Delegation of the European Commission to Indonesia, Singapore and Brunei Darussalam

South Sumatra Forest Fire Management Project (SSFFMP)

Draft Report

International Consultancy on

PEAT DOME MAPPING & ANALYSIS

Compilation of the Projects Peat Data

by

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PREFACE

The South Sumatra Forest Fire Management Project (SSFFMP) is a technical co-operation project jointly funded, in terms of the financing memorandum IDN/RELEX/1999/0103, by the European Commission and by the Government of the Republic of Indonesia through the Ministry of Forestry (MoF).

This report has been completed in accordance with the project Second annual Work Plan (AWP II) and

- in fulfilment of Activity 3.1.1.3 "conduct a landcover, landuse and peat distribution mapping study in the priority areas, and train counterparts / target groups on-the-job"
- and activity 4.1.2 "to provide technical assistance on management & organization to relevant agencies to support improvements to the fire detection and early warning system"
- to achieve Result 3 "to create capacities and support initiatives to bring land and natural resources under sustainable management" and Result 4 "to support government and non-government organizations to establish systems to monitor the impact of improved fire management on the environment and people and the results of the work place in the public domain"
- to realise the five-year project purpose, which is "Aid and facilitate the establishment of a coordinated system of fire management at province, district, sub district and village level throughout South Sumatra province in which all involved stakeholders, including the private sector, work together to reduce the negative impact of fire on the natural and social environment."

This report has been prepared with financial assistance from the Commission of the European Community. The opinions, views and recommendations expressed are those of the author and in no way reflect the official opinion of the Commission.

The report has been prepared by:

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The report is acknowledged and approved for circulation by the Project Co-Directors when duly signed below.

Palembang, 15.08.2007

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Thank you all very much.

Terima kasih.

ABBREVIATION

CDM	Clean Development Mechanism
COP	Conference of Parties
FIS	Fire Information System
FDR	Fire Danger Rating
FTA	Fire Threat Analysis
GIS	Geographical Information System
GPS	Global Positioning System
gt	giga tonne
ha	hectare
km	kilometer
m	meter
MODIS	Moderate Resolution Imaging Spectroradiometer
mt	mega tonne
SRTM	Shuttle Radar Topography Mission
SSFFMP	South Sumatra Forest Fire Management Project
t	tonne
UNFCCC	United Nations Framework Convention on Climate Change

RINGKASAN EKSEKUTIF

Kebakaran telah menjadi persoalan yang serius dan terus berulang di Indonesia, terutama di Sumatera, selama decade terakhir. Fenomena ini merupakan persoalan berdimensi local, regional, dan global.

Agar tindakan pengelolaan kebakaran dapat berhasil dengan baik, maka perlu dikembangkan pemahaman yang mendalam tentang keterkaitan/hubungan antara kebakaran dan tataguna lahan, terutama di kawasan gambut tropis. Jika api digunakan dalam pembukaan lahan pada musim kemarau, terutama musim kemarau panjang, seperti ketika terjadi El Nino, maka akan selalu ada resiko api menjadi tidak terkendali dan merambat ke dalam kawasan hutan. Terutama hutan gambut yang luas yang terdapat di kawasan pantai Sumatera dan yang dicirikan oleh lapisan gambut yang tebal dipengaruhi oleh kebakaran. Kebakaran di kawasan ini menyebabkan terjadinya pelepasan asap yang tebal, polutan, asap dan partikulat (*haze*), dan karbondioksida dalam jumlah besar ke atmosfir, yang mempengaruhi masyarakat local, Negara tetangga dan memberikan kontribusi terhadap terjadinya pemanasan global.

Tujuan konsultansi ini adalah untuk mendukung kinerja staf SSFFMP dalam evaluasi dan analisis data tentang gambut yang telah berhasil dikumpulkan oleh SSFFMP sendiri maupun oleh organisasi lainnya.

Ada 3 ruang lingkup konsultansi ini, yaitu:

1. Kompilasi semua data tentang lahan gambut dan kubah gambut di Propinsi Sumatera Selatan yang telah ada dan memadukan informasi tersebut ke dalam GIS,
2. Kalkulasi luas, volume, kandungan karbon, dan ekuivalensinya terhadap karbondioksida lahan/kubah gambut di Propinsi Sumatera Selatan, berdasarkan kompilasi data pada Ruang Lingkup 1 di atas, dan
3. Menentukan dan memberikan masukan tentang lokasi yang perlu disurvai/diambil contohnya, sehubungan dengan estimasi skala propinsi tentang luas, volume, kandungan karbon lahan/kubah gambut.

Integrasi data hasil pengamatan melalui pengeboran di Air Sugihan, OKI, ke dalam model bentuk dan volume gambut tidak dapat dilakukan karena adanya data hasil pengeboran yang hilang.

Temuan Utama

- Hasil survai lahan gambut memberikan kontribusi temuan baru yang signifikan untuk dijadikan dasar pengambilan keputusan,
- Kalkulasi volume gambut dan cadangan karbon memberikan gambaran betapa pentingnya ekosistem gambut tersebut. Hasil yang diperoleh memberikan gambaran realistis tentang sumberdaya gambut yang sebenarnya di kawasan tersebut,
- Seperti yang diharapkan, hasil konsultansi tentang modeling gambut menunjukkan bahwa volume gambut ternyata lebih tinggi dari yang diperkirakan sebelumnya. Cadang karbon yang tersimpan dalam hutan gambut pasang surut dan tanah gambut di Sumatera Selatan sangat besar, menunjukkan betapa pentingnya ekosistem ini ditinjau dari sudut isu karbon.

Rekomendasi

- Survai tambahan untuk pengamatan lebih lanjut telah dirancang bersama dengan tenaga ahli local. Data tambahan diperlukan untuk memperbaiki estimasi volume gambut,

- Estimasi baru tersebut akan memberikan gambaran yang lebih realistis tentang volume, kandungan karbon, dan ekuivalensinya terhadap karbondioksida lahan/kubah gambut Sumatera Selatan,
- Karena kedalam gambut mempunyai korelasi dengan tinggi permukaan pada kondisi optimal, maka estimasi terhadap volume kubah gambut yang tidak disurvai juga bisa dilakukan. Namun demikian, pengamatan lapangan (pengeboran) tambahan tetap perlu dilakukan agar 'diperoleh hasil yang baik" tetapi dalam jumlah jauh lebih sedikit daripada pengamatan sebelumnya. Pengamatan lebih lanjut diperlukan untuk menganalisis korelasi dan aplikasinya lebih lanjut.
- Isu gambut perlu diteliti lebih lanjut, terutama yang berkaitan dengan kehilangan (*sequestration*) karbon.

Dalam waktu dekat, neraca karbon global (*global carbon market*) di bawah Protokol Kyoto dapat di bentuk seperti halnya yang telah dilakukan oleh Uni Eropa. Implementasi kredit karbon melalui tindakan tidak melakukan penggundulan hutan memberikan peluang ekonomi yang menguntungkan bagi Indonesia. Ditinjau dari kacamata politik, hingga saat ini hanya scenario "Menekan emisi dengan menhindari penebangan hutan" yang memperoleh perhatian pada Protokol Kyoto. Sesungguhnya ini hanya salah satu dari dua sisi uang logam. Peranan lahan gambut sebagai factor karbon secara politik belum sepenuhnya diketahui. Namun demikian, jelas bahwa dalam jangka menengah "Menekan emisi melalui konservasi dan pengelolaan gambut" akan diimplementasikan ke dalam Protokol Kyoto. Oleh karena itu, pengelolaan dan proteksi gambut dapat dikaitkan dengan perdagangan karbon, yaitu manfaat financial akibat meniadakan emisi melalui langkah konservasi dan proteksi. Karena pertemuan berikutnya (COP13) yang melibatkan berbagai pihak yang tergabung dalam the United Nation Framework Convention on Climate Change (UNFCCC) akan diadakan akhir tahun ini di Bali dan Indonesia merupakan salah satu negara yang mempunyai lahan gambut yang luas, maka momen tersebut merupakan peluang untuk menciptakan kepedulian public yang lebih besar terhadap pengelolaan gambut secara berkelanjutan.

Executive Summary

Fire has become a serious, reoccurring problem in Indonesia and especially in Sumatra in the past decade. It can be seen as a disaster of local, regional and global dimension.

For successful fire management it is important to develop an in depth understanding of the dependence/linkage of fire and land use, especially in areas of tropical peat. As long as fire is used for land clearing, there will be a high risk that during the dry season and especially during prolonged droughts such as under El Nino weather conditions, fires get out of control and escape into the remaining forest resources. Especially in the coastal regions of Sumatra large areas of peat forest, characterized by thick peat soil layers, are affected by fire. This leads to the release of dense smoke, pollutants, haze and huge amounts of carbon dioxide into the atmosphere, affecting locals, neighbouring countries and representing a significant cause for global warming.

Objective of this consultancy was to support SSFFMP project staff in the evaluation and analysis of available peat data produced by the SSFFMP or other organisations.

The consultancy provided had three major topics:

1. Compilation of all available data on peat lands and domes for South Sumatra Province and accommodation of this information into a GIS.
2. Calculation of peat land/dome extend, volume, carbon content and carbon dioxide equivalent for South Sumatra Province based on the data compiled in topic 1.
3. Determination and advisory on additional locations to be surveyed/sampled in the context of the above mentioned province-scale estimation of peat lands/domes and volumes.

The planned integration of the data from additional peat depth drillings in Air Sugihan / OKI District area into the peat body and volume model was not carried out, due to missing additional peat drillings.

Major Findings

- The peat land survey gave significant new results for decision making on all levels.
- Peat volume and carbon store calculations show the importance of this ecosystem. The results give a more realistic impression of the actual peat resources in the area.
- As expected in last years consultancy on peat modelling, the findings resulted in higher peat volumes. The carbon stored in peat swamp forests and belonging peat soils of South Sumatra is immense, underlining the importance of this ecosystem in context of carbon issues.

Recommendations

- A new survey design for further investigations was developed in close cooperation with local experts. Additional field data would improve the peat volume estimations.
- These new estimations would give a more realistic view of volume, carbon content and corresponding carbon dioxide equivalents of South Sumatra's peat lands/domes.
- As the peat depth of peat domes correlates to surface heights under optimal conditions it would be possible to estimate the volume of peat domes that were not surveyed yet. Anyhow, in order to "tune" the estimations of peat domes more peat dome drillings are needed, but far less in number. Further investigations have to be done to analyse the correlation and application of this matter.
- The peat issue should be further investigated, especially in the context of carbon sequestration.

In near future a global carbon market under the Kyoto protocol could be established similar to the one established by the European Union. Carbon credits through avoided deforestation offer a profitable economic opportunity for Indonesian business. So far from the political side only the scenario "Reducing emissions through the avoidance of deforestation" is given attention under the Kyoto protocol and this is only one side of the medal. The importance of peat lands as a global carbon factor is politically not fully recognized yet. However, it is obvious that in the medium-term "Reducing emissions through peat conservation and management" will be implemented in the subsequent Kyoto protocol. Hence, peat management and protection may be connected to carbon credit trade, meaning financial benefit from emission avoidance by conservation and protection practices. As the next conference of parties (COP 13) to the United Nations Framework Convention on Climate Change (UNFCCC) is held in Bali at the end of this year and with Indonesia being one of the leading countries with regard to peat land extent this would be an opportunity to create more public awareness considering sustainable peat management.

1. Introduction

Uncontrolled wildfires became the greatest threat to the forest resources of Indonesia with serious consequences on forest and peat land ecosystems, local livelihood and health problems linked to haze (Tacconi, 2003). Fires in tropical peat swamp forests are especially damaging to the environment and health (Aldhous, 2004).

In their natural state tropical peat swamp forests sequester carbon dioxide from the atmosphere as they function as large-scale carbon sinks. Globally it is estimated that peat lands cover app. 400 million hectares of the earth´s surface and play a significant role in the carbon cycle (Page, 2004). According to Page (2004) approximately 20 % of all terrestrial carbon is sequestered in peat lands. Indonesia's tropical peat lands with an extent of about 20 Mio ha play a significant role.

Reoccurring fires in the area accelerate global warming and climate change. Tacconi (2003) states, that the Indonesian fire-hazard of the El Nino season 1997/1998 affected app. 2.12 Mio ha of peat lands. This event was linked to approximate carbon emissions between 0.81 gt and 2.57 gt, which is equivalent to the amount of 15-40 % of the annual global carbon emissions from the burning of fossil fuels (Page et al., 2002). Evidently, degradation of peat lands and large-scale peat fires have a significant and lasting impact on the global carbon cycle. In addition, hundred thousands of people in Indonesia suffer serious health problems due to the haze and pollutant release caused by large area fires. Respiratory infections, blurred vision and blood poisonings have been and will be reported in affected regions. The release of huge amounts of smoke haze affects not only people locally but extends over distances of several thousands of kilometers across Southeast Asia already leading to repeated political disputes between Malaysia and Indonesia.

Increasing drainage activities, prolonged dry seasons that coincide with El Nino events and heavy degradation caused by timber harvesting, have lasting negative effects on these highly specialized, species rich forest ecosystems. Maltby and Immrzy (1993) suspect a carbon dioxide release of 2 – 20 t/ha caused by peat land drainage and degradation. All these factors are linked to human intervention and lead to increasing drought in tropical peat lands, which is directly connected to higher fire susceptibility.

Large-scale fires regularly occur in the swampy plains of Sumatra. In the dry season of 2006 alone, the MODIS sensor detected hundreds of fire hotspots in Sumatra. A clear pattern is apparent. Most of the detected fires are found in the last remaining peat swamp forests, whereby many of these are characterised by up to 10 meters of peat depth. Murdiyarso (2005) even states that pristine tropical peat lands could be as deep as 15 m.

In their natural state, tropical peat lands contribute to biodiversity and are important water catchment areas by absorbing and storing rain and river flood water during wet periods and releasing water when rainfall is low.

South Sumatra holds large areas of peat mainly located close to the coast (Wetlands International 2004a). Coastal peat swamps are buffers between salt and freshwater hydrological systems. Inland peat areas occur in Oki regency and in north Muba regency (**Fig.1**).

Fig. 1. Province of South Sumatra and the three priority Banyuasin, Musi Banyuasin, Ogan Komering Ilir districts.

Since the late 80's South Sumatra has lost almost 90 % of its original cover of peat swamp forests (Wetlands International, 2004a). Burnt peat swamps contain large fuel loads. The absence of roads and limited access from rivers severely impede fire suppression in pristine and already disturbed peat swamp forests.

With extended dry weather condition as they occur every year during the dry season from June to September and decreased water levels in the peat soil, the peat layer progressively dries out and becomes much more prone to fire. Fire in peat swamp forests is usually extremely damaging. It kills most of the tree vegetation and thus leads to the subsequent exposure of the peat substrate to solar radiation. Exposed peat and unburnt biomass such as tree trunks increase the fuel load, representing a substantial fire threat.

Desiccation and exposure of the peat substrate result in oxidation of the peat fibres and subsequent subsidence of several centimetres per year.

Fire Information System (FIS)

According to the workplan of the SSFFMP project, under activity 4.1., an early warning system is currently established consisting of two components:

- the Fire Danger Rating (FDR)
- the Fire Threat Analysis (FTA)

The FTA is a GIS based mapping system which provides information on the risk of fire occurrence and potential fire impacts to the project stakeholders (Ruecker, 2006). Maps produced by the FTA show/consider the dependence/linkage of fire and land cover and land use and give special emphasis on the specific fire relevant properties of peatland ecosystems. A reliable peat mapping, including precise extent and depth estimations, represents an important input parameter. According to Ruecker (2006) the fire threat and dangerous fire behaviour amplify with an increased degree of disturbance of peatlands and peat forests.

Causes of wildland fire

The use of fire for land clearing has a long tradition in Indonesia. It is manifested in traditional agricultural slash and burn practices. According to Saharjo (1999) 99 % of all fires can be ascribed to human activities, independent whether they occur in natural forest, shifting cultivation or plantation areas. Often it is just negligence in the sparsely inhabited and vast peat lands, that causes a fire (intentionally or sparked off accidentally) to run out of control (Wetlands International 2004b).

Burnt peat swamps are a major fire hazard. With increasing drought and a lowering of the water table, the peat layer progressively dries out and becomes flammable. The post-fire condition of the peat lands is such that they are open and exposed to the climatic elements and, therefore, they become much more susceptible to erosion and at risk of future fires. The desiccation and exposure of the peat substrate results in oxidation of the biomass and subsequently in a more rapid subsidence.

With increasing degradation and overexploitation of the forest resources, fires set by farmers, hunters or estate crop plantations to clear forested land, frequently escape into adjacent forest areas. Fire will continue to be used for land clearing (shifting cultivation and *sonor* system), because there is no feasible alternative to prepare land. This requires that the SSFFMP project supports people improve their traditional "fire practices" to "controlled burning" or "better burning", as it is called in the mid-term review report.

Benefit of the compiled peat data

Information about the location, extent and volume of peat stored in the coastal flats of South Sumatra is required as input for the FTA and is important for stakeholders and decision-makers in land-use planning on all levels. Peat fires are - as described above - extremely damaging to the environment and to the health of the local population. Therefore, it is important to know where peat lands are found and what peat volumes are present below the surface.

This important information could be used to assist land use planning (e.g. preparation of agricultural land, management of forest plantations), fire prevention management and to estimate the amount of carbon dioxide, which can be potentially released by fire or oxidation through drainage. Peat lands, being a significant carbon sink and its crucial role in the global carbon cycle, underline the importance of improved peat and fire management, as well as a better understanding of the processes involved.

At present, the carbon storage potential in the FTA is only estimated very vague using average values over large areas. Based on this carbon loss and potential pollutant release is calculated approximately. By implementing the compiled SSFFMP peat data the precision of the FTA could be enhanced significantly, due to the higher accuracy of the input peat depth and volume.

2. Compilation of all available Peat Data

All information that was available on peat lands/domes, from primary sources as the project's peat dome survey and satellite image (SRTM, Landsat and Spot) interpretations as well as from a range of secondary sources (especially the Repprot project and Wetlands International), was compiled to come up with a province scale map of peat lands and their depths. This compiled peat data was then the basis for the further calculations on peat area extent, volume, carbon content and carbon dioxide equivalent.

As the information on peat, especially on peat depth, varies in a wide range the outcome consist of more educated estimates then of exact hard data, but this estimation is anyway important in the context of knowing the approximate volume, carbon content and carbon dioxide equivalent stored in South Sumatra's peat lands.

In future the information on carbon content stored in peat lands will be important in the context of international and national policies, treaties and protocols on climate change. Also projects based on the Clean Development Mechanism (CDM) might become a possibility in the near future.

2.1. Peat Maps

To come up with a province scale map of peat lands, three information sources were incorporated:

- A **peat land/dome map** of South Sumatra province produced by **Repprot**. Repprot was a development project funded by Great Britain to assist the transmigration effort of the Indonesian government. Within this project a detailed map of land cover, soils etc. was created to find suitable land for transmigration.
- A **peat land map** of South Sumatra province produced by **Wetlands International**. Wetlands International is the biggest non-profit organization dedicated solely to wetland conservation and their sustainable management.
- **Satellite data** (SRTM, Landsat and Spot images) of South Sumatra province.

To summarize these three information sources in one province scale peat map the Repprot peat land/dome map was used as base map and visually compared with the Wetlands international peat land map with the help of the satellite data, especially the SRTM image was useful. Areas from the Wetlands International peat land map that obviously were peat lands and not delineated in the Repprot peat land/dome map were added. Areas that were not marked as peat in both maps, the Repprot peat land/dome map and the Wetlands international peat land map, but most likely represented peat lands were visually digitized and added. Finally the borderline of this new peat land map was compared with topographic features visible in the satellite data and corrected, especially along rivers. **Fig. 2.** gives an overview of the input used for the compiled peat map and **Fig. 3**. displays the final peat map.

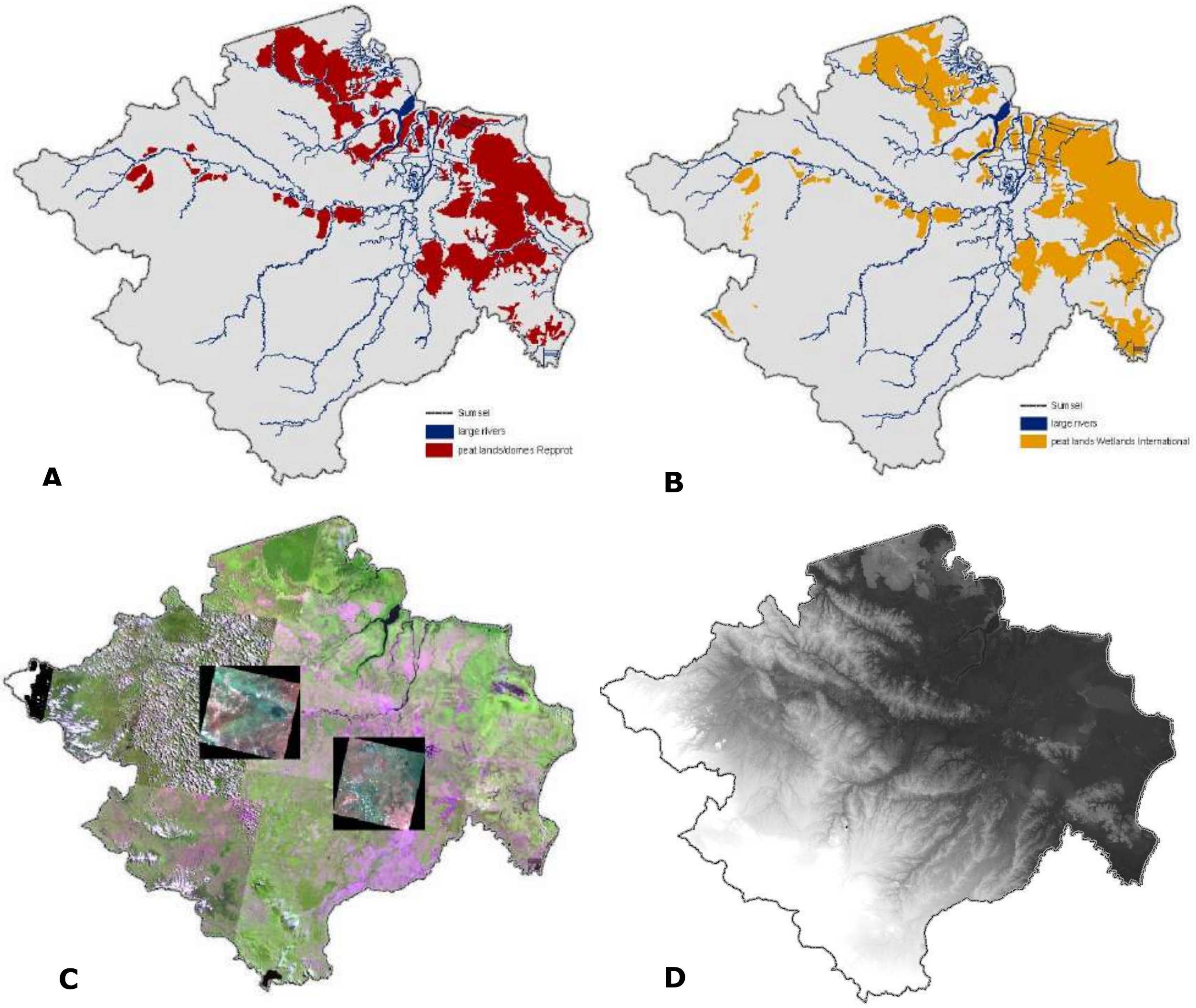

Fig. 2. Input used to compile provincial peat land map. (A) Peat land/dome map Repprot, (B) Peat land map Wetlands International, (C) Landsat and Spot (for Spot here only two examples are shown) satellite data, (D) SRTM digital model.

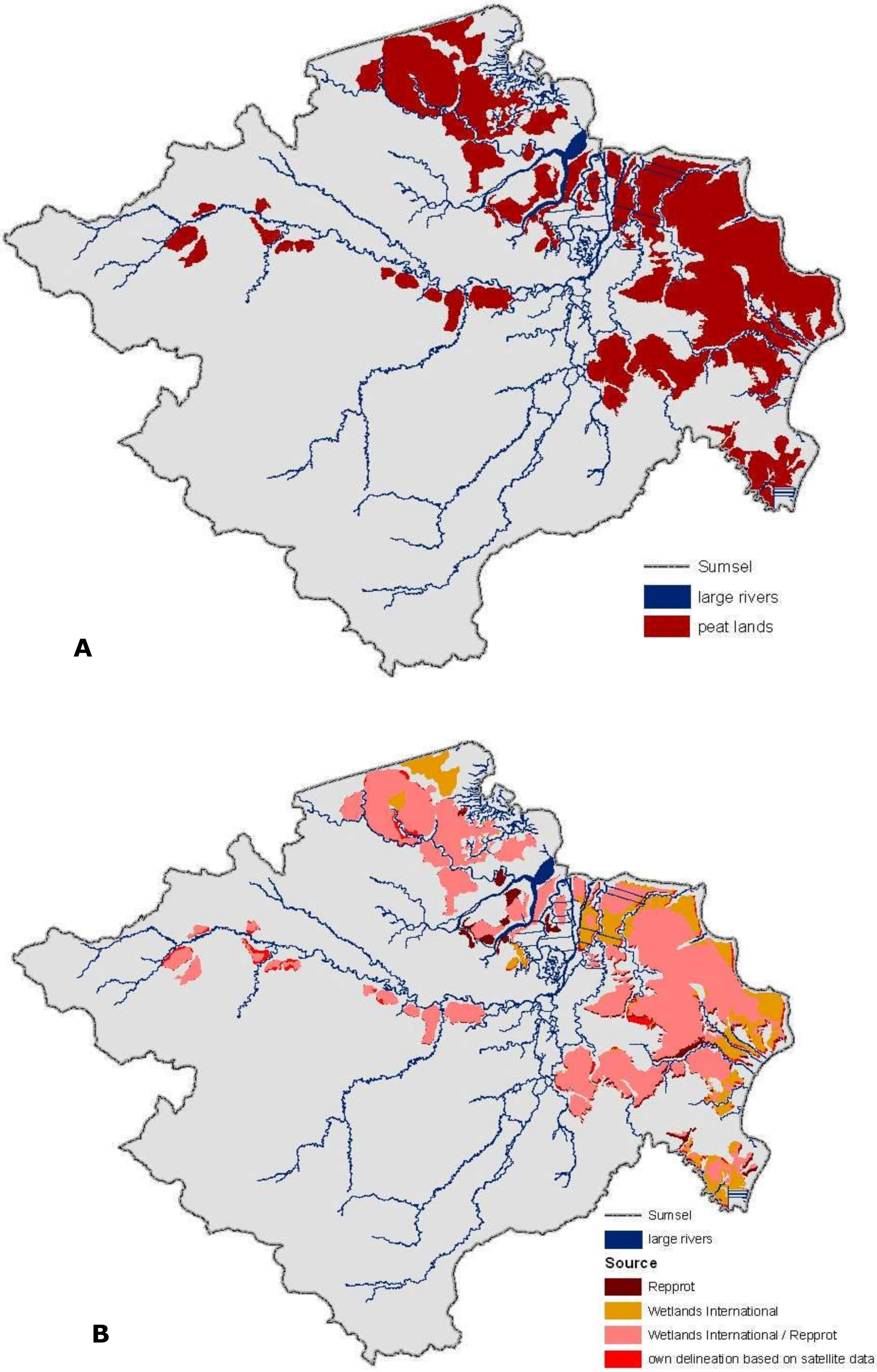

Fig. 3. Compiled peat map. (A) Compiled peat land map, (B) Compiled peat land map differentiated into which area dirived from which source.

Within this newly compiled peat land map, with the help of the SRTM data, peat domes were identified and a peat dome map was digitized. **Fig. 4.** gives examples of how these peat domes can be visually differentiated from the surrounding areas within a SRTM image and **Fig. 5.** displays the resulting peat dome map of the South Sumatra Province.

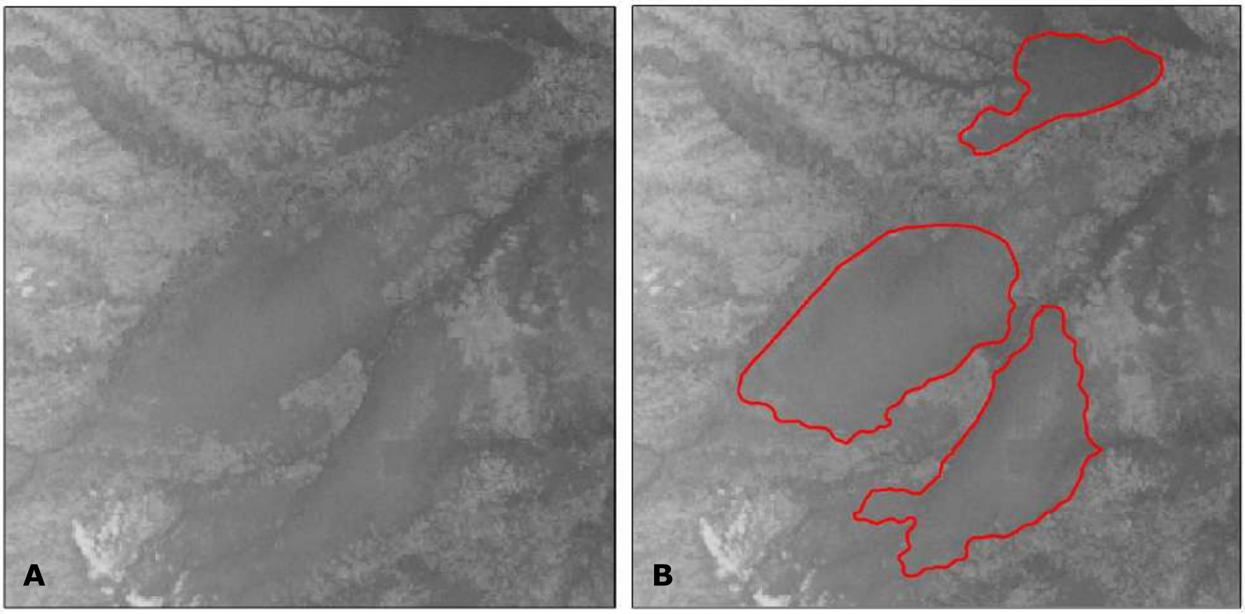

Fig. 4. Peat dome delineation with the Help of SRTM data. (A) SRTM Data, (B) SRTM data with delineated peat domes

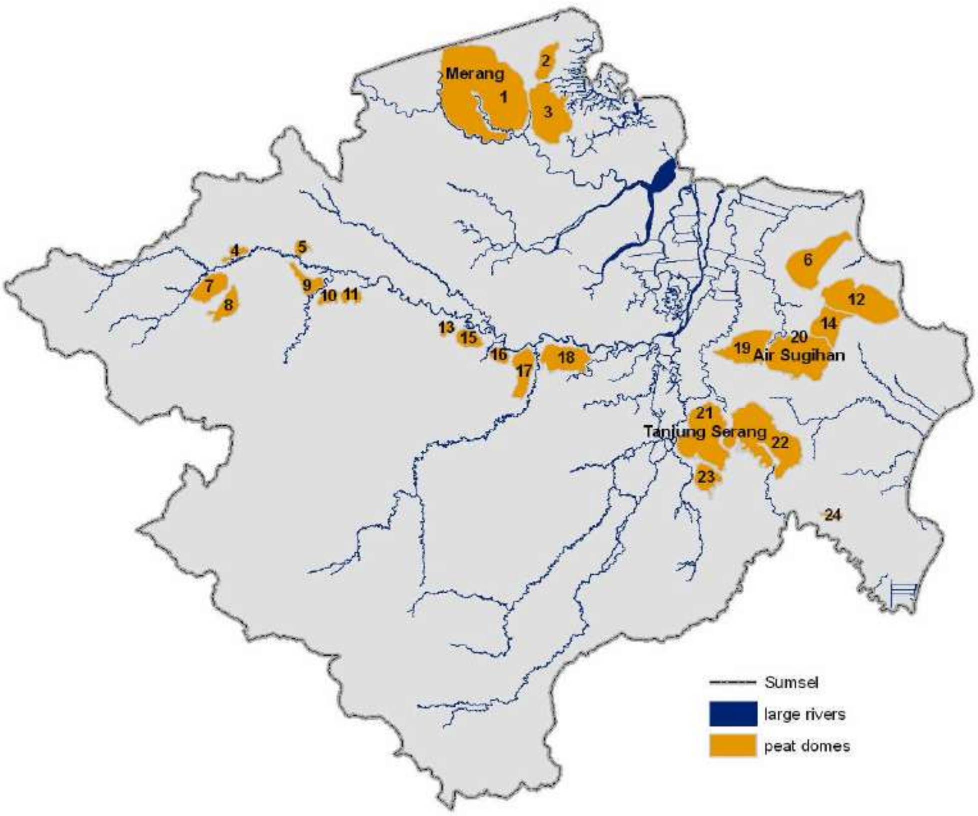

Fig. 5. Compiled peat dome map with names given by SSFFMP to specific peat domes and numbers given to all peat domes by the editor.

2.2. Peat Depths from Maps

For further calculations peat depths given by Repprot and Wetlands International were incorporated. Following depths were attributed to the following maps.

For peat lands:

- Repprot peat land/dome map: Original Repprot peat land/dome map with the depths given there.
- Wetlands International peat land map: Original Wetlands International peat land map with the depths given there.
- Complied peat land map with Repprot peat depths: Extent of the newly compiled peat land map with the depth given by Repprot attributed to it. If polygons of the compiled peat land map did not overlay the Repprot peat land/dome map the depth of the nearest peat land was attributed to these polygons. If a polygon of the compiled peat land map was between two different depth readings of the Repprot peat land/dome map these two values were averaged.
- Compiled peat land map with Wetlands International peat depths: Extent of the newly compiled peat land map with the depth given by Wetlands International attributed to it. If polygons of the compiled peat land map did not overlay the Wetlands International peat land map the depth of the nearest peat land was attributed to these polygons.
- Compiled peat land map with average Repprot peat depths: Extent of the newly compiled peat land map with the overall average depth of the Repprot peat land/dome map attributed to it.
- Compiled peat land map with average Wetlands International peat depths: Extent of the newly compiled peat land map with the overall average depth of the Wetlands International peat land map attributed to it.

For peat domes:

- Compiled peat dome map with Repprot peat depths: Extent of the newly compiled peat dome map with the depth given by Repprot attributed to it. If polygons of the compiled peat dome map did not overlay the Repprot peat land/dome map the depth of the nearest peat land was attributed to these polygons. If a polygon of the compiled peat dome map was between two different depth readings of the Repprot peat land/dome map these two values were averaged.
- Compiled peat dome map with Wetlands International peat depths: Extent of the newly compiled peat dome map with the depth given by Wetlands International attributed to it. If polygons of the compiled peat dome map did not overlay the Wetlands International peat land map the depth of the nearest peat land was attributed to these polygons.

2.3. Peat Depths from Peat Drillings

For further calculations also peat depths given by peat depth drillings were incorporated. Drillings from three different sources were available. Peat depth drillings conducted by SSFFMP, Air Sugihan Provincial Mining Service and the University in Palembang. **Fig. 5.** displays the location of all available peat depth drillings. Following depths were attributed to the newly compiled maps.

For peat lands:

- Compiled peat land map with the average depth of all SSFFMP peat depth drillings
- Compiled peat land map with the average depth of the Air Sugihan Provincial Mining service peat depth drillings
- Compiled peat land map with the average depth of the University in Palembang peat depth drillings
- Compiled peat land map with the average depth of all available peat depth drillings

For peat domes:

- Compiled peat dome map with average individual peat dome depths calculated from all available peat depth drillings

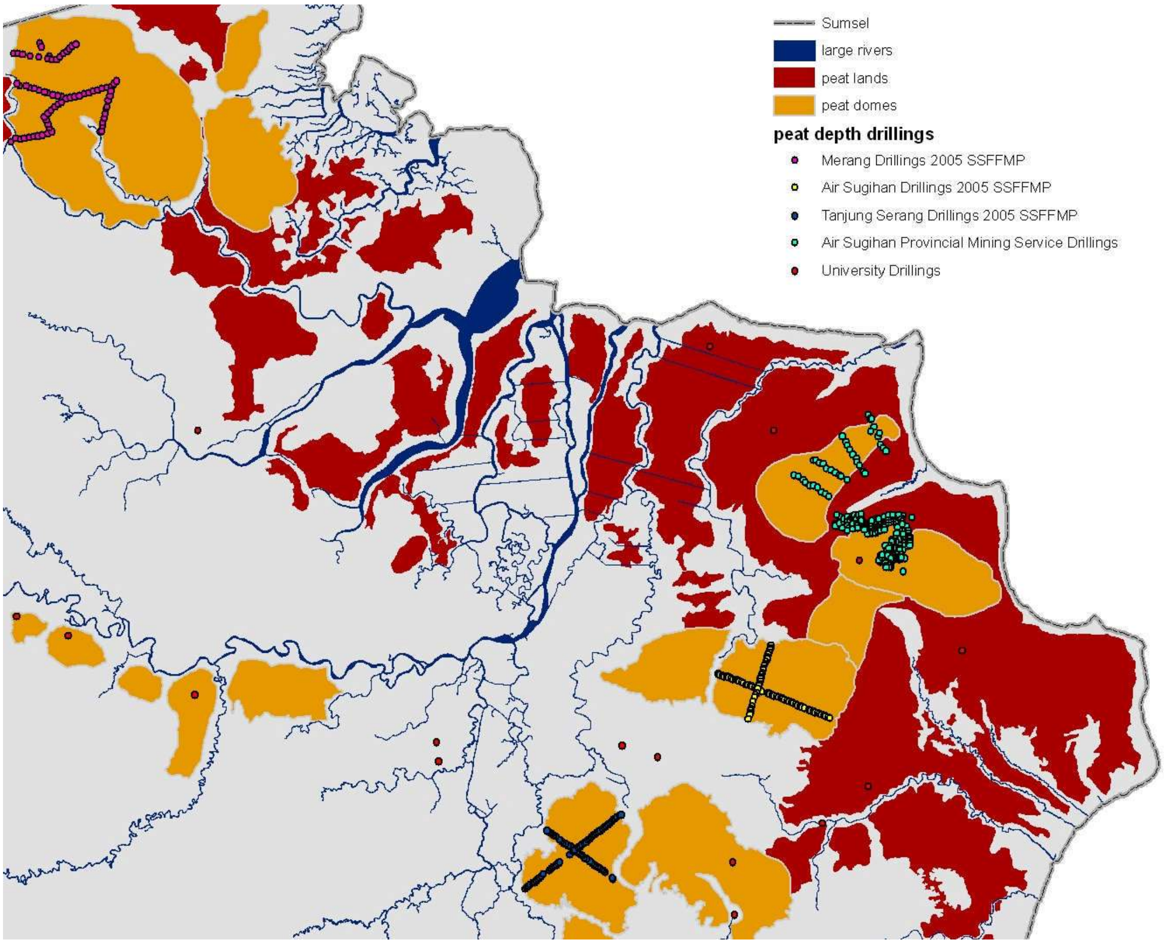

Fig. 6. All available peat depth drillings

2.4. Peat Depths from 3D Models

Also for further calculations the depths resulting from the 3D modelling of the three peat domes Merang, Air Sugihan and Tanjung Serang were used. Following depths were attributed to the newly compiled maps.

For peat lands:

- Compiled peat land map with the average peat depth of all the three 3D models Merang, Air Sugihan and Tanjung Serang

For peat domes:

- Compiled peat dome map with the depth of the individual three 3D models Merang, Air Sugihan and Tanjung Serang, but for further calculations the volume from the model was used and not the average peat depth of all three 3D models

Fig. 6. Displays bedrock/surface models calculated for the three peat domes Muba, Air Sugihan and Tanjung.

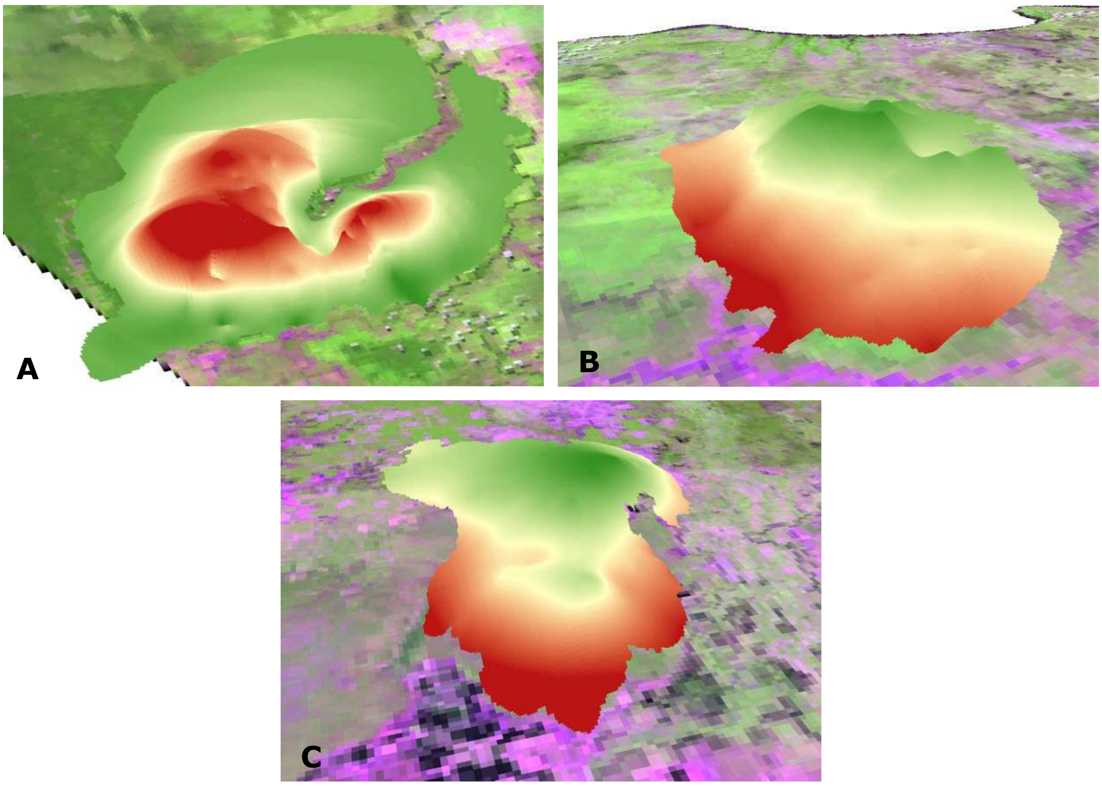

Fig. 7. 3D peat models. (A) Merang bedrock model, (B) Air Sugihan surface model, (C) Tanjung Serang surface model

3. Area, Volume, Carbon and Carbon Dioxide Calculations

For all these different sources area, volume, carbon content and the corresponding carbon dioxide equivalent of the peat lands/domes were calculated.

3.1. Area

To calculate the area extend of the peat lands/domes of the original peat land/dome maps (Repprot and Wetlands International) and the newly compiled peat land/dome map the ArcGIS™ software was applied.

3.2. Volume

On behalf of these peat areas, the corresponding volume estimations of the peat lands/domes were calculated by incorporating the different peat depth sources mentioned in chapters 2.2. - 2.4.

3.3. Carbon Content

For these different volume specifications the carbon content was estimated. The carbon stored within the peat deposits was calculated based on a peat bulk density of 0.1 g cm^{-3}, and a peat carbon content of 57 % (Neuzil, 1997).

3.4. Carbon Dioxide Equivalent

To deduce the carbon dioxide equivalent from the carbon content it was multiplied by the molecular weight of the carbon dioxide molecule. The expansion factor applied was 3.67.

4. Results

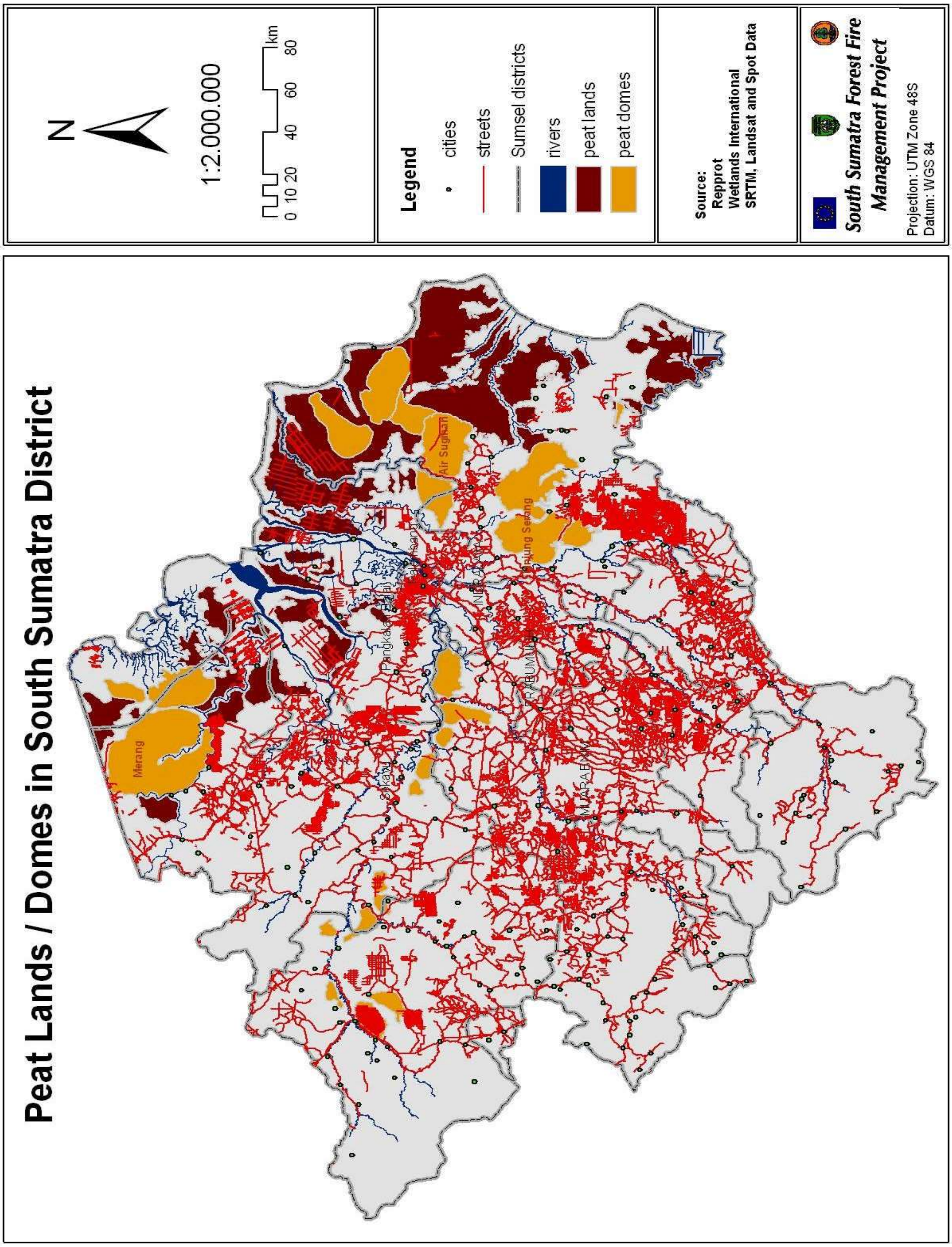

Fig. 8. Compiled peat land/dome map South Sumatra Province

Fig. 8. displays the compiled peat land/dome dome distribution for the South Sumatra Province. As can be seen in **Table 1.** the area covered by peat within this compiled map, which is 1476227 ha (marked red in **Table 1.**), lies between the estimates given by Repprot and Wetlands International. Repprot estimates are 269645 ha lower and Wetlands International estimates 393693 ha higher than the ones of this study. It can also be seen that the area of peat domes alone, which is 614674 ha (marked red in **Table 1.**), is not even half the size of the whole peat land extent. So there is a considerable amount of peat in South Sumatra that does not form a distinguishable peat dome.

Table 1. Area extent of peat lands/domes

Peat Map	Area (ha)
Repprot Peat Map	1206582
Wetlands International Peat Map	1869920
Compiled Peat Map	**1476227**
Compiled Peat Map (only Peat Domes)	**614674**

Table 2. displays volume, carbon content and carbon dioxide equivalents for the peat lands of South Sumatra. The highest estimate, with a volume of 65.84 $m^3 * 10^9$ (marked red in **Table 2.**), is the calculation based on the mean depth of the Provincial Mining Service peat depth drillings. The lowest estimate, with a volume of 65.84 $m^3 * 10^9$ (marked red in **Table 2.**), is the calculation based on the peat depths given in the original Repprot data. The average peat volume, carbon content and carbon dioxide equivalent over all estimates respectively are 33.57 $m^3 * 10^9$ for the peat volume, 1913.55 mt for the carbon content and 7022.72 mt for the carbon dioxide equivalent.

Table 2. Volume, carbon content and carbon dioxide equivalent for the peat lands of the South Sumatra Province

Peat Maps	Depth	Area	Volume	Carbon Content		Carbon Dioxide	
	m	ha	m^3*10^9	mt	gt	mt	gt
Original Peat Land Maps:							
Repprot Peat Map	-	1206582	**19.70**	**1124.79**	**1.12**	**4127.98**	**4.13**
Wetlands International Peat Map	-	1869920	27.80	1585.24	1.59	5817.83	5.82
Compiled Peat Land Map with:							
Repprot Peat Depths	-	1476227	27.17	1548.54	1.55	5683.16	5.68
Wetlands International Peat Depths	-	1476227	22.50	1282.54	1.28	4706.93	4.71
Mean Depth Repprot	1.45	1476227	21.41	1220.10	1.22	4477.77	4.48
Mean Depth Wetlands International	1.40	1476227	20.67	1178.03	1.18	4323.37	4.32
Mean Depth 3D Models	2.13	1476227	31.44	1792.29	1.79	6577.69	6.58
Mean Depth SSFFMP Drillings	3.26	1476227	48.12	2743.12	2.74	10067.27	10.07
Mean Depth Mining Service Drillings	4.46	1476227	**65.84**	**3752.86**	**3.75**	**13773.01**	**13.77**
Mean Depth University Drillings	1.89	1476227	27.90	1590.34	1.59	5836.54	5.84
Mean Depth all available Drillings	**3.84**	**1476227**	**56.69**	**3231.17**	**3.23**	**11858.38**	**11.86**

Generally can be said that the estimates given in the original Repprot and Wetlands International data and also the corresponding estimates, if the peat depths of these two sources are applied to the newly compiled peat land/dome map, are considerably lower than the estimates calculated either on the basis of the developed 3D models or the conducted peat depth drillings.

The effort undertaken by the SSFFMP was important to show that there is a presumably higher amount of peat volume present in the South Sumatra Province then there was assumed up to date. This directly leads to higher carbon storage and carbon dioxide equivalents that have to be taken into consideration for future sustainable natural resource planning.

From our point of view the best estimates considering peat volume, carbon content and carbon dioxide equivalent for the whole of the South Sumatra Province is currently achieved by applying the mean depth of all the available peat depth drillings to the calculations (marked yellow in **Table 2.**). This is so because this data set has the best available distribution of peat depths over the whole area, which would not be achieved by only applying certain peat depth drilling data sets (e.g. only the peat depth drillings by SSFFMP). As up until now only three peat dome models are available we do not think it is feasible to use these peat domes as calculation basis for the whole area of South Sumatra. Also the fact that almost half of the peat lands do not form distinguishable peat domes leads to the conclusion that it is better to use the mean of all available peat depth drillings as calculation basis. Based on these conclusions following peat volume, carbon content and carbon dioxide equivalents for South Sumatra were estimated (**Table 3.**).

Table 3. Final peat volume, carbon content and carbon dioxide equivalent estimations

Volume	**Carbon Content**		**Carbon Dioxide**	
m^3*10^9	**mt**	**gt**	**mt**	**gt**
56.69	3231.17	3.23	11858.38	11.86

It has to be considered that these 491 peat depth drillings were not evenly distributed over a peat land area of 1476227 ha and due to this a high statistical accuracy cannot be expected. This also shows that it would be very important to collect more peat depth drillings dispersed over the whole area in order to attain a more realistic view.

Fig. 9. displays the compiled peat dome distribution for the South Sumatra Province. The numbers of the different peat domes were attributed to them by the editor. In this map the three modelled peat domes Merang, Air Sugihan and Tanjung Serang are also indicated. On basis of this peat dome map the volume, carbon content and carbon dioxide equivalent were estimated for every peat dome individually.

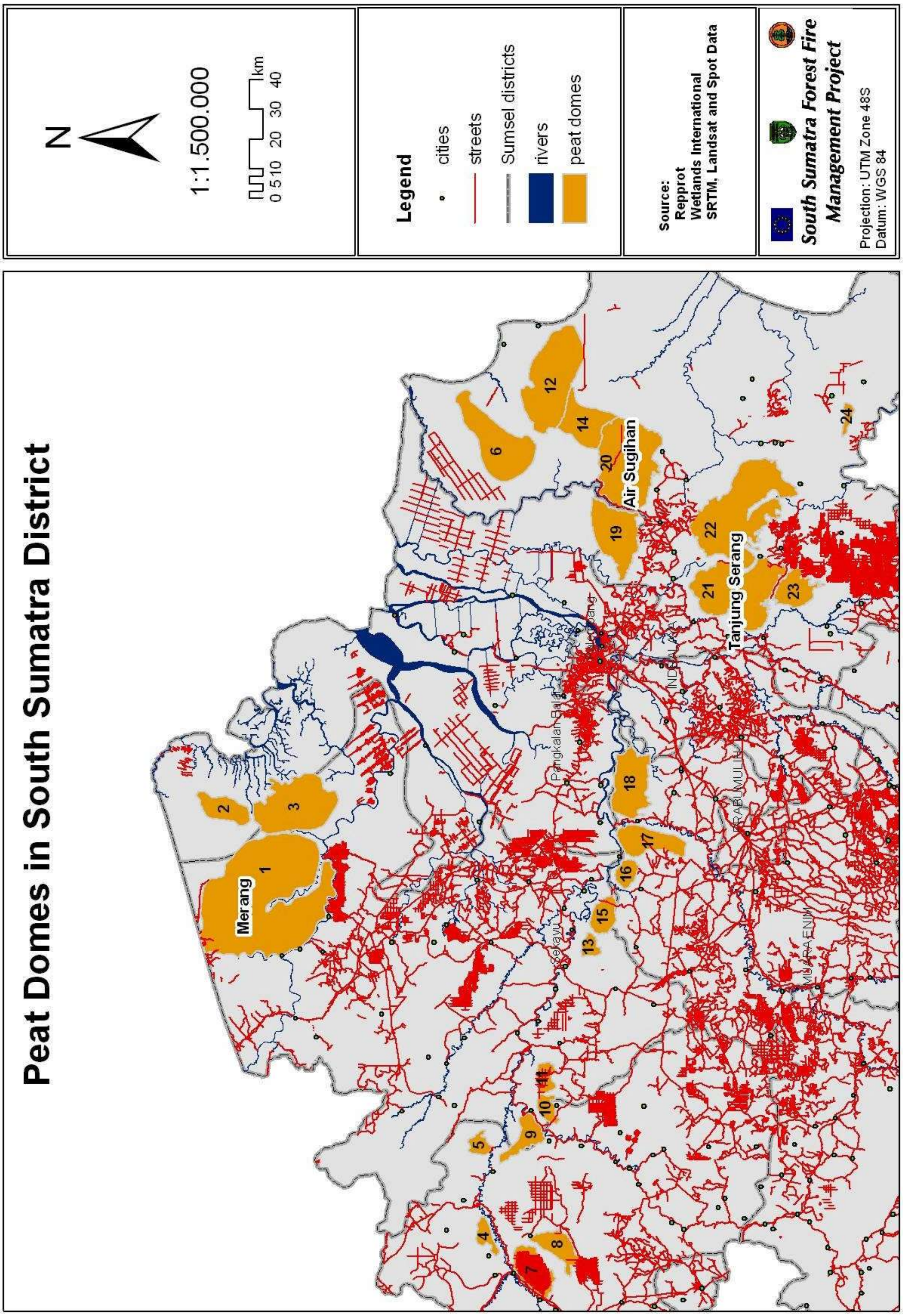

Fig. 9. Compiled peat dome map South Sumatra

Tables 4. and **5.** display volume, carbon content and carbon dioxide equivalents of the individual peat domes in South Sumatra. The most realistic estimates are those from the 3D models (marked yellow in **Table 5.**). But only three peat domes were modelled and it is believed that these interpolation results still underestimate the peat volume. More peat drillings would further enhance the results and strengthen the validity of these models. If individual peat dome estimates are based on the available peat depth drillings it has to be considered that the calculations of peat dome numbers 13, 15, 17 and 22 (**Table 6.** and marked red in **Table 5.**) were based only on one single peat depth drilling.

Table 4. Volume, carbon content and carbon dioxide equivalent of the individual peat domes in the South Sumatra Province (1)

			Compiled Peat Dome Map Repprot Peat Depths				Compiled Peat Dome Map Wetlands International Peat Depths			
Peat Domes		Area	Depth	Volume	C	CO_2	Depth	Volume	C	CO_2
Number	Name	ha	m	m^3*10^8	gt	gt	m	m^3*10^8	gt	gt
1	Merang	138200	2.50	34.55	0.20	0.72	1.5	20.73	0.12	0.43
2		11891	0.00	-	-	-	3	3.567	0.02	0.07
3		40683	2.50	10.17	0.06	0.21	1.5	6.102	0.03	0.13
4		4976	2.50	1.244	0.01	0.03	1.5	0.746	0.00	0.02
5		4225	2.50	1.056	0.01	0.02	1.5	0.634	0.00	0.01
6		35934	2.50	8.984	0.05	0.19	1.5	5.390	0.03	0.11
7		15507	2.50	3.877	0.02	0.08	1.5	2.326	0.01	0.05
8		11514	2.50	2.879	0.02	0.06	1.5	1.727	0.01	0.04
9		9673	2.50	2.418	0.01	0.05	1.5	1.451	0.01	0.03
10		4960	2.50	1.240	0.01	0.03	1.5	0.744	0.00	0.02
11		5521	2.50	1.380	0.01	0.03	1.5	0.828	0.00	0.02
12		46993	2.50	11.75	0.07	0.25	1.5	7.049	0.04	0.15
13		3726	2.50	0.931	0.01	0.02	1.5	0.559	0.00	0.01
14		18980	2.50	4.745	0.03	0.10	1.5	2.847	0.02	0.06
15		8441	2.50	2.110	0.01	0.04	1.5	1.266	0.01	0.03
16		5463	0.90	0.492	0.00	0.01	1.5	0.819	0.00	0.02
17		16657	0.90	1.499	0.01	0.03	2.25	3.748	0.02	0.08
18		23688	0.90	2.132	0.01	0.04	2.25	5.330	0.03	0.11
19		27150	1.70	4.615	0.03	0.10	1.5	4.072	0.02	0.09
20	Air Sugihan	50348	1.70	8.559	0.05	0.18	1.5	7.552	0.04	0.16
21	Tanjung Serang	48801	0.90	4.392	0.03	0.09	1.5	7.320	0.04	0.15
22		66165	0.90	5.955	0.03	0.12	1.5	9.925	0.06	0.21
23		12632	0.90	1.137	0.01	0.02	1.5	1.895	0.01	0.04
24		2546	0.90	0.229	0.00	0.00	1.5	0.382	0.00	0.01

Table 5. Volume, carbon content and carbon dioxide equivalent of the individual peat domes in the South Sumatra Province (2)

			Compiled Peat Dome Map 3D Models				Compiled Peat Dome Map Peat Depths Mean of Drillings			
Peat Domes		Area	Depth	Volume	C	CO_2	Depth	Volume	C	CO_2
Number	Name	ha	m	m^3*10^8	gt	gt	m	m^3*10^8	gt	gt
1	Merang	138200	1.26	17.90	0.10	0.37	2,.46	34.00	0.19	0.71
2		11891	-	-	-	-	-	-	-	-
3		40683	-	-	-	-	-	-	-	-
4		4976	-	-	-	-	-	-	-	-
5		4225	-	-	-	-	-	-	-	-
6		35934	-	-	-	-	4.45	15.99	0.09	0.33
7		15507	-	-	-	-	-	-	-	-
8		11514	-	-	-	-	-	-	-	-
9		9673	-	-	-	-	-	-	-	-
10		4960	-	-	-	-	-	-	-	-
11		5521	-	-	-	-	-	-	-	-
12		46993	-	-	-	-	4.45	20.91	0.12	0.44
13		3726	-	-	-	-	0.3	0.112	0.00	0.00
14		18980	-	-	-	-	-	-	-	-
15		8441	-	-	-	-	2.9	2.448	0.01	0.05
16		5463	-	-	-	-	-	-	-	-
17		16657	-	-	-	-	3.5	5.830	0.03	0.12
18		23688	-	-	-	-	-	-	-	-
19		27150	-	-	-	-	-	-	-	-
20	Air Sugihan	50348	3.28	14.00	0.08	0.29	3.77	18.98	0.11	0.40
21	Tanjung Serang	48801	1.84	9.300	0.05	0.19	3.39	16.54	0.09	0.35
22		66165	-	-	-	-	1.755	11.61	0.07	0.24
23		12632	-	-	-	-	-	-	-	-
24		2546	-	-	-	-	-	-	-	-

Table 6. Estimates of area, peat depth, volume, carbon content and carbon dioixde equivalent for the three modelled peat domes

	Area	Mean Peat Depth from 3D Model	Volume	Carbon Content	Carbon Dioxide Equivalent
Peat Dome Name	ha	m	m^3*10^8	gt	gt
Merang	138200	1.26	17.90	0.10	0.37
Air Sugihan	50348	3.28	14.00	0.08	0.29
Tanjung Serang	48801	1.84	9.300	0.05	0.19

5. New Survey Design

The new survey design was prepared in close cooperation with the field survey team. The sampling scheme considered beside optimal sample distribution also accessibility (rivers, villages, logging trails, etc) and required efforts. Main objective of this new survey design was to disperse the peat drilling over the whole area of South Sumatra, so that also areas that do not build up distinguishable peat domes are surveyed. These newly proposed areas for peat drillings were classified into priority classes, with one representing the highest priority. This was done so that the survey team knows which areas are the most important ones to get data from.

But also drillings within peat domes should further be carried because more peat dome drillings would help to enhance the results and strengthen the validity of the 3D models. Especially the drillings in the Tanjung Serang peat dome, as proposed in the last report, would be helpful. If there is the possibility and the budget all the drillings proposed in the last report would still be helpful. The GPS coordinates for the additional drilling sites at Tanjung Serang were determined in ArcGIS™ using the advanced setting of the field calculator. The corresponding coordinates are shown in Annex II. **Fig. 10.** gives an overview of these newly proposed drilling areas. A more detailed map was distributed to the SSFFMP staff.

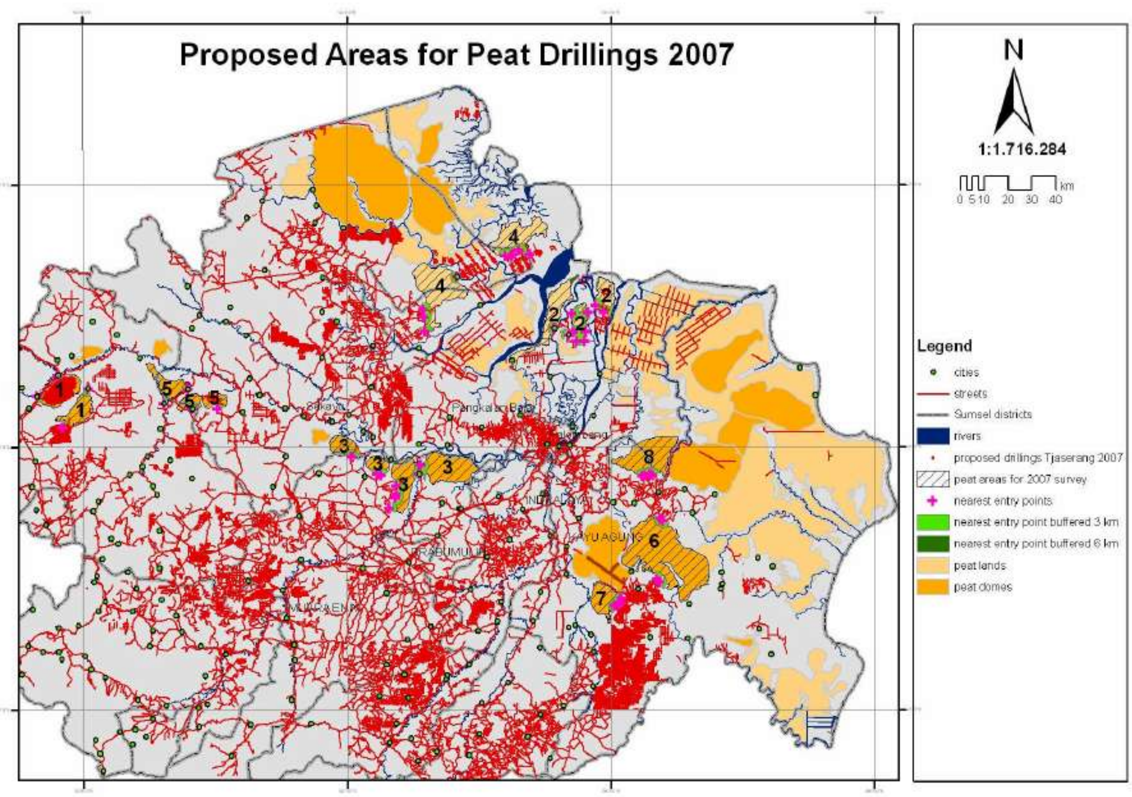

Fig. 10. Peat areas for additional peat drillings 2007

6. Recommendations

The results of this survey show for the first time at least the order of magnitude concerning peat volume, which is stored in the coastal flats of Sumsel and probably also other parts of Sumatra and Kalimantan.

It is beyond the mandate of the SSFFMP project to do a comprehensive and detailed analysis of the peat deposits in South Sumatra. This survey has to be done by the responsible administration. The present investigation aims at demonstrating the importance to have information on peat topology and thickness available for planning and decision-making.

- A new survey design for further investigations was developed in close cooperation with local experts. Additional field data would improve the peat volume estimations.
- These new estimations would give a more realistic view of volume, carbon content and corresponding carbon dioxide equivalents of South Sumatra's peat lands/domes.
- As the peat depth of peat domes correlates to surface heights under optimal conditions it would be possible to estimate the volume of peat domes that were not surveyed yet. Anyhow, in order to "tune" the estimations of peat domes more peat dome drillings are needed, but far less in number. Further investigations have to be done to analyse the correlation and application of this matter.
- The peat issue should be further investigated, especially in the context of carbon sequestration.

In near future a global carbon market under the Kyoto protocol could be established similar to the one established by the European Union. Carbon credits through avoided deforestation offer a profitable economic opportunity for Indonesian business. So far from the political side only the scenario "Reducing emissions through the avoidance of deforestation" is given attention under the Kyoto protocol and this is only one side of the medal. The importance of peat lands as a global carbon factor is politically not fully recognized yet. However, it is obvious that in the medium-term "Reducing emissions through peat conservation and management" will be implemented in the subsequent Kyoto protocol. Hence, peat management and protection may be connected to carbon credit trade, meaning financial benefit from emission avoidance by conservation and protection practices. As the next conference of parties (COP 13) to the United Nations Framework Convention on Climate Change (UNFCCC) is held in Bali at the end of this year and with Indonesia being one of the leading countries with regard to peat land extent this would be an opportunity to create more public awareness considering sustainable peat management.

Deliverables

1) All original and processed / analyzed data and GIS data on CD-ROM
2) Draft report comprising major findings and recommendations agreed upon with the Teamleader of the SSFFMP Project Management Unit (PMU) in electronic and printed version
3) Presentation of Approach & Results in a Powerpoint presentation
4) Final report in electronic and printed (6 pcs.) version and Time Sheets

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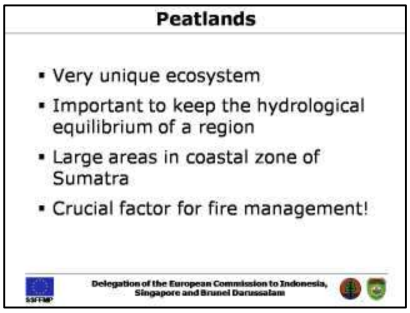
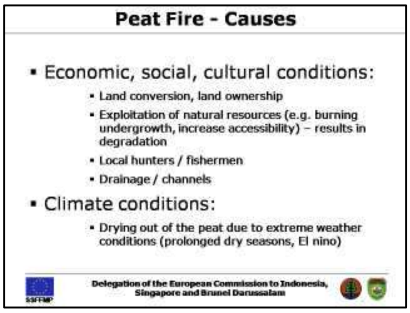
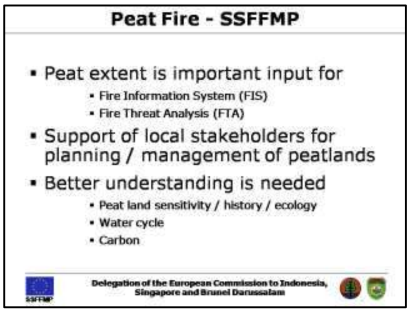
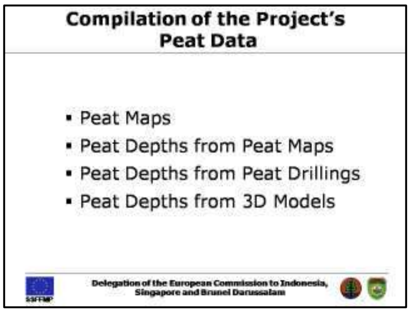
ANNEX I

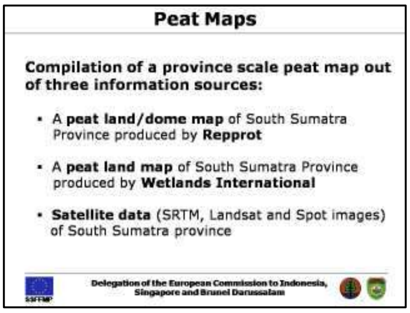
PowerPoint presentation on the compilation of the projects peat land and dome data presented to local stakeholders at SSFFMP on the 10.08.2007.

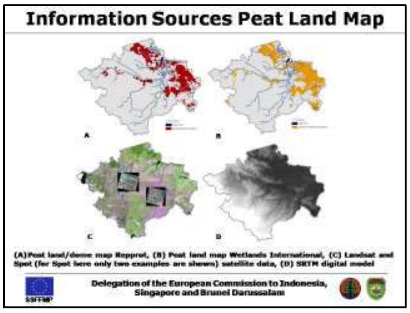


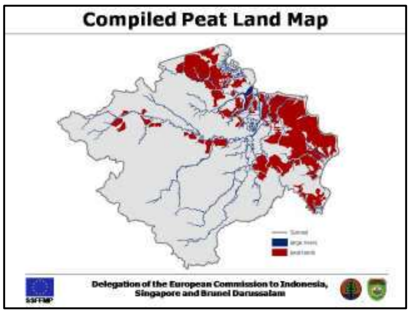


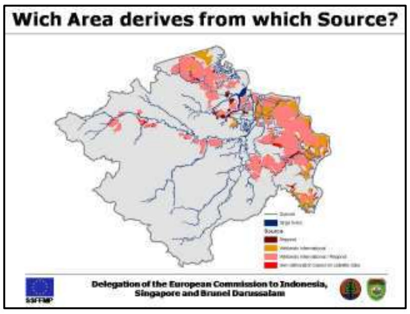


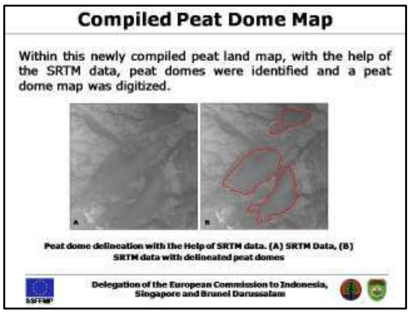


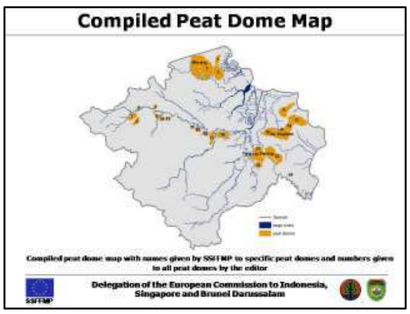












Peat Depths from Maps

For further calculations peat depths given by Repprot and Wetlands International were incorporated. Following depths were attributed to the following maps.

For peat lands:
- Peat depths from Repprot peat land/dome map
- Peat depths from Wetlands International peat land map
- Compiled peat land map with Repprot peat depths
- Compiled peat land map with Wetlands International peat depths
- Compiled peat land map with average Repprot peat depths
- Compiled peat land map with average Wetlands International peat depths

For peat domes:
- Compiled peat dome map with Repprot peat depths
- Compiled peat dome map with Wetlands International peat depths

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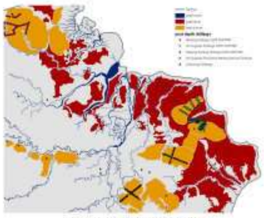
Peat Depths from Peat Drillings



All available peat depth drillings

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Peat Depths from Peat Drillings

Following depths were attributed to the newly compiled maps.

For peat lands:
- Compiled peat land map with the average depth of all SSFFMP peat depth drillings
- Compiled peat land map with the average depth of the Air Sugihan Provincial Mining service peat depth drillings
- Compiled peat land map with the average depth of the University in Palembang peat depth drillings
- Compiled peat land map with the average depth of all available peat depth drillings

For peat domes:
- Compiled peat dome map with average individual peat dome depths calculated from all available peat depth drillings

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Peat Depths from 3D Models

Also for further calculations the depths resulting from the 3D modelling of the three peat domes Merang, Air Sugihan and Tanjung Serang were used. Following depths were attributed to the newly compiled maps.

For peat lands:
- Compiled peat land map with the average peat depth of all the three 3D models Merang, Air Sugihan and Tanjung Serang

For peat domes:
- Compiled peat dome map with the depth of the individual three 3D Models Merang, Air Sugihan and Tanjung Serang, but for further calculations the volume from the model was used and not the average peat depth of all the three 3D models

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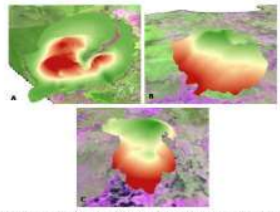
Peat Depths from 3D Models



3D peat models: (A) Merang bedrock model, (B) Air Sugihan surface model, (C) Tanjung Serang surface model

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Calculations

For all these different sources area, volume, carbon content and the corresponding carbon dioxide equivalent of the peat lands/domes were calculated:

Area
To calculate the area extend of the peat lands/domes the ArcGIS™ software was applied.

Volume
On behalf of these peat areas, the corresponding volume estimations of the peat lands/domes were calculated by incorporating the different peat depth sources mentioned earlier.

Carbon Content
For these different volumes the carbon content was estimated. The carbon stored within the peat deposits was calculated based on a peat bulk density of 0.1 g cm⁻³, and a peat carbon content of 57 % (Neuzil, 1997).

Carbon Dioxide Equivalent
To deduce the carbon dioxide equivalent from the carbon content it was multiplied by the molecular weight of the carbon dioxide molecule. The expansion factor applied was 3.67.

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Results: Area

- **Area covered by peat within compiled map lies between the estimates given by Repprot and Wetlands International.**
- **Repprot estimates are 269645 ha lower and Wetlands International estimates 393693 ha higher.**
- **It can also be seen that the area of peat domes alone with 614674 ha is not even half the size of the whole peat land extent.**

Peat Map	Area (ha)
Repprot Peat Map	1206582
Wetlands International Peat Map	1869920
Compiled Peat Map	**1476227**
Compiled Peat Map (only Peat Domes)	**614674**

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Calculations: Volume, Carbon and Carbon Dioxide

Peat Maps	Depth	Area	Volume	Carbon Content		Carbon Dioxide	
	m	ha	m^3*10^9	mt	gt	mt	gt
Original Peat Land Maps:							
Repprot Peat Map	–	1206582	19.70	1124.79	1.12	4127.98	4.13
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Compiled Peat Land Map with:							
Repprot Peat Depths	–	1476227	27.17	1548.54	1.55	5683.16	5.68
Wetlands International Peat Depths	–	1476227	22.50	1282.54	1.28	4706.93	4.71
Mean Depth Repprot	1.45	1476227	21.41	1220.10	1.22	4477.77	4.48
Mean Depth Wetlands International	1.40	1476227	20.67	1178.03	1.18	4323.37	4.32
Mean Depth 3D Models	2.13	1476227	31.44	1792.29	1.79	6577.69	6.58
Mean Depth SSFFMP Drillings	3.26	1476227	48.12	2743.12	2.74	10067.27	10.07
Mean Depth Mining Service Drillings	4.46	1476227	65.84	3752.86	3.75	13772.81	13.77
Mean Depth University Drillings	1.89	1476227	27.90	1590.34	1.59	5836.54	5.84
Mean Depth all available Drillings	3.84	1476227	56.69	3231.17	3.23	11858.38	11.86

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Calculations Peat Lands: Best Estimates

Best estimates considering peat volume, carbon content and carbon dioxide equivalent for South Sumatra Province is currently achieved by applying the mean depth of all the available peat depth drillings to the calculations:

Volume	Carbon Content		Carbon Dioxide	
m^3*10^9	mt	gt	mt	gt
56.69	3231.17	3.23	11858.38	11.86

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Calculations Peat Domes: Best Estimates

The most realistic estimates are those from the 3D models:

	Area	Mean Peat Depth from 3D Model	Volume	Carbon Content	Carbon Dioxide Equivalent
Dome Name	ha	m	m^3*10^9	gt	gt
Merang	138200	1.26	17.90	0.10	0.37
Air Sugihan	50348	3.28	14.00	0.08	0.29
Tanjung Serang	48801	1.84	9.300	0.05	0.19

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Importance of Peat Survey

- Peatland **unique resource**
- Peatland **cannot be restored**
- Better understanding of peat issue to support:
  - **Fire management!**
  - **Land use planning!**
- **Support stakeholders + local government** in planning and management
- Possible future **carbon trade**

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Benefit of the Compiled Peat Data

- By implementing the compiled SSFFMP peat data the precision of the FTA could be enhanced significantly, due to the higher accuracy of the input peat depth and volume.
- This important information could assist land use planning, fire prevention management and to estimate the amount of carbon dioxide, which can be potentially released by fire or oxidation through drainage. This information is important for stakeholders and decision-makers on all levels.

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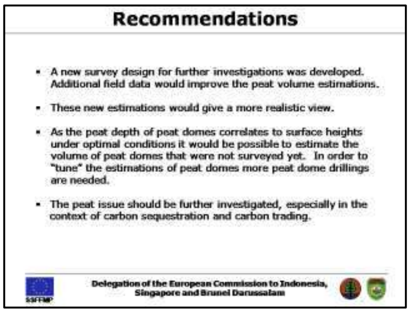
Recommendations
A new survey design for further investigations was developed. Additional field data would improve the peat volume estimations.
These new estimations would give a more realistic view.
As the peat depth of peat domes correlates to surface heights under optimal conditions it would be possible to estimate the volume of peat domes that were not surveyed yet. In order to "tune" the estimations of peat domes more peat dome drillings are needed.
The peat issue should be further investigated, especially in the context of carbon sequestration and carbon trading.
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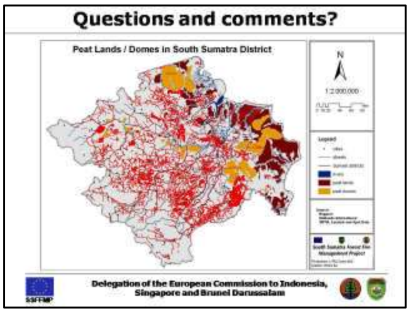
Questions and comments?
Peat Lands / Domes in South Sumatra District
N
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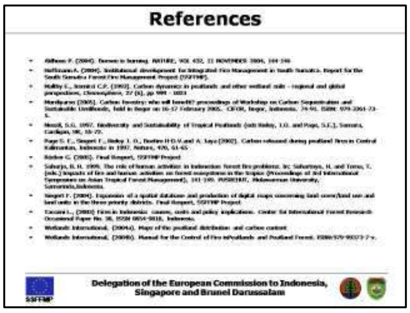
References
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Thank you for your attention!
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ANNEX II

Coordinates of the proposed new peat drillings at the Tanjerung Serang peat dome:

Drilling Nr.	X	Y	Drilling Nr.	X	Y
1	490504,00094	9621578,00187	36	504629,35379	9611247,25132
2	490907,58245	9621282,83757	37	505032,93530	9610952,08702
3	491311,16396	9620987,67326	38	505436,51681	9610656,92272
4	491714,74547	9620692,50896	39	502982,99913	9619027,99892
5	492118,32698	9620397,34466	40	502646,48294	9618658,19241
6	492521,90849	9620102,18036	41	502309,96675	9618288,38590
7	492925,49000	9619807,01606	42	501973,45056	9617918,57939
8	493329,07151	9619511,85176	43	501636,93438	9617548,77287
9	493732,65302	9619216,68746	44	501300,41819	9617178,96636
10	494136,23453	9618921,52316	45	500963,90200	9616809,15985
11	494539,81604	9618626,35885	46	500627,38581	9616439,35334
12	494943,39755	9618331,19455	47	500290,86962	9616069,54683
13	495346,97906	9618036,03025	48	499954,35343	9615699,74032
14	495750,56057	9617740,86595	49	499617,83725	9615329,93381
15	496154,14208	9617445,70165			
16	496557,72359	9617150,53735			
17	496961,30510	9616855,37305			
18	497364,88661	9616560,20874			
19	497768,46812	9616265,04444			
20	498172,04963	9615969,88014			
21	498575,63114	9615674,71584			
22	498979,21265	9615379,55154			
23	499382,79416	9615084,38724			
24	499786,37567	9614789,22294			
25	500189,95718	9614494,05863			
26	500593,53869	9614198,89433			
27	500997,12020	9613903,73003			
28	501400,70171	9613608,56573			
29	501804,28322	9613313,40143			
30	502207,86473	9613018,23713			
31	502611,44624	9612723,07283			
32	503015,02775	9612427,90853			
33	503418,60926	9612132,74422			
34	503822,19077	9611837,57992			
35	504225,77228	9611542,41562			