JOINT COOPERATION PROGRAMME

Component C3:

Lowland / Peatland subsidence – Future drainability

Document C3.1

PPPs first workshop on *Peatland subsidence and flooding modelling*

Bandung

26-28 July 2011

Project: 1201430.000

Client: Water Mondiaal
Partners for Water
Royal Netherlands Embassy in Jakarta

Period: January 2011 – March 2013

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Deltares
Enabling Delta Life

Peatland extent in Indonesia, and scale & rate of drainage / conversion in recent years

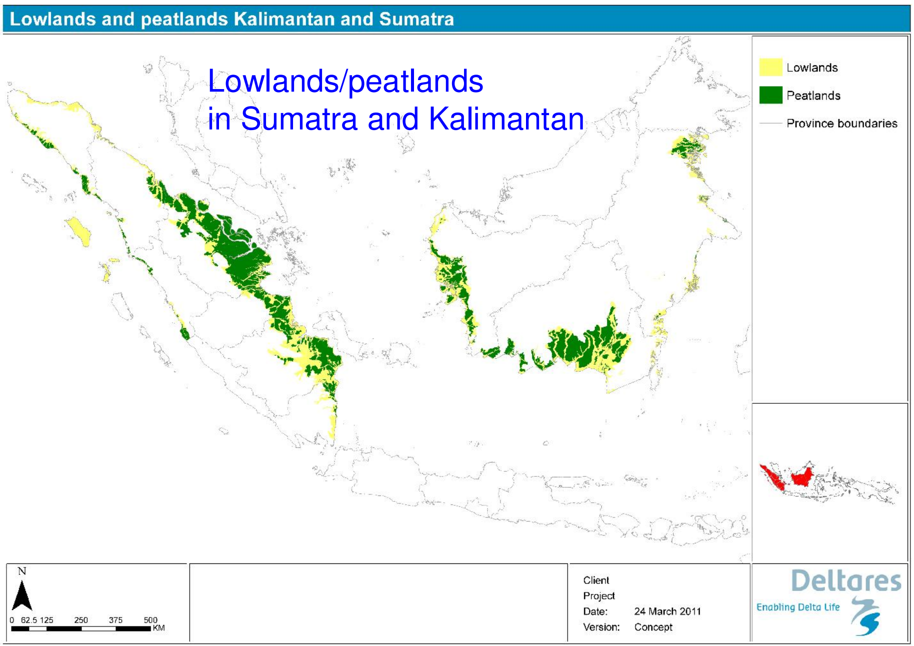
Al Hooijer

For JCP kick-off workshop on peatland subsidence and flooding modeling
26-28 July 2011

Peatland extent & condition

Indonesia has about 21 Million hectare of peatland

- **12 % of the land area**
- **Over 60% of the lowland area (of ~35 Mha, depending of definition)**



Many policy makers are not much aware of the extent or location of peatlands, which complicates planning and management.

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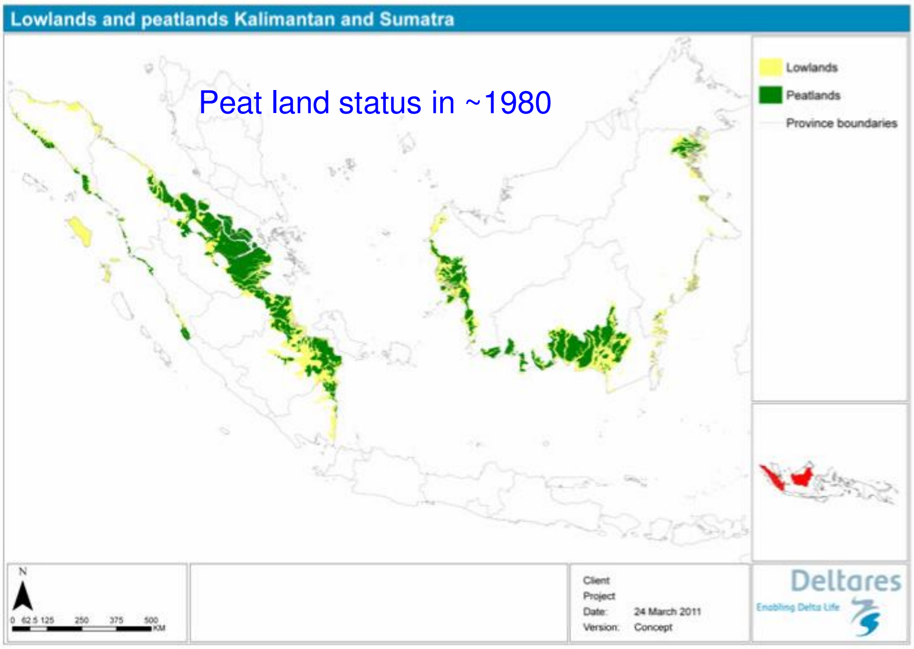
Peatland extent & condition

Indonesia has about 21 Million hectare of peatland:

- **Nearly all of this was largely intact in 1980, only 30 years ago, and even in 1995…**



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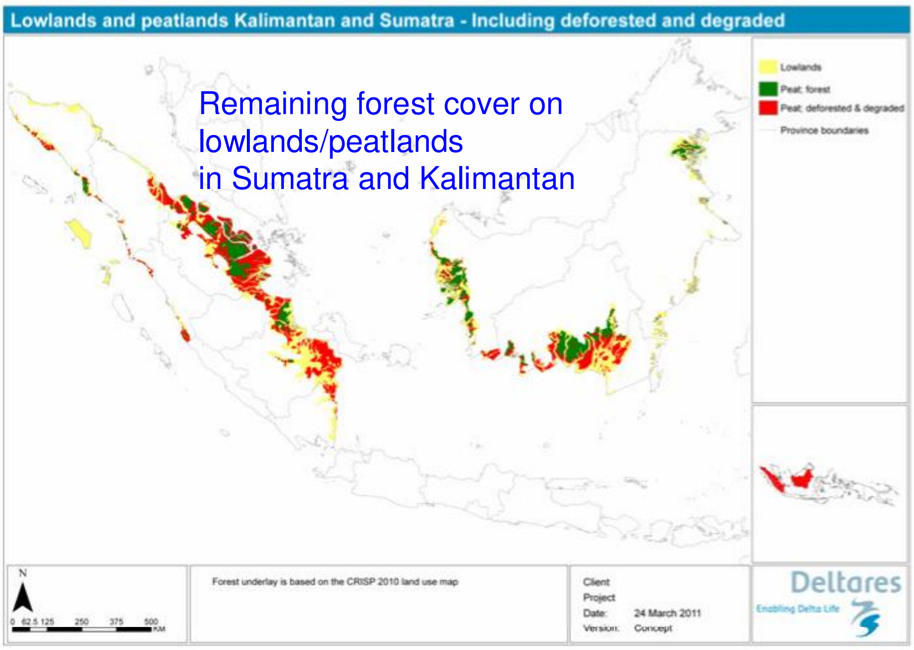

Most peatland forest has been lost, in the last 20 years…

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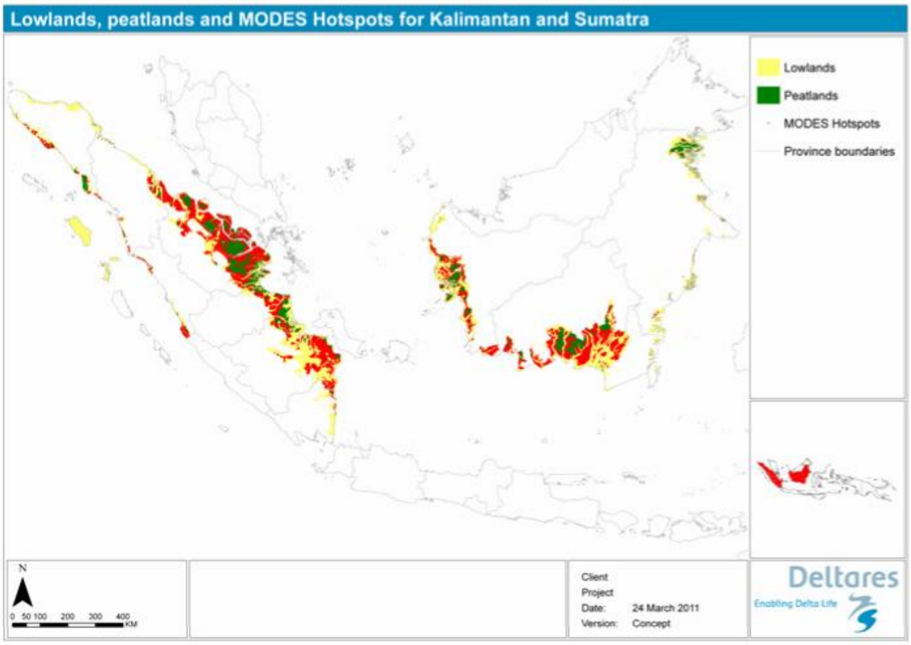
Peatland extent & condition

Map of lowlands and <u>fires on peatlands</u>.

► **Fires are caused by drainage and ‘matches’: always man-made. Drought ‘helps’ the fires but does not cause it: undrained peat forests do not burn.**



Research shows: fire frequency has been lower since 2006 as these were very wet years, but <u>fire risk has increased</u>. Should 2011 be as dry as 2006, fires could be worse…

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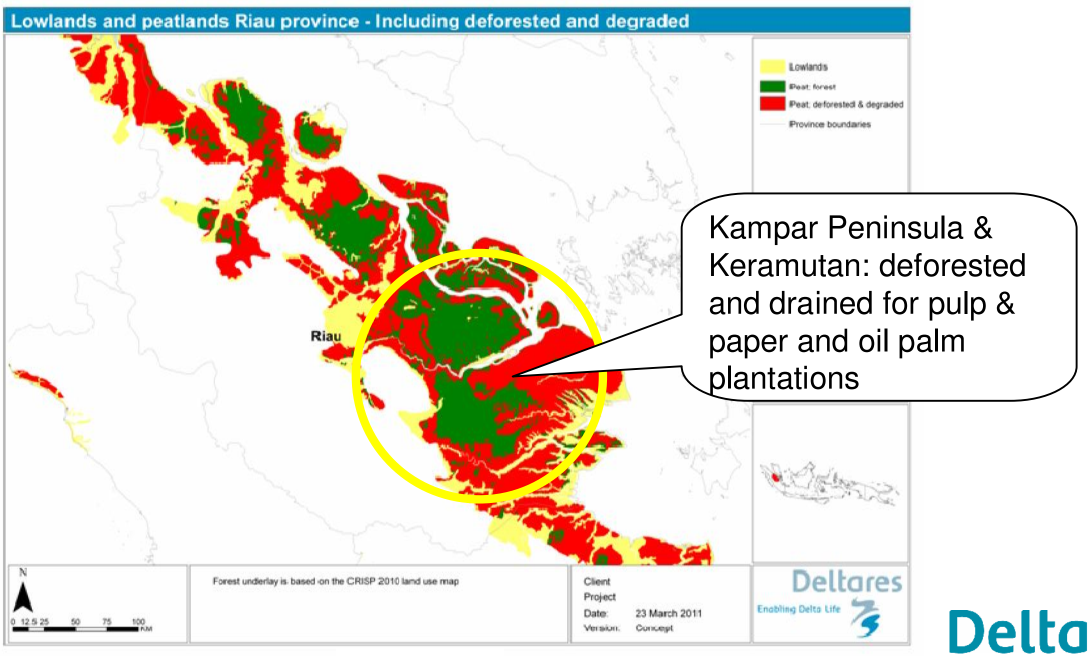
Peatland extent & condition

Map of lowlands and current land cover on peatlands in <u>Riau and Kalteng</u>.

► **‘Hot spot’ provinces for many issues in Indonesia have the largest peatland cover.**



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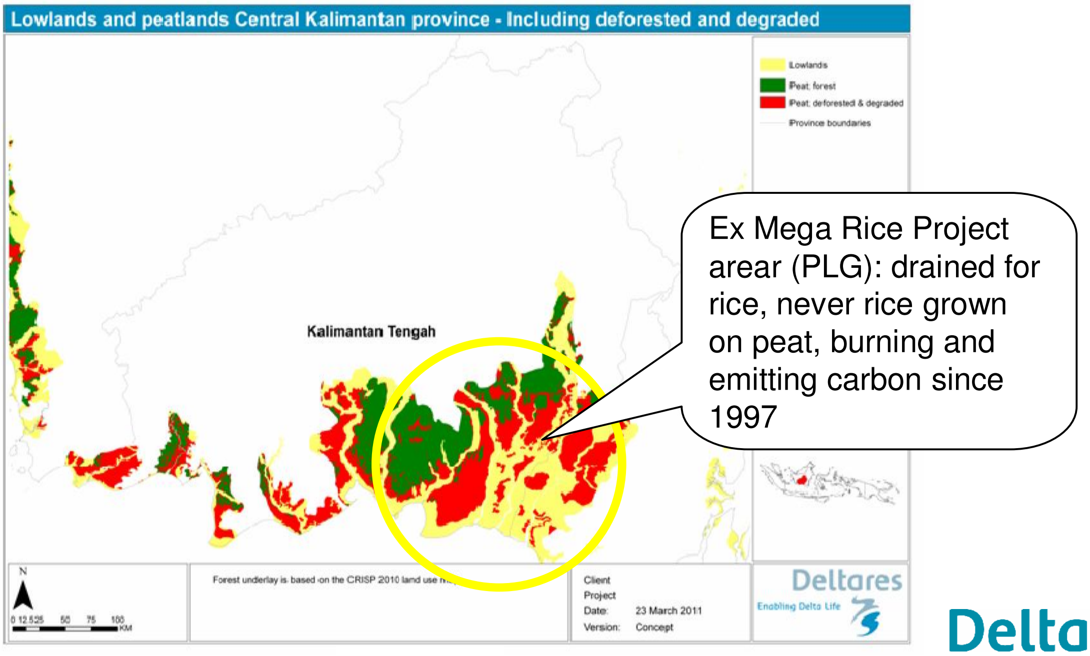

Peatland extent & condition

Peatland clearing

Peatland extent & condition

Peatland drainage

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Peatland extent & condition

Oil palm plantation establishment

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Peatland extent & condition

Very poor water management leading to low productivity, high carbon emissions, high fire risk…

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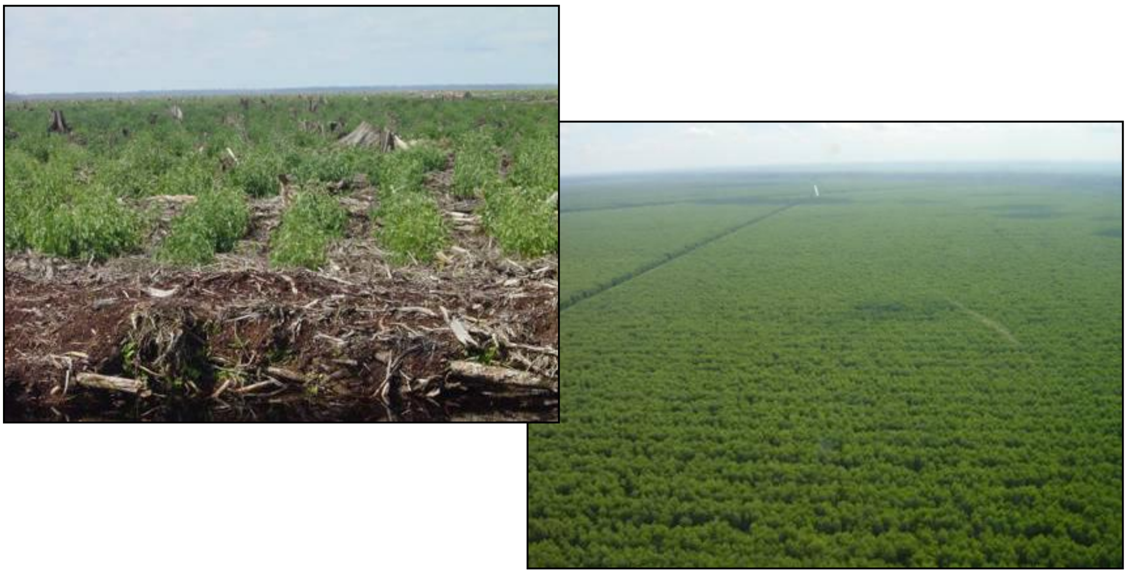
Peatland extent & condition

Other peatland is converted to acacia (pulp) plantations



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Peatland extent & condition

And some to rice fields, in lowland development schemes…

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Peatland extent & condition

Or to small-scale vegetable farming…

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Peatland extent & condition

But most deforested peatlands are not productive at all: they are degraded peatlands, unused and burning frequently.

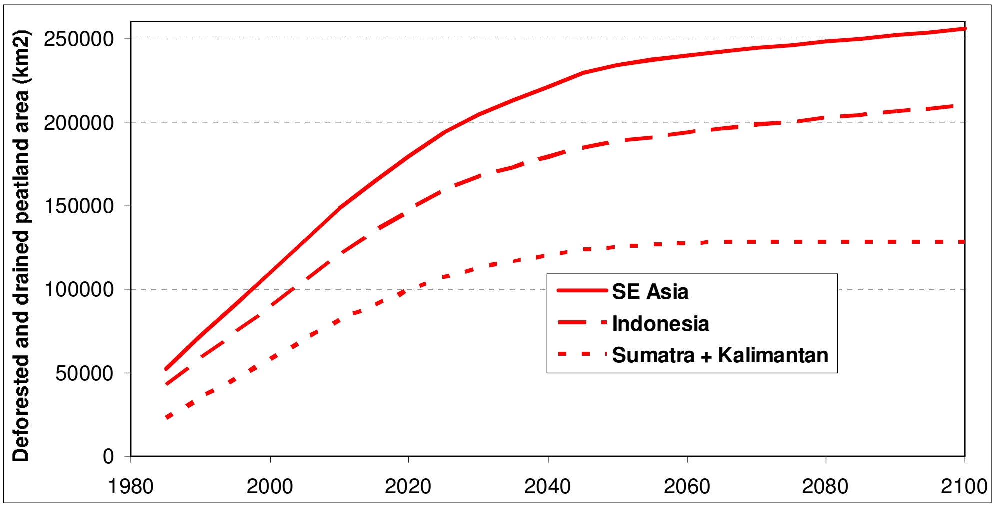
Peatland extent & condition

But most deforested peatlands are not productive at all: they are degraded peatlands, unused and burning frequently.

Peatland extent & condition

<u>Peatland deforestation and drainage patterns in Indonesia</u>

Peatlands were considered unsuitable for agricultural development until 1980-1995. Peatland deforestation has rapidly accelerated over last 20 years. Most peatland is now fully deforested, and hardly any is left intact (outside Papua).



Peatland issues

Many of Indonesias 'difficult policy issues' are in the lowlands:

- **National food security: where can more rice be grown?**
- **Palm oil / pulp & paper: where can export crops be grown?**
- **Carbon emissions from fires and peat oxidation (SATGAS / REDD)?**
- **Poverty alleviation / transmigration: where and how?**
- **Flooding / Sea+River level rise: which areas are save to develop?**

Questions?

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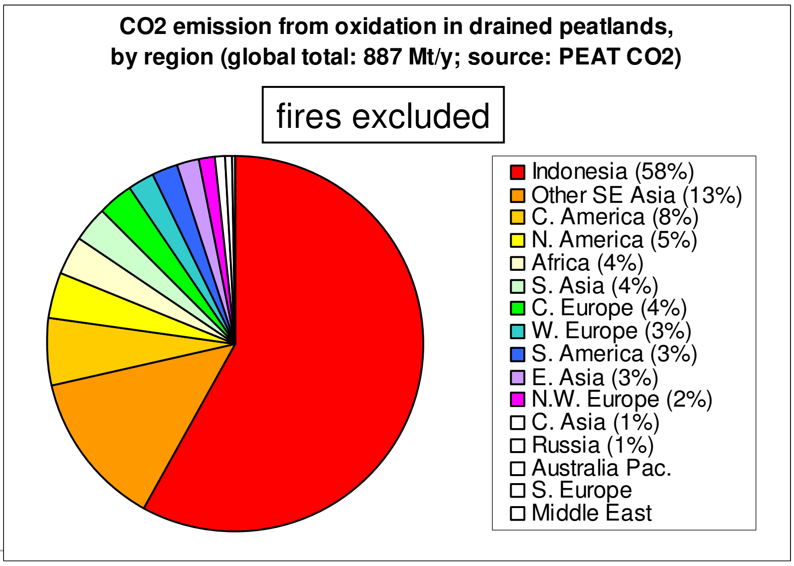
Impacts of peatland drainage: carbon emissions, haze/smoke, subsidence and flooding

Al Hooijer

For JCP kick-off workshop on peatland subsidence and flooding modeling
26-28 July 2011

Carbon emissions resulting from peatland drainage and fires

Carbon emissions from Indonesia's degrades peatlands are globally significant, at equivalent to 3%-8% of global emissions from fossil fuel burning. Greatest single land-use related carbon source in the world.



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Peatland drainage impacts

Fire patterns in relation to land use developments to date

The consequences of fires are felt locally...

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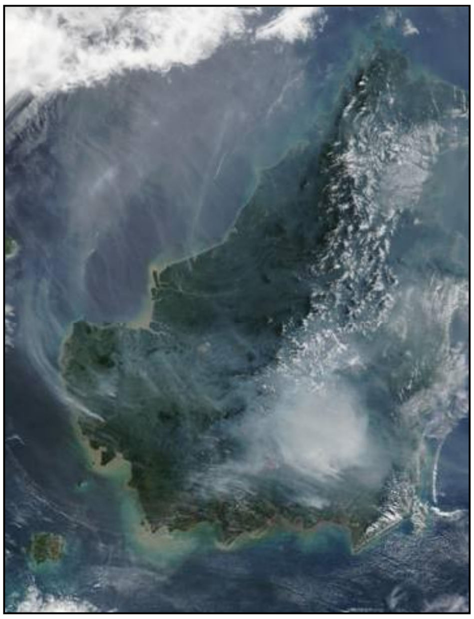
Peatland drainage impacts

Fire patterns in relation to land use developments to date

The consequences of fires are felt regionally…



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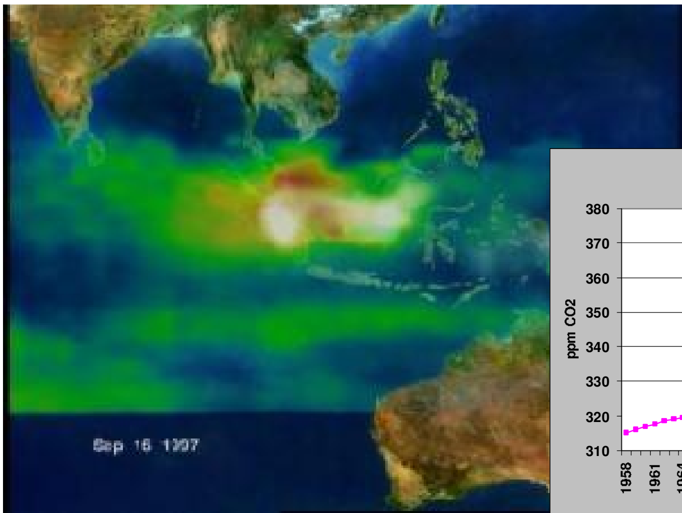

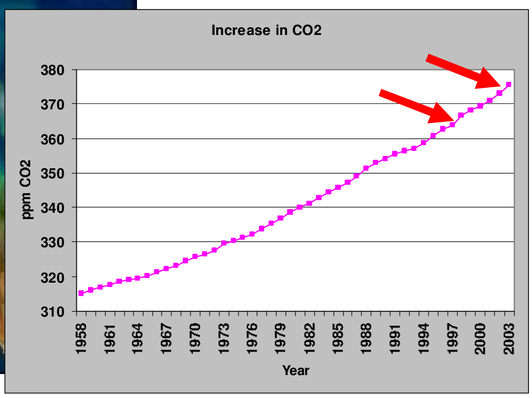

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Peatland drainage impacts

<u>Values of natural peatland in Indonesia</u>

As long as there is no drainage and no fires, selective logging in peatlands can be productive and sustainable in the long term.

This production is lost after clearing or fires.

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Peatland drainage impacts

<u>Values of natural peatland in Indonesia</u>

Peatlands are now a last refuge for the biodiversity in SE Asia, which is the highest in the world

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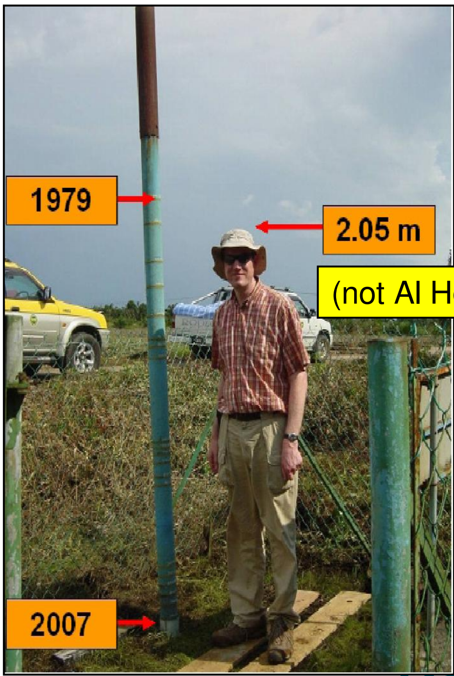
Peatland drainage impacts

<u>Subsidence resulting from peatland drainage and fires</u>

Loss of carbon from peatland, after drainage, results in lowering of the peat surface.



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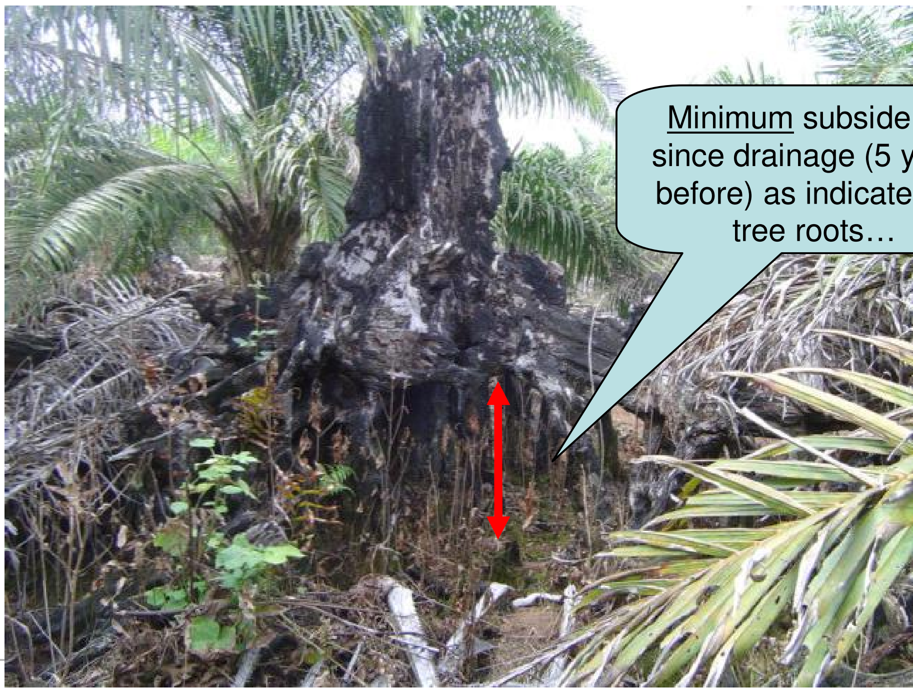
Peatland drainage impacts

Subsidence resulting from peatland drainage and fires

The evidence is everywhere



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Peatland drainage impacts

Subsidence resulting from peatland drainage and fires

The evidence is everywhere

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Peatland drainage impacts

Subsidence resulting from peatland drainage and fires

The evidence is everywhere

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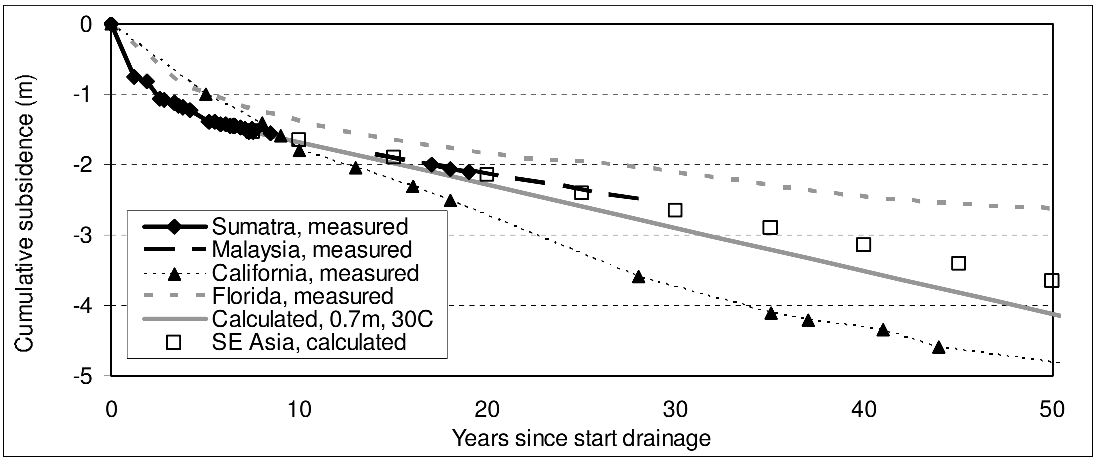
Peatland drainage impacts

So all field observations confirm what science tells us: peatland drainage inevitably leads to oxidation of the peat, which inevitably leads to subsidence. We also know a lot about how fast this subsidence proceeds…



What we don't know very well, yet, is what the effect of this subsidence will be, on drainability, flooding and future agricultural production.

For this, we need to know the position of the peat surface and peat bottom relative to Sea level (and river level).

Questions?

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What we know about peat depth and elevation in relation to Sea level

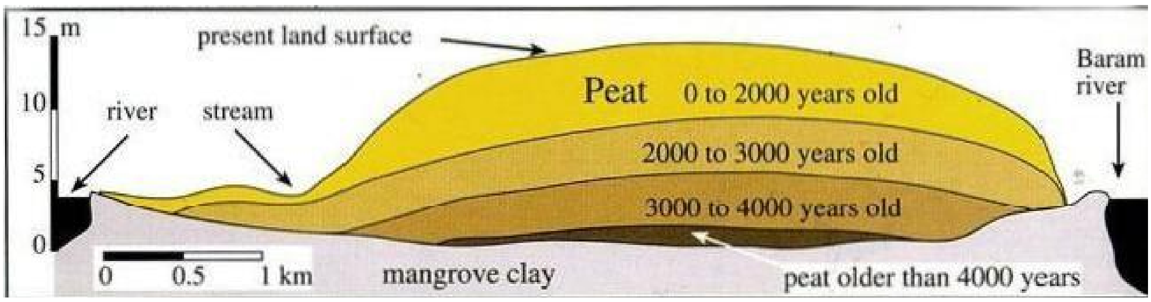
Al Hooijer

For JCP kick-off workshop on peatland subsidence and flooding modeling
26-28 July 2011

Peat depth and elevation

Quickscan: cross sections of peatlands in SE Asia have been collected from literature and project reports.

Sarawak



Peat depth and elevation

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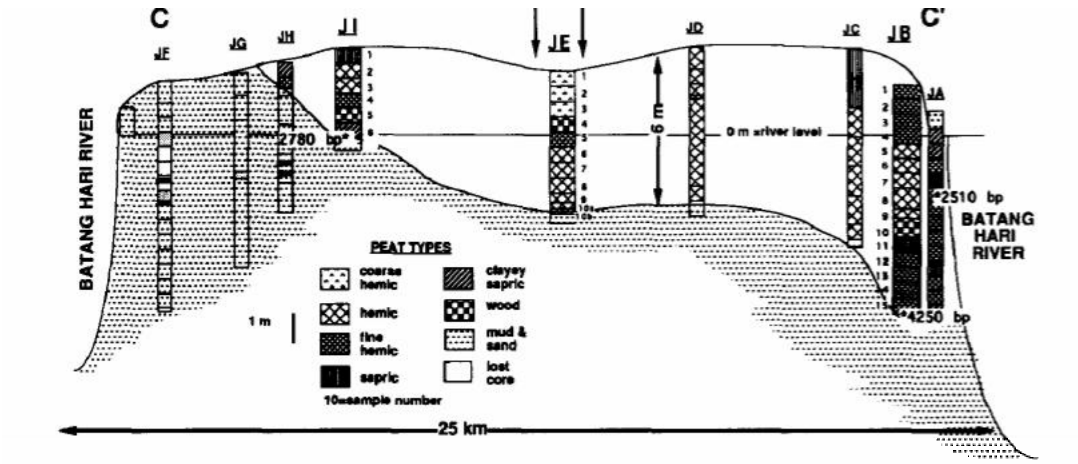
Jambi



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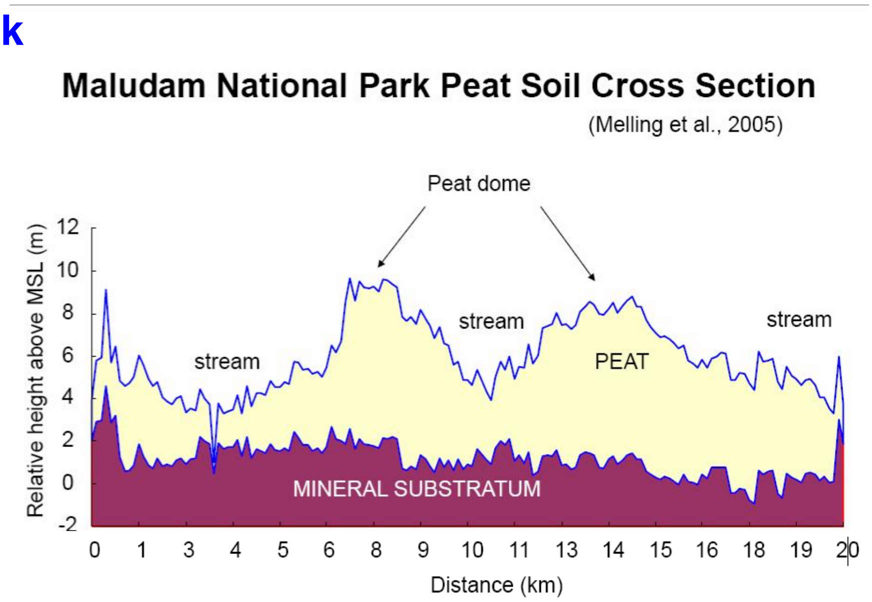

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Sarawak

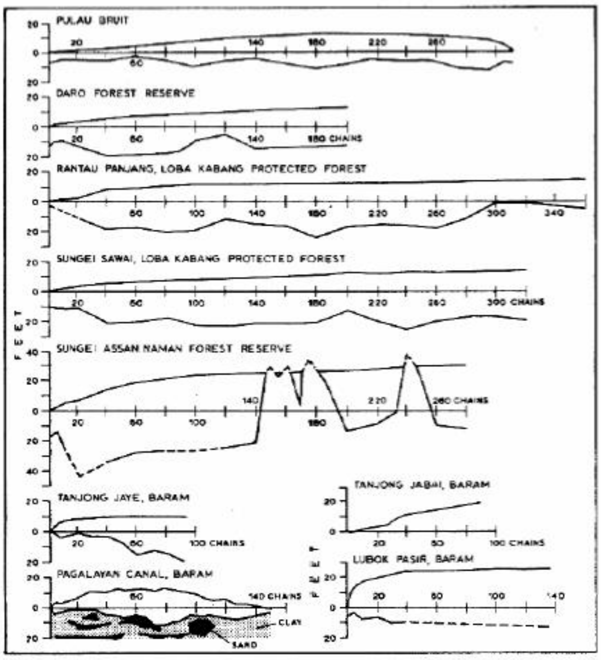

Fig. 2. Peat profiles in the Rajang delta and Baram river.

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Peat depth and elevation

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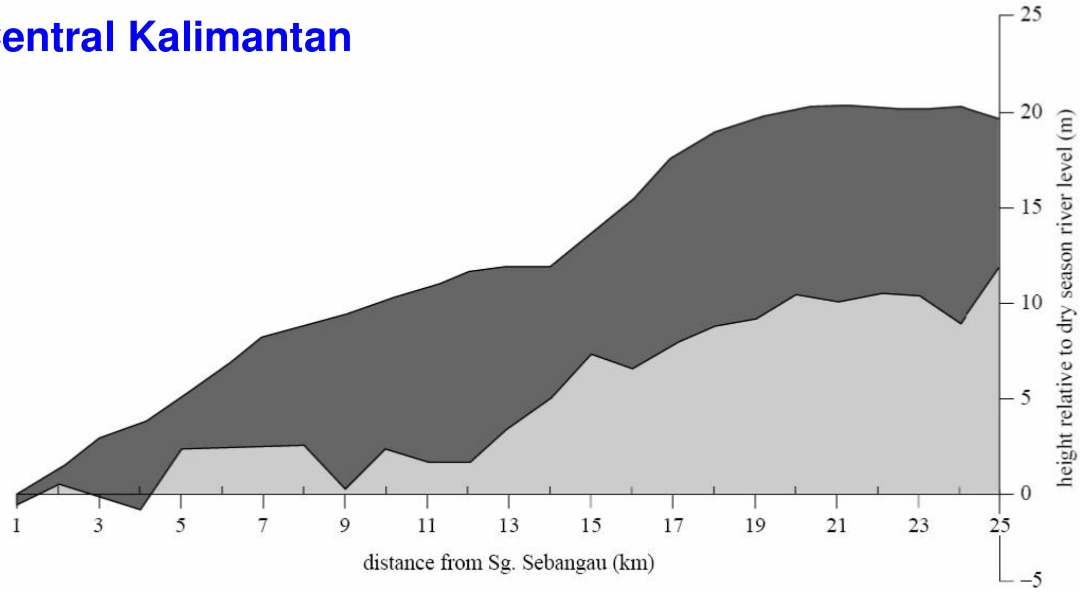
Central Kalimantan



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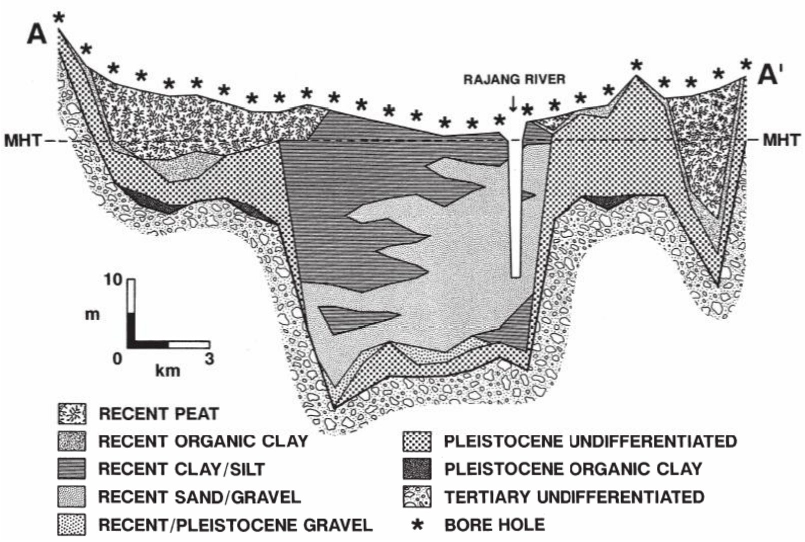

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Peat depth and elevation

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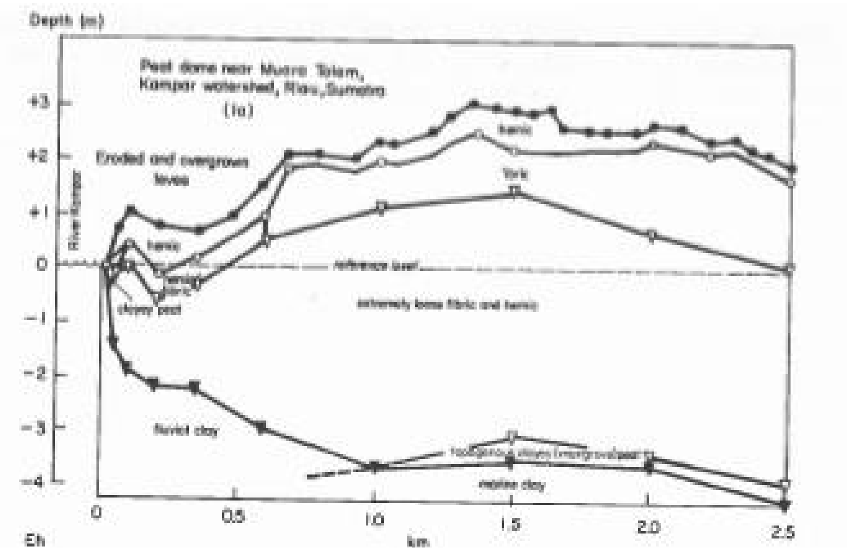
Riau



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Peat depth and elevation

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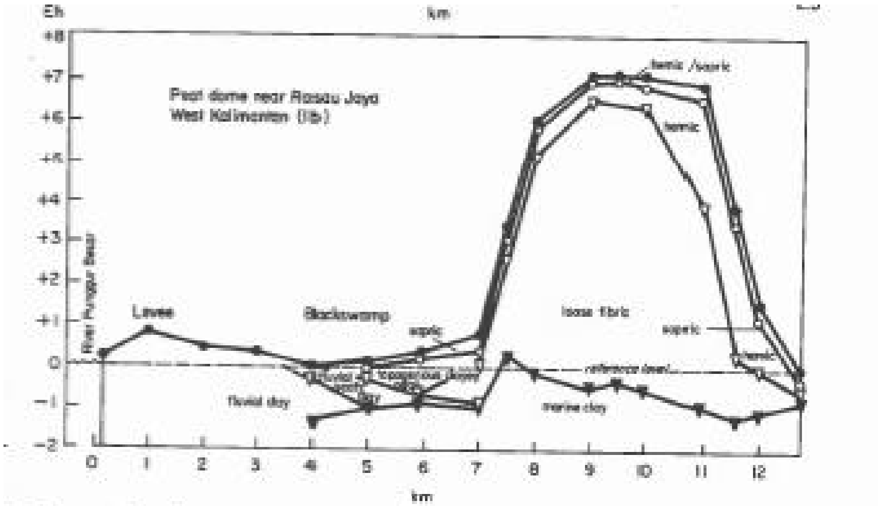
West Kalimantan

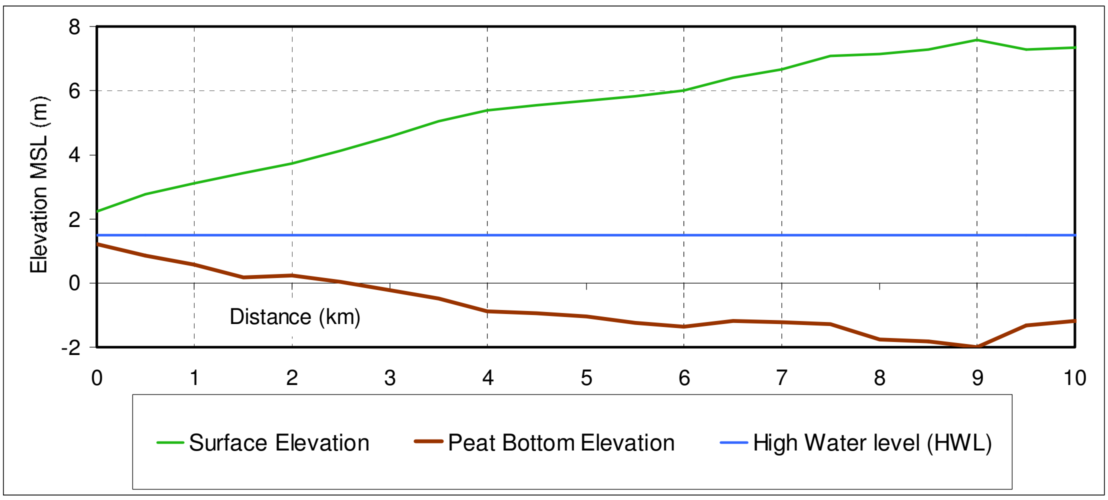


1. Cross-section of two representative ombrogenous peat domes.

Peat depth and elevation

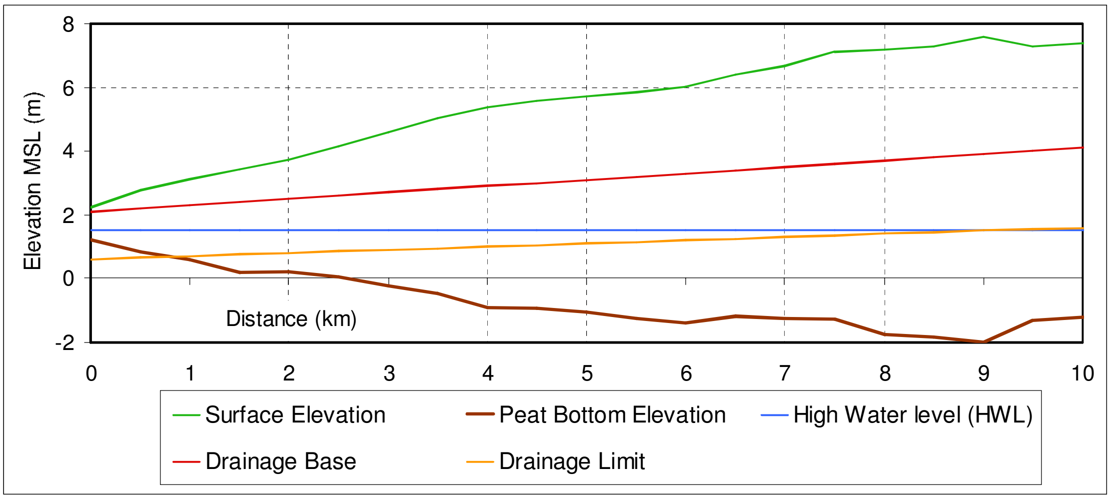
The average cross section for Indonesia was constructed (16 cross sections)

►Very similar to Sarawak; difference largely due to difference in cross section length and number.



Peat depth and elevation

The average cross section for Indonesia was constructed (16 cross sections)
With drainage base & limit added

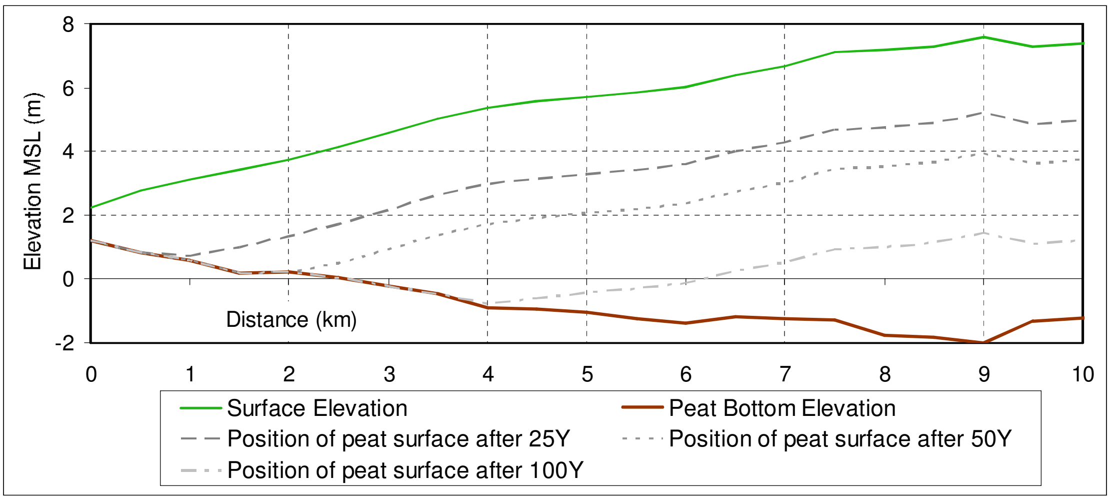


Deltares

Peat depth and elevation

The average cross section for Indonesia was constructed (16 cross sections)

With surface levels after 25, 50 and 100 years drainage added

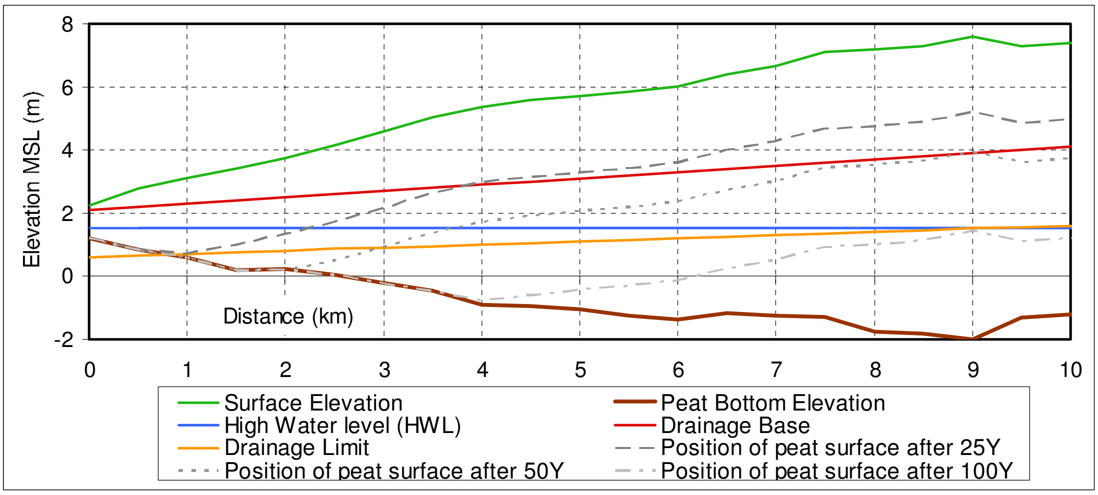


Deltares

Peat depth and elevation

The average cross section for Indonesia was constructed (16 cross sections)

With drainage base & limit + surface levels after 25, 50 and 100 years drainage added



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Peat depth and elevation

Resulting statistics are indicative, and maybe surprising, but need further work, with more data and with Indonesian experts, in the Joint Cooperation Programme?

	Sarawak	Kalimantan + Sumatra	**Sarawak + Kalimantan + Sumatra**
Number of cross sections available	27	16	**43**
Average length of cross sections, from river (km)	7.0	12.2	**9.0**
Average peat depth (m)			
Average peat depth (m)	6.2	7.5	**6.7**
Percentage peat depth > 3m	81%	88%	**83%**
Position of peat surface			
Position above MSL, 1 km from river (m)	3.8	3.1	**3.6**
Position above MSL, 5 km from river (m)	5.9	5.7	**5.8**
Position of peat bottom			
Percentage peat bottom below MSL	60	68	**63**
% peat bottom below MSL + Sea Level Rise[a]	67	75	**70**
% peat bottom below High Water Level[b]	83	94	**87**
% peat bottom below Drainage Base[c]	92	97	**94**
Trend in start of drainage problems (peat surface below Drainage Base)			
after 25 years	46	48	**46**
after 50 years	70	68	**69**
after 100 years	83	89	**85**
Trend in end of gravity drainage (peat surface below Mean Sea Level)			
after 25 years	12	12	**12**
after 50 years	32	27	**30**
after 100 years	52	52	**52**

[a] *A value of 0.5 has been assumed for Sea Level Rise over 100 years (IPCC, 2007)*

[b] *High Water Level: High Tide Level near the Sea, and Flood level along inland rivers*

[c] *The Drainage Base was defined by adding a conveyance gradient of 0.2 m/km to HWL for River dominated water levels, and to MSL for Sea dominated water levels.*

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Questions?

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Fundamentals of peatland development and peat characteristics

Al Hooijer

For JCP kick-off workshop on peatland subsidence and flooding modeling
28-28 July 2011

What is peat?

Peat soils consist mostly of water (90%), held together by vegetation remains (= mostly carbon).

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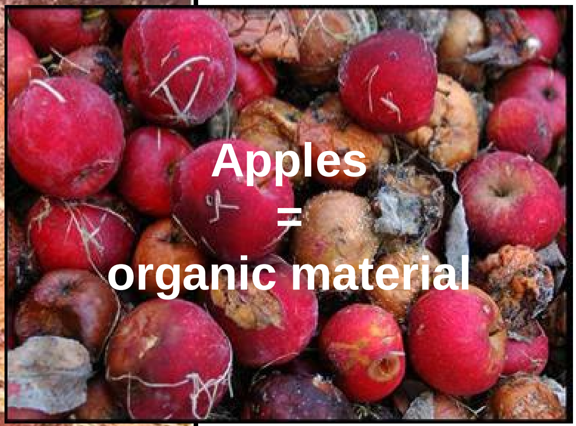
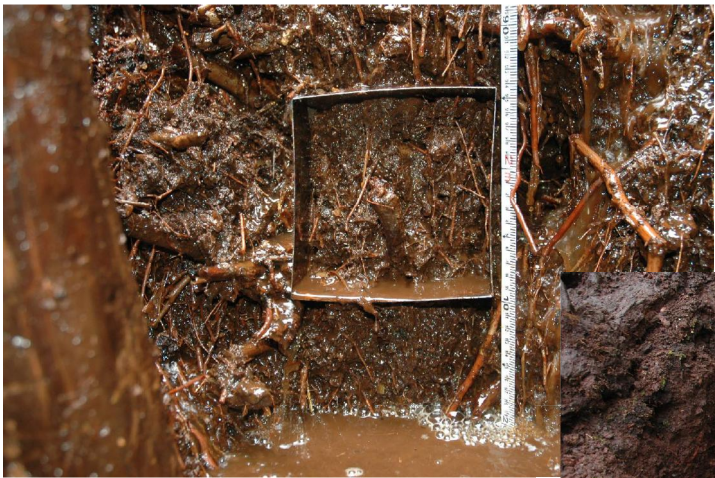


What is peat?

Typical peat in Indonesia, in thick/deep deposits: fibric matrix with wood remains.



What is peat?

Consisting only of water and vegetation remains, peatlands are not really ‘land’ in the classic sense but are wetlands.

Peatlands need to be managed rather like water bodies (lakes) to prevent loss of the water that supports the peat surface, i.e. to prevent subsidence.

Until now most peatland water management in SE Asia does not recognize this fact and can therefore not result in sustainable peatland development and conservation.

What are peatlands?

Intact peatswamps (more or less…): vulnerabilities due to fine eco-hydrological balances…

What are peatlands?

Clearing and fires…

What are peatlands?

Effects of peatland clearing and drainage at the local scale:
unit carbon emissions, subsidence

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What are peatlands?

Effects of peatland clearing and drainage at the large scale: plantations often not (very) productive, much degraded / burnt forest

(Note that the unplanted but drained area around plantationss is often as large as the planted area.)

What are peatlands?

In peatlands converted to plantations, as in degraded peatlands, conditions have changed radically compared to natural conditions:

1. **From very wet to dry, through drainage**

What are peatlands?

In peatlands converted to plantations, as in degraded peatlands, conditions have changed radically compared to natural conditions:

1. From very wet to dry, through drainage
2. From dense vegetation cover to open, leading to high soil temperature
3. From low nutrients to high nutrients, through vegetation
4. From stable soil to disturbed soil

Each of these effects causes peat oxidation.
Carbon loss from drained peatlands is therefore inevitable.

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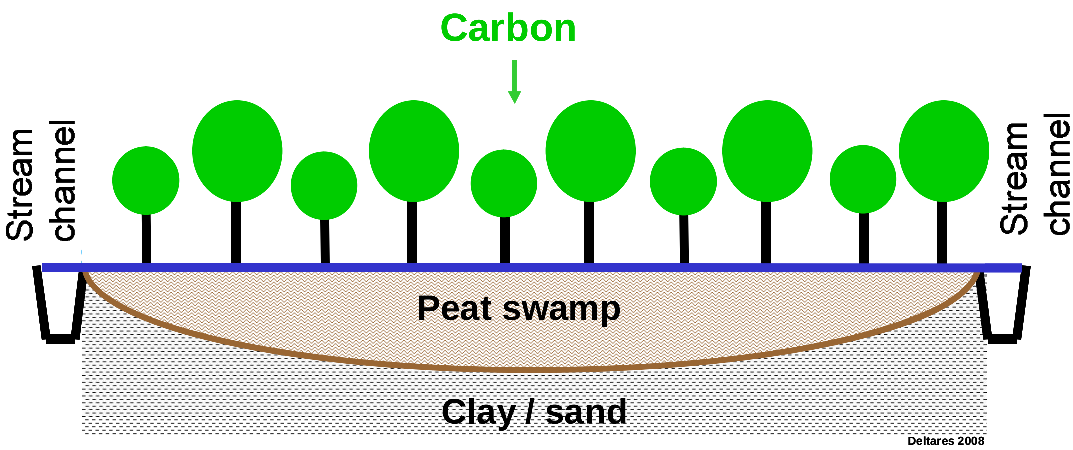
The basics of peatland carbon storage

How do peatlands develop?

Peatlands develop where dead vegetation (carbon) accumulates over thousands of years, in water-saturated conditions



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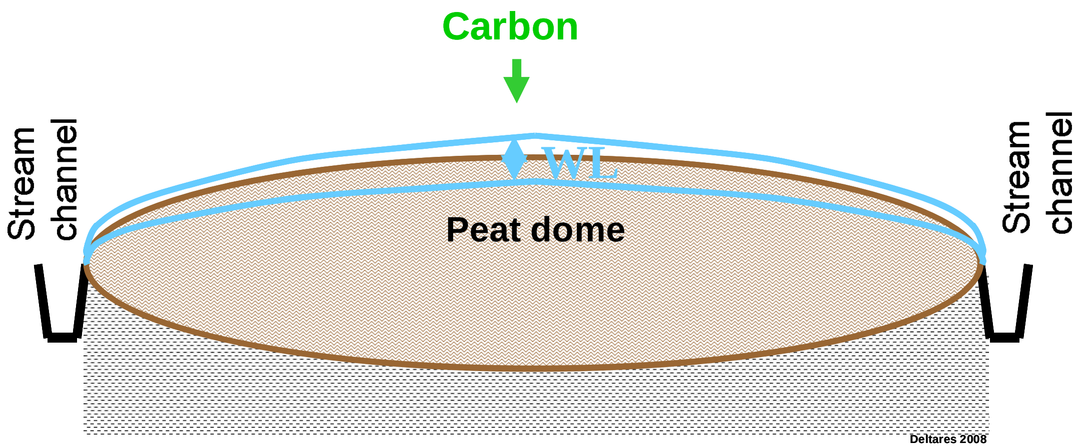
The basics of peatland carbon storage

How do peatlands develop?

Peat accumulation continues as long as water tables are near the soil surface: ‘carbon sink’



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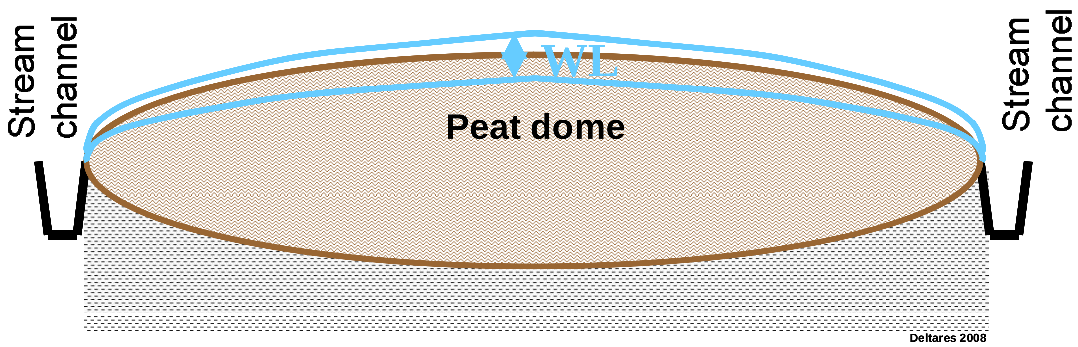
The basics of peatland carbon storage

Why are peatlands different from other lowland areas?

Peat soils consist mostly of water (90%), held together by vegetation remains i.e. mostly carbon (10%)

Peatlands are in some ways more like lakes than land: they are wetlands



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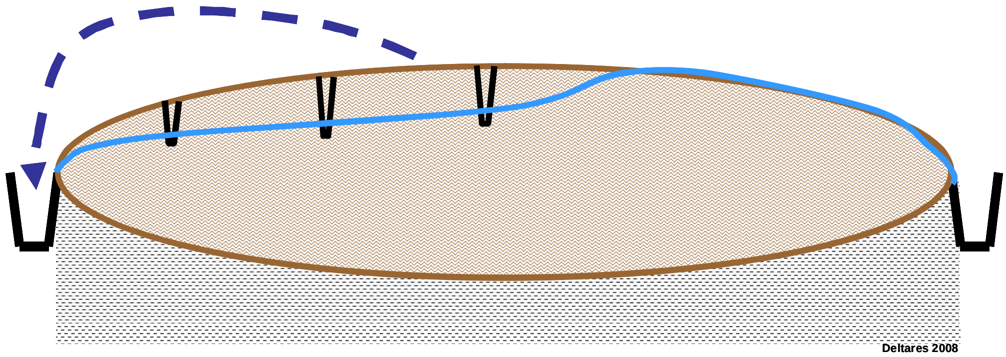
The basics of peatland carbon storage

Why does peatland drainage lead to subsidence, flooding, fire and CO_2 emissions?

Drainage lowers water table and dries the peat



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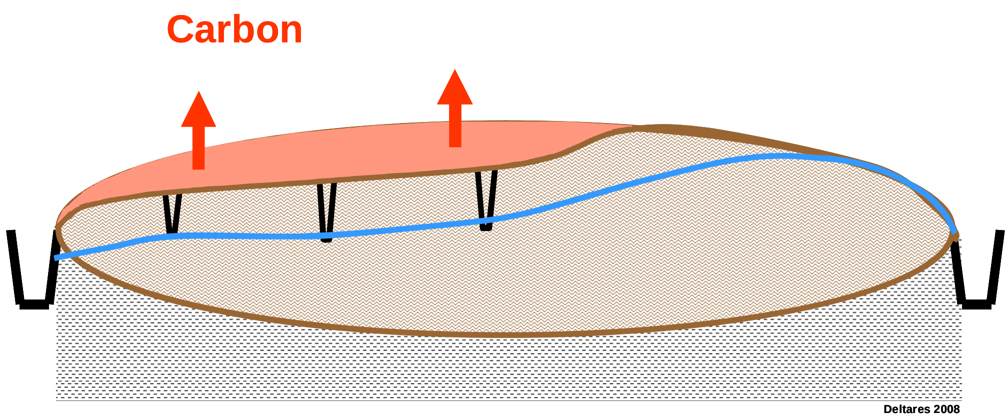
The basics of peatland carbon storage

Why does peatland drainage lead to subsidence, flooding, fire and CO_2 emissions?

Drainage lowers water table and dries the peat

Dry peat will burn easily, but also decomposes ('rotting') without fires: 'carbon source'



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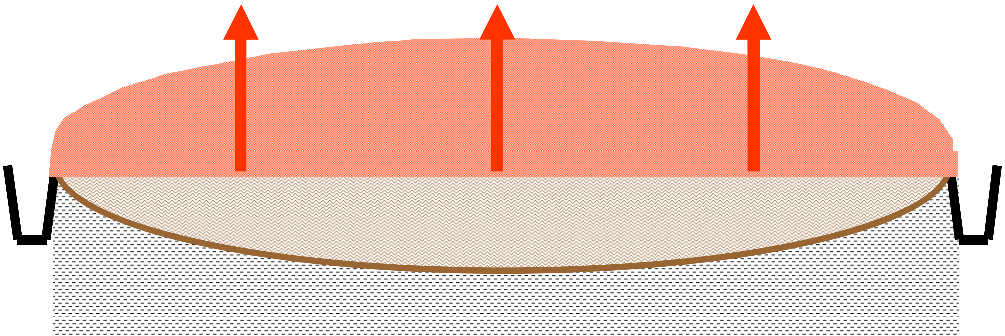
The basics of peatland carbon storage

What is the long-term impact?

Peat loss can be quick (fires) or slow (oxidation)

Without rewetting all peat above drainage limit (River / Sea) will be lost



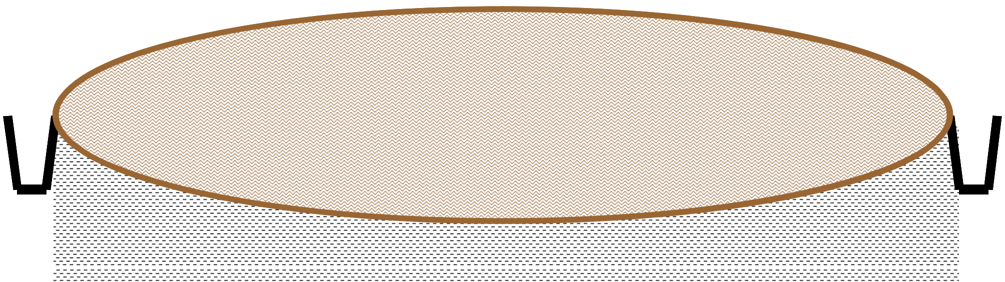
Deltares 2008

The basics of peatland carbon storage

What are the impacts of peatland drainage?

General environmental impacts:

- **Smoke emissions: local health problems and regional haze**
- **CO_2 emissions (and other greenhouse gases)**
- **Remaining conservation forest progressively drained and lost**



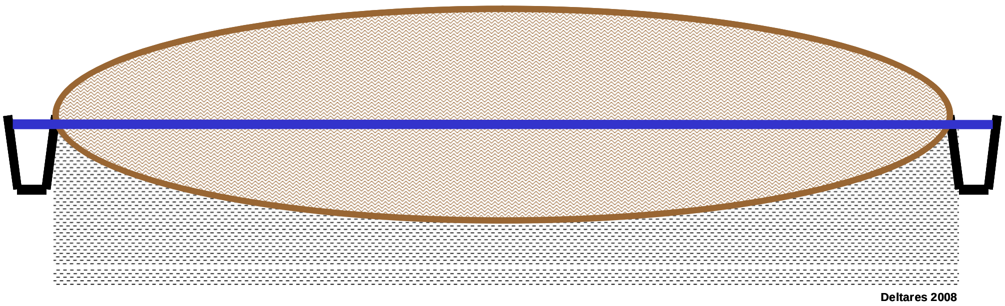
Deltares 2008

The basics of peatland carbon storage

What are the impacts of peatland drainage?

Impacts directly relevant to peatland agricultural productivity:

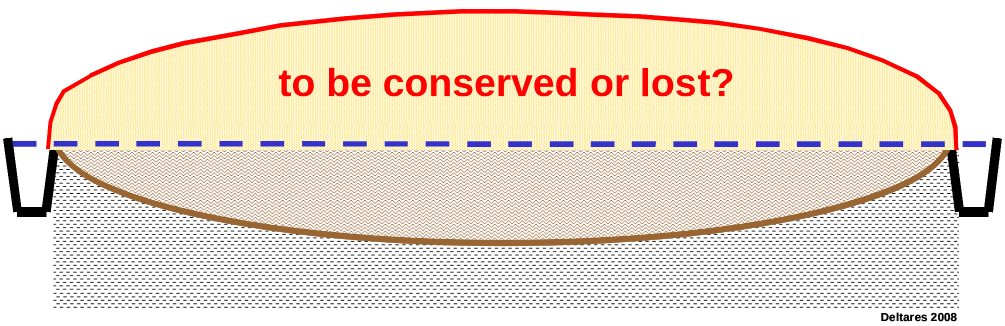
- **Peat subsidence increases flooding and reduces drainability: will be less productive / unproductive in future; many drained peatlands already frequently flooded now**
- **Further production loss if peat underlain by 'acid sulphate' soils**
- **Possible downstream production loss and damages if river flood flows increase**



The basics of peatland carbon storage

How can these impacts be stopped or reduced?

Peat loss is assumed to stop when the peat is fully 'rewetted', but it is not clear how soon decomposition ends after the balance between soil carbon, landscape morphology and vegetation has been disturbed. Probably decades, possibly centuries.



Questions?

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Studies on oxidation and subsidence in tropical peat

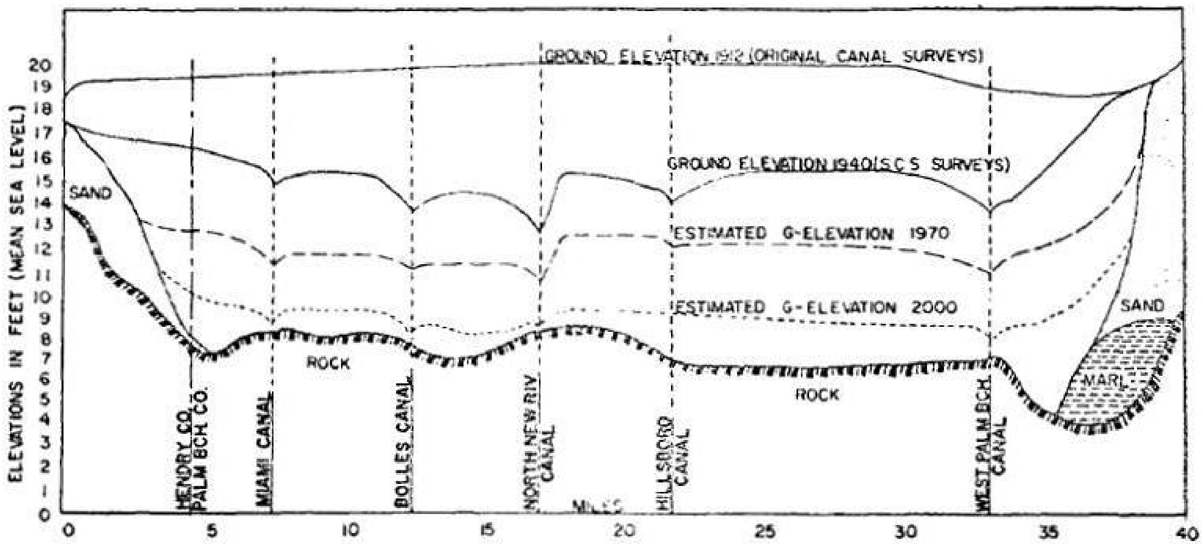
Al Hooijer

For JCP kick-off workshop on peatland subsidence and flooding modeling
28-28 July 2011

The first major study: Everglades, USA

Drained in 1912, subsidence now monitored for 100 years. It was found that:

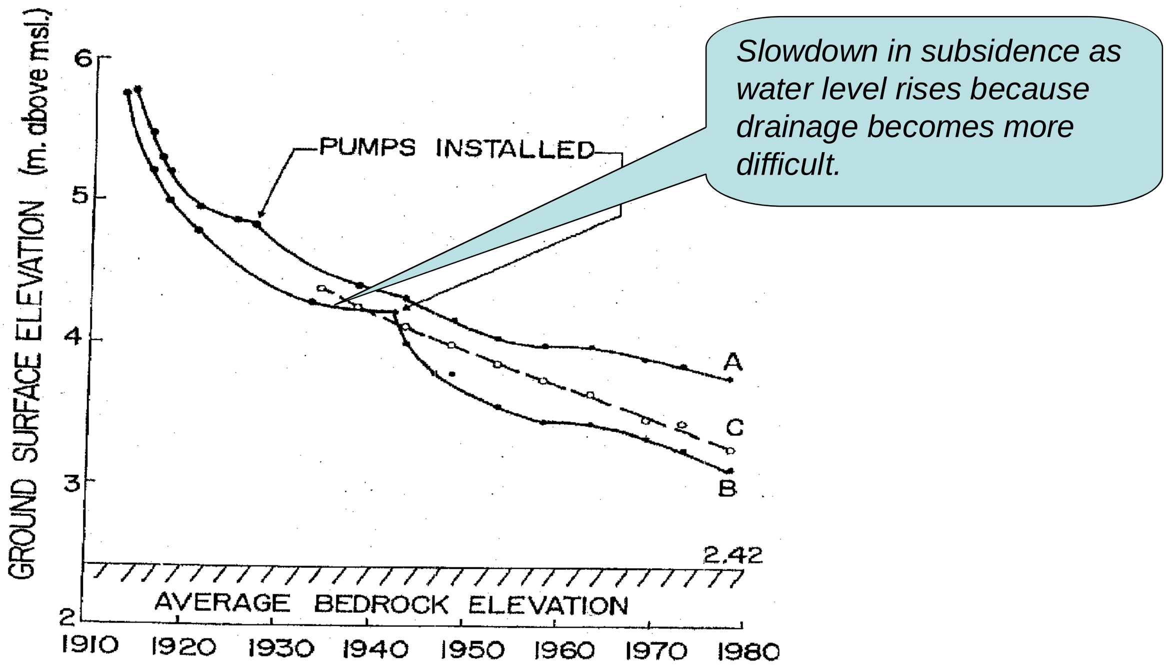
- **Subsidence is caused mostly (up to 90% since start) by peat oxidation**
- **Subsidence continues at a constant rate, after a reduction in the first 5 years**
- **Subsidence can not be stopped as long as peat is drained**
- **Therefore, peatland drainage was stopped in the USA, and in most other countries, since the 1950s**



Deltares

The first major study: Everglades, USA

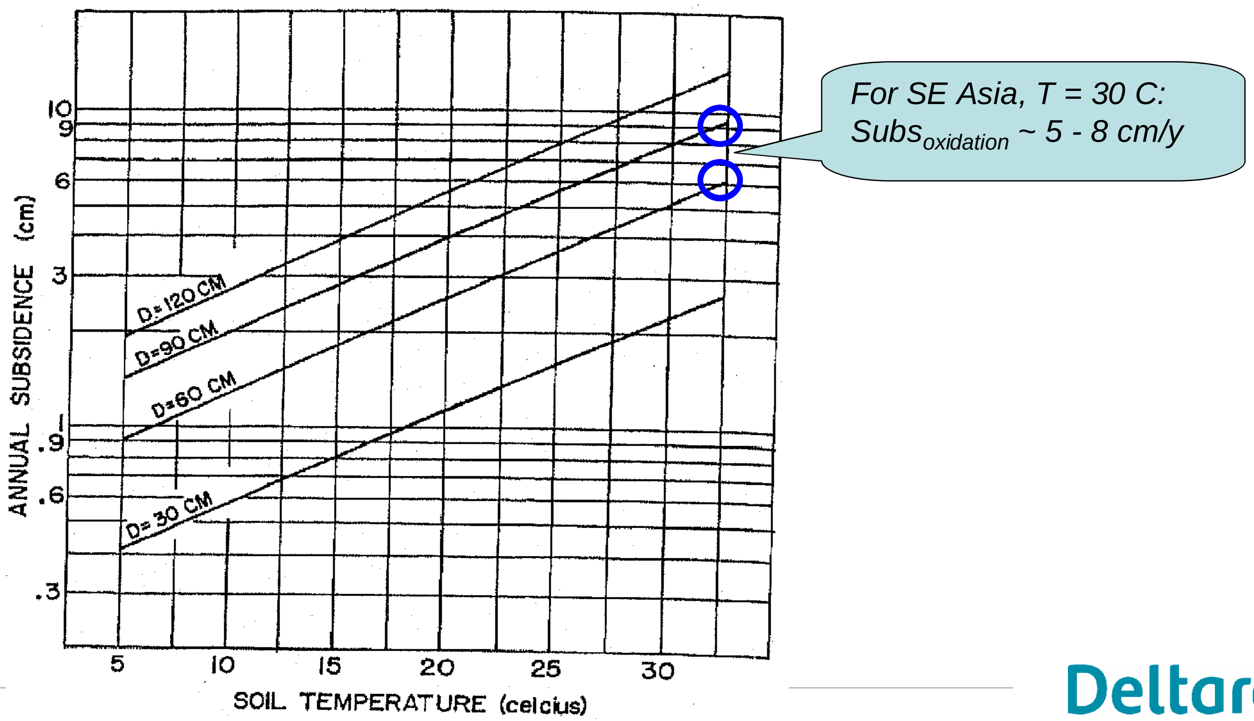
Subsidence at constant water depth is constant, but changes when water depth changes.



Deltares

The first major study: Everglades, USA

Clear relation between subsidence rate and water depth and temperature, in USA peatlands

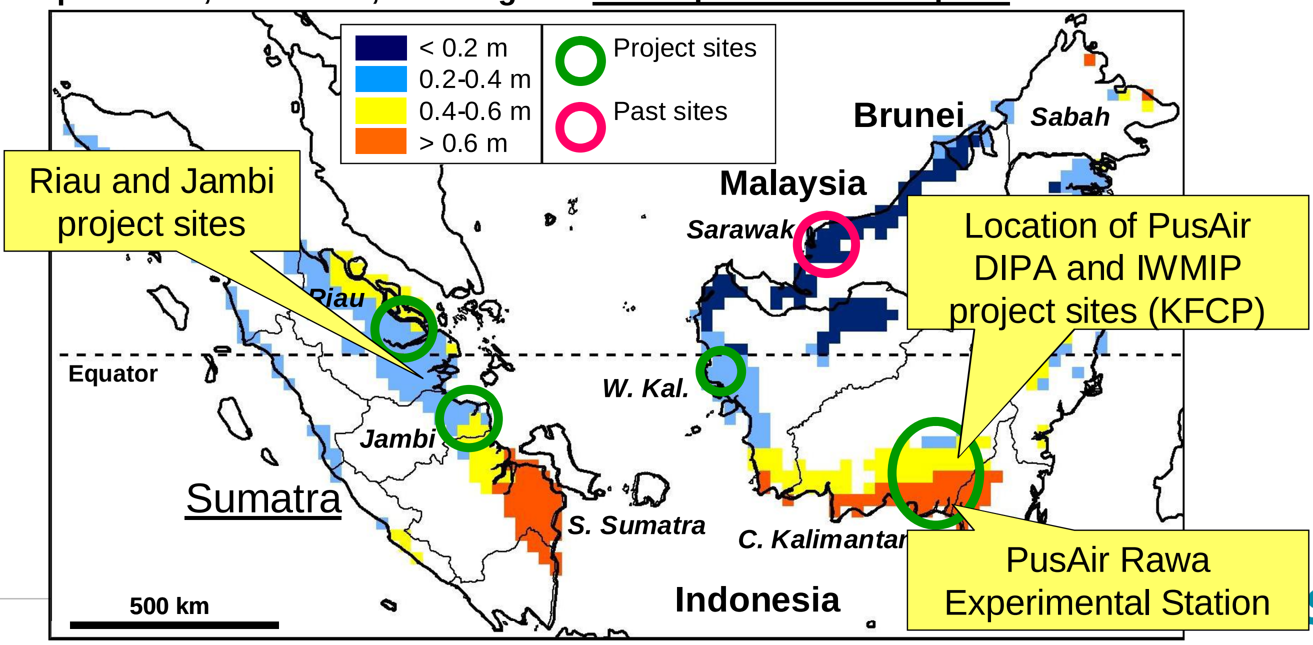


Deltares

The most recent study: acacia and oil palm plantations in Riau and Jambi

- **By Deltares, with universities of Helsinki, Leicester, Singapore and Jambi.**
- **Measurements 2007-2010, <u>at a larger cale than all earlier studies combined.</u>**
- **First publications now coming out, have <u>greatly reduced uncertainties</u>.**

Overlaying a map of modelled average annual lowest groundwater depth in peatlands, 2002-2008, showing that <u>not all peatlands are equal!!</u>



The most recent study: acacia and oil palm plantations in Riau and Jambi

<u>**Research and training**</u>

Key measurements:

- **Peat surface subsidence (>200 points, monthly)**
- **CO_2 gas flux (144 points; 2300 measurements)**
- **Water table depth**
- **Soil temperature**
- **Soil bulk density (>1000 samples)**

Other:

- **Rainfall**
- **Soil moisture**
- **Elevation surveys**
- **Canal hydrology**

The most recent study: acacia and oil palm plantations in Riau and Jambi

Field training: the basics of subsidence

<u>Minimum</u> subsidence since drainage (5 years before) as indicated by tree roots…

The most recent study: acacia and oil palm plantations in Riau and Jambi

Field training: measuring peat depth & setting up subsidence pole

Deltares

The most recent study: acacia and oil palm plantations in Riau and Jambi

Peat sampling: ring samples from pits

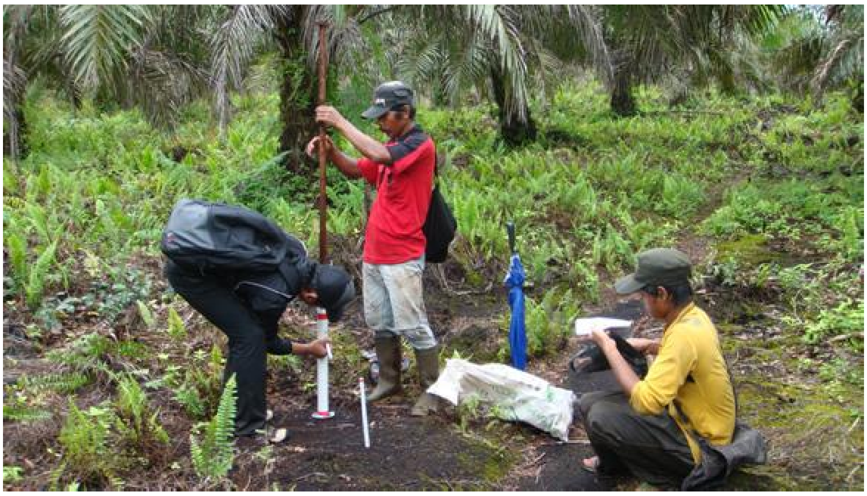
Deltares

The most recent study: acacia and oil palm plantations in Riau and Jambi

Peat sampling: ring samples from pits

The most recent study: acacia and oil palm plantations in Riau and Jambi

Subsidence pole



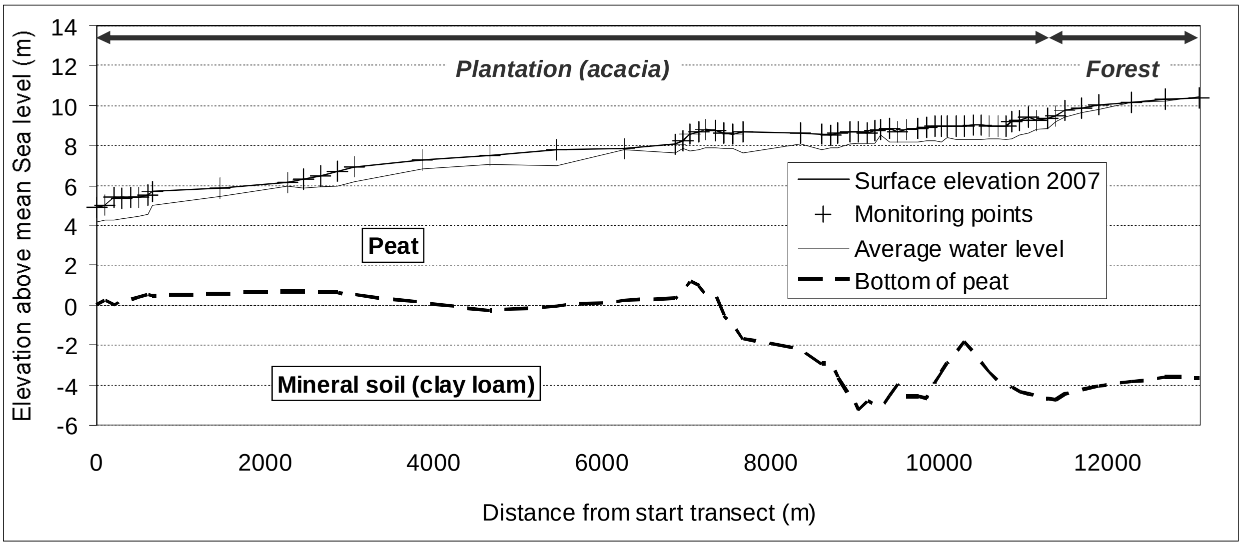
The most recent study: acacia and oil palm plantations in Riau and Jambi

Training and discussions with Bappeda etc

Deltares

The most recent study: acacia and oil palm plantations in Riau and Jambi

Typical cross section as studied in Riau and Jambi

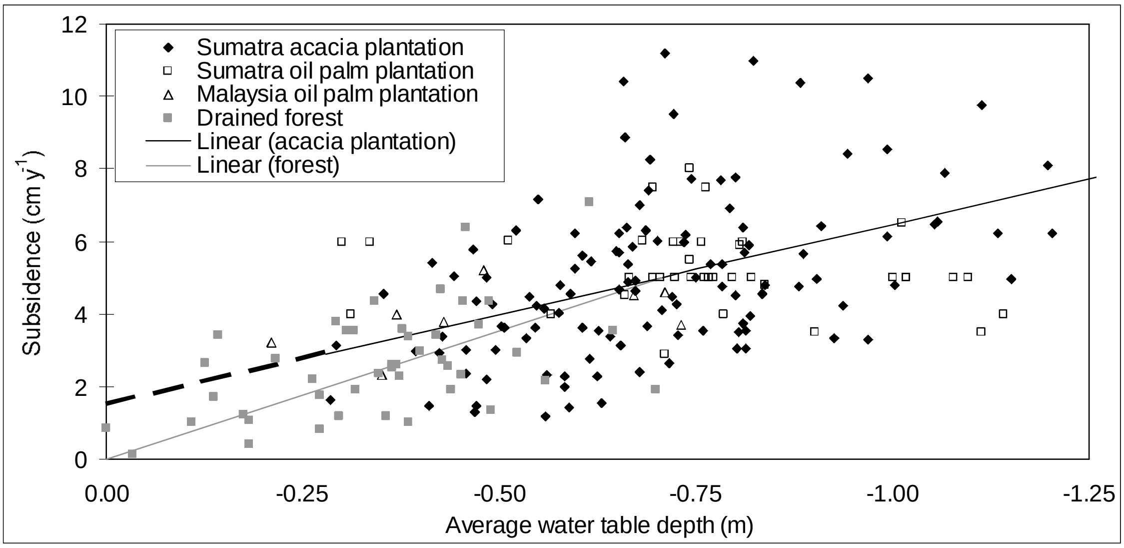


Peat depths studied are 3 to 19 metres.

Deltares

The most recent study: acacia and oil palm plantations in Riau and Jambi

Subsidence data as measured in Sumatra (plus some in Malaysia), in relation to average water table depth.

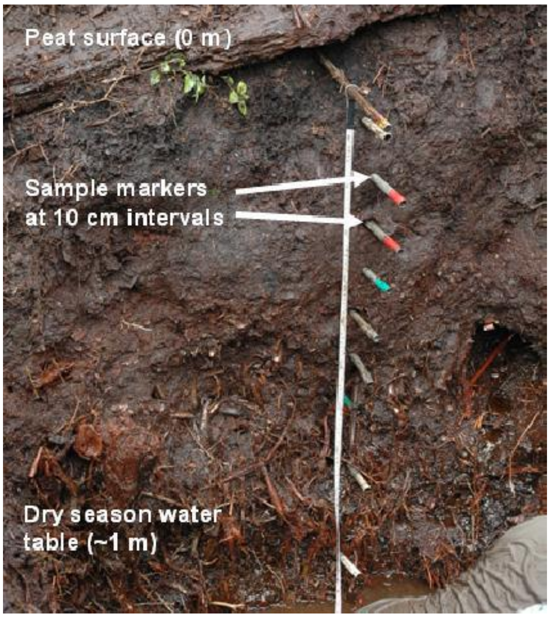


Conclusions: average 5.2 cm/y at 0.7 m drainage depth.

Deltares

The most recent study: acacia and oil palm plantations in Riau and Jambi

Bulk density profiles as studied in Riau and Jambi



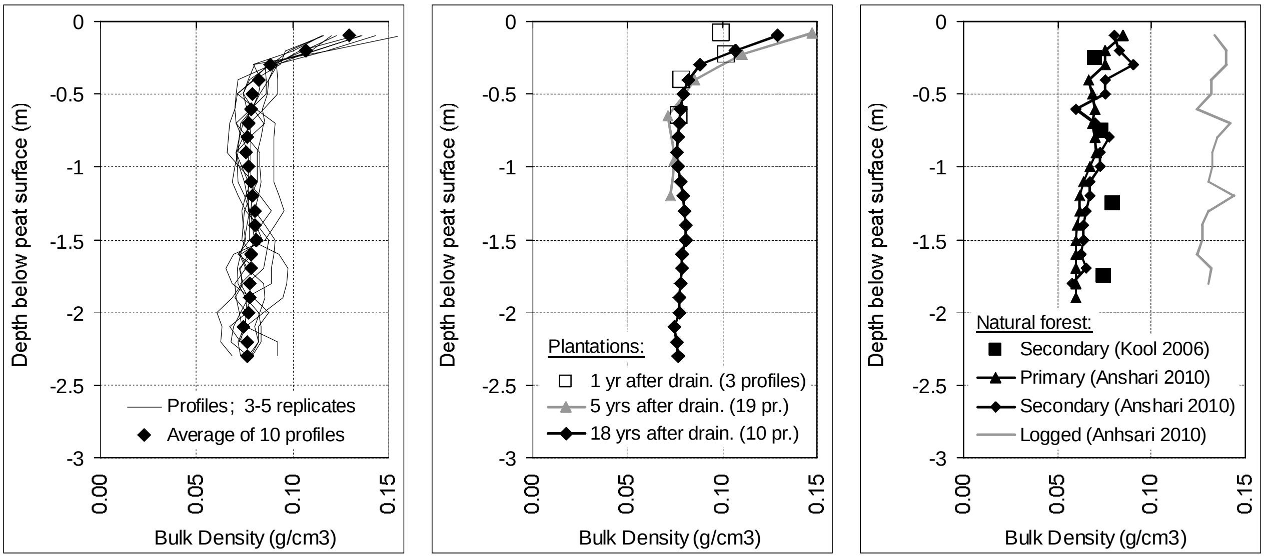
Conclusion: clear change in peat characteristics in upper 0.5 metres, but not below: indicates peat oxidation occurs mostlt near the surface.

Deltares

The most recent study: acacia and oil palm plantations in Riau and Jambi

Bulk density profiles as studied in Riau and Jambi

Individual sections in drained peat | Typical average sections after 1 – 5 – 18 years | Profiles in undrained peatland

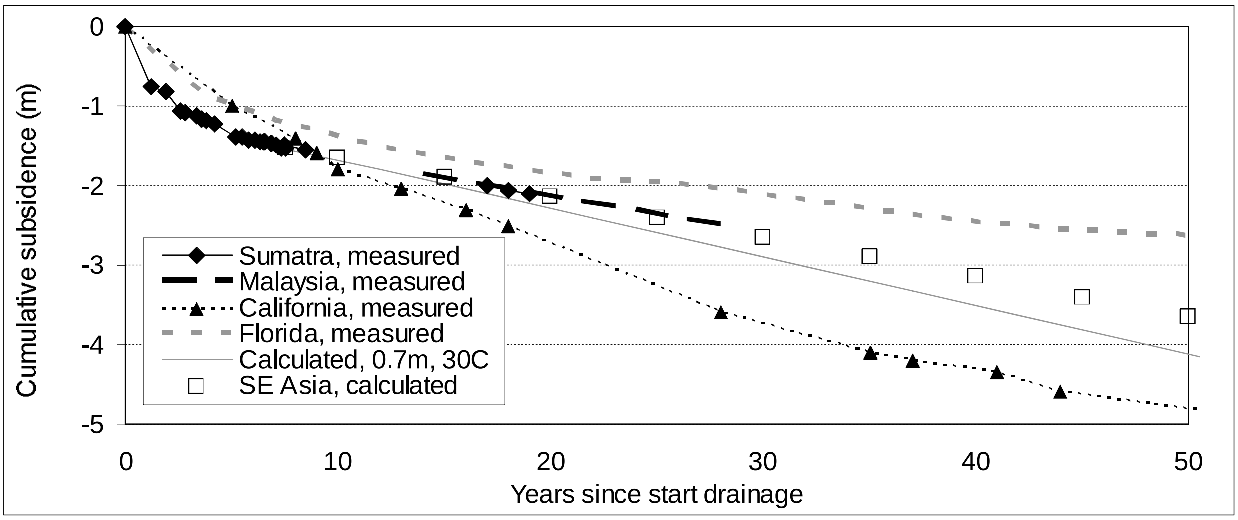


Conclusion: bulk density does not change after first 5 years, and only changes in top layer of peat. Therefore, <u>oxidation is dominant in subsidence</u>, not compaction / consolidation

The most recent study: acacia and oil palm plantations in Riau and Jambi

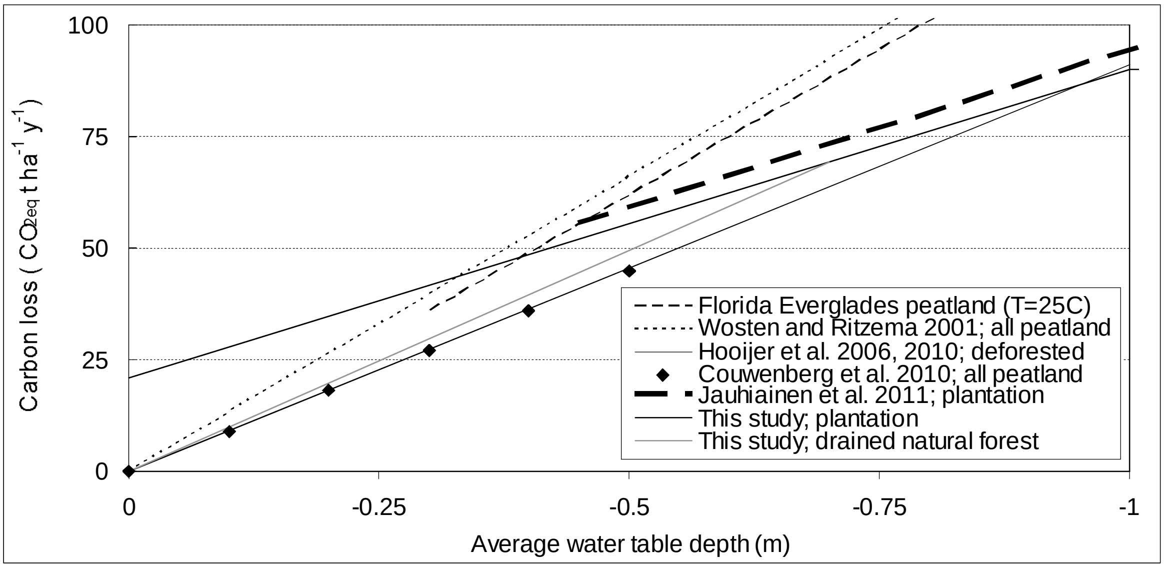
Subsidence records for different tropical locations in SE Asia and semi-tropical locations in USA

- **Subsidence records remarkably similar**
- **Subsidence always 4-8 cm/y at average water depth of ~0.7 m**
- **Subsidence does not slow down in time**
- **In deep peat in SE Asia: <u>2.5m after 25 years; up to 6m after 100y.</u>**



The most recent study: acacia and oil palm plantations in Riau and Jambi

Different studies, using different techniques, have found mostly similar relations between water depth and carbon loss (= CO_2 emission)



Conclusions: there is no question that subsidence is mostly a result of carbon loss.

Questions?

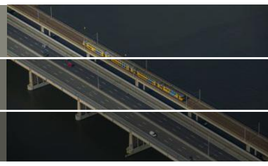
Deltares

Exercises

Marnix van der Vat

JCP Workshop peatland subsidence
Bandung, July 26 and 27, 2011

Exercise 1: subsidence curves



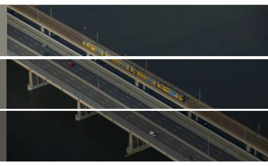
Construct a table and a graph of annual subsidence rate and remaining peat thickness for 4 different forms of land use

Duration 100 years

Initial peat thickness 10m

Initial subsidence after conversion:	year 1	70cm
	year 2	45cm

Exercise 1: subsidence curves



Annual subsidence per land use category:

1 Natural forest

  2 mm/year growth

2 Degraded forest with dense net of logging tracks/canals 0.6m deep

  subs= 7.06 * drainage depth (subs in cm, drain in m)

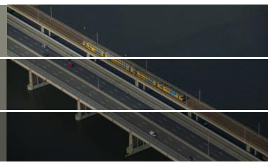
  till depth of loggin tracks is reached

3 Plantation drained at 1.2m depth

4 Plantation drained at 0.6m depth

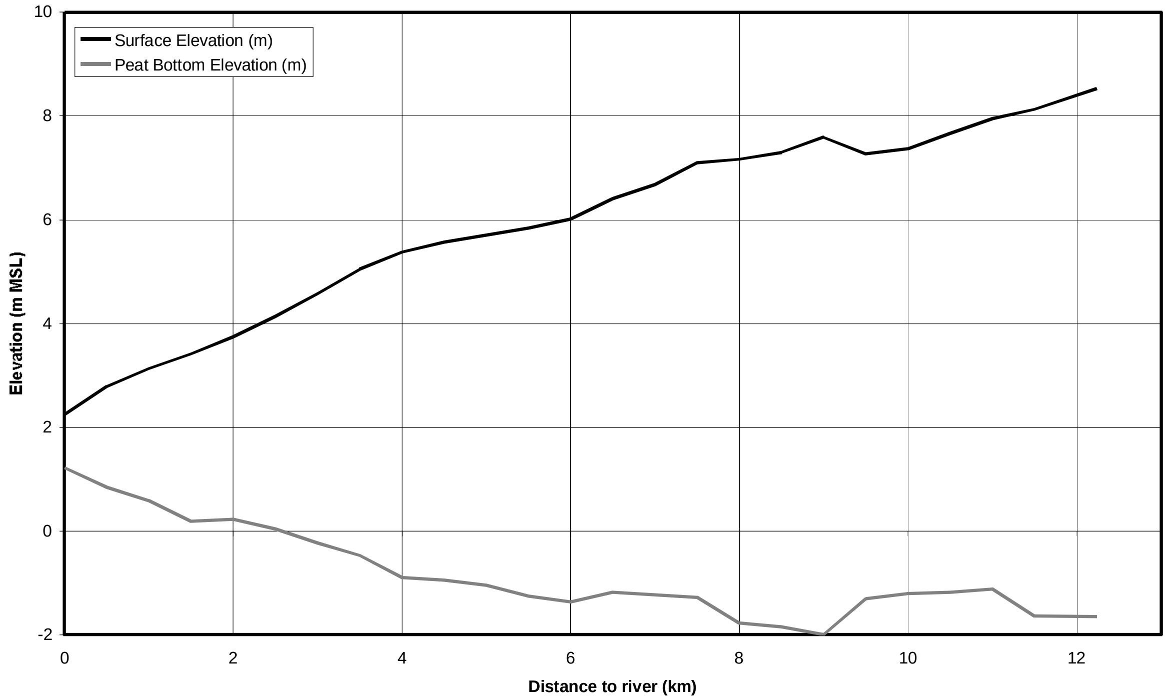
  subs =1.5 + 4.98 * drainage depth (subs in cm, drain in m)

Exercise 1: subsidence curves



- How much peat remains after 100 years for each of the four land uses?
- How do the speed of subsidence and growth of peat compare?
- How does impact of initial subsidence compare to other subsidence on the long term?
- What is the long term impact of different drainage depths in plantations?

Exercise 2: Subsidence on average profile



Exercise 2: Subsidence on average profile

Construct a table of remaining elevation after conversion to plantation during 100 years subisdence (and a graph at 25 years intervals)

Initial peat thickness 10m

Initial subsidence after conversion:	year 1	70cm
	year 2	45cm

Plantation drained at 0.6m depth

subs =1.5 + 4.98 * drainage depth (subs in cm, drain in m)

Exercise 3: Impact of subsidence on flooding & drainability

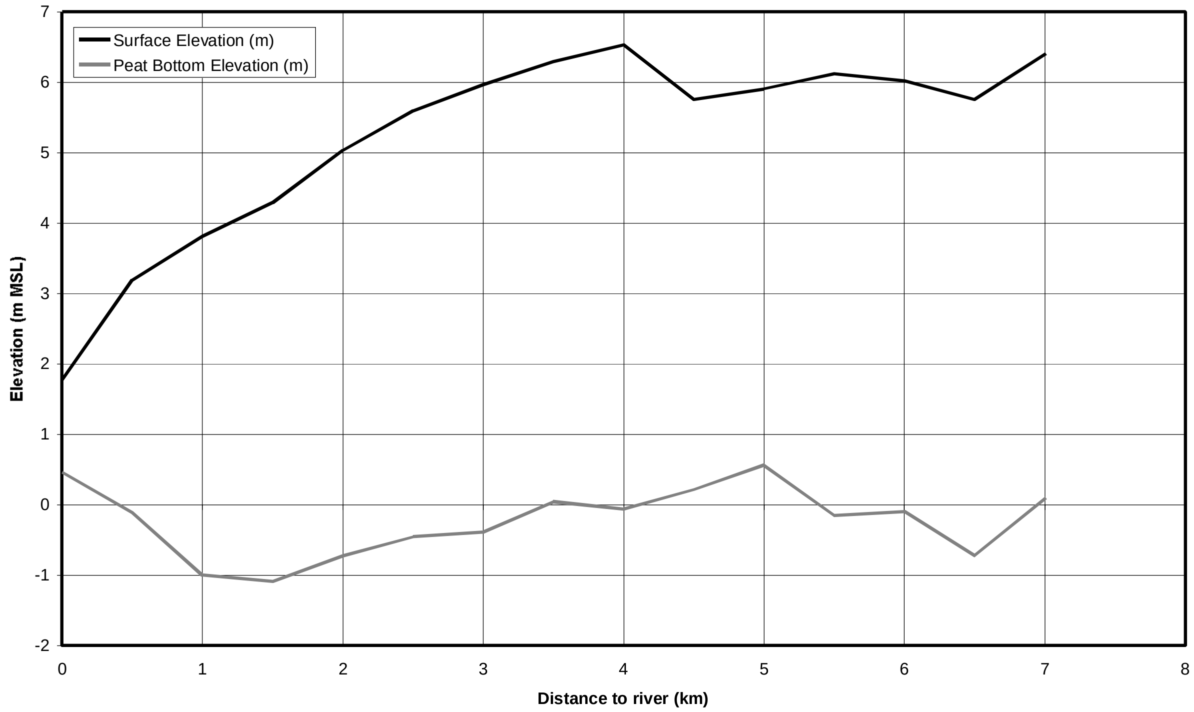
Add HWL and zero drainage level to graph and tabulate (from graph at 25 year interval) percentage length of profile with flooding and drainability problems

High water level:	1.5 m	
Head loss:	20 cm/km (starting at MSL)	
Drainability classes:	1	< 0 cm
	2	0 – 30 cm
	3	30 – 60 cm
	4	> 60cm

Exercise 3: Impact of subsidence on flooding & drainability

- How many percent of the profile experiences flooding and drainage problems after 50 years?
- How many percent of the profile can be sustainably developed for 100 years?

Exercise 4: Sarawak profile



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Exercise 4: Sarawak profile

- Compare results for flood and drainage with Indonesian profile and explain the differences

Deltares

Exercise 5: Sea Level Rise

Add 1cm per year SLR (high estimate) to the HWL and zero drainage level and repeat the profile analysis of flood and drainage for Indonesia

Compare results in table with and without SLR. What is the influence of SLR? How important is SLR compared to subsidence?

How many percent does now experience problems after 50 years? And how many percent does not have problems after 10 years?

Deltares

Exercise 6: with 2 types of land use in the profile

Repeat subsidence analysis on Indonesian average profile but now with first 4km from river plantation drained at 1.2m and after that natural forest

Is this result possible in reality? What will happen in reality to the peat under the forest?

Deltares

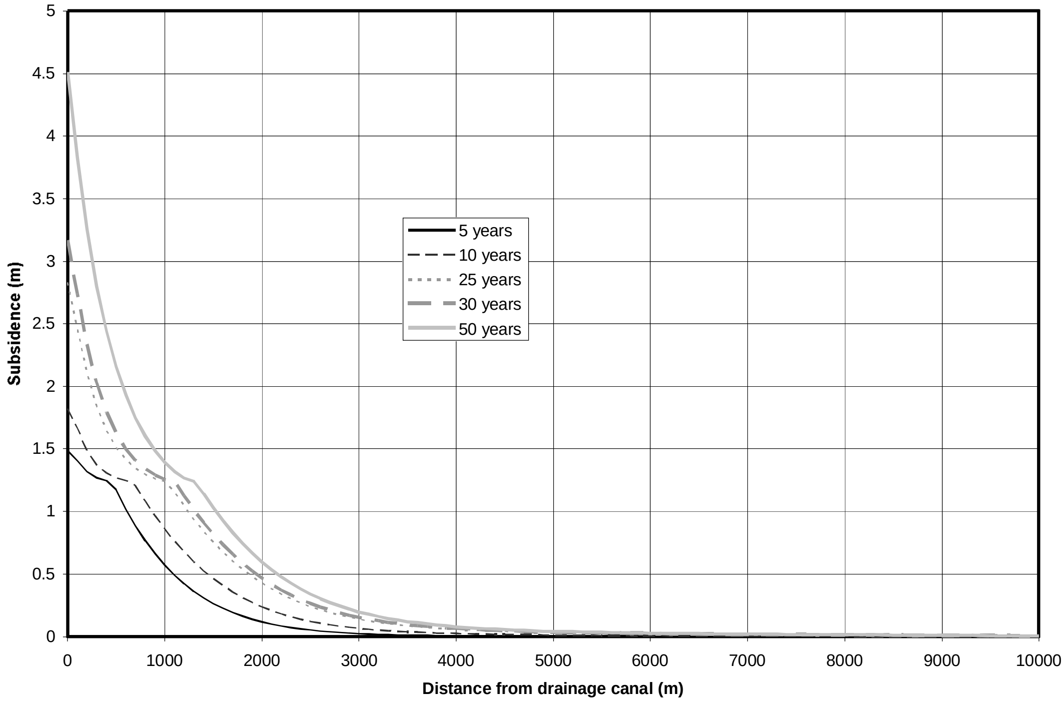
Exercise 7: determine required extent of buffer

- Peat thickness 10m
- Hydraulic conductivity 100m/d
- Drainage depth 1.2m

Determine the required width of the buffer from plantation with 1.2m drainage depth to keep subsidence in conservation area below 5cm over 50 years

Deltares

Exercise 7: determine required extent of buffer



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Exercise 8: Calculate emissions

Use the results of exercise 1 to calculate emissions (rate per year and cummulative) for a period of 100 years for 4 different landuses

Carbon storage: 15.1 ton CO2/ha/cm

Compare emission rates with the storage under natural forest

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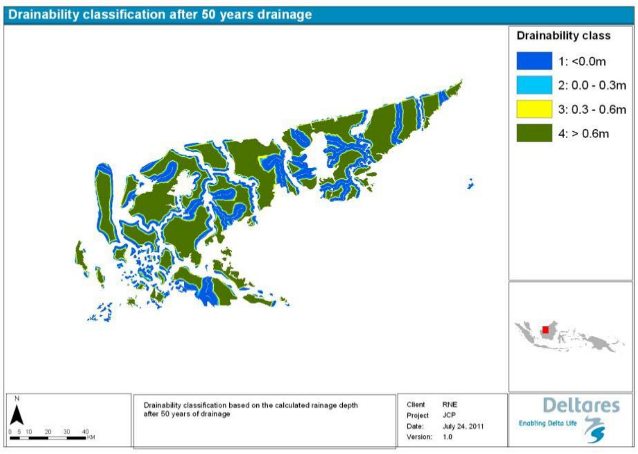
Deltares
Enabling Delta Life

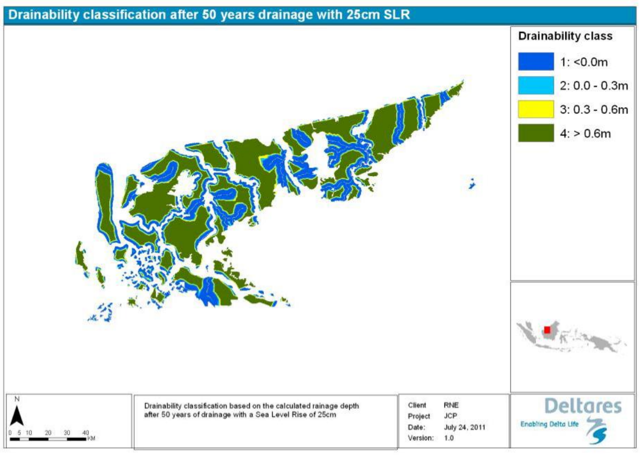
Peatland subsidence and flood model for Indonesia

Marnix van der Vat

JCP Workshop peatland subsidence
Bandung, July 26 and 27, 2011

Sarawak





Sarawak model

Demonstration model without:

- DEM
- on peat thickness
- actual land use and prognoses future development

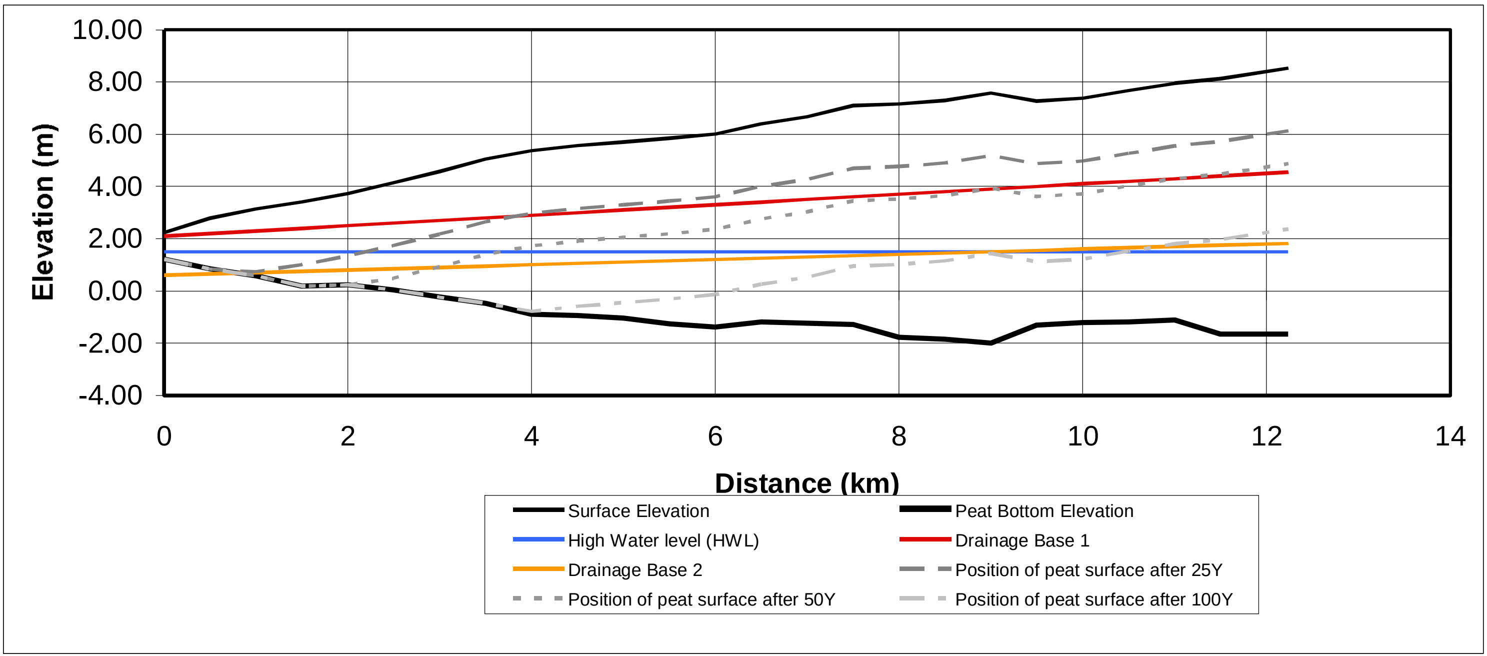
Deltares

Indonesian model - incremental development

1. Focus first on case study areas with better data (Jambi, South Sumtra, Kampar), later gradual extension to rest of Indonesian lowlands
2. Demonstration model as for Sarawak derived from average peat dome profile and peat extent map
3. Replace approximate DEM from average profile with improved lowland DEM (to be developed)
4. Replace peat thickness from average profile with improved peat thickness map (to be developed)
5. Include actual land use, concessions and prognoses for land use development

Deltares

1. Demonstration model on average profile



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Peat dome profiles

- Combination on data of elevation and peat thickness (or peat bottom elevation)
- Measured in a line from a drainage basis (river, lake or sea)
- With for each data point the distance to the drainage basis
- Preferably with data on mean and maximum water level at drainage basis
- With all elevations relative to the same reference level (preferably MSL)
- To be collected from published literature, reports and unpublished studies
- Now data for 16 profiles collected

Deltares

1. Demonstration model on average profile

Actions:

1. Collect more existing data on peat dome surface elevation and peat thickness (peat bottom elevation) as a function of distance to river
2. Prepare new approximations for DEM and peat thickness
3. Run demonstration model

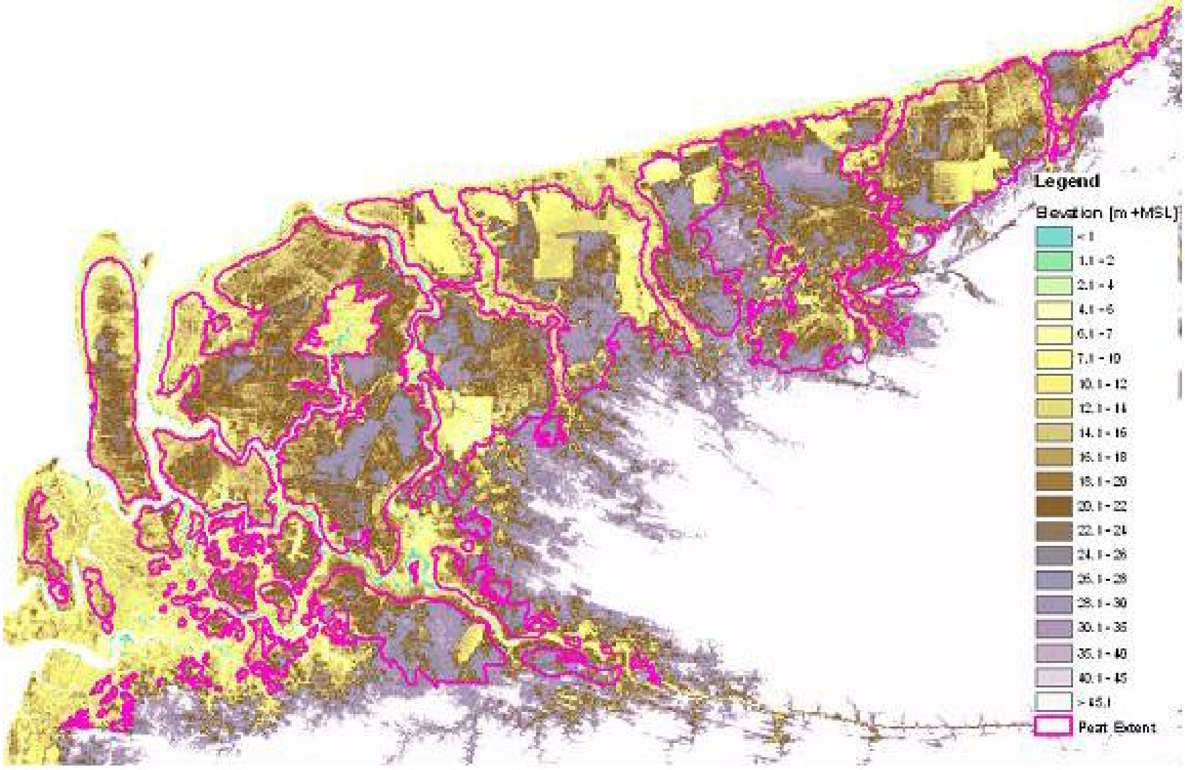
Deltares

Elevation data requirements

- An accurate Indonesian lowland DEM
- Vertical accuracy within 1 meter
- Horizontal resolution 1x1km or finer

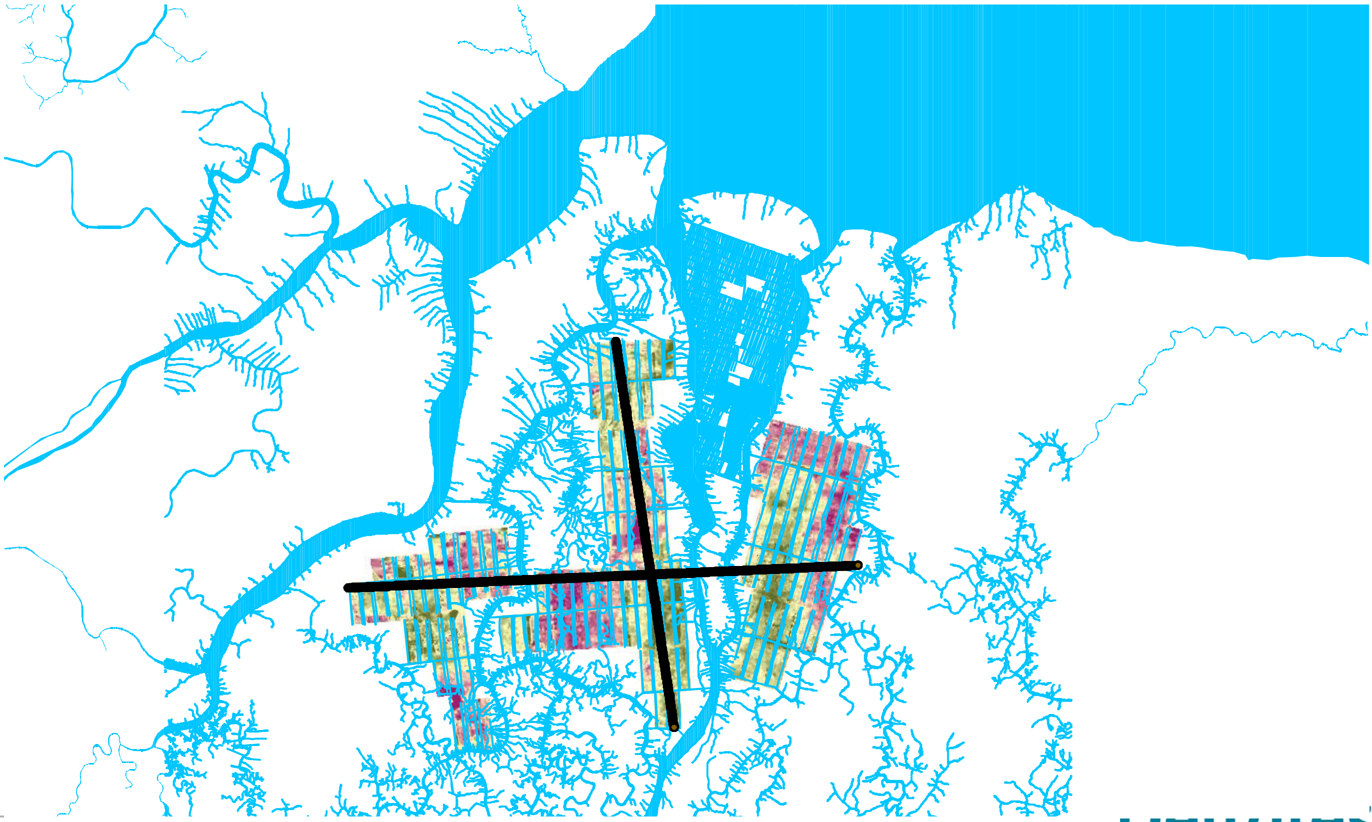
Deltares

DEM - SRTM



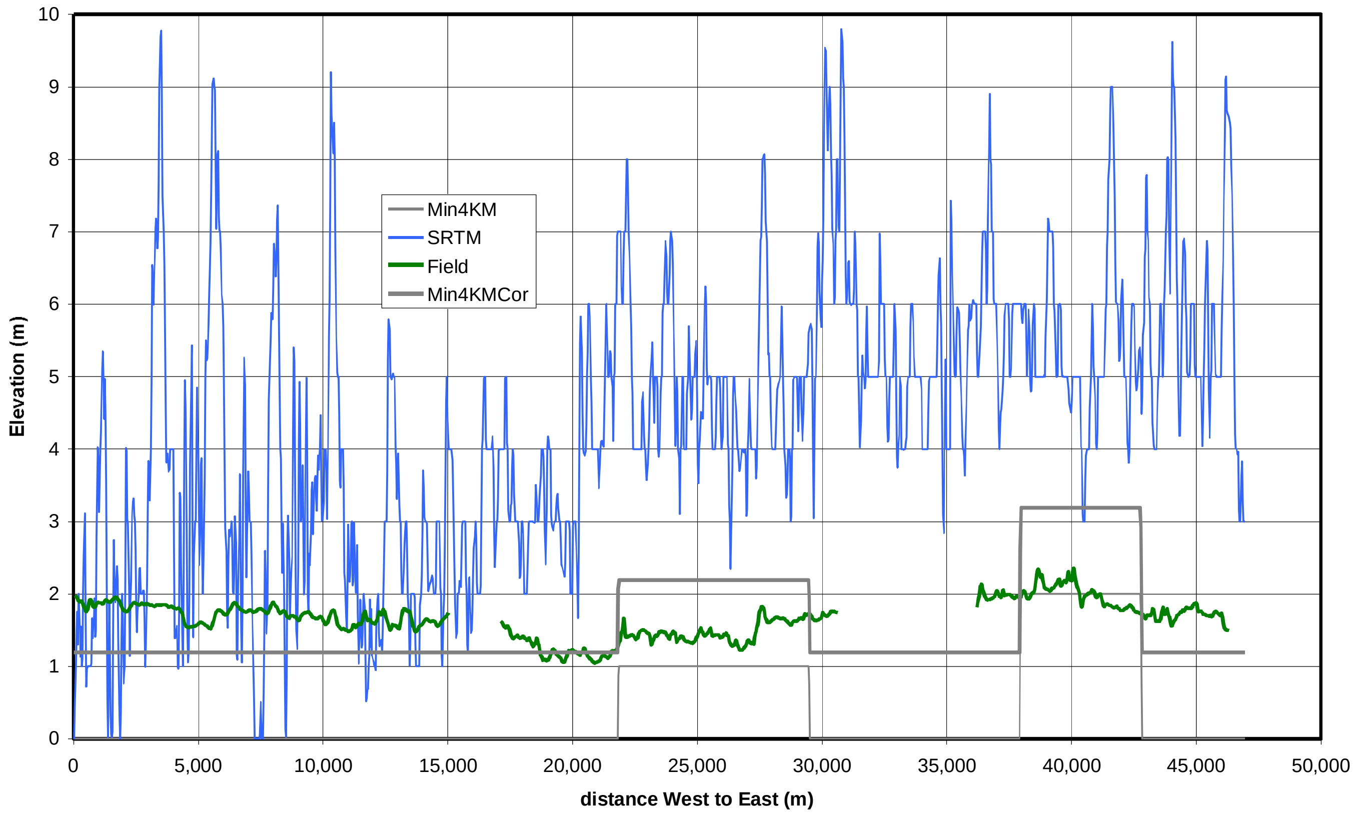
Deltares

SRTM30 South-Sumatra



Deltares

SRTM30 South-Sumatra

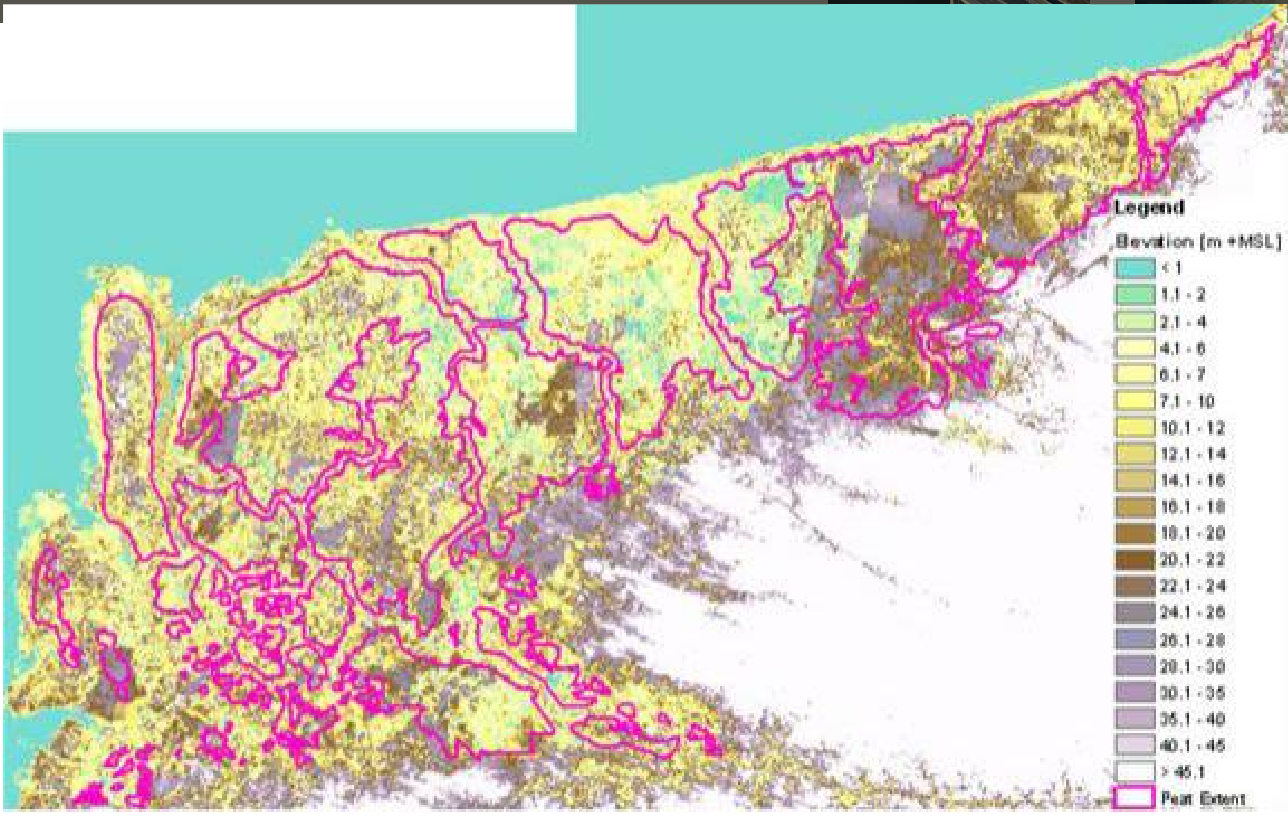


SRTM DEM

- Horizontal resolution 90x90m (publicly available)
- Horizontal resolution 30x30m (available to Indonesian authorities, LAPAN)
- Vertical resolution 1 meter
- Data collection not recent
- Data not filtered for vegetation

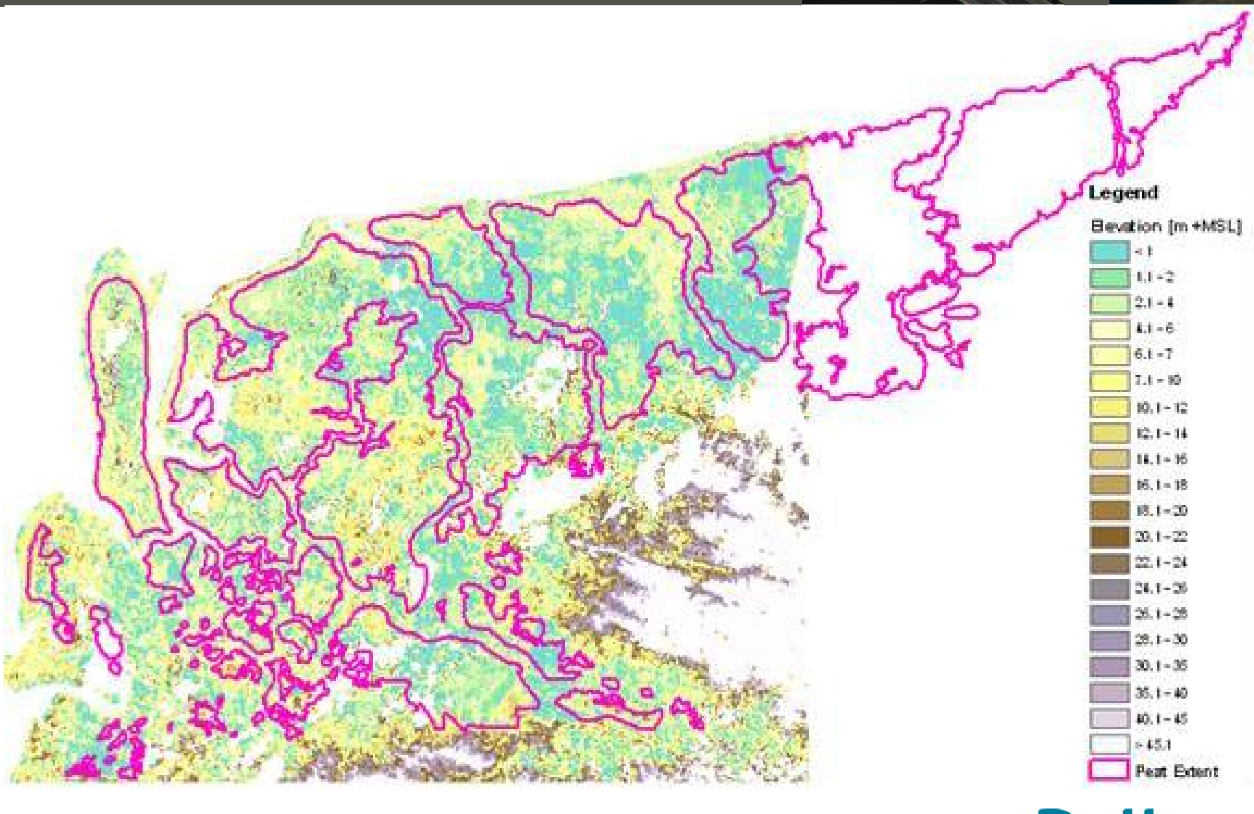
Deltares

DEM – ASTER GDEM



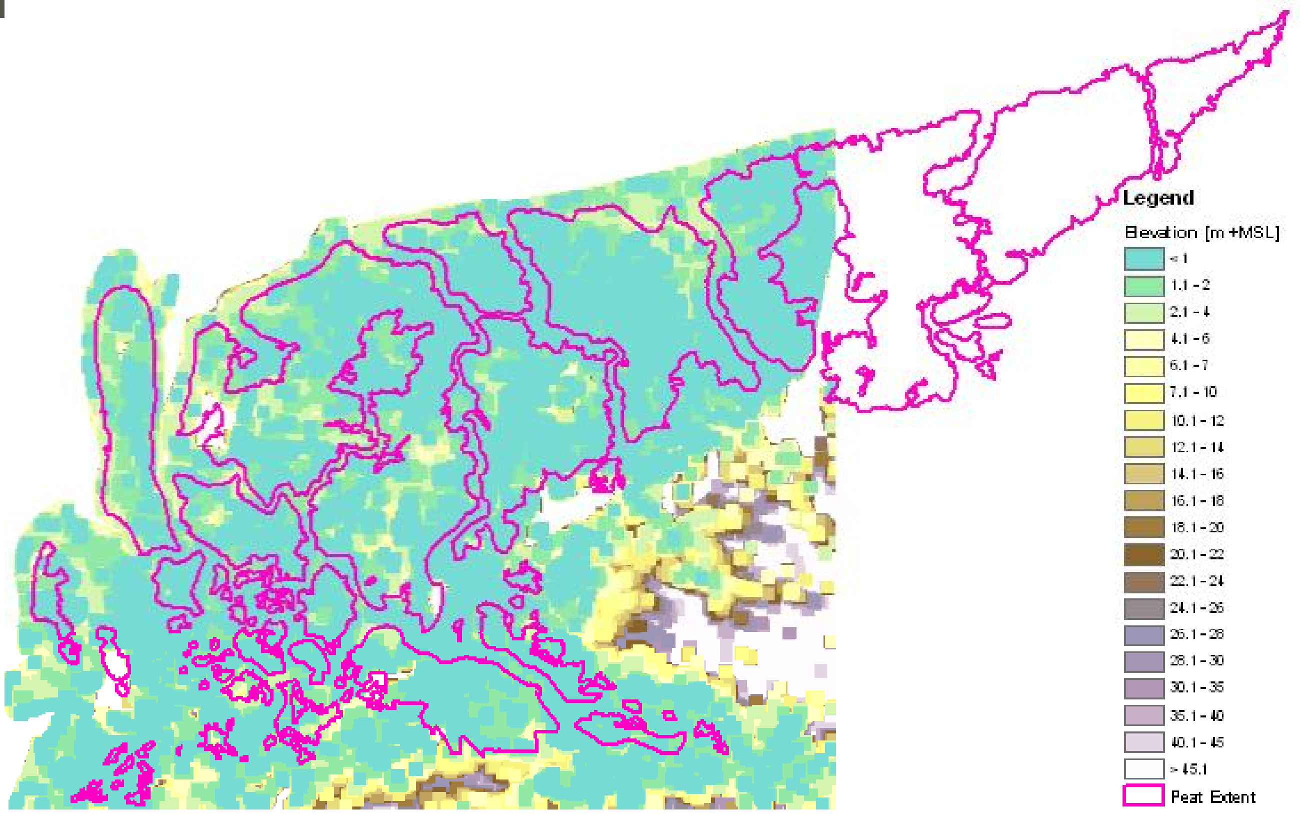
Deltares

DEM - ASTER GDEM, SRTM removed



Deltares

DEM – ASTER GDEM, SRTM removed, 2km min



ASTER GDEM

- Horizontal resolution 15*15m
- Vertical accuracy to be determined
- No complete coverage
- Not filtered for vegetation
- More recent data collection, but data collected at different moments

LiDAR

- To be collected for EMRP area, Central Kalimantan
- Expensive, so no complete coverage
- Expected to have high horizontal resolution (several point per m^2)
- Expected to have high vertical accuracy (within 20cm)

Deltares

2. Improved DEM for Indonesian Lowlands

- Cooperate with BAKOSURTANAL and LAPAN
- Combine different data sets
  - SRTM
  - ASTER
  - Other

Deltares

Peat thickness data requirements

- Accurate map of peat extent
- Horizontal resolution 1x1km or finer
- Accuracy peat thickness within 1m

Deltares

3. Improved peat thickness map

- In cooperation with partners (PUSLITANAK, University of Jambi?)
- Combine different data sets:
  - WI Peat Atlas
  - PUSLITANAK
  - RePPProT
  - Local databases

Deltares

4. Land use, concessions and prognoses

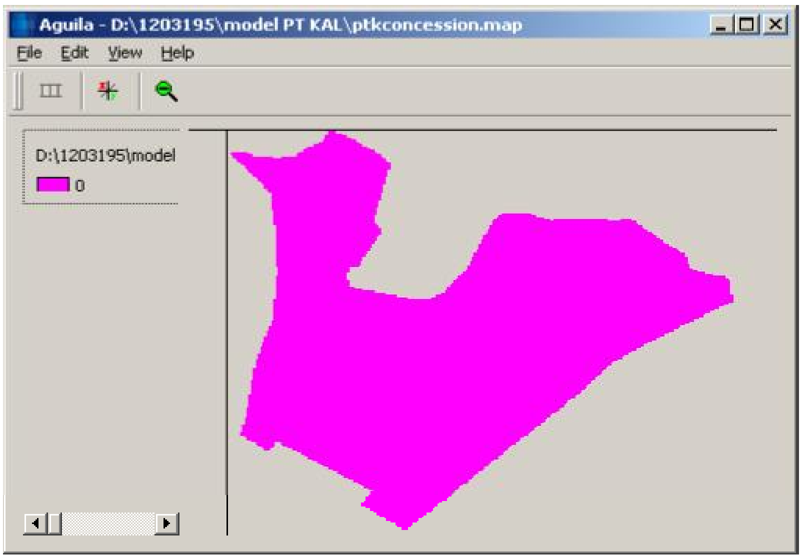
- Should primarily be expected from BAPENAS
- Concession data from Forestry
- Transmigration data from Agriculture
- Actual land cover from CRISP

First results of an emission model for two scenarios

Marnix van der Vat

PCRaster training
Bandung, July 28, 2011

Input concession



Deltares

Assumptions

Peat depth class 100-200cm, 1.5m

Peat depth class 400-800cm, 6.0m

No buffer outside concession

No buffer outside peat

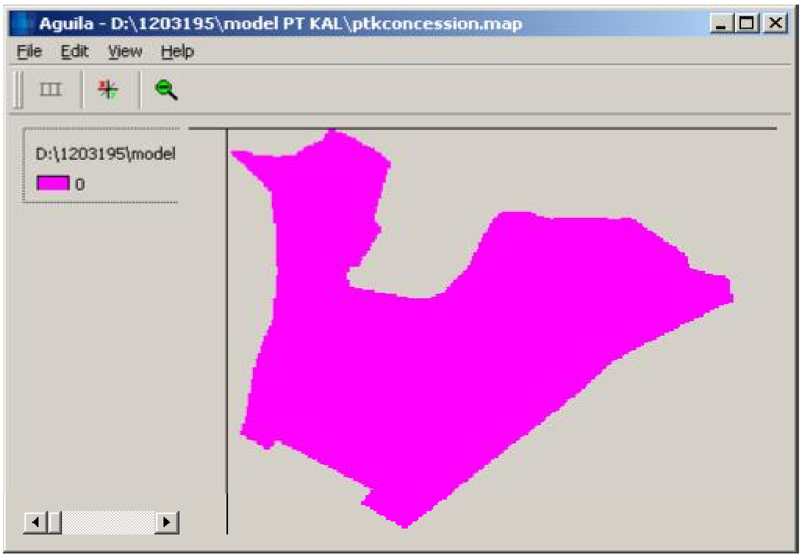
Plantation is all not in CAA and buffer (so also outside concession)

Emission factor 15.10 ton CO2/ha/cm for both initial and residual subsidence

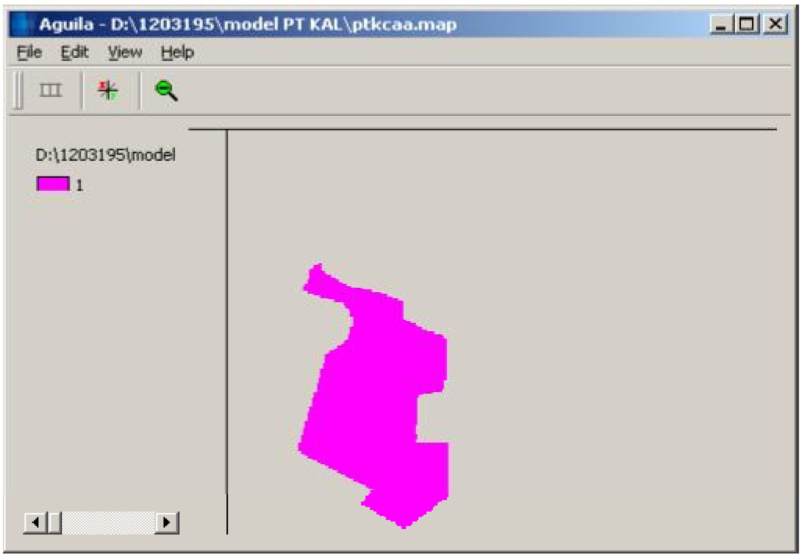
Scenarios

Scenario 1	Scenario 2
▪ Conservation ▪ Transmissivity 1000m2/d ▪ Drainage level plantation 1.2m constant depth ▪ Drainage levels canals and logging tracks fixed at 0.6m (so drainage depth does not follow subsidence) ▪ Buffer extent 1000m	▪ Development (all plantation) ▪ Transmissivity 1000m2/d ▪ Drainage level plantation 1.2m constant depth (so drainage depth follows subsidence)

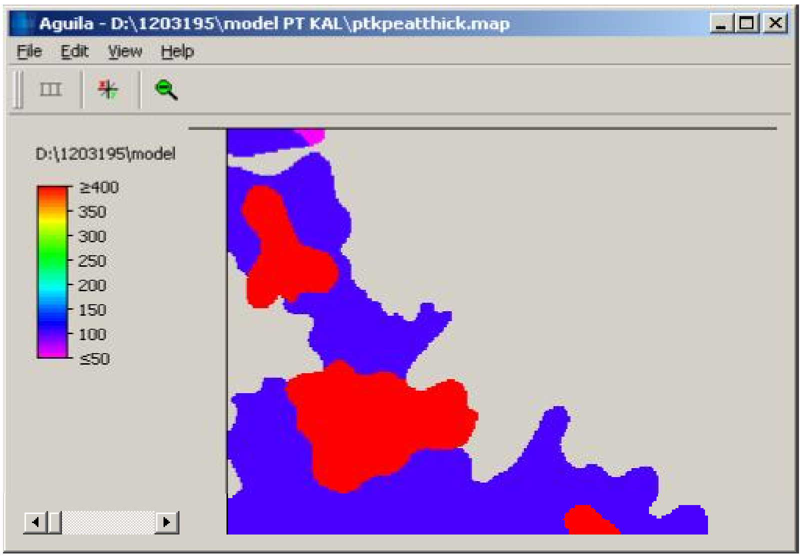
Input concession



Input CAA

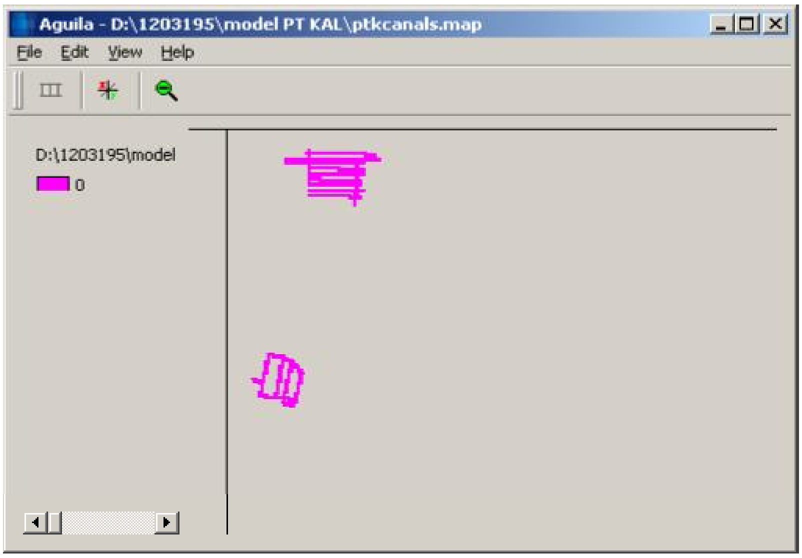


Input peat thickness



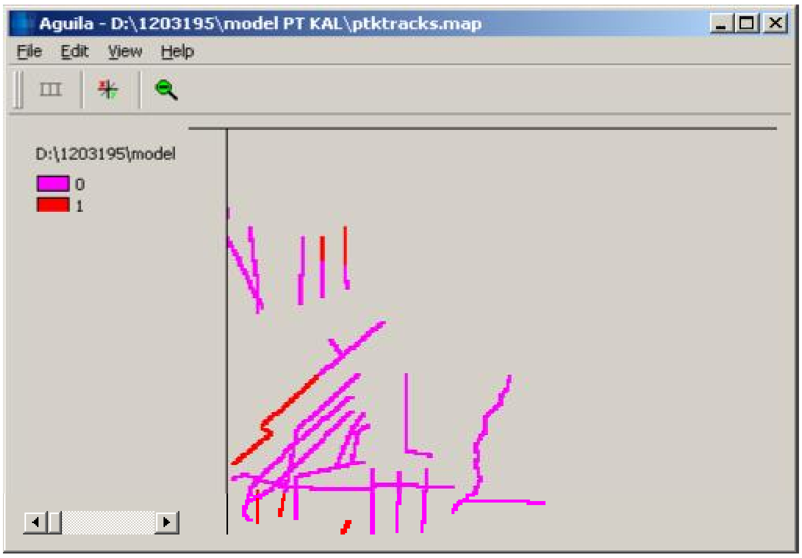
Deltares

Input canals

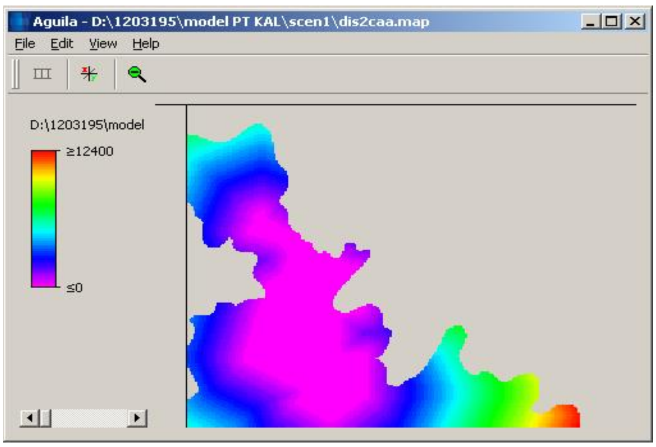


Deltares

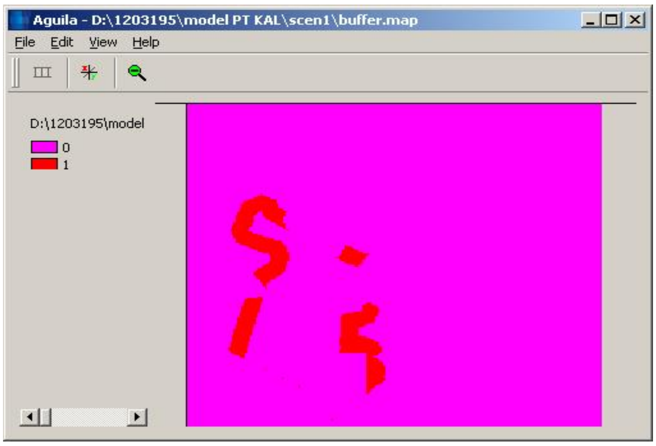
Input logging tracks



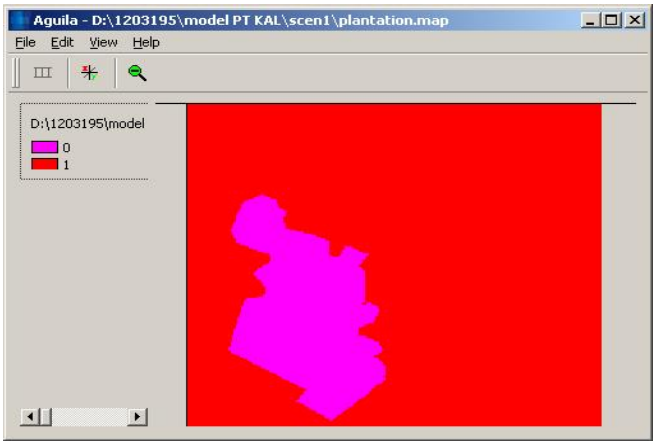
Distance to CAA

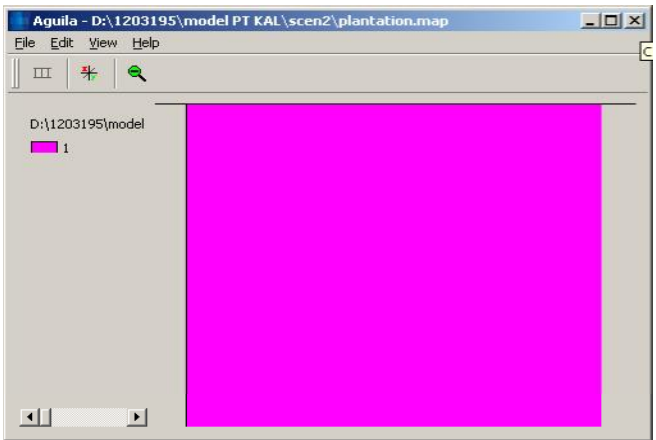


Buffer

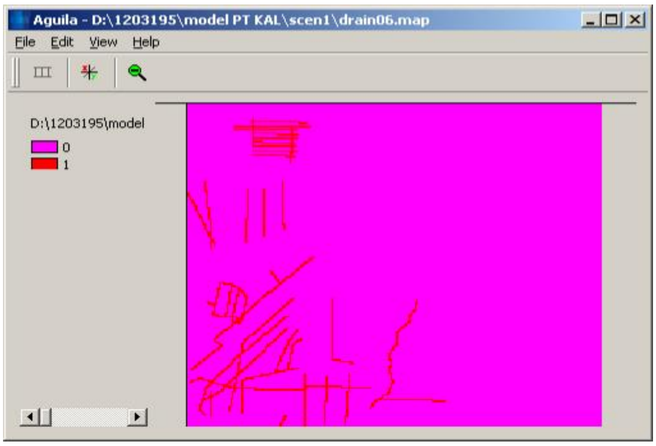


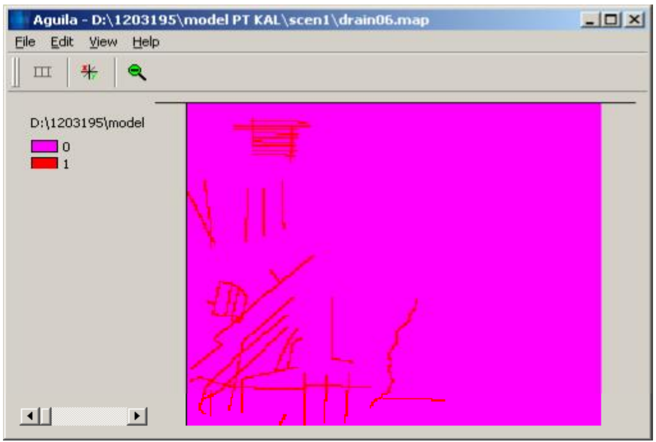
Plantation



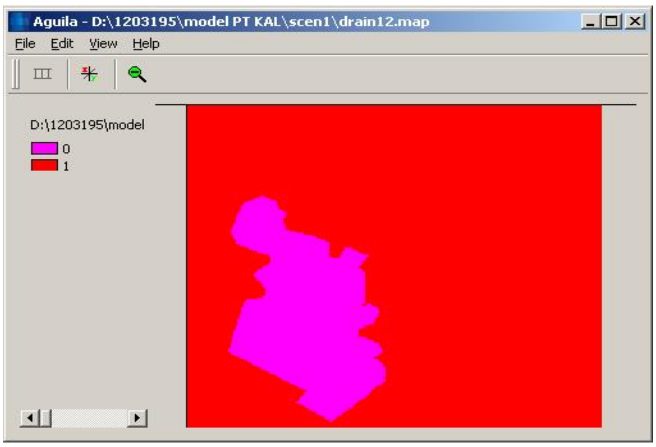


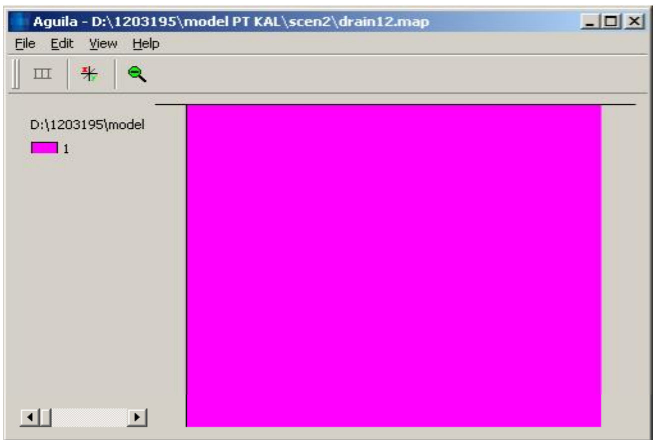
Drainage initial at 0.6m



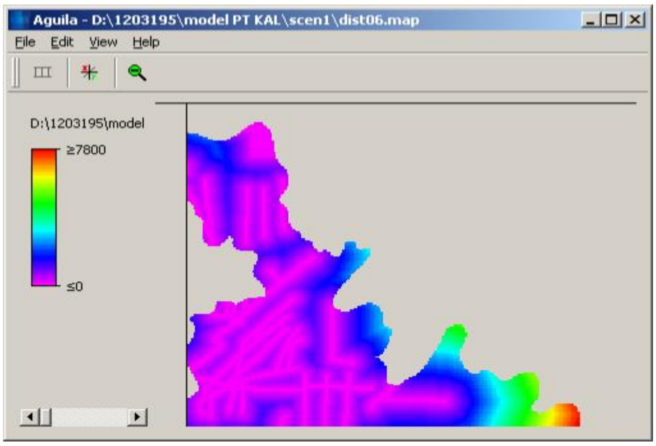


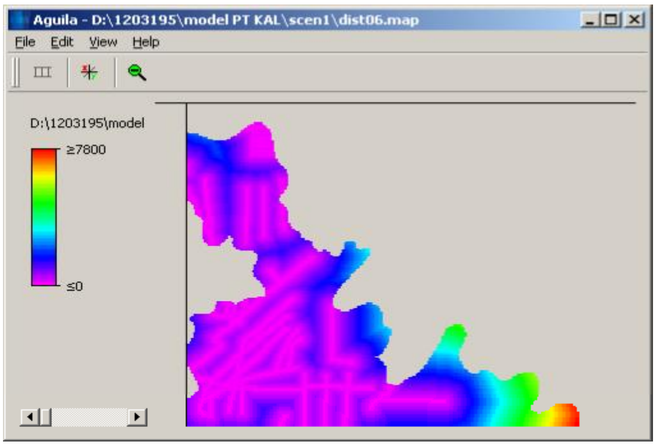
Drainage initial at 1.2m





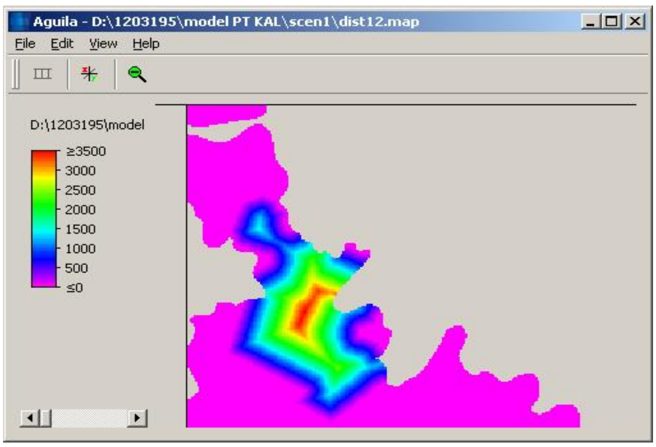
Distance to 0.6m drainage

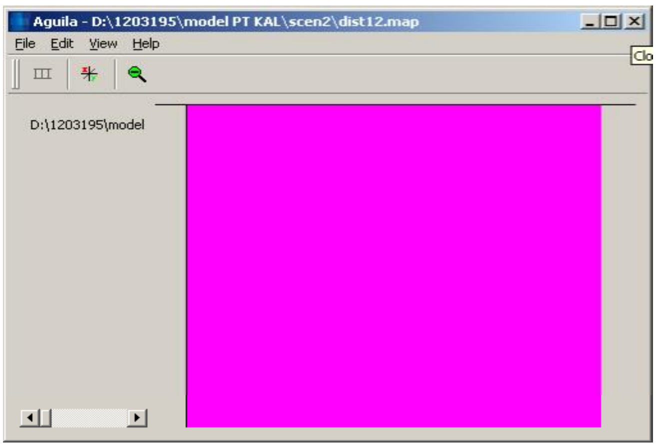




Deltares

Distance to 1.2m drainage

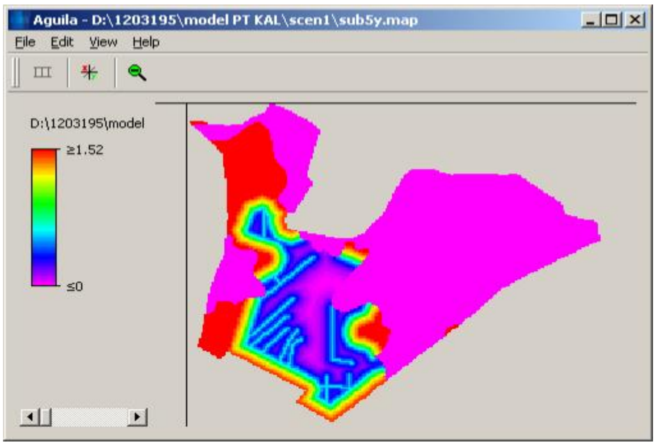


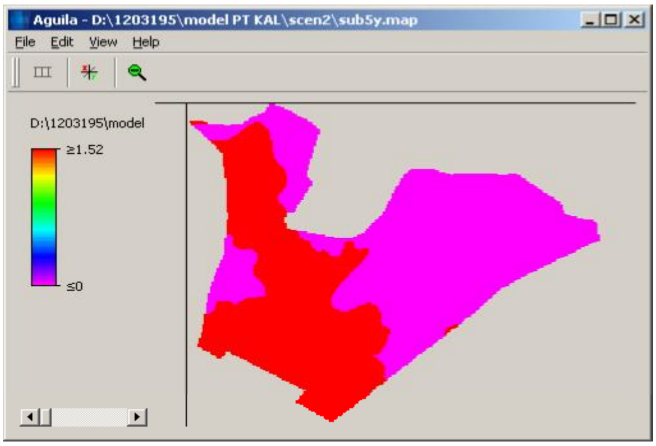


All 0

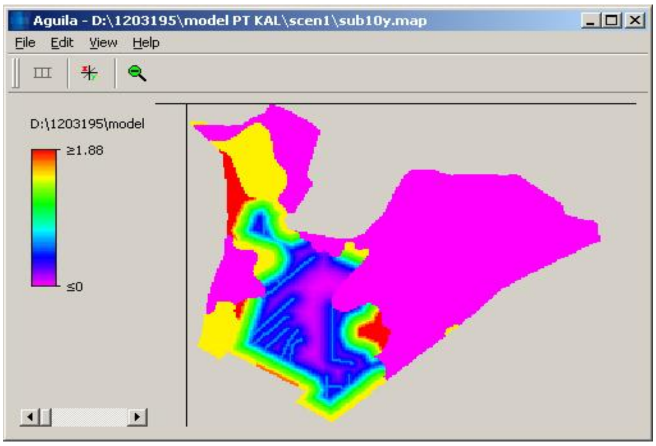
Deltares

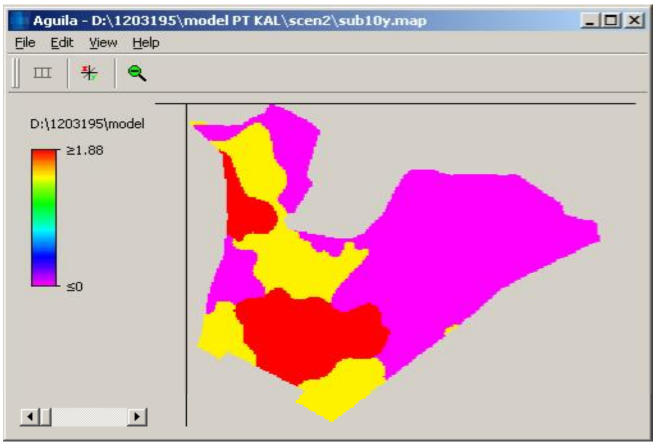
Subsidence after 5 years



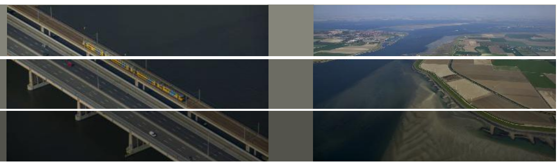


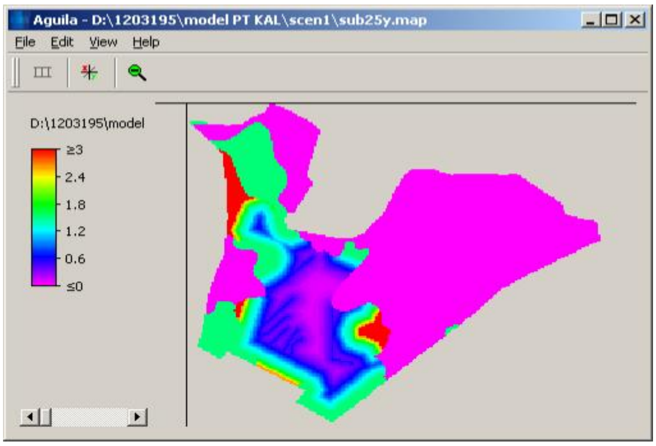
Subsidence after 10 years

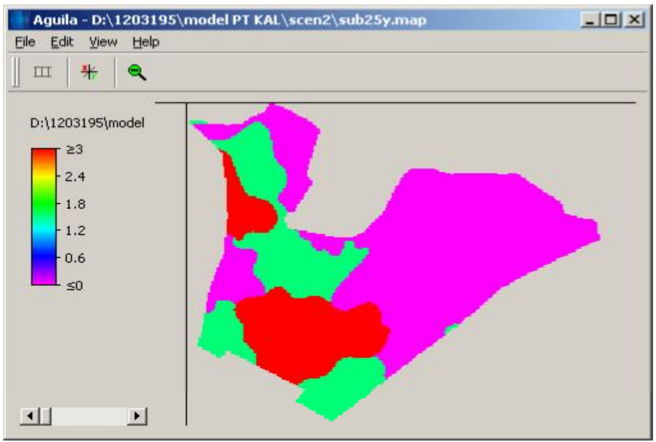




Subsidence after 25 years

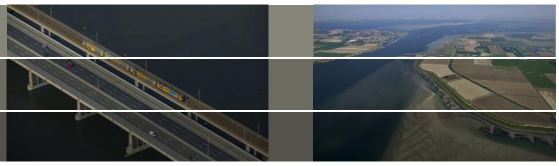


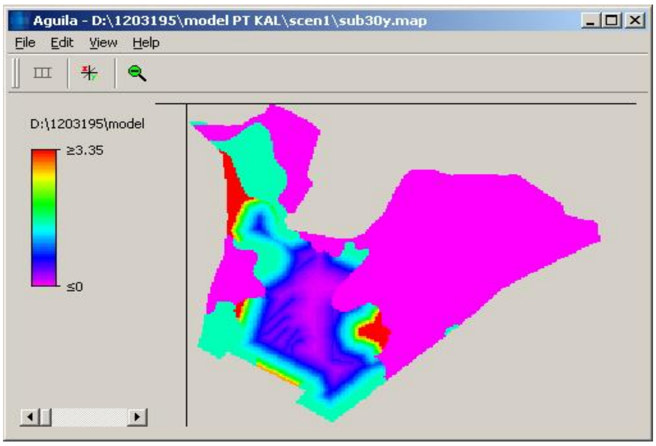


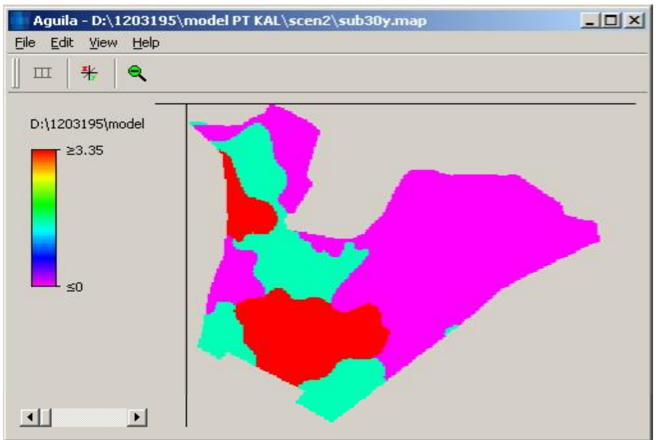


Deltares

Subsidence after 30 years

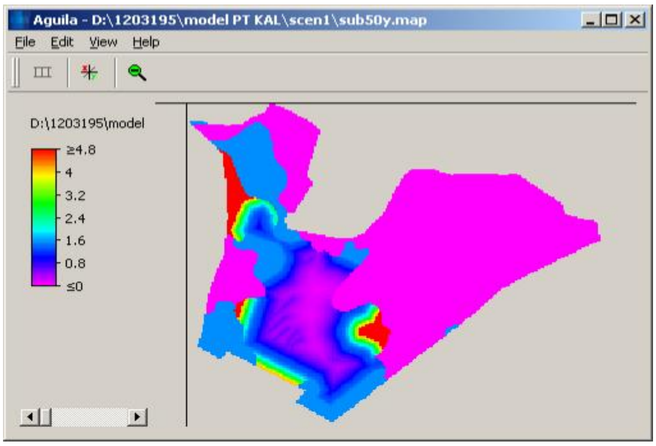


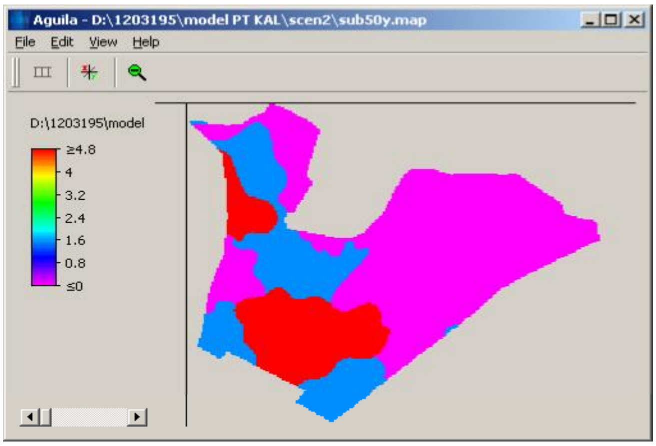




Deltares

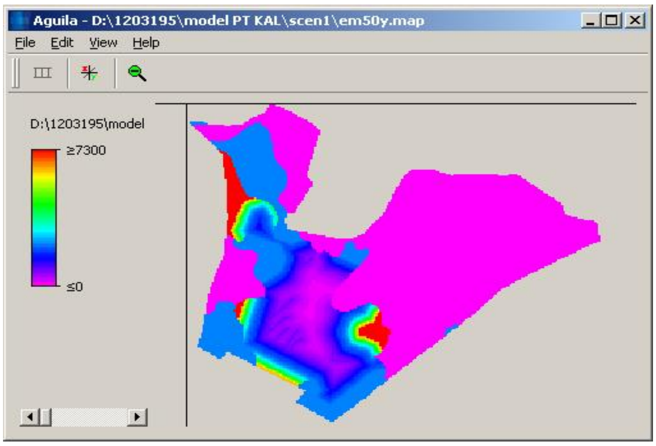
Subsidence after 50 years

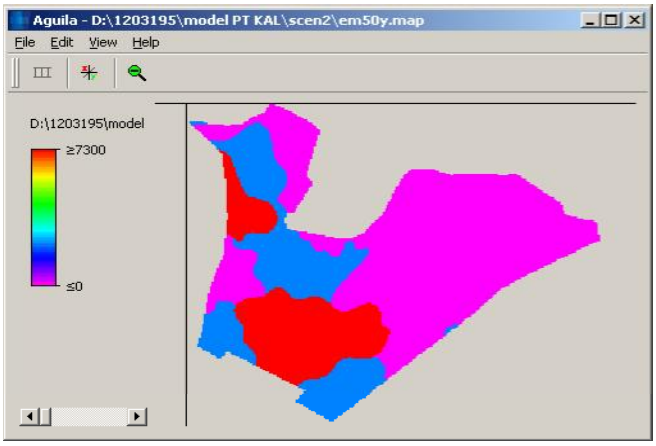




Deltares

Emission after 50 years (ton CO2/ha)

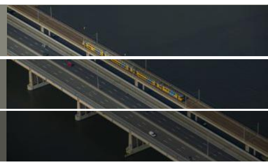




Deltares

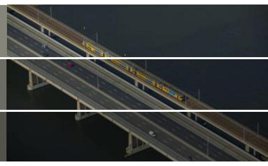
Total emission (Mton CO2)			
Year	Scenario 1	Scenario 2	Reduction
5	107,000	196,000	88,000
10	122,000	217,000	96,000
25	150,000	282,000	132,000
30	158,000	304,000	146,000
50	189,000	390,000	201,000

Average annual emission (Mton CO2/y)			
Year	Scenario 1	Scenario 2	Reduction
5	21,000	39,000	18,000
10	12,000	22,000	10,000
25	6,000	11,000	5,000
30	5,000	10,000	5,000
50	4,000	8,000	4,000




Average total emission within concession (ton CO2/ha)			
Year	Scenario 1	Scenario 2	Reduction
5	537	979	442
10	608	1087	479
25	749	1411	662
30	790	1520	730
50	943	1951	1008

Deltares




Average annual emission within concession (ton CO2/ha/y)			
Year	Scenario 1	Scenario 2	Reduction
5	107	196	88
10	61	109	48
25	30	56	26
30	26	51	24
50	19	39	20

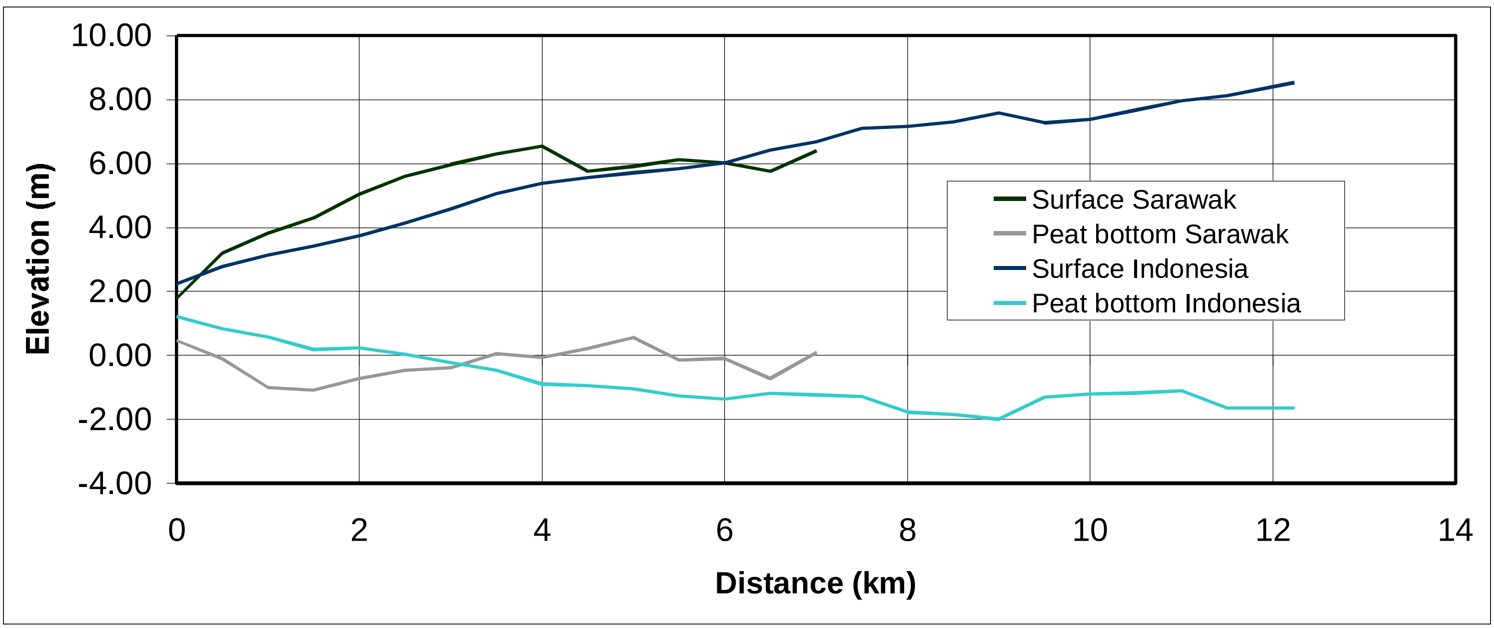
Deltares

Sarwak subsidence model trial application

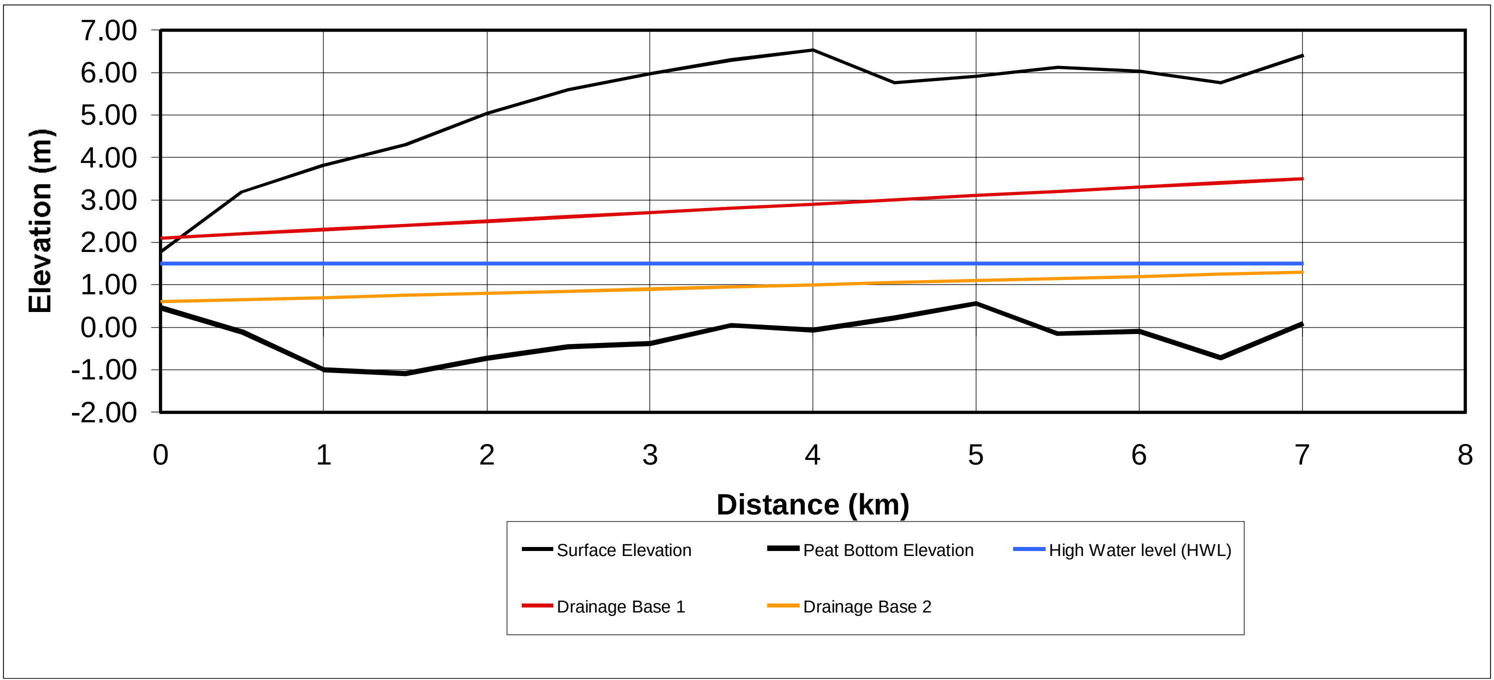
Marnix van der Vat

JCP Workshop peatland subsidence
Bandung, July 26 and 27, 2011

Average profile Indonesian and Sarawak peat domes

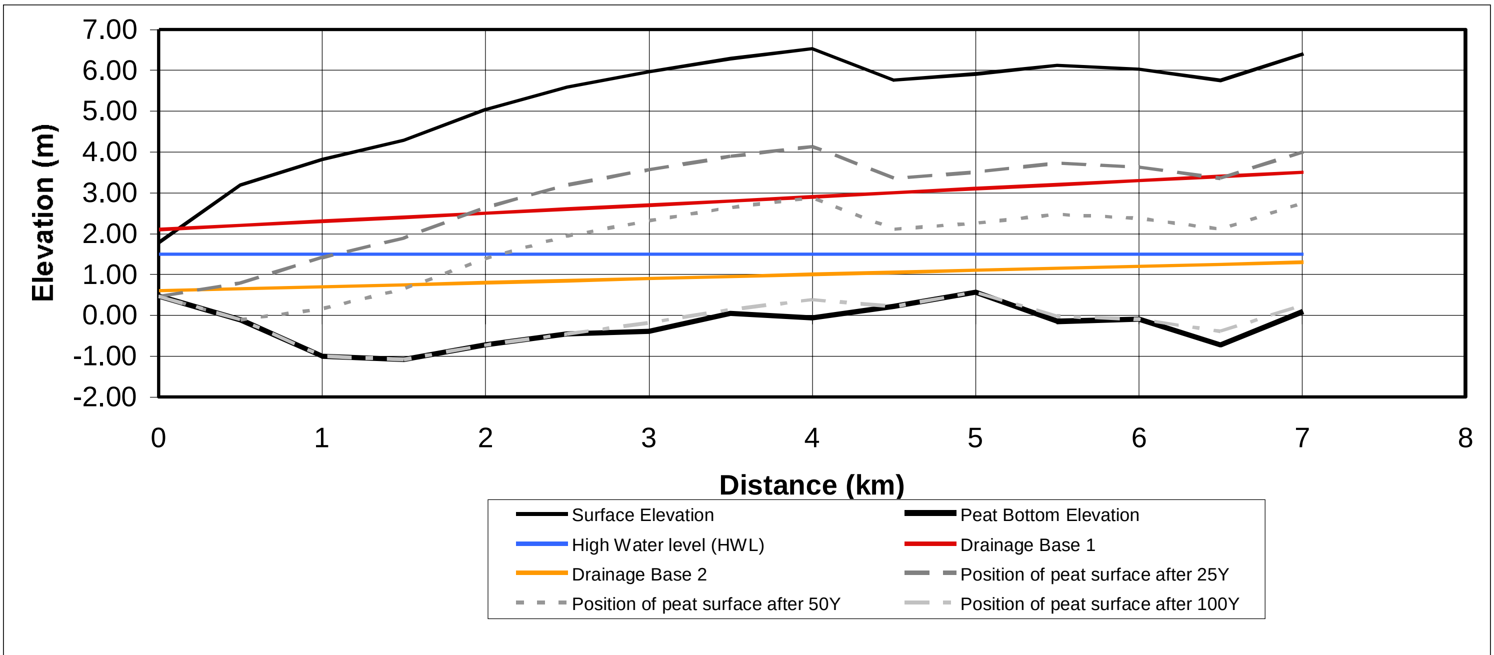


Flooding and drainage limits



Deltares

Development flooding and drainage problems



Deltares

Geographical model

To support planning we need a map

Locations of areas with and without potential problems

Identification of areas to conserve and areas to develop

To make a map we need a geographical model and input maps

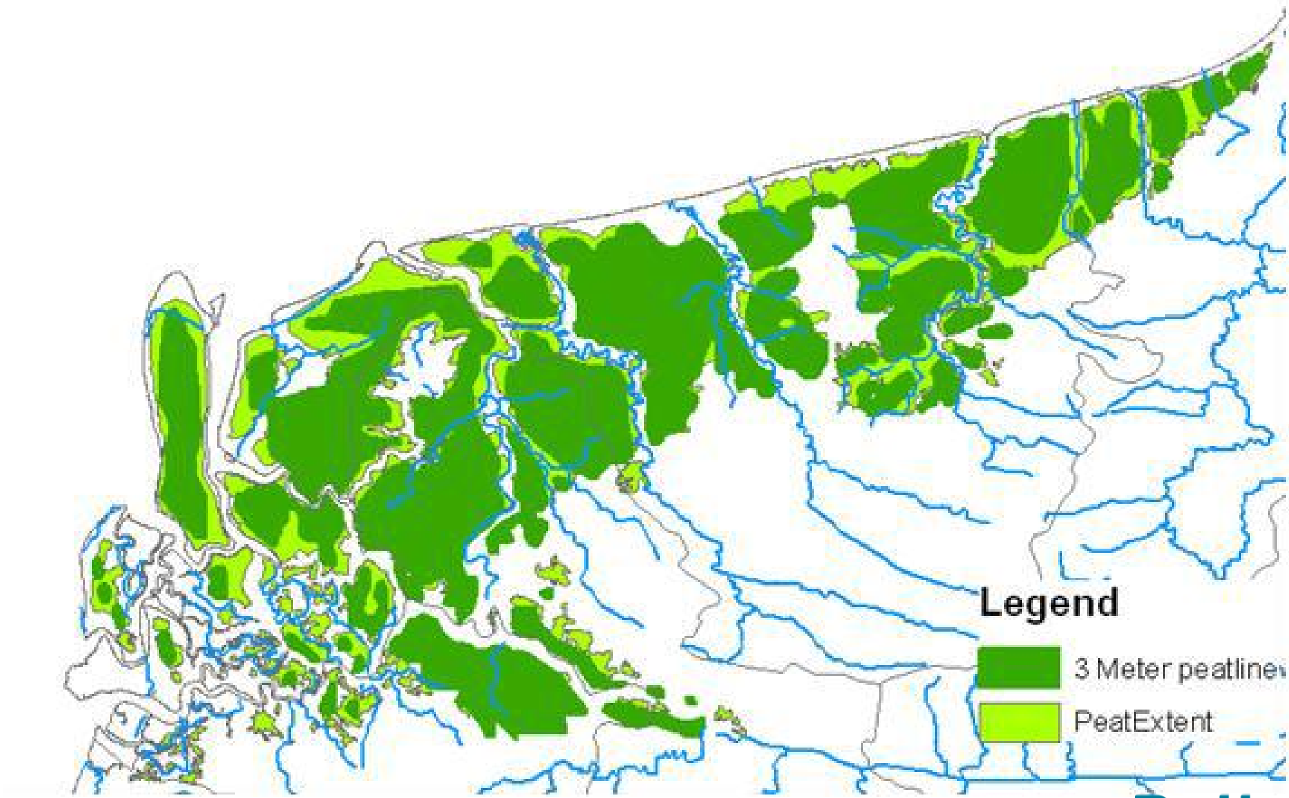
Geographical model works with same relations as Excel on distance to river

To make a map we need input maps

Input maps

- Coastline
- Rivers
- Peat thickness
- Elevation (DEM)

Coast, river and peat extent



Deltares

Input data

- No peat thickness
- No DEM

→ Take these from average profile as a relation of distance from river

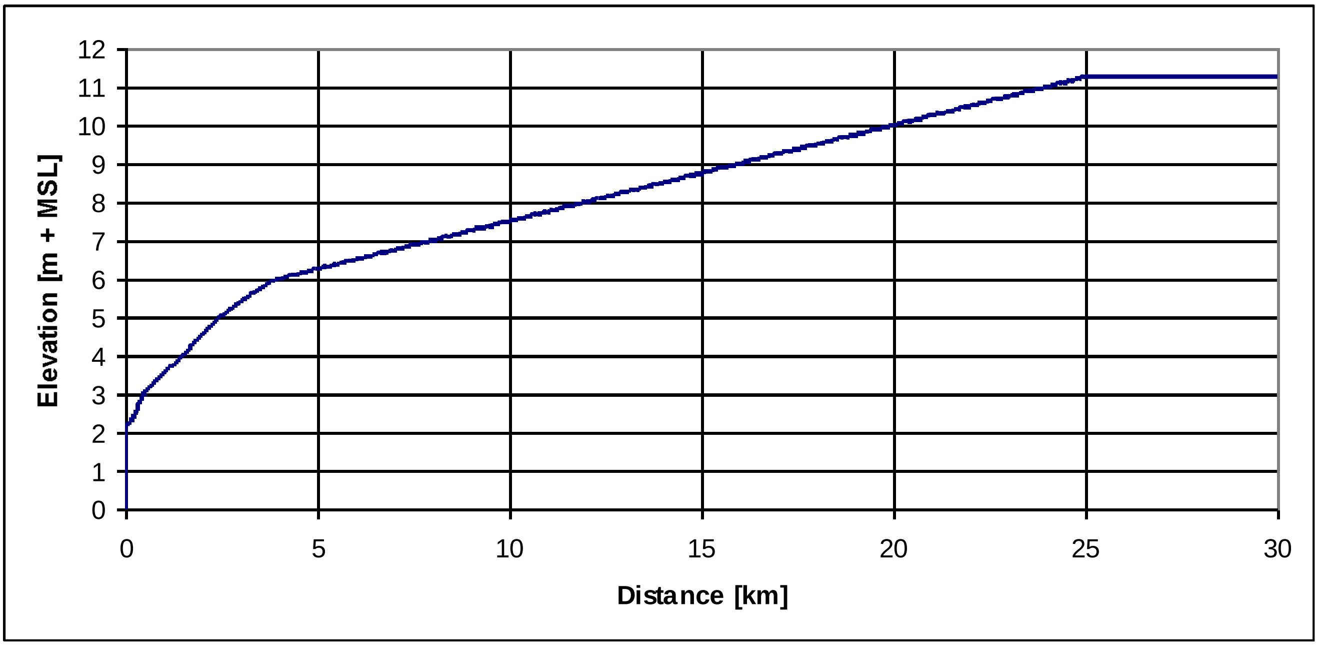
Deltares

Approximation of DEM

- Idealized relation between elevation and distance to river/sea
- Map of distance to river
- Map of distance to sea

Deltares

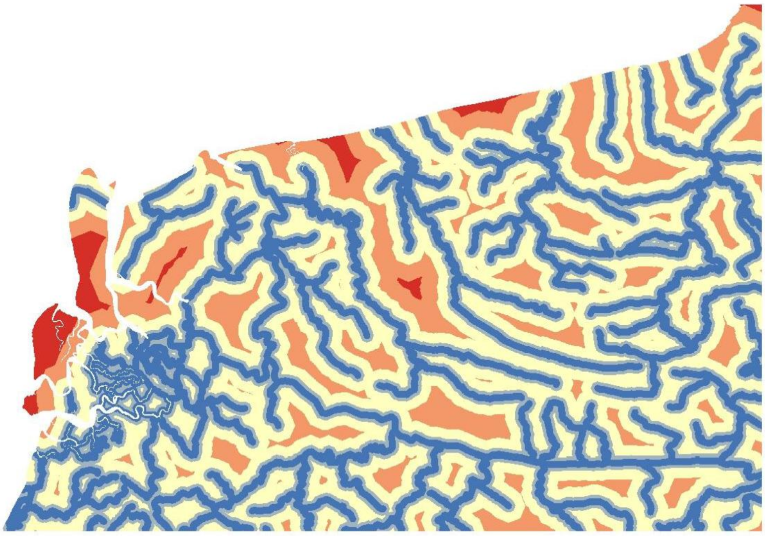
Relation between distance to river and elevation



Deltares

Map of distance to river

Distance to the nearest river



Kilometers from nearest river

- < 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10

N
0 5 10 20 30 40 KM

Map of distance to the nearest river

Client	RNE
Project	JCP
Date:	July 24, 2011
Version:	1.0

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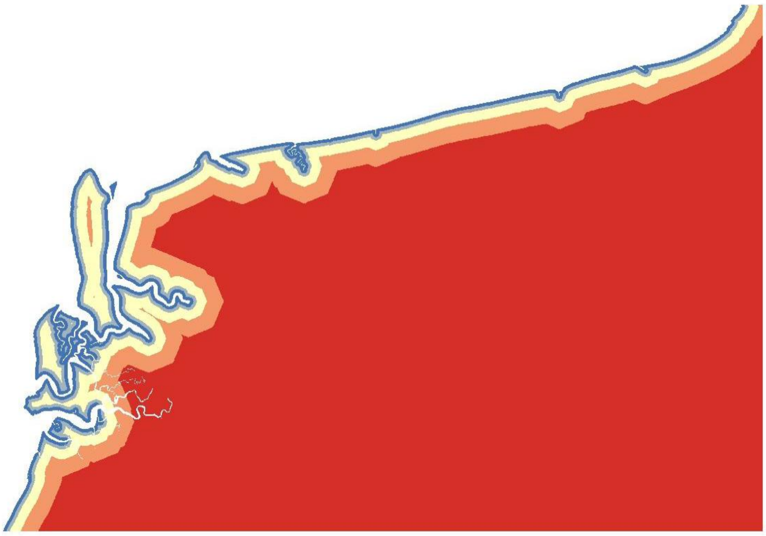
Deltares

Map of distance to sea

Distance to the sea



Kilometers from the sea

- < 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10

N
0 5 10 20 30 40 KM

Map of distance to the sea

Client	RNE
Project	JCP
Date:	July 24, 2011
Version:	1.0

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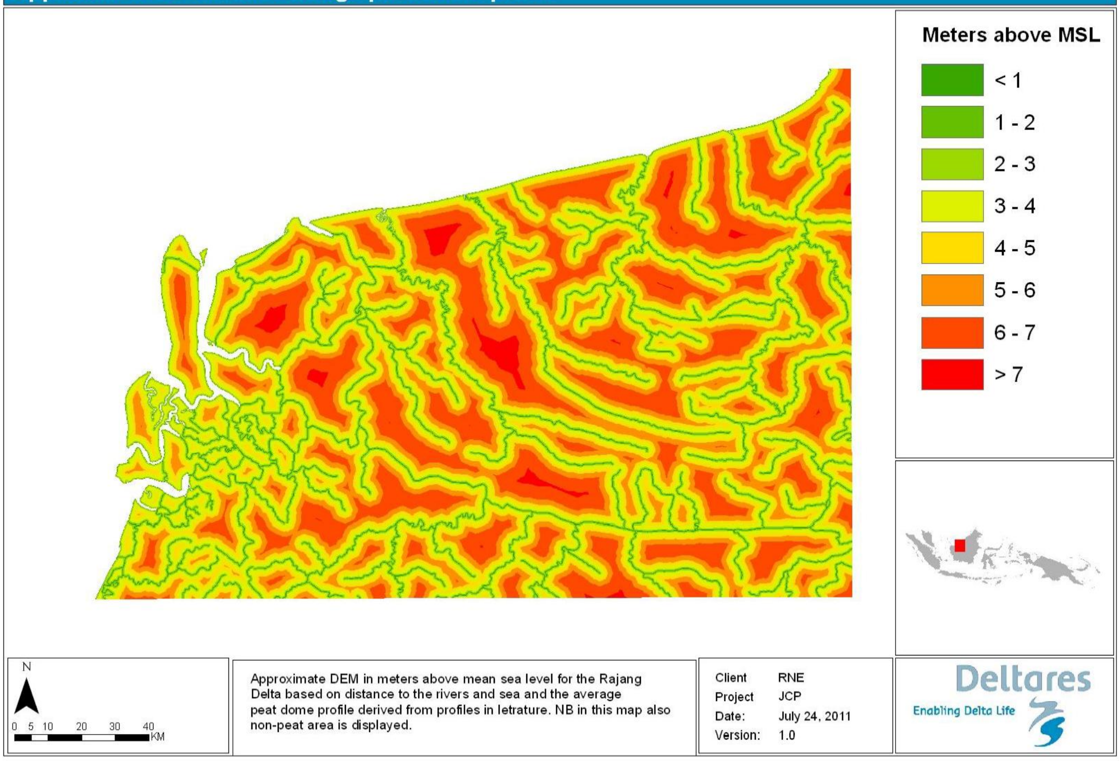
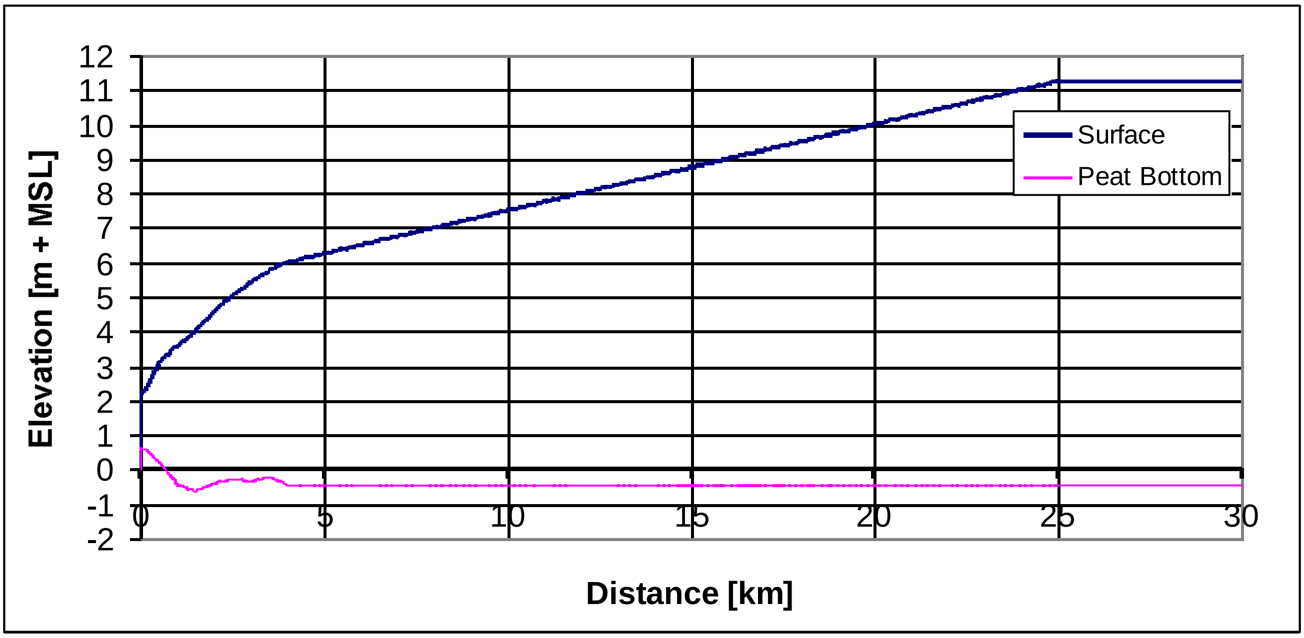
Approximate DEM

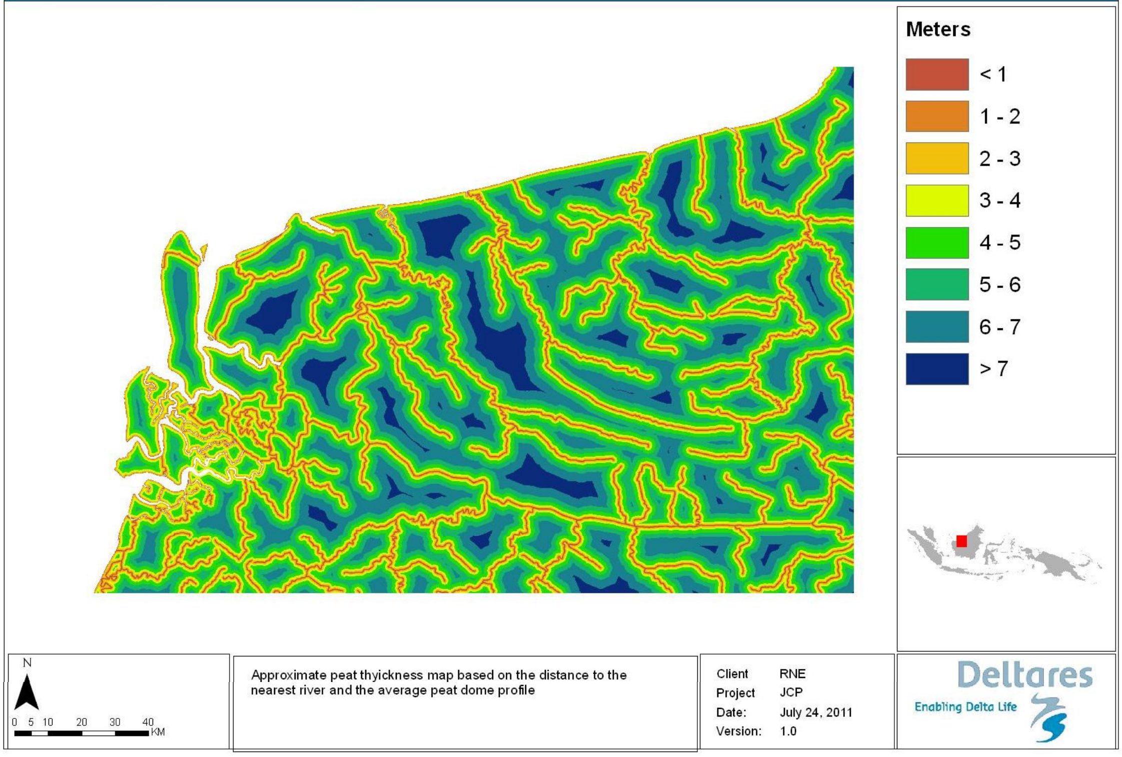


Relation between distance to river and peat bottom elevation



Approximate peat thickness

Approximate peat thickness map



Approximate peat thyickness map based on the distance to the nearest river and the average peat dome profile

Client	RNE
Project	JCP
Date:	July 24, 2011
Version:	1.0

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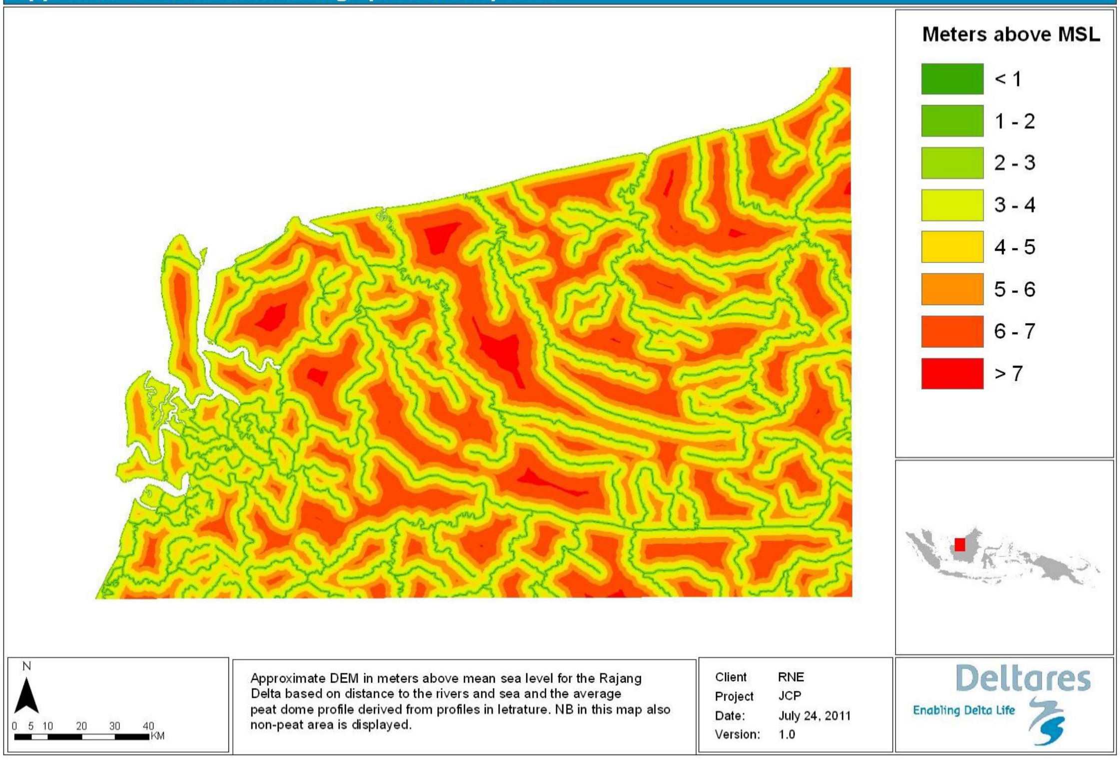
Approximate DEM

Approximate DEM from average peat dome profile



Approximate DEM in meters above mean sea level for the Rajang Delta based on distance to the rivers and sea and the average peat dome profile derived from profiles in letrature. NB in this map also non-peat area is displayed.

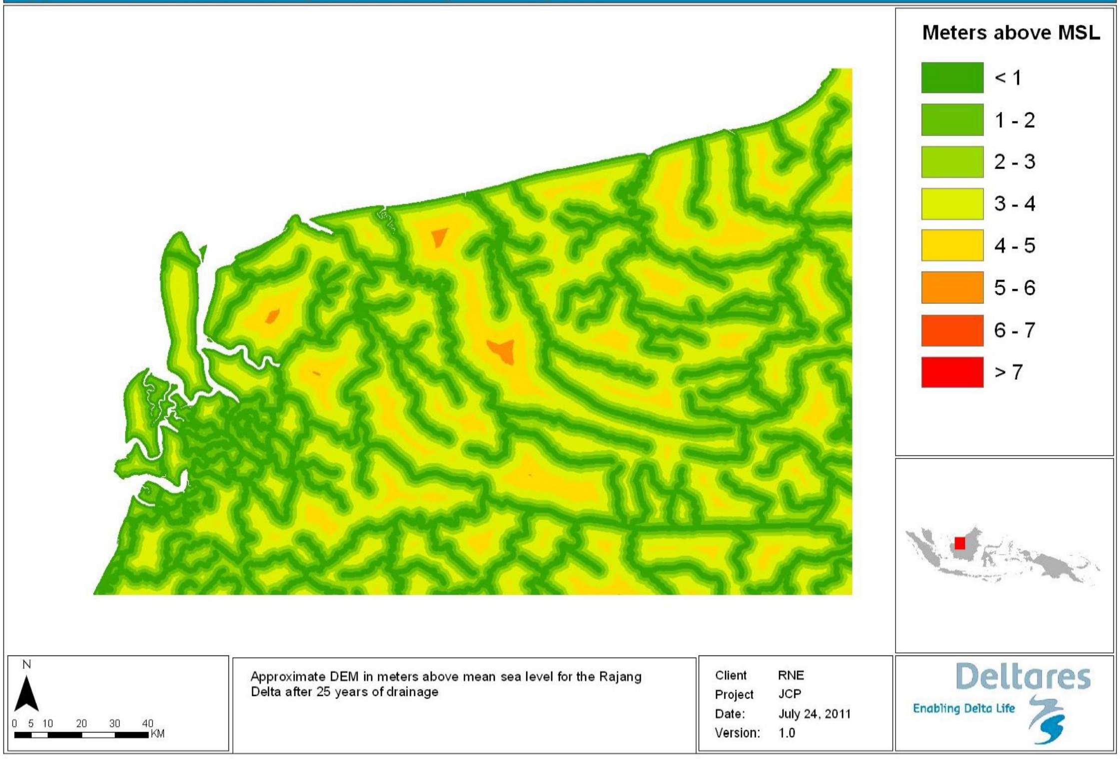
Client	RNE
Project	JCP
Date:	July 24, 2011
Version:	1.0

Deltares
Enabling Delta Life

Deltares

DEM after 25 years drainage

Approximate DEM after 25 years drainage of the peat



Approximate DEM in meters above mean sea level for the Rajang Delta after 25 years of drainage

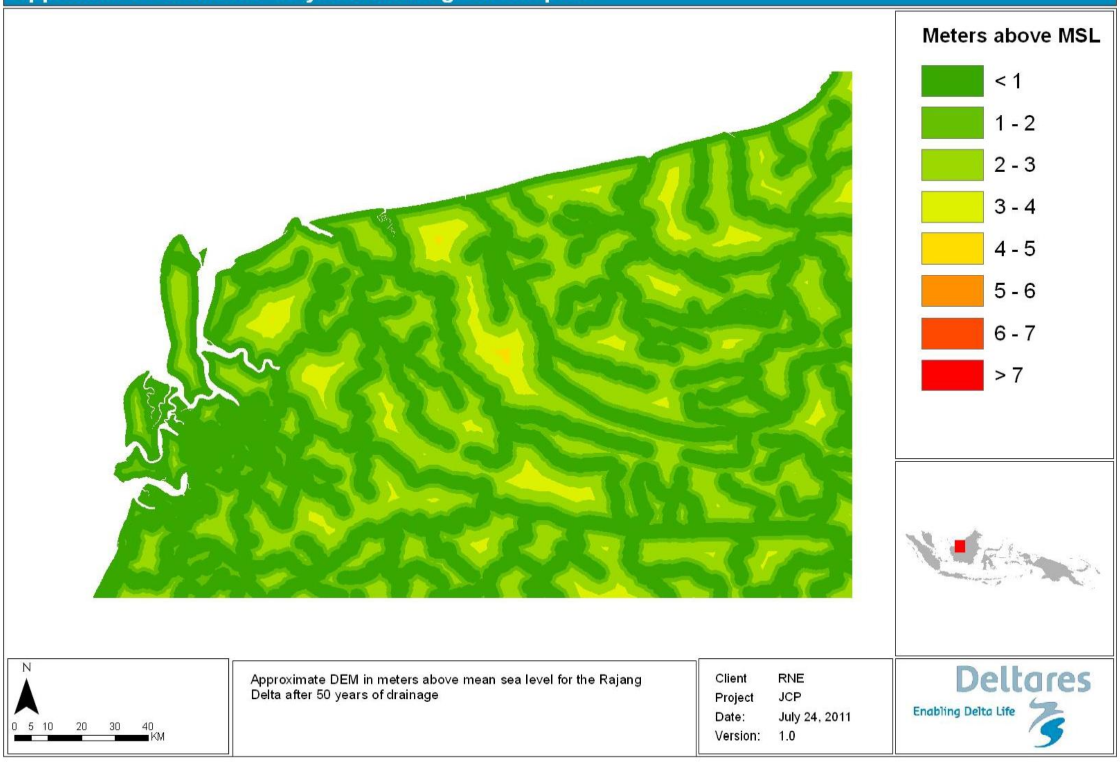
Client RNE
Project JCP
Date: July 24, 2011
Version: 1.0

Deltares
Enabling Delta Life

Deltares

DEM after 50 years drainage

Approximate DEM after 50 years drainage of the peat



Approximate DEM in meters above mean sea level for the Rajang Delta after 50 years of drainage

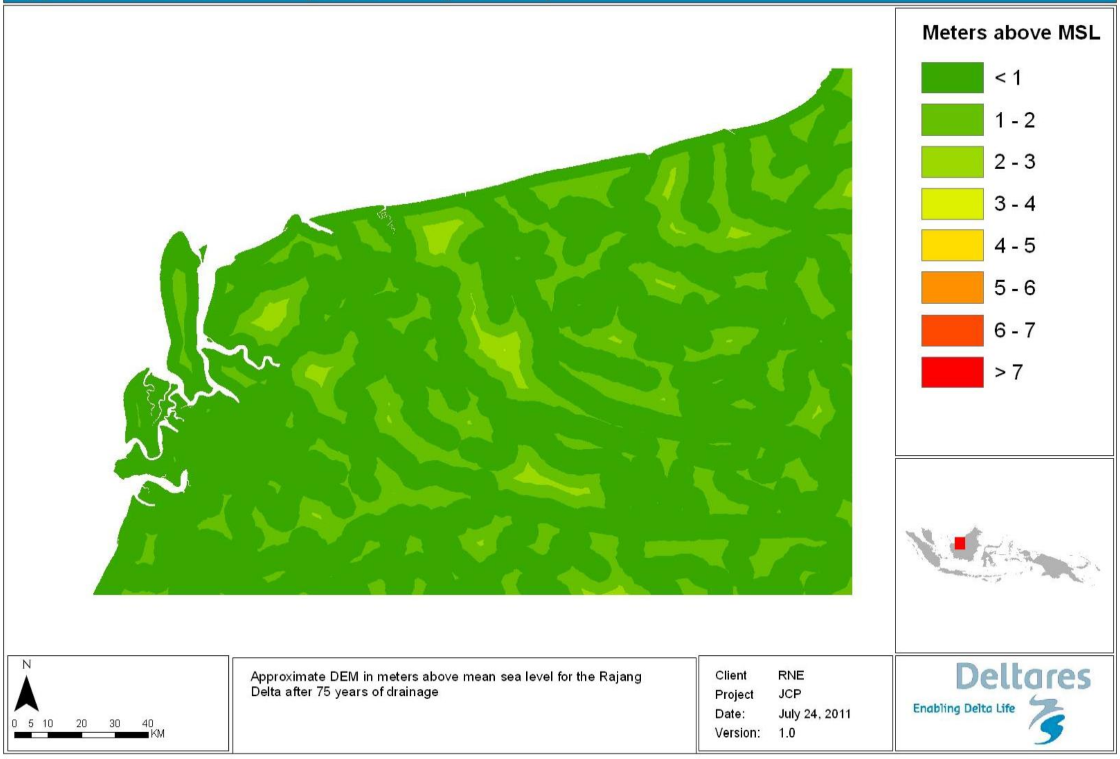
Client RNE
Project JCP
Date: July 24, 2011
Version: 1.0

Deltares
Enabling Delta Life

Deltares

DEM after 75 years drainage

Approximate DEM after 75 years drainage of the peat



Approximate DEM in meters above mean sea level for the Rajang Delta after 75 years of drainage

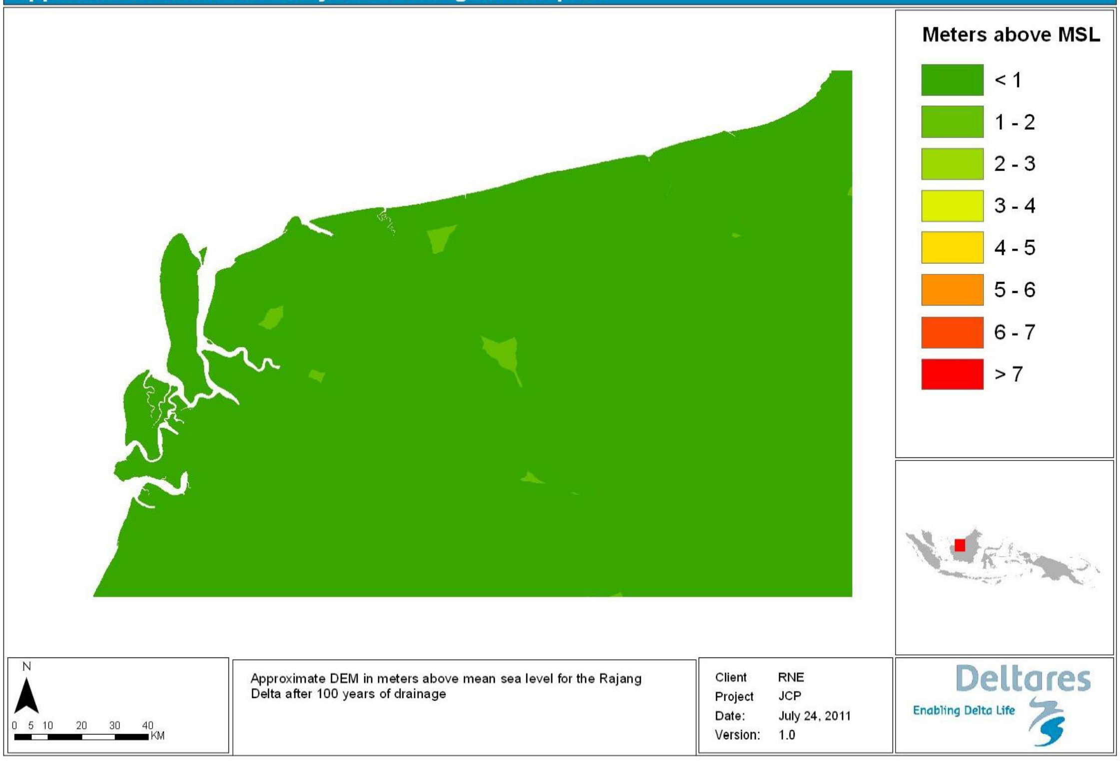
Client: RNE
Project: JCP
Date: July 24, 2011
Version: 1.0

Deltares
Enabling Delta Life

Deltares

DEM after 100 years drainage

Approximate DEM after 100 years drainage of the peat



Approximate DEM in meters above mean sea level for the Rajang Delta after 100 years of drainage

Client: RNE
Project: JCP
Date: July 24, 2011
Version: 1.0

Deltares
Enabling Delta Life

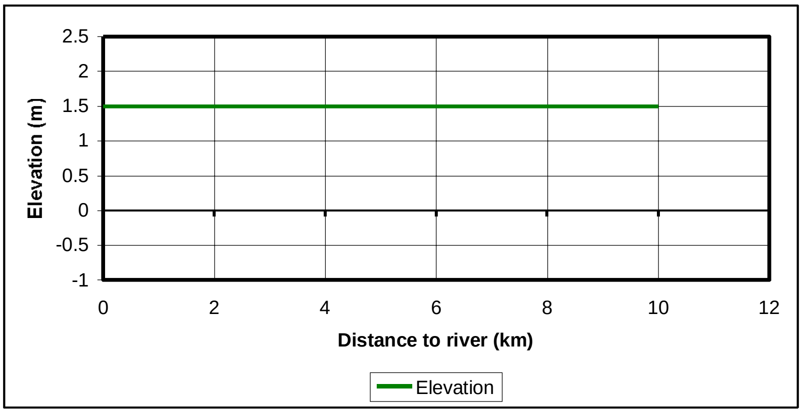
Deltares

Calculation of drainability

- Zero drainage level
  HDrain0 = D2river * head loss (20cm/km)
- Drainge depth = Elevation – HDrain0
- Classify:
  1. < 0m
  2. 0 – 0.3m
  3. 0.3 – 0.6m
  4. > 0.6m

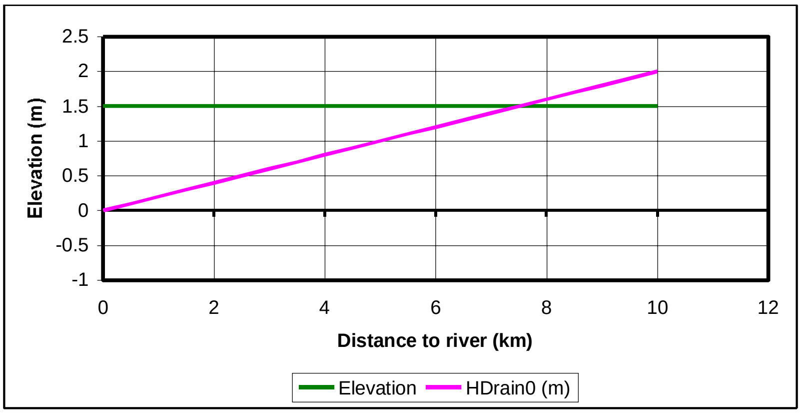
Deltares

Example of drainability calculation



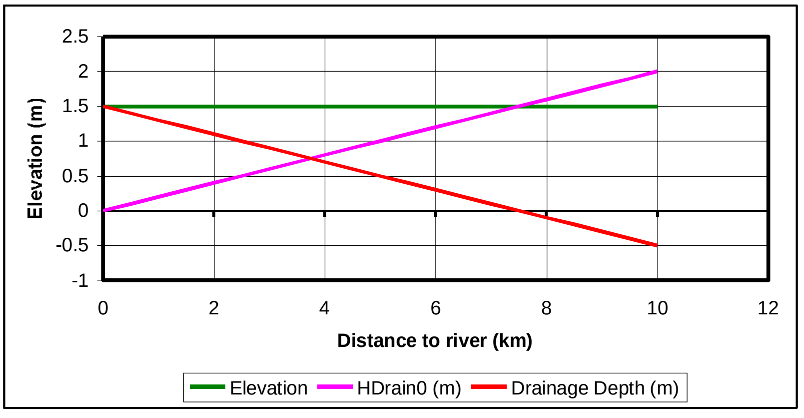
Deltares

Example of drainability calculation



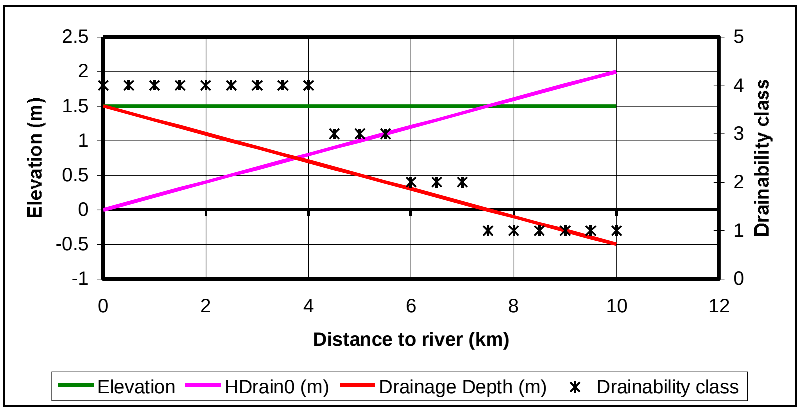
Deltares

Example of drainability calculation

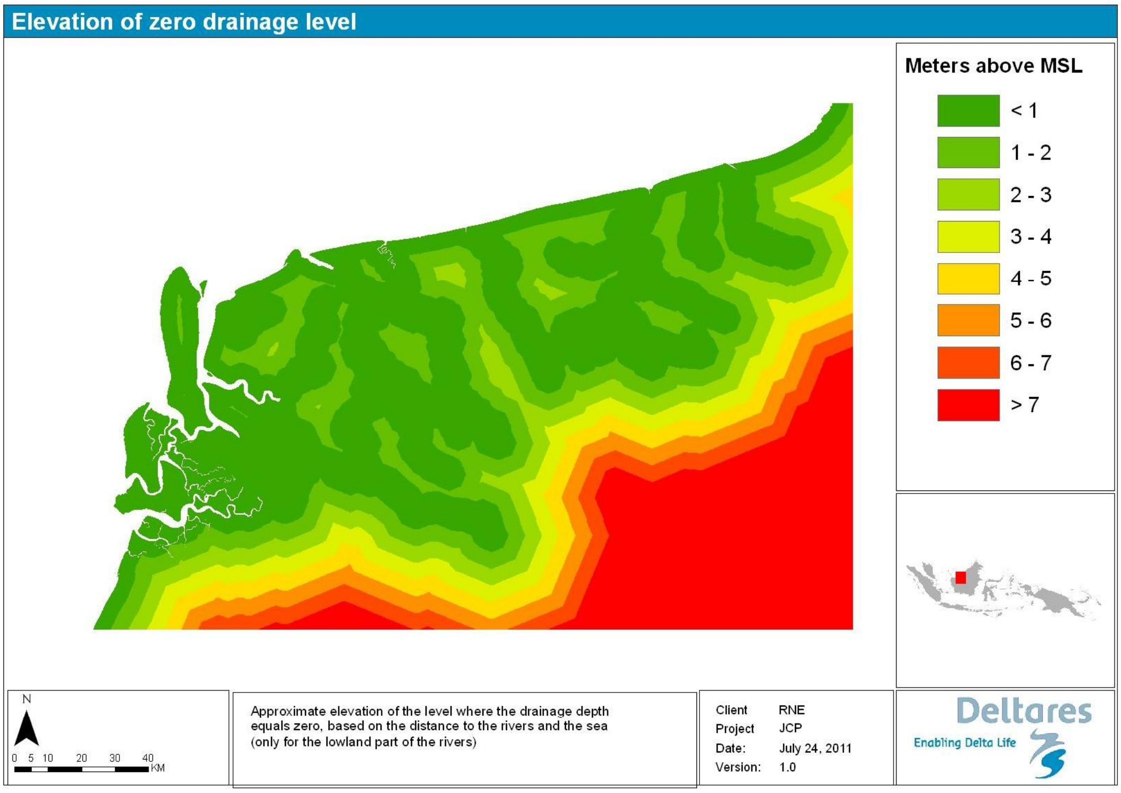


Deltares

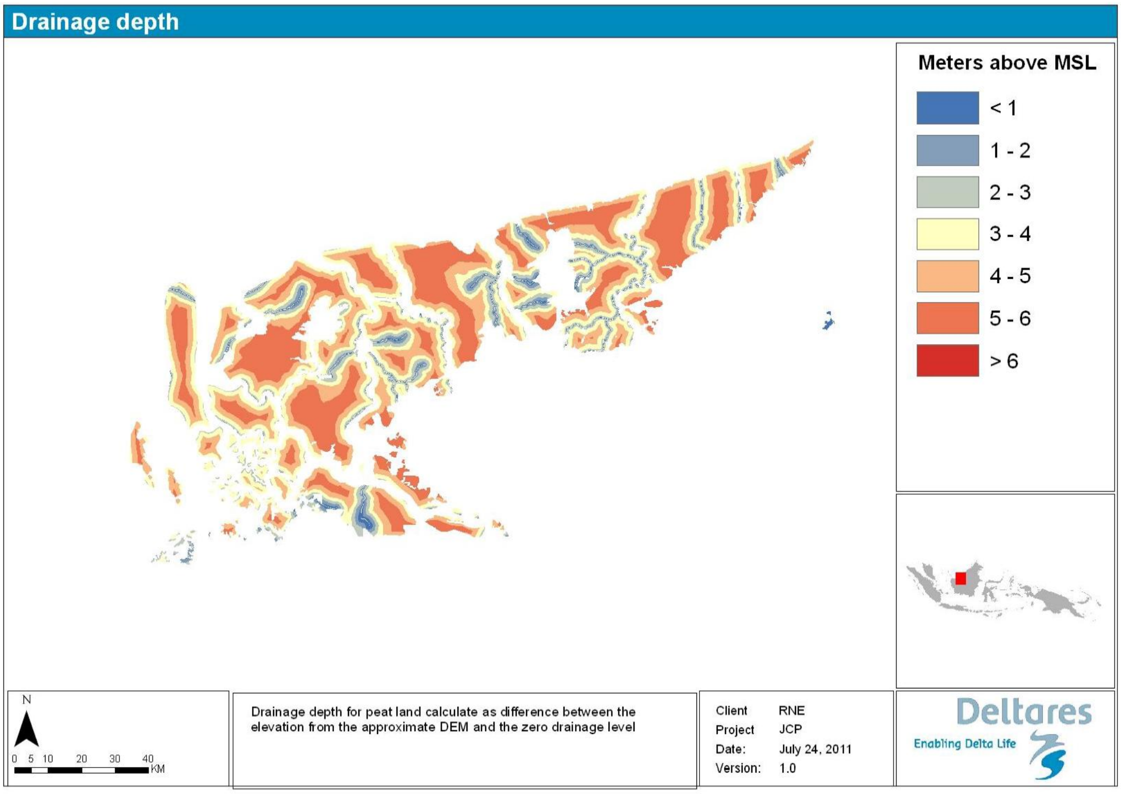
Example of drainability calculation



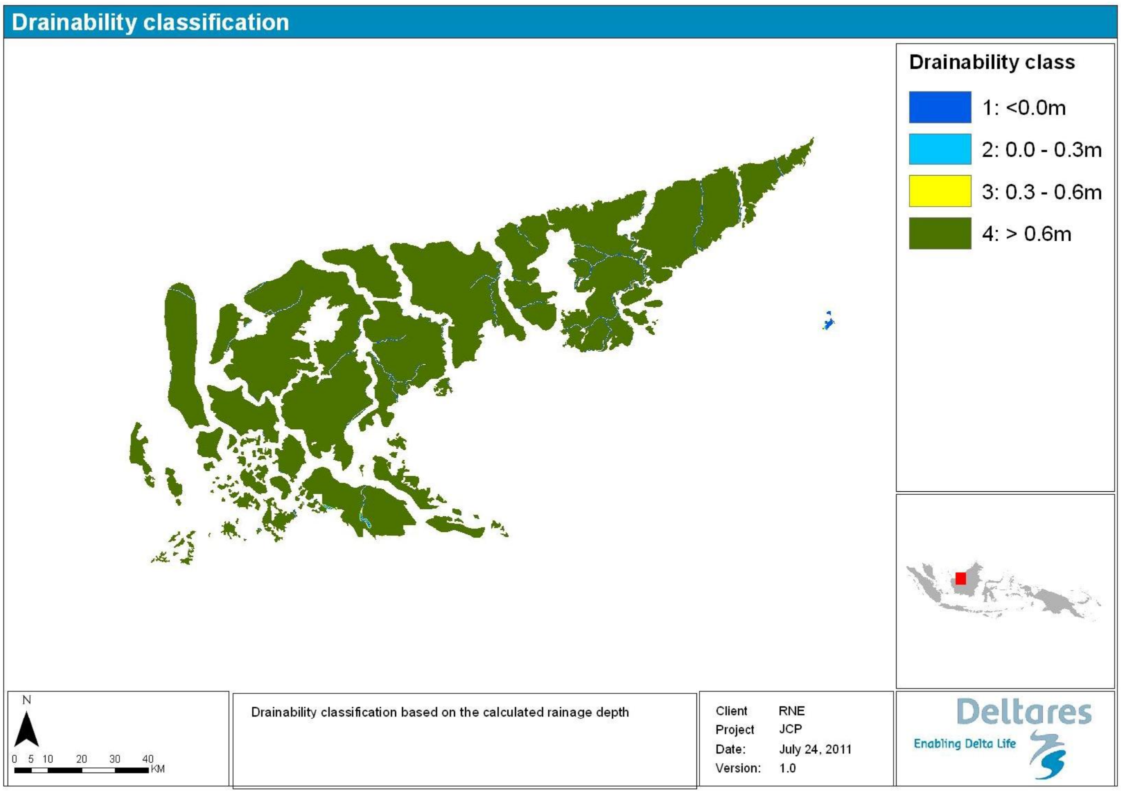
Zero drainage level



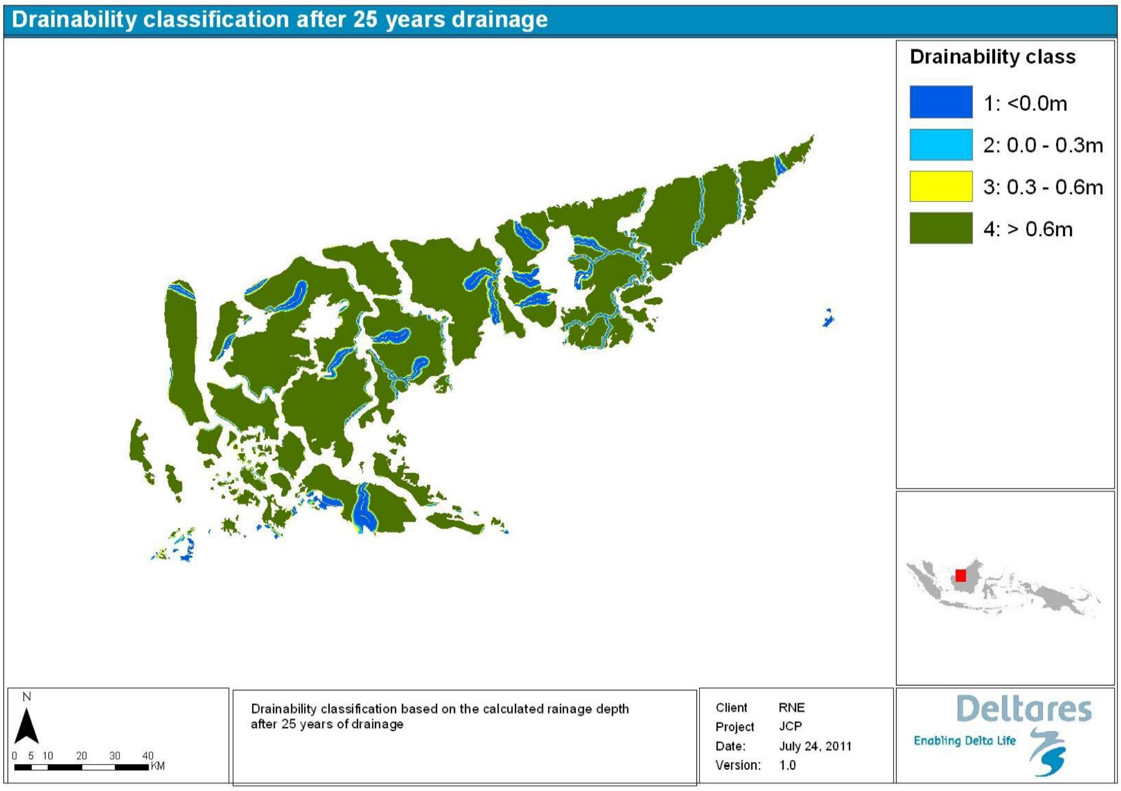
Initial Drainage Depth



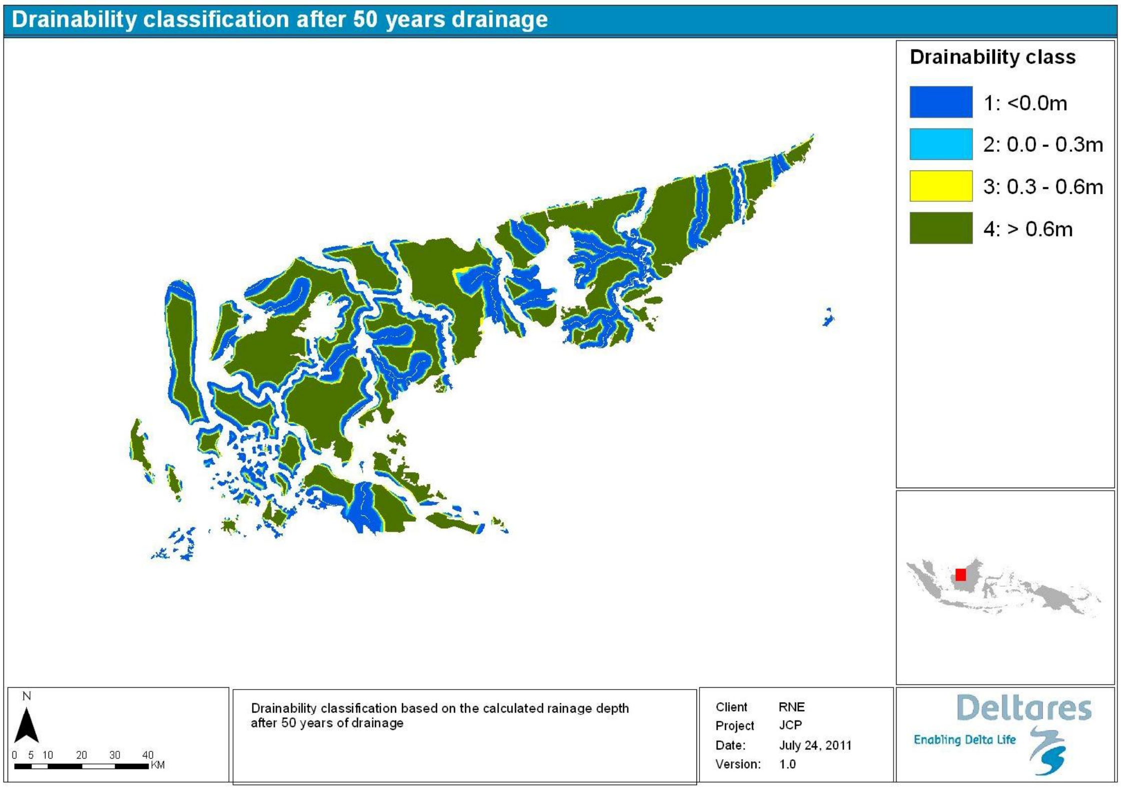
Initial drainage classification



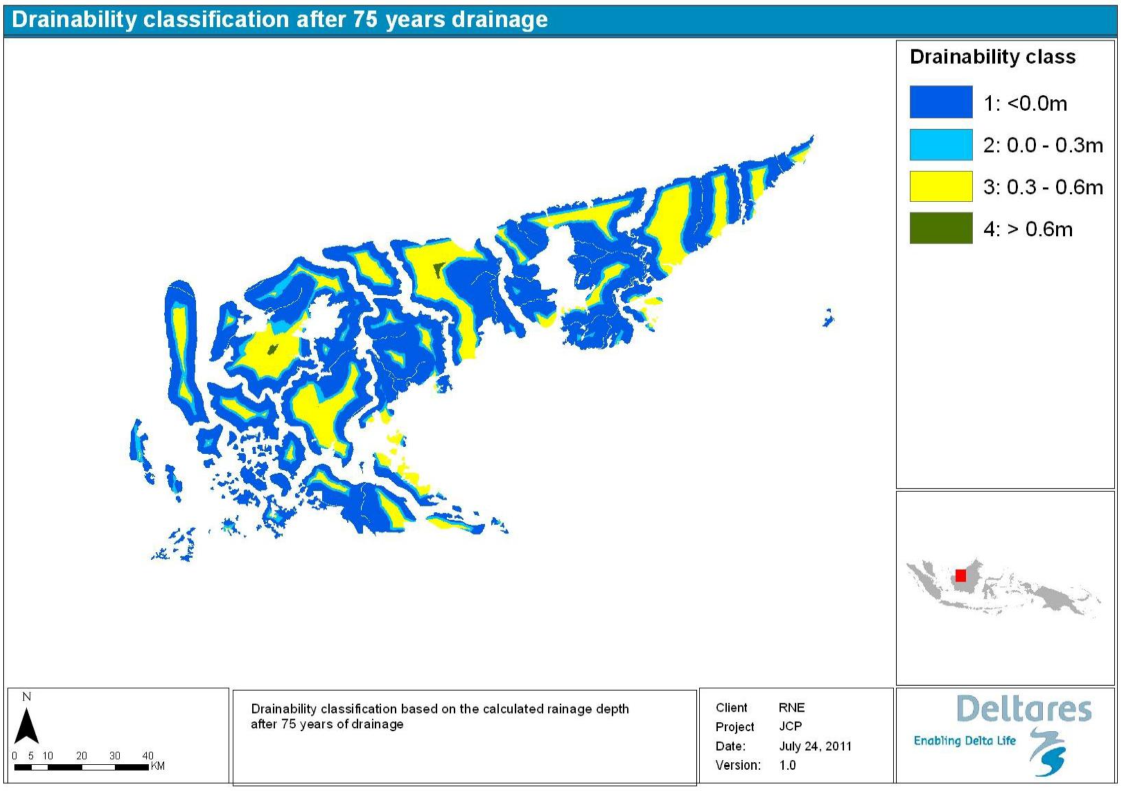
Drainability after 25 years of drainage



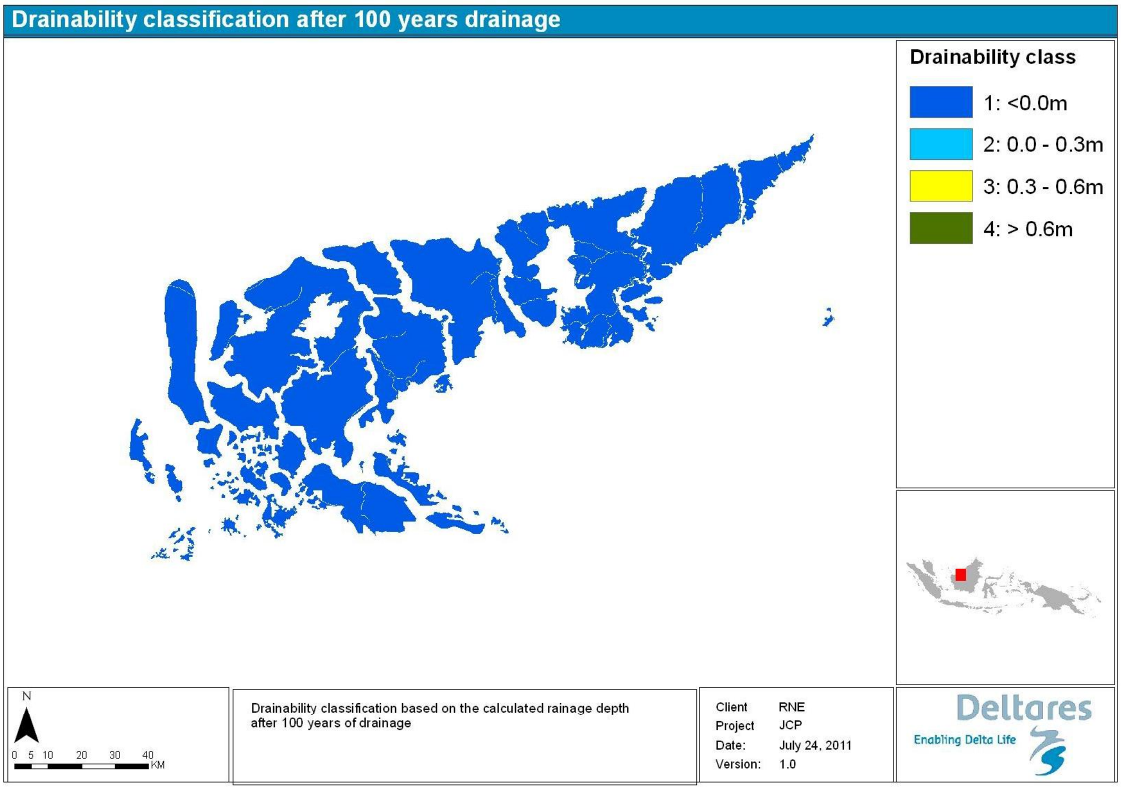
Drainability after 50 years of drainage



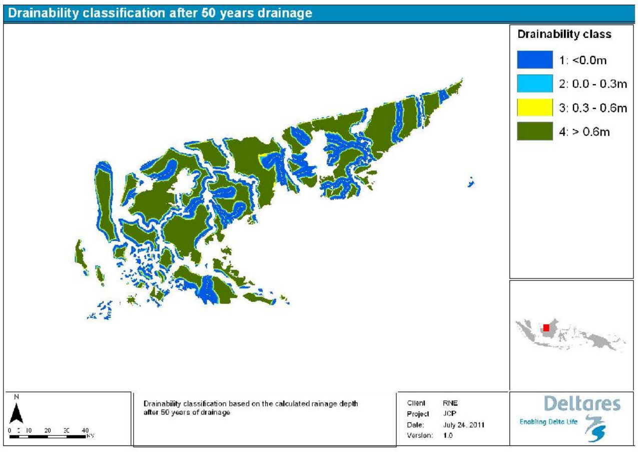
Drainability after 75 years of drainage

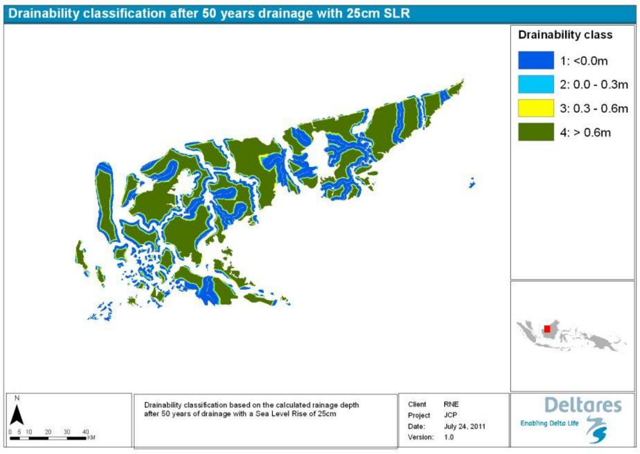


Drainability after 100 years of drainage



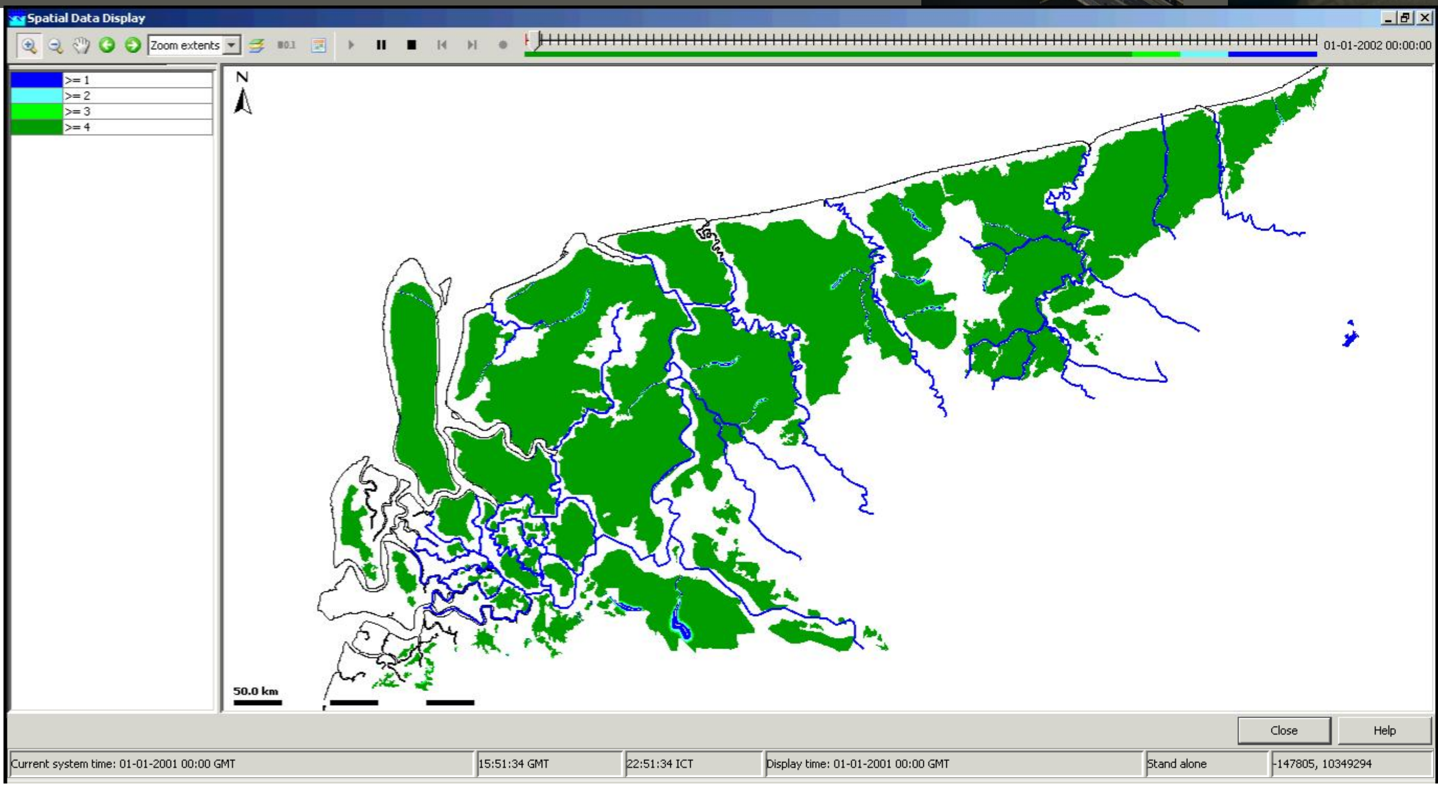
Influence of SLR on drainability





Deltares

Annimation



Deltares