213096	159030	6.17	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-227-A	07-Apr-2017	216985	158306	no peat	clay	mangrove	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-227-B	07-Apr-2017	217003	158300	no peat	clay	mangrove	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
CROSSCHECK to 226	07-Apr-2017	216638	158371	no peat	clay	mangrove	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1 / Crosscheck
CROSSCHECK to 225	07-Apr-2017	215983	158250	no peat	clay	mangrove	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1 / Crosscheck
GPS-213-A	07-Apr-2017	213046	159370	5.56	clay	palm plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-213-B	07-Apr-2017	213047	159376	5.56	clay	palm plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-273-A	07-Apr-2017	214122	159226	5.05	clay	palm plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-273-B	07-Apr-2017	214115	159234	5.05	clay	palm plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-272-A	07-Apr-2017	214270	159702	4.05	clay	palm plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-272-B	07-Apr-2017	214267	159711	3.6	clay	palm plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-271-A	07-Apr-2017	214411	160191	1.05	clay	palm plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-271-B	07-Apr-2017	214405	160196	1.05	clay	palm plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-270-A	07-Apr-2017	214574	160662	0.6	clay	pinang trees	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-270-B	07-Apr-2017	214567	160664	0.6	clay	pinang trees	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-274-A	07-Apr-2017	213972	158752	6.05	clay	rubber plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-274-B	07-Apr-2017	213976	158740	6.6	clay	rubber plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-222-A	07-Apr-2017	214516	158009	5.56	clay	shrub	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-222-B	07-Apr-2017	214511	158011	6.01	clay	shrub	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-224-A	07-Apr-2017	215500	158130	1.56	clay	yard of village house	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-224-B	07-Apr-2017	215495	158125	1.56	clay	yard of village house	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-275-A	07-Apr-2017	213838	158277	7.05	clay	yard of village house	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-275-B	07-Apr-2017	213846	158286	7.05	clay	yard of village house	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-131-A	08-Apr-2017	218557	165295	2.01	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-131-B	08-Apr-2017	218564	165287	2.56	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-129-A	08-Apr-2017	217725	165856	4.17	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-129-B	08-Apr-2017	217722	165850	4.17	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-21-A	08-Apr-2017	215512	163749	1.01	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-21-B	08-Apr-2017	215502	163759	1.01	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-212-A	08-Apr-2017	212990	159870	4.15	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-212-B	08-Apr-2017	212987	159886	4.05	clay	coconut plantation	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
CROSSCHECK to 23	08-Apr-2017	215474	163178	no peat	clay	mangrove	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1/Crosscheck
CROSSCHECK to 22	08-Apr-2017	215510	163269	no peat	clay	mangrove	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1/Crosscheck
CROSSCHECK TO GPS209 AND GPS210	08-Apr-2017	213023	160653	no peat	clay	mangrove	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1/Crosscheck
GPS-134-A	08-Apr-2017	219733	164504	no peat	clay	mangrove (beach)	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-134-B	08-Apr-2017	219746	164514	no peat	clay	mangrove (beach)	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-133-A	08-Apr-2017	219387	164752	no peat	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-133-B	08-Apr-2017	219388	164745	no peat	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-130-A	08-Apr-2017	218148	165572	3.56	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-130-B	08-Apr-2017	218139	165577	4.17	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-20-A	08-Apr-2017	215657	164220	4.17	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-20-B	08-Apr-2017	215663	164224	4.56	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-269-A	08-Apr-2017	214680	161095	0.6	clay	shrub	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-269-B	08-Apr-2017	214683	161095	0.6	clay	shrub	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-132-A	08-Apr-2017	218970	165018	no peat	clay	yard of village house	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-132-B	08-Apr-2017	218973	165019	no peat	clay	yard of village house	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-211-A	08-Apr-2017	212941	160368	1.6	clay	yard of village house	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 1
GPS-211-B	08-Apr-2017	212948	160371	1.6	clay	yard of village house	Desa Kembung Luar	Deltares, ITB, Desa Penebal, Desa Kembung Luar	Replicate 2
GPS-14-A	09-Apr-2017	216517	167111	5.17	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-14-B	09-Apr-2017	216511	167109	5.17	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-12-A	09-Apr-2017	216784	168069	4.01	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-12-B	09-Apr-2017	216793	168064	4.01	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-217-A	09-Apr-2017	214439	164031	3.05	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-217-B	09-Apr-2017	214431	164033	3.05	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-219-A	09-Apr-2017	214454	165025	5.6	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-219-B	09-Apr-2017	214451	165018	5.6	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-220-A	09-Apr-2017	214468	165510	5.05	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-220-B	09-Apr-2017	214477	165510	4.6	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
CROSSCHECK To GPS215	09-Apr-2017	214424	163461	no peat	clay	mangrove-river	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1/Crosscheck
GPS-19-A	09-Apr-2017	215806	164704	4.56	clay	palm plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-19-B	09-Apr-2017	215804	164714	4.56	clay	palm plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-218-A	09-Apr-2017	214448	164510	4.6	clay	pinang trees	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-218-B	09-Apr-2017	214443	164522	4.6	clay	pinang trees	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-16-A	09-Apr-2017	216236	166158	6.17	clay	rubber in coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-16-B	09-Apr-2017	216243	166158	6.17	clay	rubber in coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-18-A	09-Apr-2017	215937	165196	5.56	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-18-B	09-Apr-2017	215930	165199	5.56	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-17-A	09-Apr-2017	216086	165674	4.17	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-17-B	09-Apr-2017	216081	165683	4.17	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-15-A	09-Apr-2017	216364	166640	6.62	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-15-B	09-Apr-2017	216355	166636	7.17	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-221-A	09-Apr-2017	214459	165869	4.6	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-221-B	09-Apr-2017	214462	165848	4.6	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-216-A	09-Apr-2017	214449	163508	no peat	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-216-B	09-Apr-2017	214449	163512	no peat	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-13-A	09-Apr-2017	216667	167593	5.01	clay	shrub	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-13-B	09-Apr-2017	216663	167591	5.17	clay	shrub	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-315-A	10-Apr-2017	212894	167418	5.01	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-315-B	10-Apr-2017	212888	167422	5.17	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-126-A	10-Apr-2017	211186	164837	6.6	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-126-B	10-Apr-2017	211200	164824	7.05	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-128-A	10-Apr-2017	210835	165818	6.05	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-128-B	10-Apr-2017	210843	165810	5.6	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-121-A	10-Apr-2017	212077	162500	no peat	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-121-B	10-Apr-2017	212080	162497	no peat	clay	coconut plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2

Waypoint	Date	X-UTM48N	Y-UTM48N	Peat Thickness	Mineral Soil	LULC	Location	Field Team	Remarks
GPS-319-A	10-Apr-2017	214935	167509	6.56	clay	palm in yard of village house	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-319-B	10-Apr-2017	214939	167518	6.56	clay	palm in yard of village house	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-125-A	10-Apr-2017	211362	164366	5.6	clay	palm plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-125-B	10-Apr-2017	211358	164351	5.6	clay	palm plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-124-A	10-Apr-2017	211549	163902	4.6	clay	palm plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-124-B	10-Apr-2017	211555	163897	5.05	clay	palm plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-123-A	10-Apr-2017	211720	163440	4.05	clay	palm plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-123-B	10-Apr-2017	211702	163438	4.05	clay	palm plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-318-A	10-Apr-2017	214392	167483	3.17	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-318-B	10-Apr-2017	214398	167490	3.17	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-316-A	10-Apr-2017	213402	167452	4.56	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-316-B	10-Apr-2017	213395	167453	4.56	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-314-A	10-Apr-2017	212388	167399	5.56	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-314-B	10-Apr-2017	212391	167404	5.6	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-122-A	10-Apr-2017	211898	162964	3.05	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-122-B	10-Apr-2017	211895	162962	3.05	clay	rubber plantation	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-127-A	10-Apr-2017	211008	165327	6.05	clay	shrub	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-127-B	10-Apr-2017	211014	165326	6.05	clay	shrub	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-317-A	10-Apr-2017	213903	167465	2.56	clay	yard of village house	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 1
GPS-317-B	10-Apr-2017	213901	167474	2.56	clay	yard of village house	Desa Teluk Pambang	Deltares, ITB, Desa Penebal, Desa Teluk Pambang	Replicate 2
GPS-84-A	11-Apr-2017	212246	168443	3.17	clay	coconut plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-84-B	11-Apr-2017	212249	168446	3.17	clay	coconut plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-82-A	11-Apr-2017	212541	169377	no peat	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-82-B	11-Apr-2017	212525	169385	no peat	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-83-A	11-Apr-2017	212396	168913	2.01	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-83-B	11-Apr-2017	212394	168915	2.17	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-85-A	12-Apr-2017	212111	167947	4.56	clay	coconut plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-85-B	12-Apr-2017	212115	167957	4.56	clay	coconut plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-87-A	12-Apr-2017	211753	166778	6.17	clay	coconut plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-87-B	12-Apr-2017	211765	166776	6.56	clay	coconut plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-88-A	12-Apr-2017	208761	170381	4.17	clay	coconut plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-88-B	12-Apr-2017	208757	170375	4.17	clay	coconut plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-208-A	12-Apr-2017	211592	169508	0.6	clay	coconut plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-208-B	12-Apr-2017	211595	169504	0.6	clay	coconut plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-86-A	12-Apr-2017	211961	167474	5.56	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-86-B	12-Apr-2017	211961	167470	5.56	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-207-A	12-Apr-2017	211184	169507	2.6	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-207-B	12-Apr-2017	211190	169503	2.6	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-205-A	12-Apr-2017	210180	169490	4.6	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-205-B	12-Apr-2017	210174	169490	4.6	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-204-A	12-Apr-2017	209686	169496	6.6	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-204-B	12-Apr-2017	209661	169494	7.05	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-202-A	12-Apr-2017	208682	169474	6.05	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-202-B	12-Apr-2017	208671	169477	5.6	clay	palm plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-206-A	12-Apr-2017	210676	169500	3.6	clay	pinang trees	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-206-B	12-Apr-2017	210679	169486	3.6	clay	pinang trees	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-89-A	12-Apr-2017	209038	170085	5.56	clay	rubber plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-89-B	12-Apr-2017	209050	170085	5.56	clay	rubber plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-203-A	12-Apr-2017	209190	169481	6.05	clay	rubber plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-203-B	12-Apr-2017	209191	169487	6.05	clay	rubber plantation	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-90-A	12-Apr-2017	209456	169676	6.17	clay	yard of village house	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 1
GPS-90B	12-Apr-2017	209453	169684	6.17	clay	yard of village house	Desa Muntai	Deltares, ITB, Desa Penebal, Desa Muntai	Replicate 2
GPS-265-A	13-Apr-2017	204128	167750	2.17	clay	palm plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 1
GPS-265-B	13-Apr-2017	204133	167753	2.17	clay	palm plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 2
GPS-264-A	13-Apr-2017	204052	167257	5.17	clay	palm plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 1
GPS-264-B	13-Apr-2017	204043	167256	5.56	clay	palm plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 2
GPS-313-A	13-Apr-2017	206363	166772	6.05	clay	palm plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 1
GPS-313-B	13-Apr-2017	206367	166779	6.05	clay	palm plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 2
GPS-267-A	13-Apr-2017	204267	168737	no peat	clay	rubber plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 1
GPS-267-B	13-Apr-2017	204261	168736	no peat	clay	rubber plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 2
GPS-266-A	13-Apr-2017	204202	168241	1.01	clay	rubber plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 1
GPS-266-B	13-Apr-2017	204197	168242	1.01	clay	rubber plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 2
GPS-263-A	13-Apr-2017	203997	166754	7.17	clay	rubber plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 1
GPS-263-B	13-Apr-2017	204004	166756	7.17	clay	rubber plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 2
GPS-312-A	13-Apr-2017	206190	167051	6.6	clay	rubber plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 1
GPS-312-B	13-Apr-2017	206194	167056	6.6	clay	rubber plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 2
GPS-311-A	13-Apr-2017	205927	167485	6.15	clay	rubber plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 1
GPS-311-B	13-Apr-2017	205918	167481	6.15	clay	rubber plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 2
GPS-268-A	13-Apr-2017	204318	169132	no peat	clay	yard of village house	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 1
GPS-268-B	13-Apr-2017	204311	169136	no peat	clay	yard of village house	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 2
GPS-201-A	14-Apr-2017	208172	169473	6.05	clay	coconut plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 1
GPS-201-B	14-Apr-2017	208173	169473	6.15	clay	coconut plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 2
GPS-197-A	14-Apr-2017	206174	169443	0.6	clay	palm plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 1
GPS-197-B	14-Apr-2017	206182	169441	0.6	clay	palm plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 2
GPS-200-A	14-Apr-2017	207680	169469	6.6	clay	palm plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 1
GPS-200-B	14-Apr-2017	207682	169477	6.6	clay	palm plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 2
GPS-306-A	14-Apr-2017	204620	169577	no peat	clay	palm plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 1
GPS-306-B	14-Apr-2017	204616	169584	no peat	clay	palm plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 2
GPS-309-A	14-Apr-2017	205407	168336	no peat	clay	rubber plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 1
GPS-309-B	14-Apr-2017	205396	168335	no peat	clay	rubber plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 2
GPS-199-A	14-Apr-2017	207178	169451	5.05	clay	rubber plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 1
GPS-199-B	14-Apr-2017	207183	169458	5.05	clay	rubber plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 2
GPS-198-A	14-Apr-2017	206670	169450	0.6	clay	rubber plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 1
GPS-198-B	14-Apr-2017	206670	169458	0.6	clay	rubber plantation	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 2
GPS-262-A	14-Apr-2017	203920	166270	8.01	clay	rubber plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 1
GPS-262-B	14-Apr-2017	203909	166262	8.17	clay	rubber plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 2
GPS-307-A	14-Apr-2017	204874	169181	no peat	clay	rubber plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 1
GPS-307-B	14-Apr-2017	204871	169186	no peat	clay	rubber plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 2
GPS-308-A	14-Apr-2017	205138	168753	no peat	clay	rubber plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 1
GPS-308-B	14-Apr-2017	205138	168759	no peat	clay	rubber plantation	Desa Bantan Sari	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 2
GPS-310-A	14-Apr-2017	205656	167909	4.05	clay	shrub	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 1
GPS-310-B	14-Apr-2017	205646	167908	3.6	clay	shrub	Desa Bantan Timur	Deltares, ITB, Desa Penebal, Desa Bantan Timur	Replicate 2
GPS-152-A	15-Apr-2017	202031	167527	6.56	clay	coconut plantation	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 1
GPS-152-B	15-Apr-2017	202030	167534	6.56	clay	coconut plantation	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 2
GPS-154-A	15-Apr-2017	201942	168527	3.05	clay	coconut plantation	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 1
GPS-154-B	15-Apr-2017	201941	168531	3.05	clay	coconut plantation	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 2
GPS-151-A	15-Apr-2017	202075	167021	7.17	clay	rubber plantation	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 1
GPS-151-B	15-Apr-2017	202068	167028	7.17	clay	rubber plantation	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 2

Waypoint	Date	X-UTM48N	Y-UTM48N	Peat Thickness	Mineral Soil	LULC	Location	Field Team	Remarks
GPS-153-A	15-Apr-2017	201990	168031	5.17	clay	rubber plantation	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 1
GPS-153-B	15-Apr-2017	201983	168029	5.17	clay	rubber plantation	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 2
GPS-155-A	15-Apr-2017	201902	169034	3.21	clay	rubber plantation	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 1
GPS-155-B	15-Apr-2017	201880	169032	3.6	clay	rubber plantation	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 2
GPS-156-A	15-Apr-2017	201849	169520	no peat	clay	rubber plantation	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 1
GPS-156-B	15-Apr-2017	201837	169532	no peat	clay	rubber plantation	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 2
GPS-157-A	15-Apr-2017	201798	170012	no peat	clay	yard of village house	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 1
GPS-157-B	15-Apr-2017	201790	170012	no peat	clay	yard of village house	Desa Bantan Air	Deltares, ITB, Desa Penebal, Desa Bantan Air	Replicate 2
AP-15-A	16-Apr-2017	198283	164423	8.17	clay	shrub	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
AP-15-B	16-Apr-2017	198288	164424	8.01	clay	shrub	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
AP-14-A	16-Apr-2017	198295	164919	7.17	clay	shrub	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
AP-14-B	16-Apr-2017	198289	164928	7.17	clay	shrub	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
AP-00-A	16-Apr-2017	199612	161960	6.05	clay	shrub	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
AP-00-B	16-Apr-2017	199619	161961	5.6	clay	shrub	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
AP-01-A	16-Apr-2017	199356	162370	6.6	clay	shrub	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
AP-01-B	16-Apr-2017	199360	162365	7.05	clay	shrub	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
AP-03-A	17-Apr-2017	203721	164413	6.05	clay	palm plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 1
AP-03-B	17-Apr-2017	203723	164430	6.05	clay	palm plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 2
AP-13-A	17-Apr-2017	196171	163090	7.17	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
AP-13-B	17-Apr-2017	196165	163091	7.17	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
AP-12-A	17-Apr-2017	195986	163597	7.01	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 1
AP-12-B	17-Apr-2017	195983	163593	6.56	clay	rubber plantation	Desa Penebal	Deltares, ITB, Desa Penebal	Replicate 2
AP-02-A	17-Apr-2017	203770	164978	7.05	clay	shrub	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 1
AP-02-B	17-Apr-2017	203769	164968	7.05	clay	shrub	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Bantan Sari	Replicate 2
AP-10-A	18-Apr-2017	212298	158054	8.21	clay	forest	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
AP-10-B	18-Apr-2017	212305	158056	8.6	clay	forest	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
AP-06-A	18-Apr-2017	207243	164223	8.01	clay	palm plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
AP-06-B	18-Apr-2017	207247	164229	8.17	clay	palm plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-75-A	18-Apr-2017	211879	158319	7.05	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-75-B	18-Apr-2017	211878	158325	7.6	clay	rubber plantation	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2
AP-07-A	18-Apr-2017	207133	163725	6.56	clay	shrub	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
AP-07-B	18-Apr-2017	207127	163726	6.56	clay	shrub	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
GPS-176-A	19-Apr-2017	209313	157324	6.6	clay	forest	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-176-B	19-Apr-2017	209304	157322	6.6	clay	forest	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
AP-04-A	19-Apr-2017	203489	155684	6.17	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal	Replicate 1
AP-04-B	19-Apr-2017	203490	155679	6.17	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal	Replicate 2
AP-05-A	19-Apr-2017	203933	155427	7.01	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal	Replicate 1
AP-05-B	19-Apr-2017	203936	155429	7.01	clay	shrub	Desa Ketam Putih	Deltares, ITB, Desa Penebal	Replicate 2
GPS-177-A	19-Apr-2017	209789	157072	7.05	clay	shrub	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 1
GPS-177-B	19-Apr-2017	209781	157064	7.05	clay	shrub	Desa Pematang Duku	Deltares, ITB, Desa Penebal	Replicate 2
AP-08-A	20-Apr-2017	217556	145127	7.17	clay	rubber plantation	Desa Palkun	Deltares, ITB, Desa Penebal, Desa Palkun	Replicate 1
AP-08-B	20-Apr-2017	217552	145134	7.56	clay	rubber plantation	Desa Palkun	Deltares, ITB, Desa Penebal, Desa Palkun	Replicate 2
GPS-260-A	20-Apr-2017	206875	162753	6.01	clay	shrub	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 1
GPS-260-B	20-Apr-2017	206870	162754	6.01	clay	shrub	Desa Pematang Duku	Deltares, ITB, Desa Penebal, Desa Pematang Duku	Replicate 2