Bodemdaling in de Vietnamese Mekong delta
Presentatie Hofvijverkring

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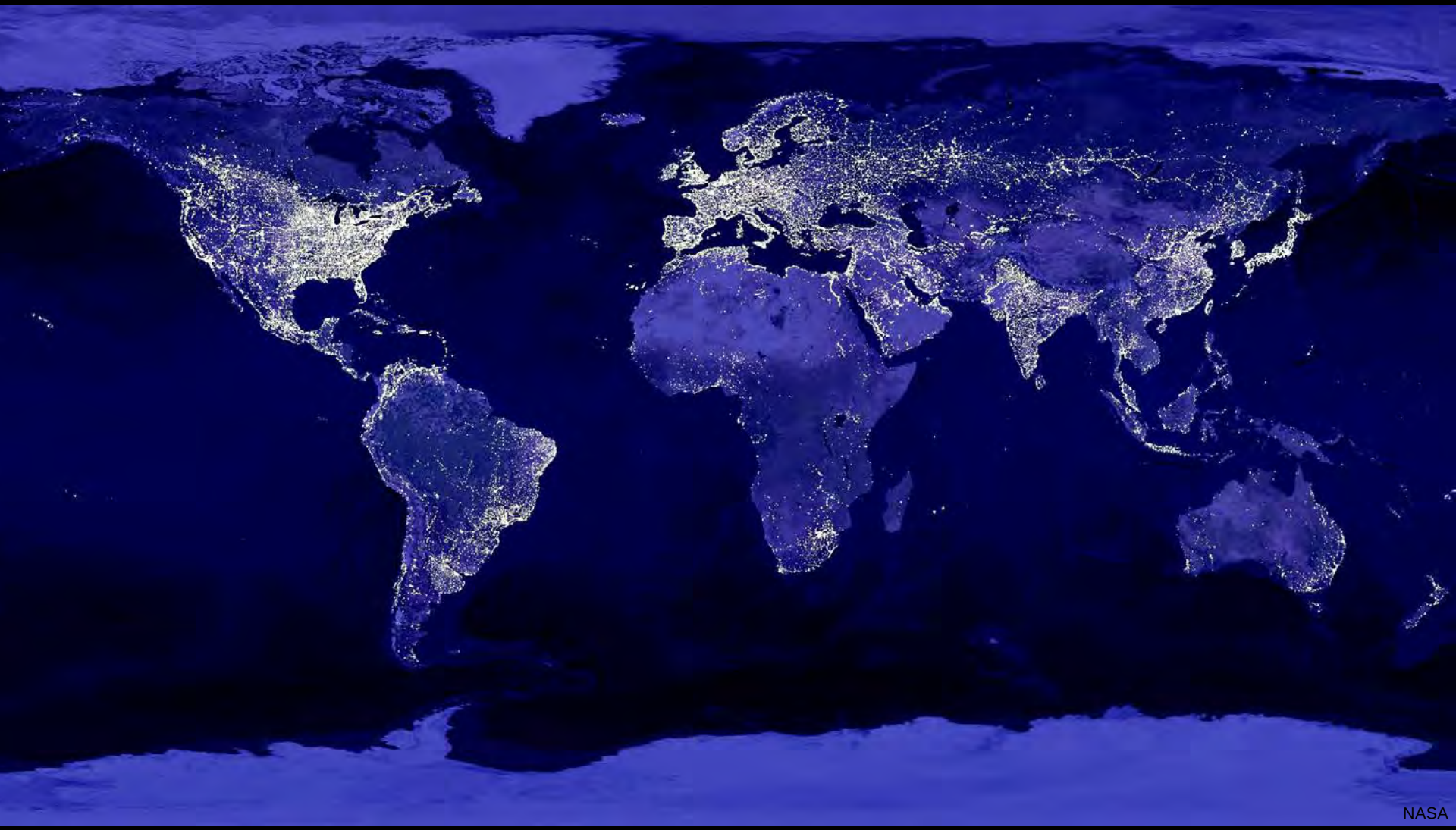
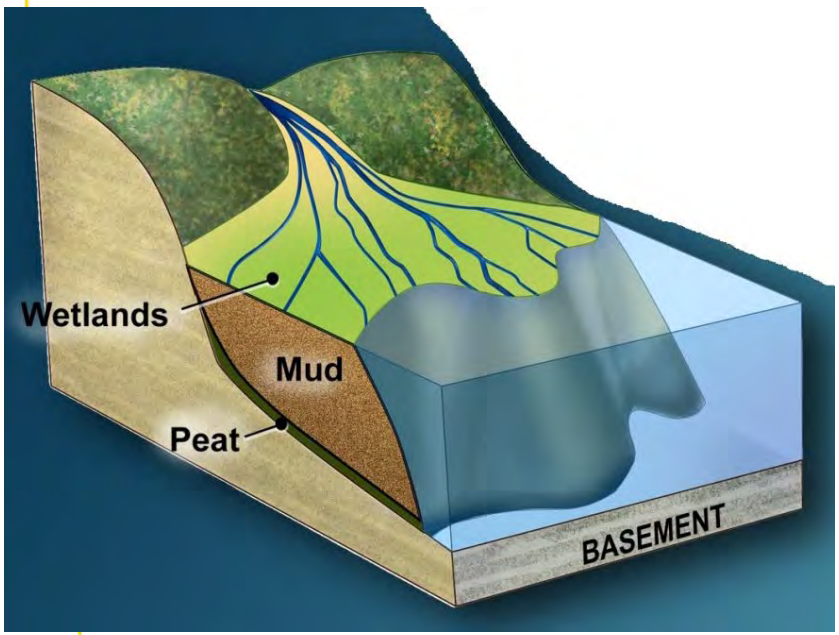
We zijn met veel



En we leven graag aan de kust

Deltas zijn aantrekkelijk!



- Dichtbevolkt
- Vruchtbare bodems
- Grondstofrijk
- Unieke/waardevolle ecosystemen

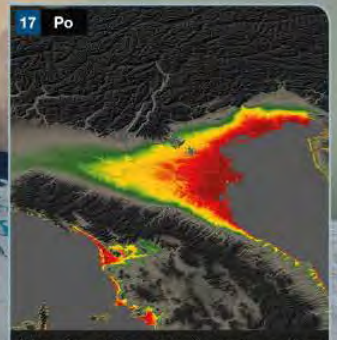
→ Hoge economische waarde

Deltas zijn laaggelegen

14 Colorado

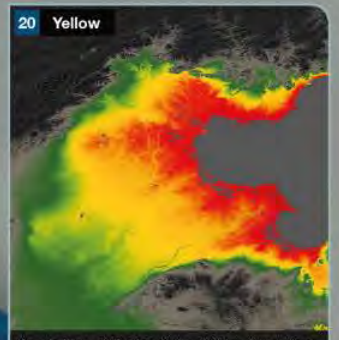
After farms and urban areas have taken their water allotments, the Colorado River slows to a trickle by the time it reaches its delta. Sometimes it stops flowing altogether and then no sediment is deposited.

17 Po



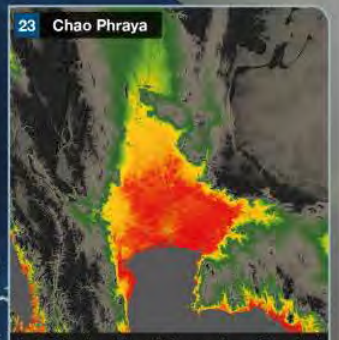
The Po delta experienced a 6cm annual subsidence rate, due to sea-level rise and methane extraction. This reduced dramatically once methane extraction ended.

20 Yellow



As deltas sink the risk of flooding rises. In the Yellow River delta typhoons have caused 5m-high storm surges.

23 Chao Phraya

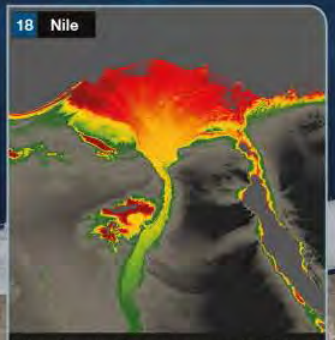


In 2011, the Chao Phraya river flooded swamping Bangkok and leaving much of the capital submerged for months. The city has been sinking for decades due to groundwater extraction. Steep taxes on groundwater have slowed subsidence substantially.

Amazon

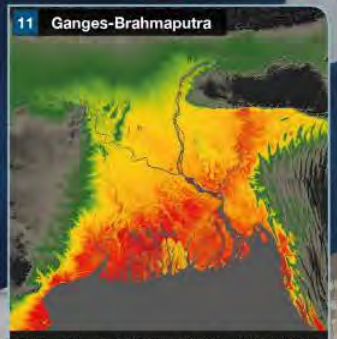
Despite forest destruction, hydro-electric dam projects and more impacts upstream, the Amazon River delta is in relatively good health. Nearly 3 million people live on the delta but its sheer size dampens human impacts.

18 Nile



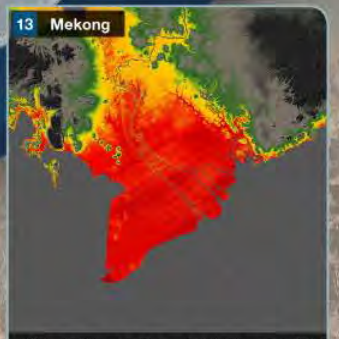
The Aswan Dam traps nearly 98% of sediment flow downstream. Without those soils, the Nile Delta has compacted and sunk. Relative sea-level rise there is 4.8 millimetres every year.

11 Ganges-Brahmaputra



The delta is home to over 100 million people making it the most populated on Earth. Effective sea-level rise is up to 18 millimetres per year. In 2007–08, substantial flooding affected the Ganges, Mekong, Irrawaddy, Chao Phraya, Brahmani, Mahanadi, Krishna and Godavari. More than 100,000 died and more than a million people were displaced.

13 Mekong



Like other deltas, farmers on the Mekong have cut down mangroves to create space for shrimp ponds. Surveys indicate roughly half the mangrove forests have disappeared. Mangroves help prevent erosion and are important flood defences.

ELEVATION (metres)

-3 3 6 10 20 30 40 100 500

SOURCES

Syvitski J P M *et al.* (2009) *Nature Geoscience* 2: 681-686. doi:10.1038/ngeo629

Ericson J P *et al.* (2006) *Global and Planetary Change* 50: 63-82. doi:10.1016/j.gloplacha.2005.07.004

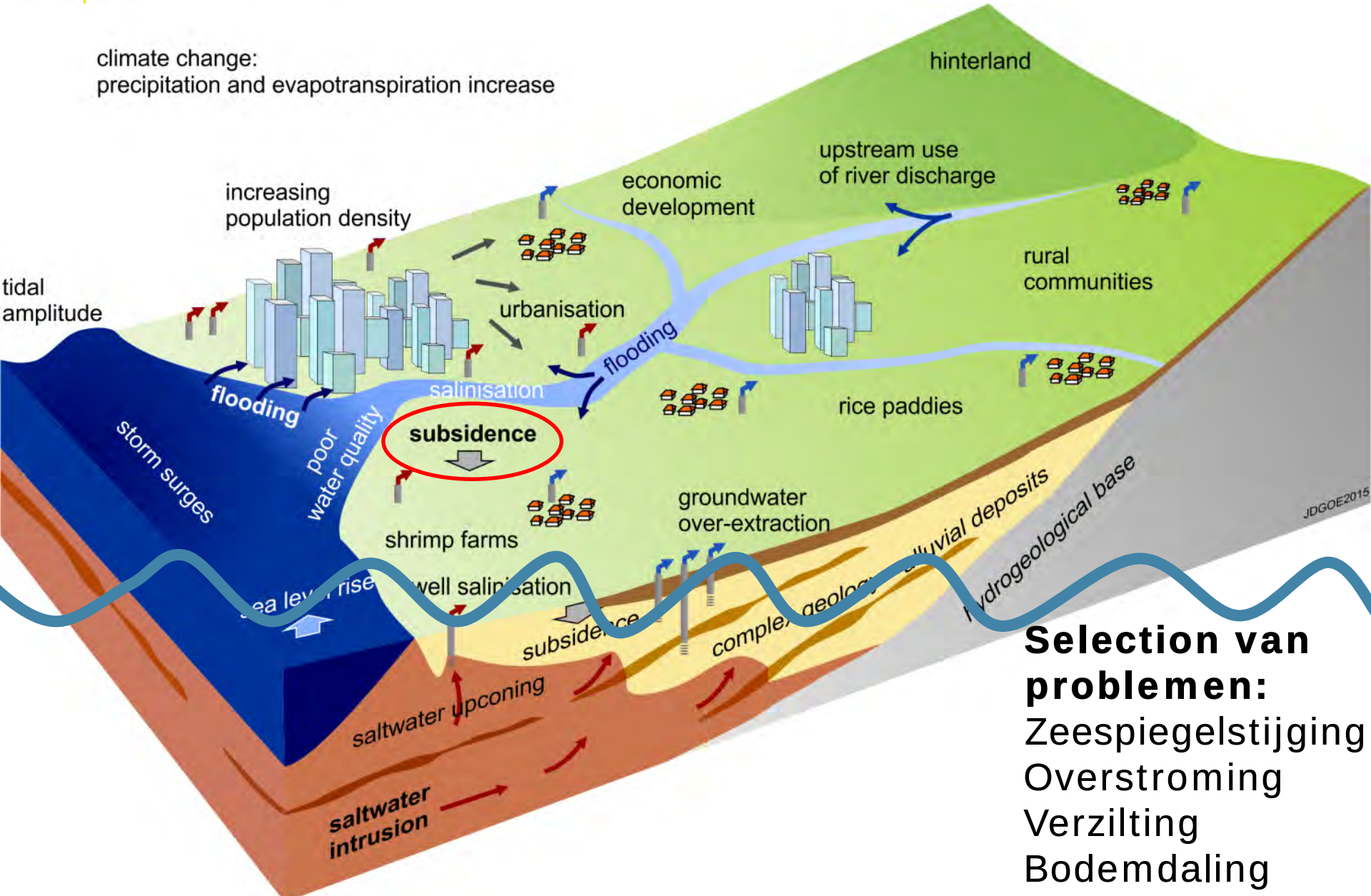
IPCC (2013) Summary for Policy Makers. In: Stocker T F *et al.* (eds) *Climate Change 2013: The physical science basis.* Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, USA. www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf

Elevation Data: NASA Shuttle Radar Topography Mission Global 3 arc second V003

Cartography and design: Globaia

Universiteit Utrecht

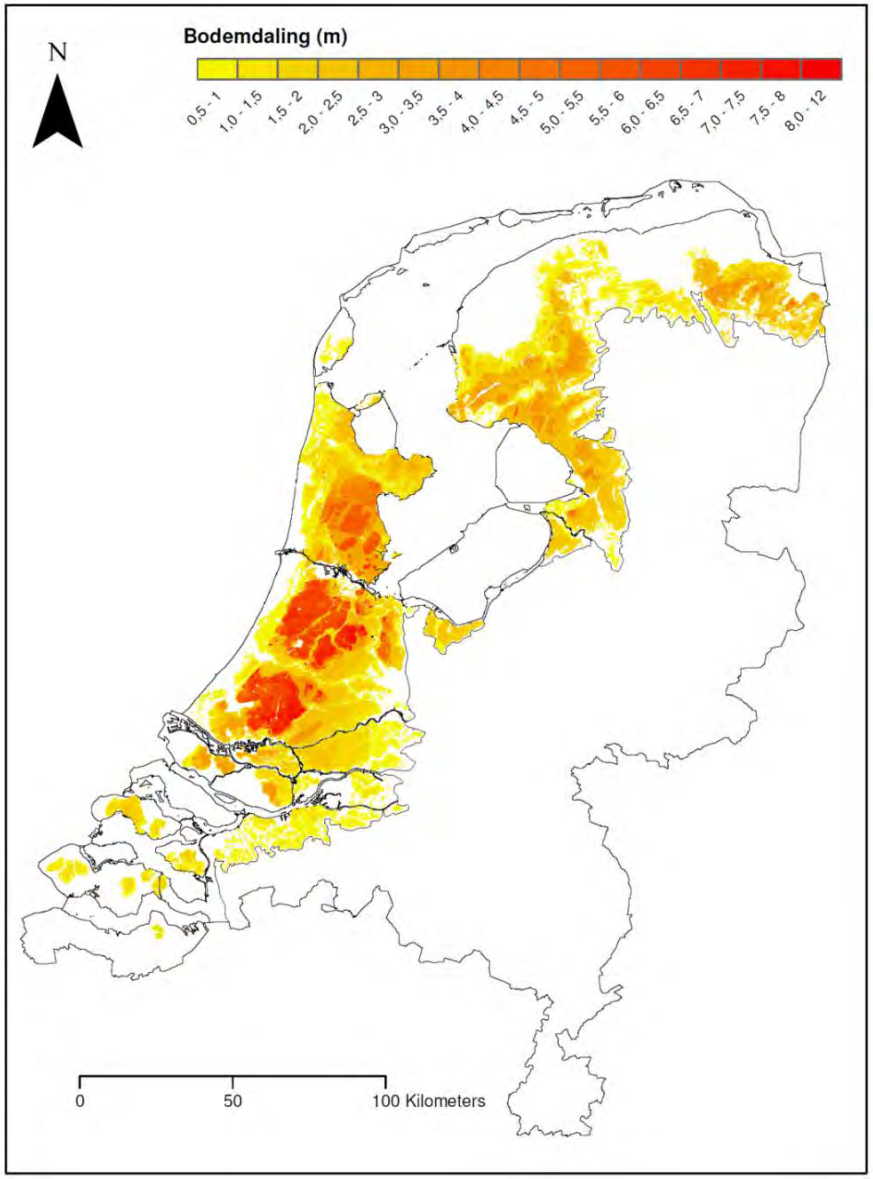
Veranderingen in deltas

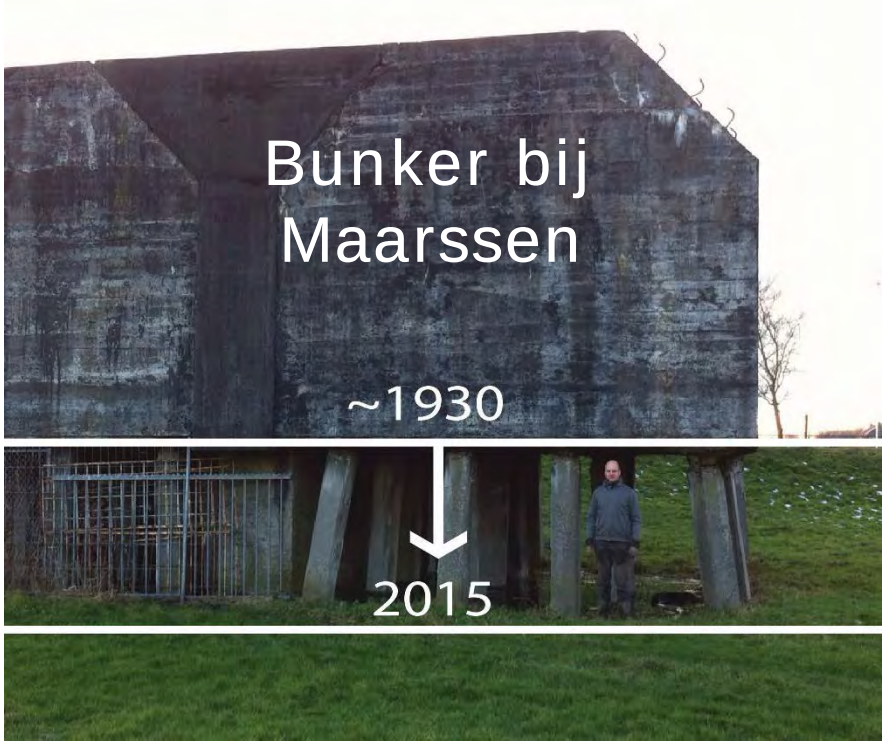


Selection van problemen:

Zeespiegelstijging
Overstroming
Verzilting
Bodemdaling

Bodemdaling in Nederland





Bodemdaling door menselijk landgebruik:

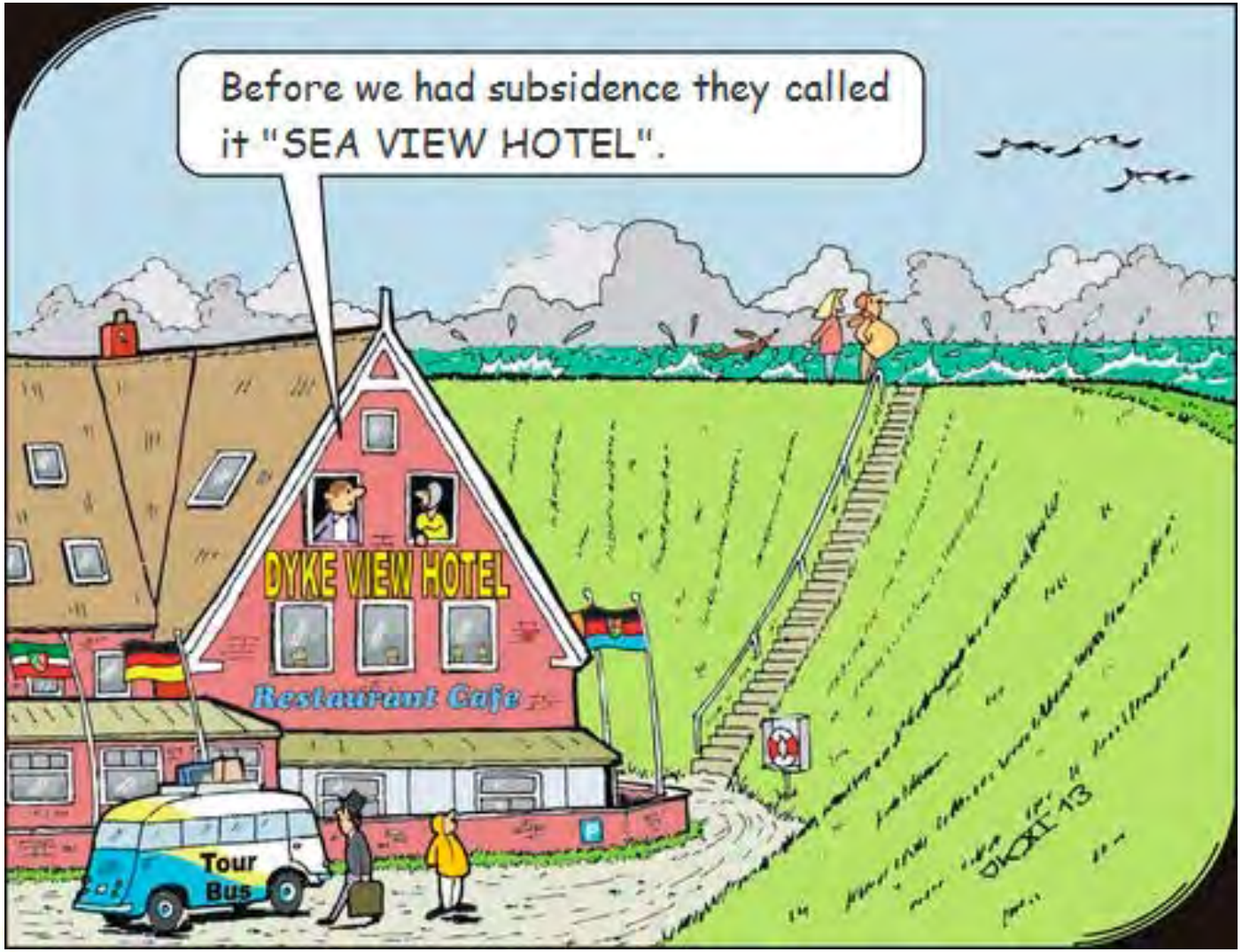
i. On average: 2.0 m

ii. Maximal: 12 m

Erkens et al.

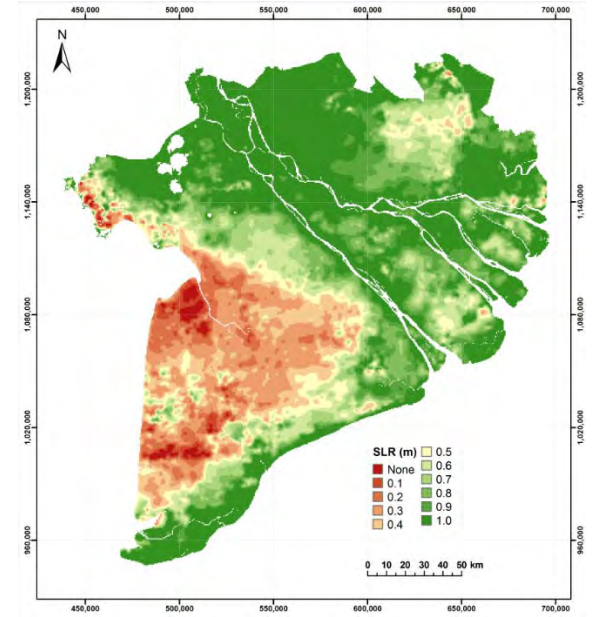
Absolute zeespiegelstijging *versus* Bodemdaling

Relative zeespiegelstijging!



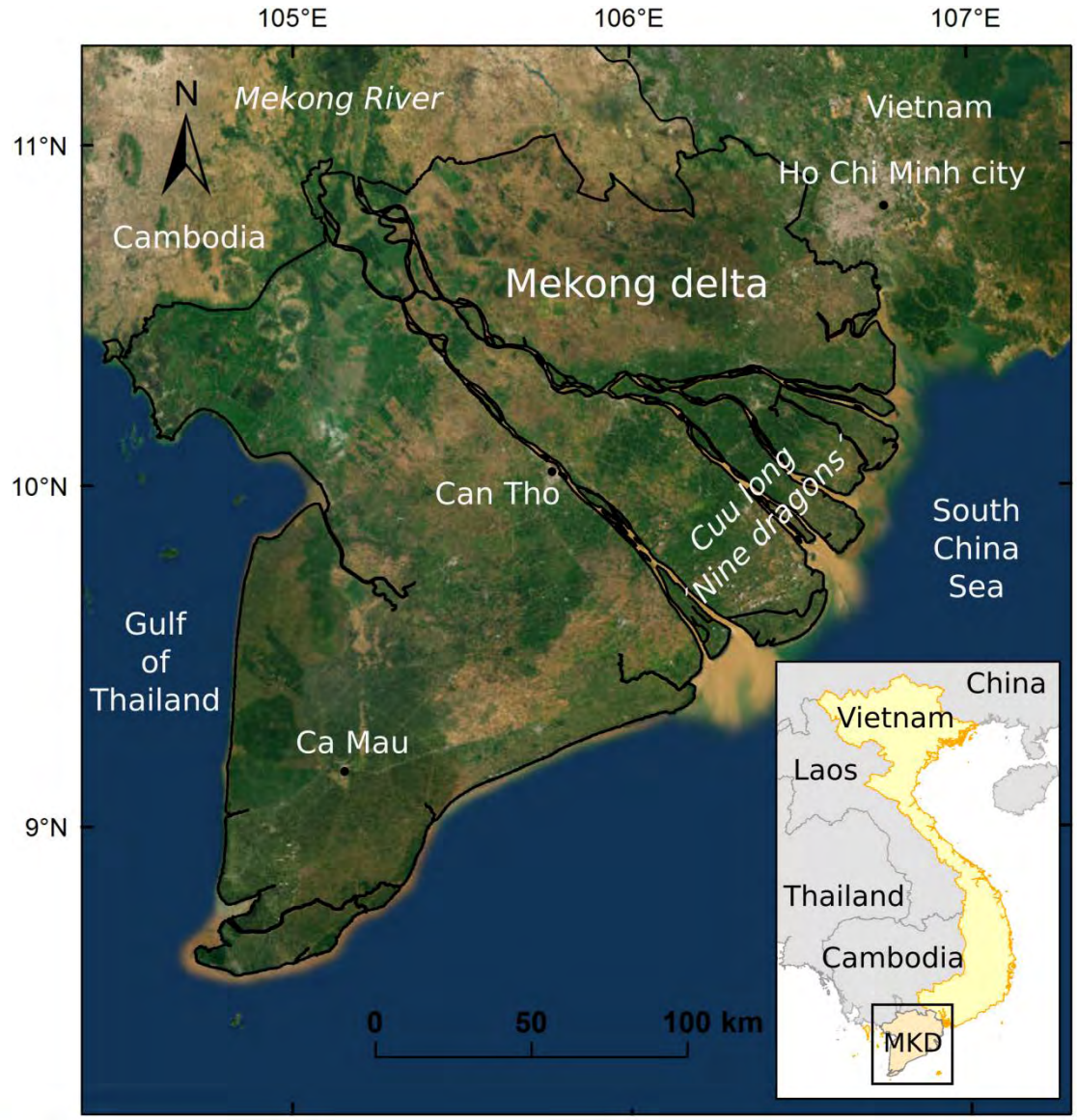
Veel deltas wereldwijd zakken steeds sneller!

Mekong delta



>50% below 1 meter above SL

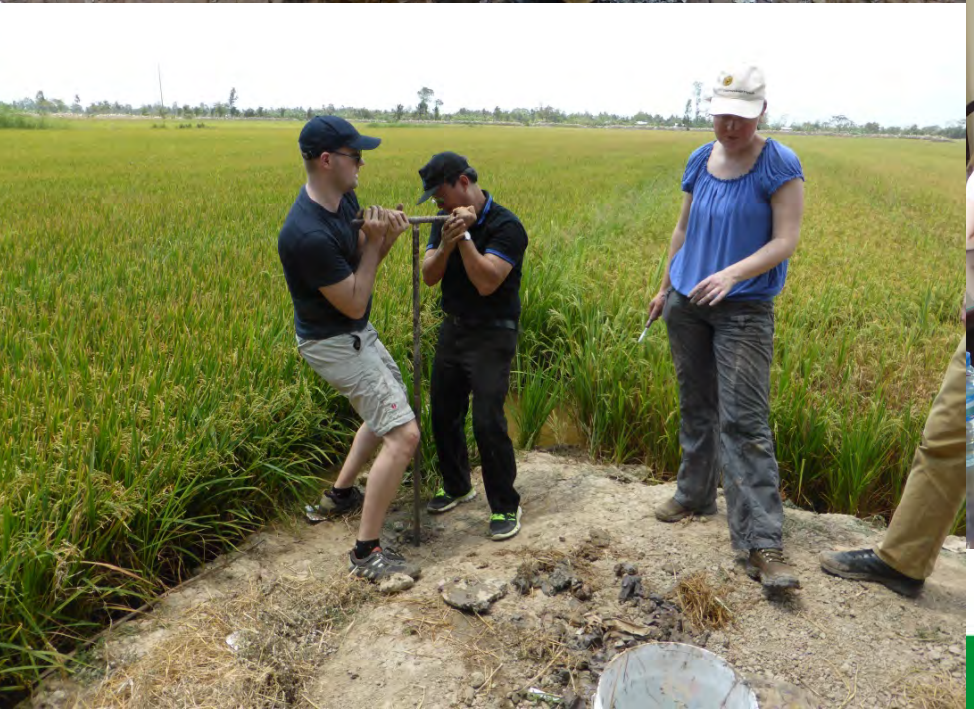
Minderhoud et al., 2019 (Nature Communications



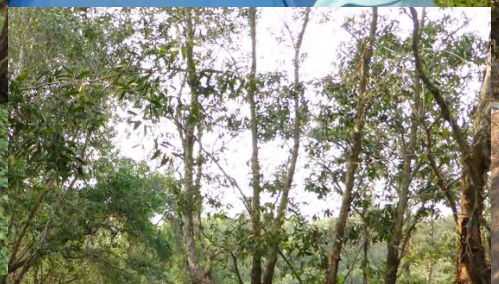
Minderhoud


A
B
C
Minderhoud

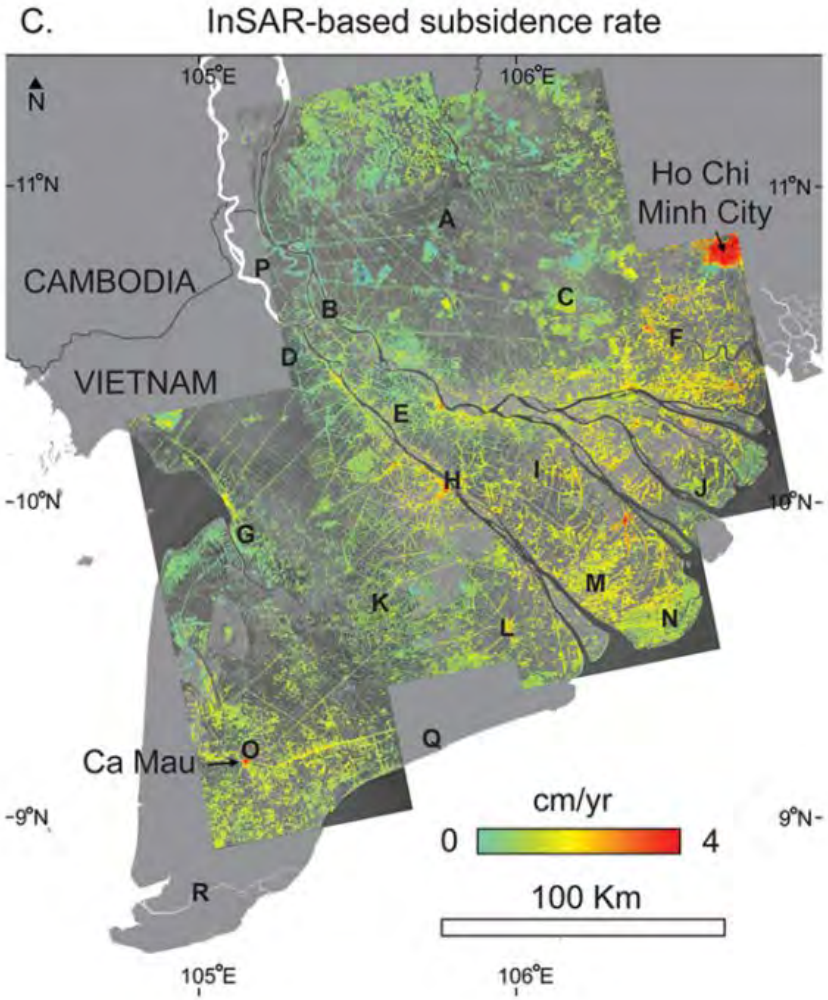

ĐẢNG CỘNG SẢN VIỆT NAM, QUANG



Exploring the delta



Bodemdaling in de Mekong delta



Erban et al. 2014
measured subsidence
2006-2010

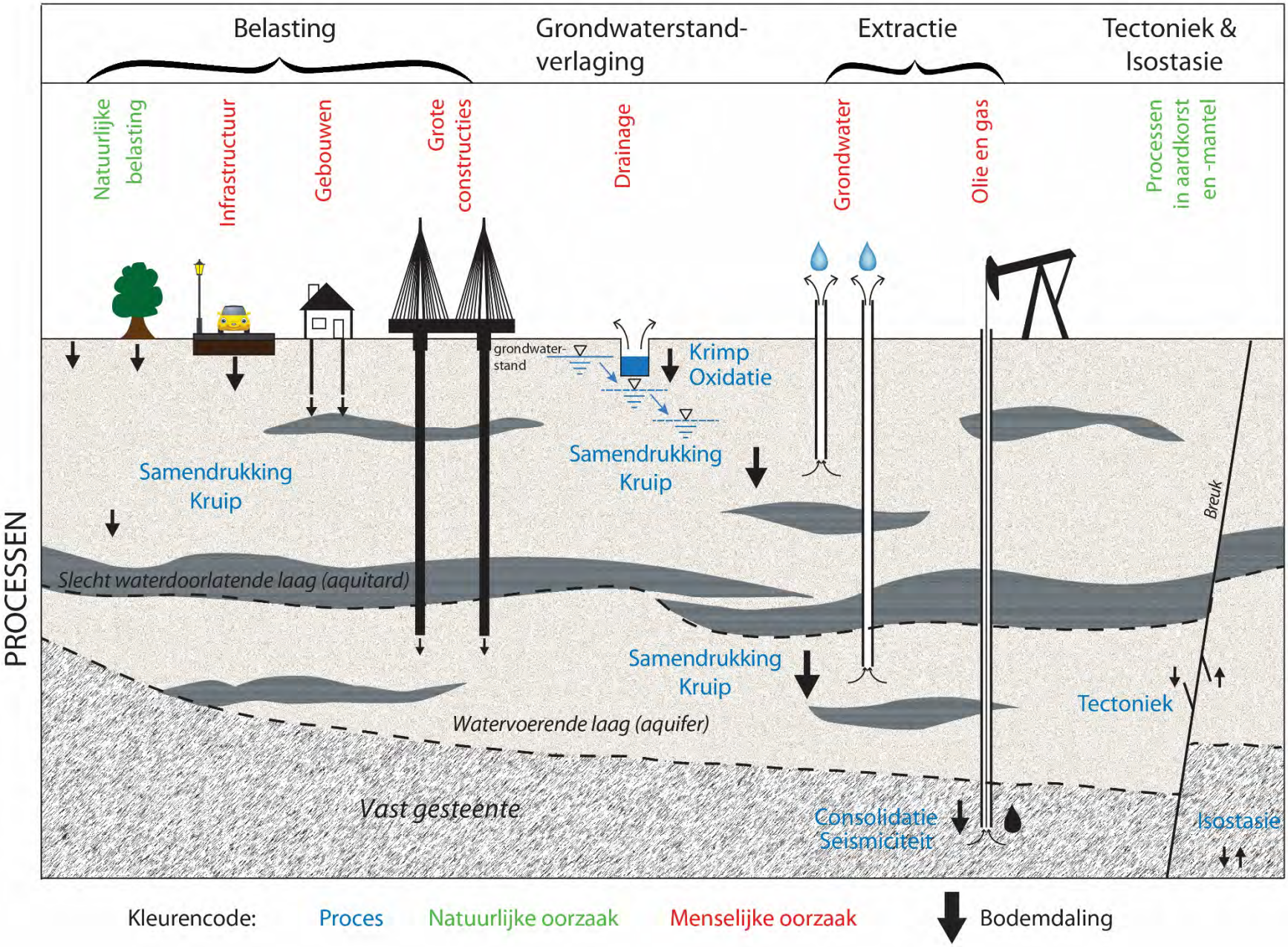
Bodemdaling in de Mekong delta

Oppervlakkige bodemdaling, zichtbaar rondom bruggen en gebouwen

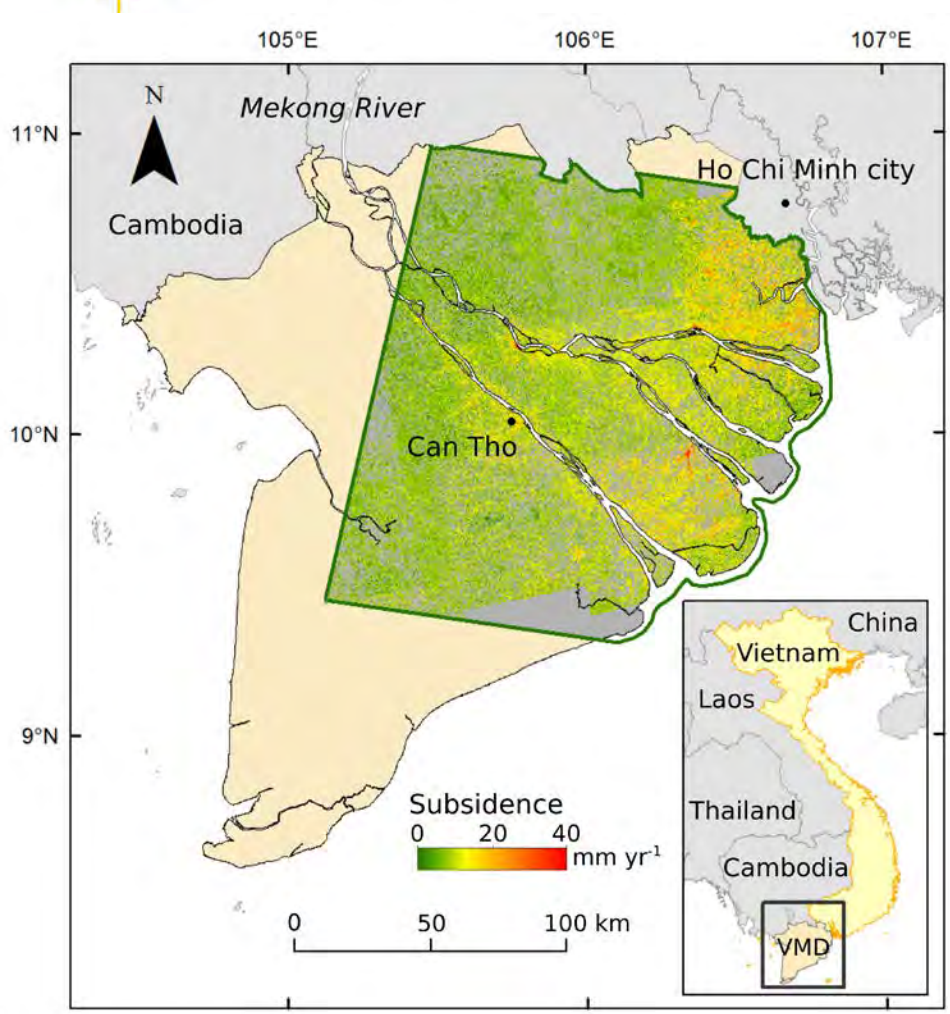
Wat veroorzaakt bodemdaling in een delta?

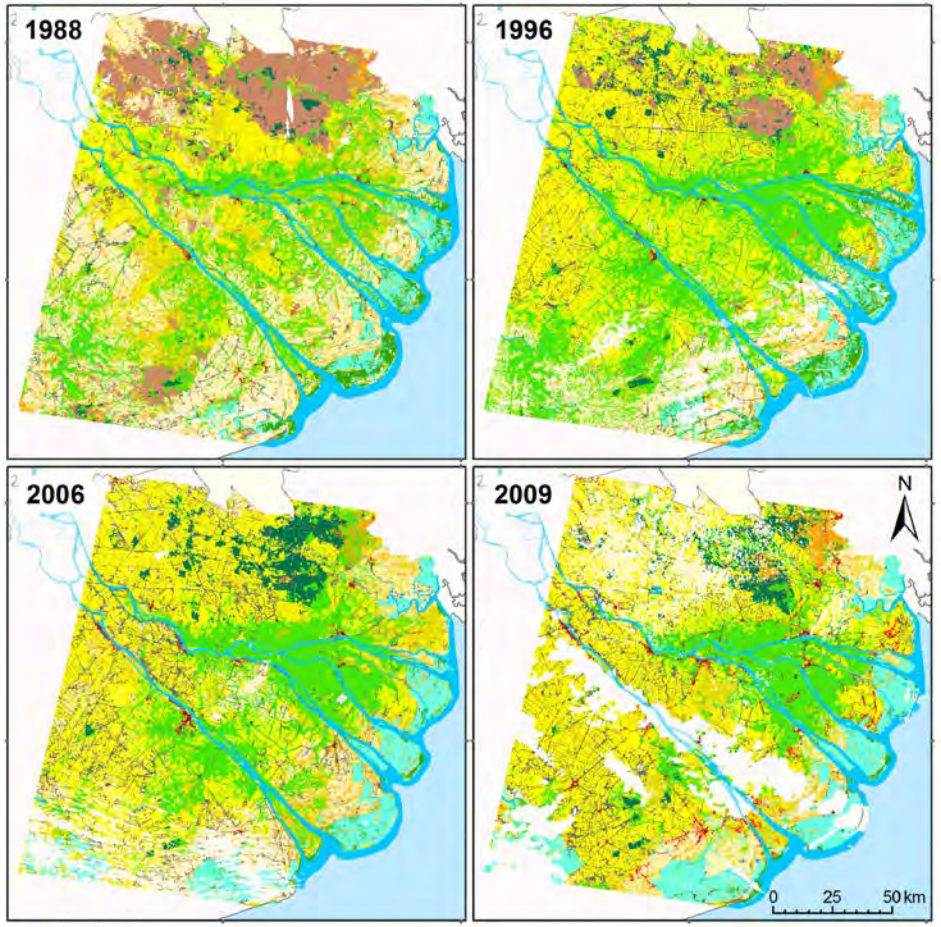
Diepe bodemdaling, zichtbaar rondom waterputten

OORZAKEN VAN BODEMDALING



Bewijs van menselijke invloed op bodemdaling





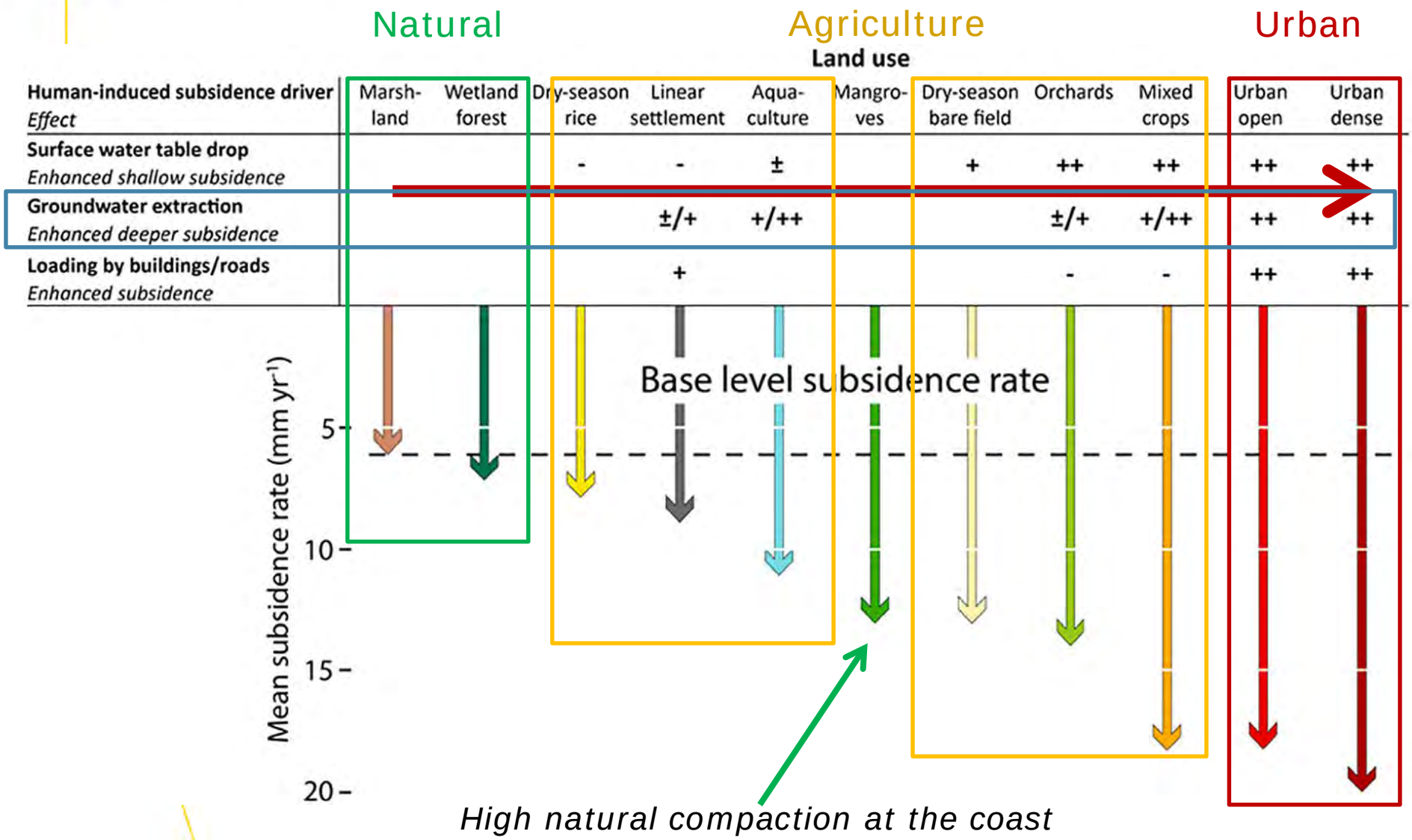
Legend

Agriculture / aquaculture
- Dry season full crop - mainly rice
- Dry season partly crop - mainly rice
- Dry season bare field
- Mixed crops - non-rice
- Orchard
- Aquaculture

Forested / undeveloped
- Mangrove
- Wetland forest
- Wasteland/marsh

Build-up
- Urban dense
- Urban open
- Line build-up

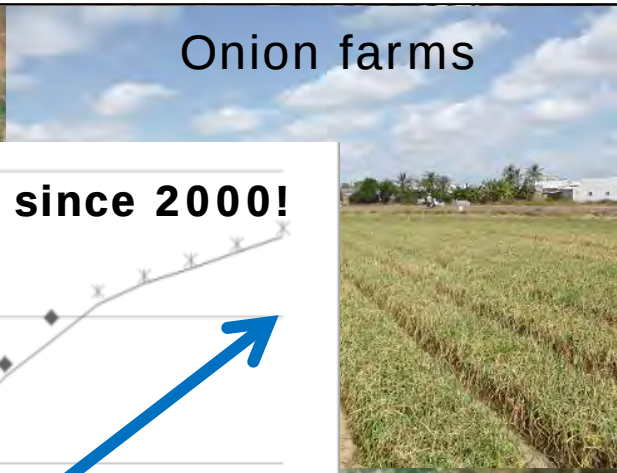
Bewijs van menselijke invloed op bodemdaling

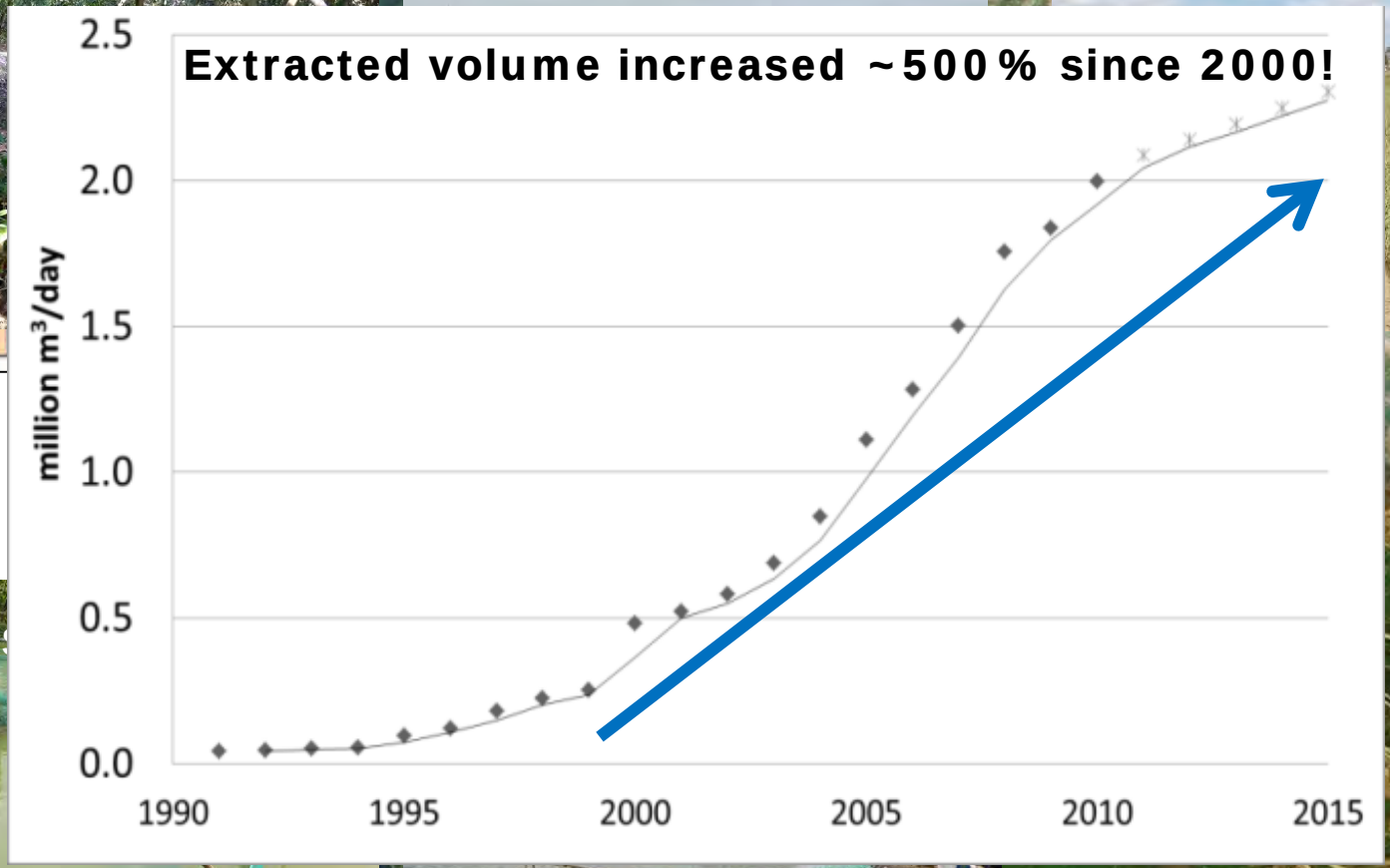


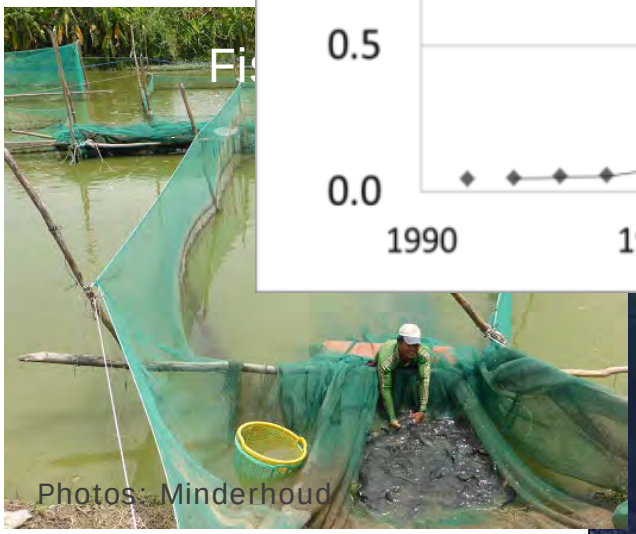
High natural compaction at the coast

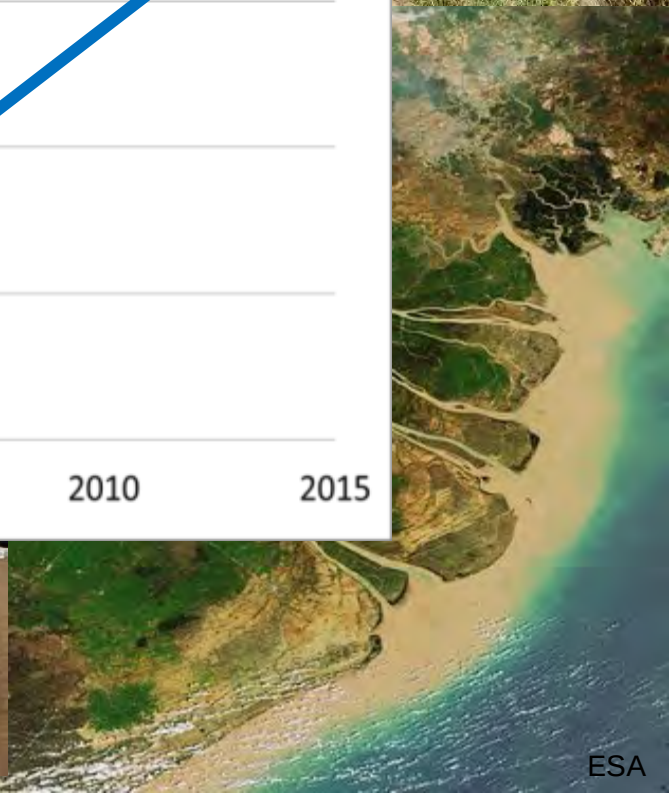
Minderhoud et al., 2018. *Science of the Total Environment*

‘Rijstkom’ van Vietnam







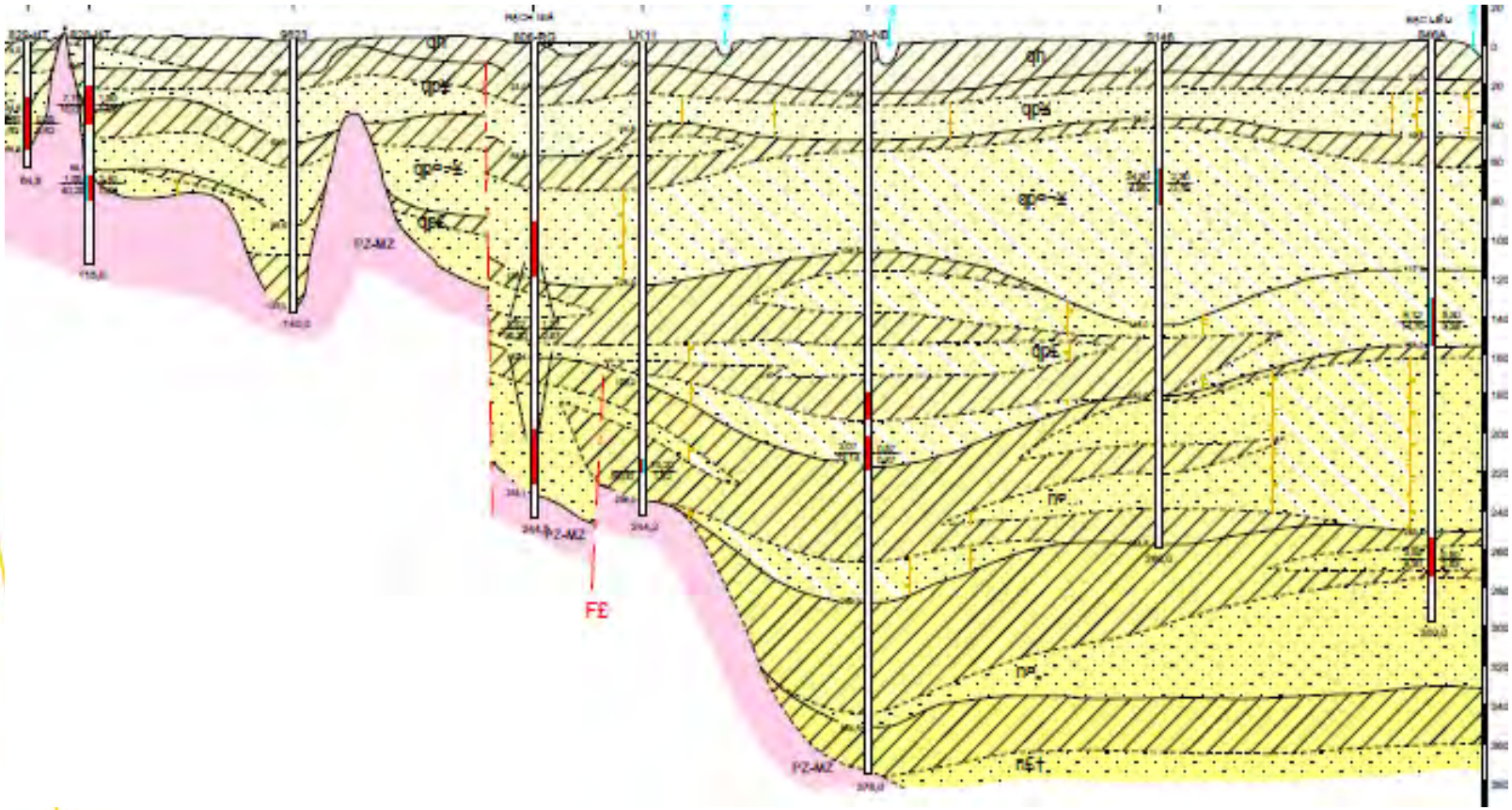


Photos: Minderhoud

ESA

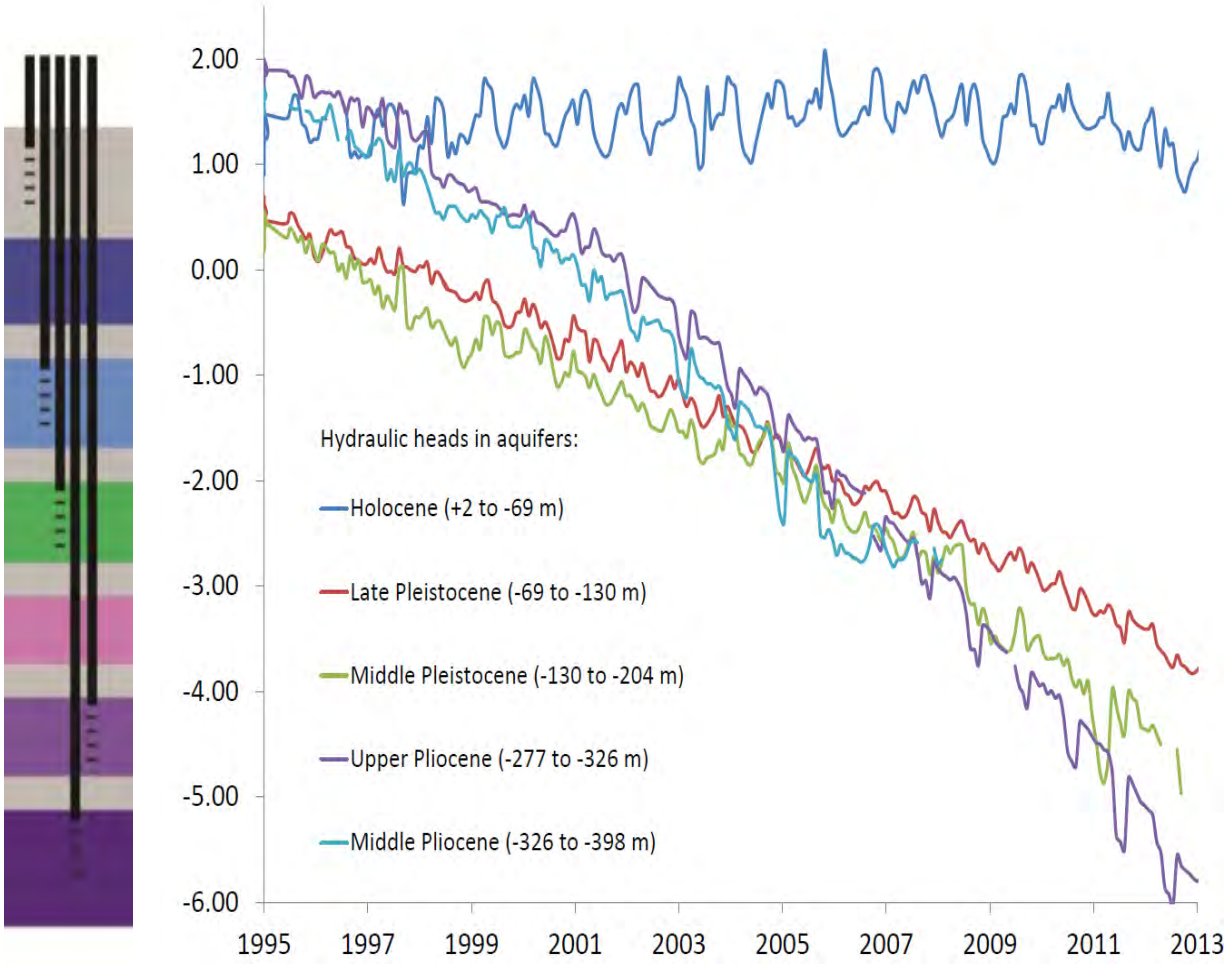
Universiteit Utrecht

Grondwater komt uit de ondergrond



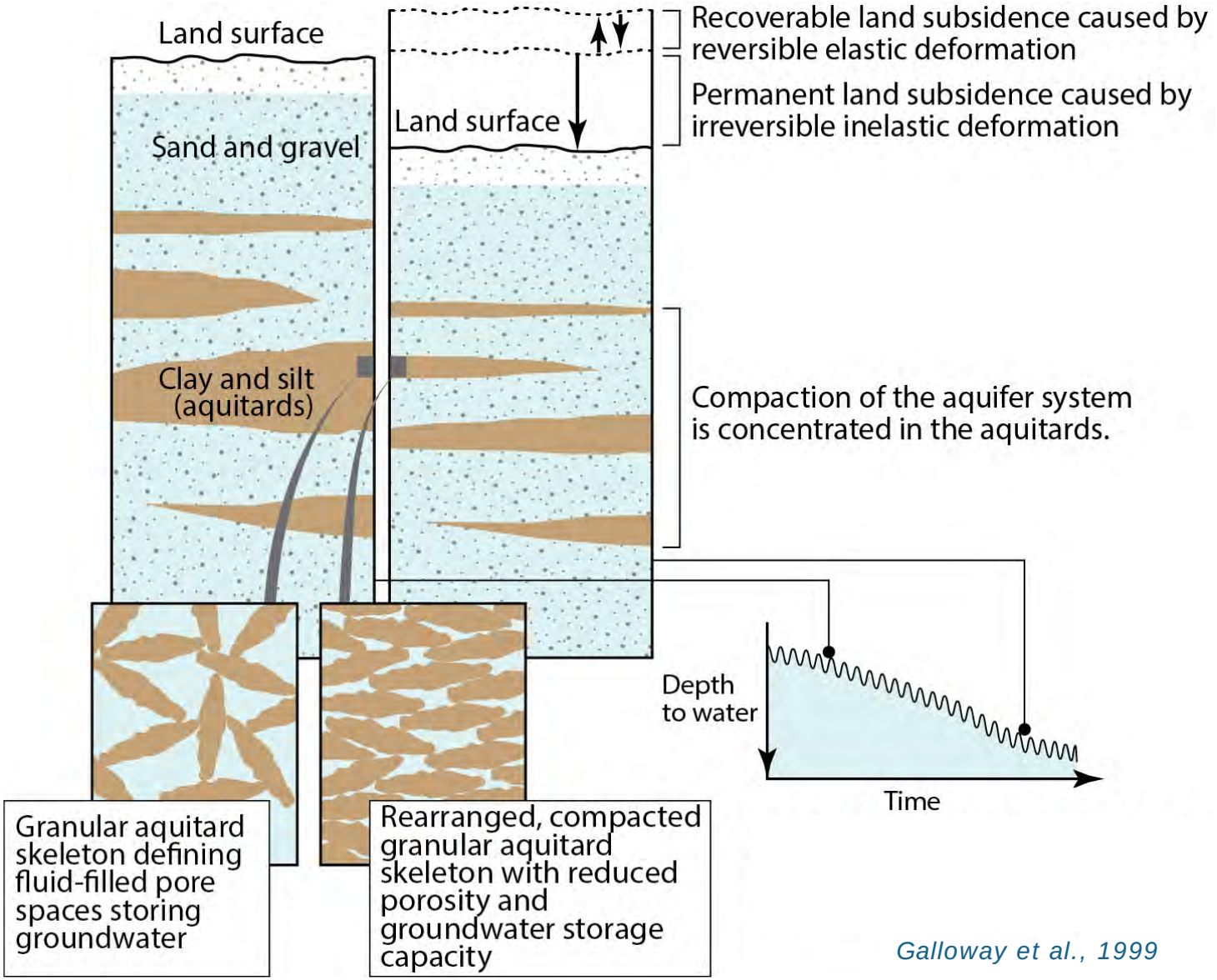
Over 500 m thick in some areas

Result van 25 jaar grondwateronttrekking: Druk in de watervoerende pakketen neemt af



Monitoring wells near Can Tho
Representable for the situation in the whole Mekong delta

Grondwaterstandsverlaging zorgt voor klei compactering → Bodemdaling



Galloway et al., 1999

Klei deeltjes gedragen zich net als vuile vaat

‘Natuurlijke’ sedimentatie van vaat:
Veel porie ruimte

‘Herorganisatie’ van borden:
Weinig porie ruimte

Onderzoeksvraag

Hoeveel bodemdaling wordt er veroorzaakt door grondwateronttrekking?

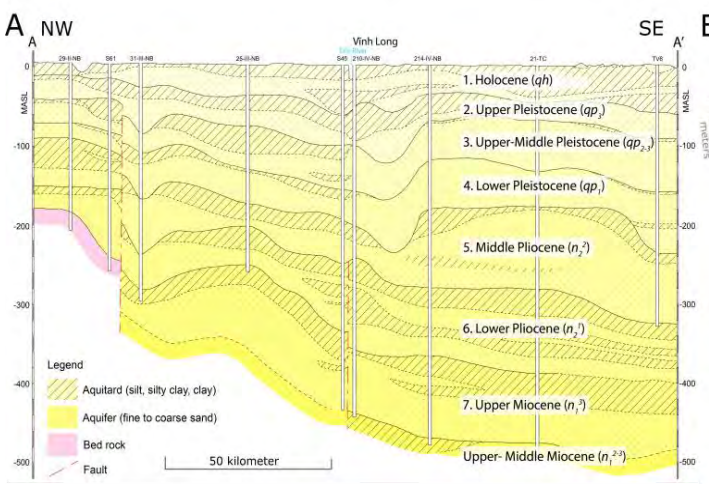
Approach

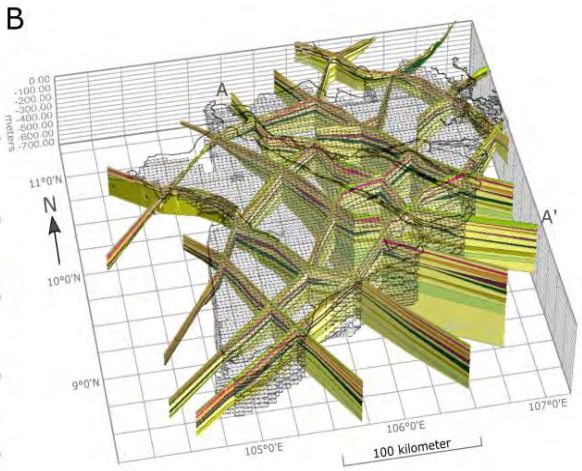
3D computer model

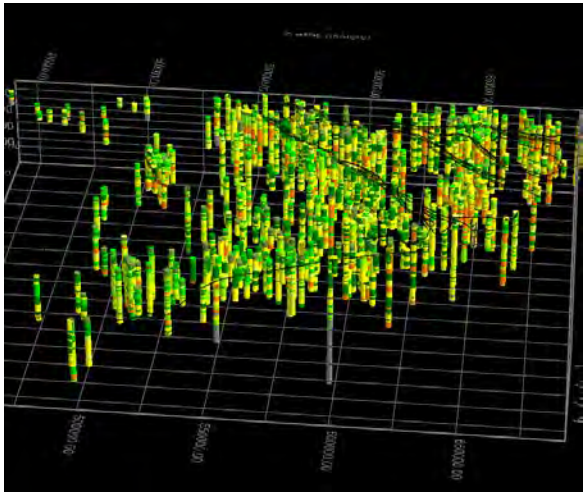
Wetenschappelijke disciplines:

Geologie, Hydrogeologie, Geotechniek, Aardobservatie (Remote sensing)

Hydrogeologisch computermodel

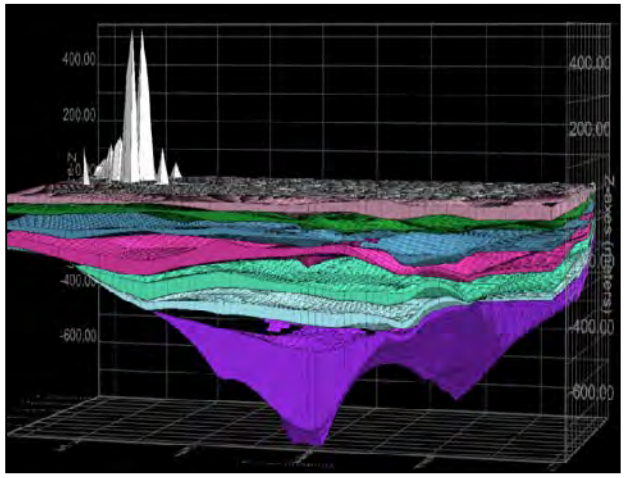




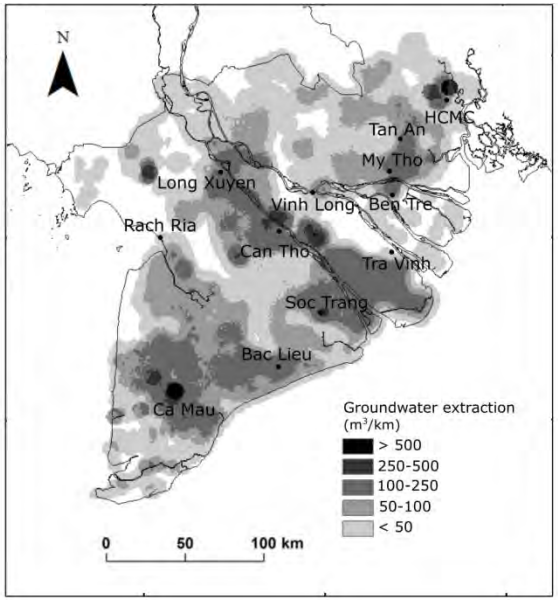


Geological boreholes and cross-sections

Model dimensions: >400x300 km



3D hydrogeological subsurface model

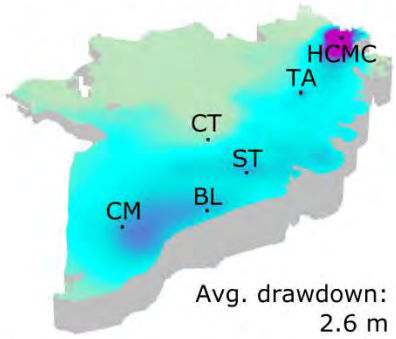


Modelled extractions

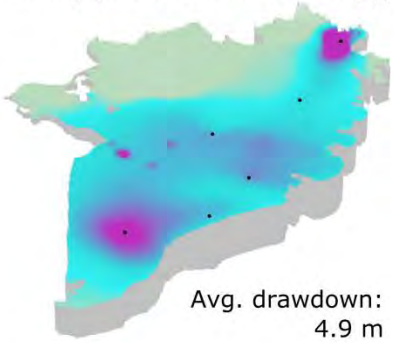
Scientific video abstract of Minderhoud et al.,
"Impact of 25 years groundwater extraction on subsidence in the Mekong delta, Vietnam
Environmental Research Letters: https://www.youtube.com/watch?v=cMr_BKzY4lU

Model resultaten:
Waterstandsverlagingen na 25 jaar grondwateronttrekking

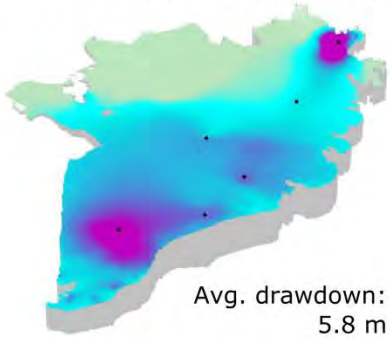
1. Holocene (*qh*)



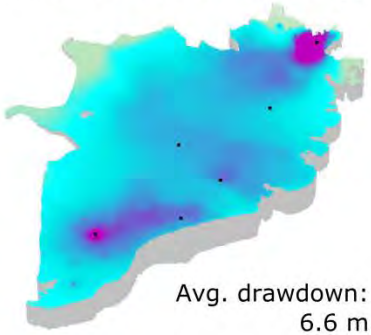
2. Upper Pleistocene (qp_3)



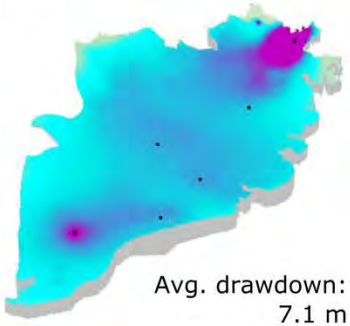
3. Middle Pleistocene (qp_{2-3})



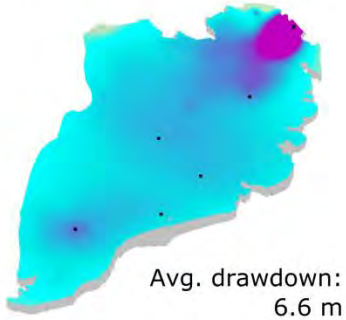
4. Lower Pleistocene (qp_1)



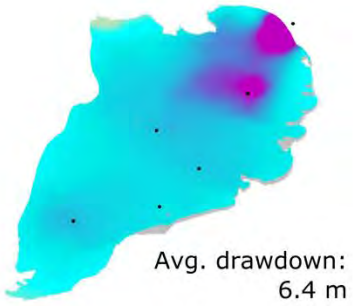
5. Middle Pliocene (n_2^2)

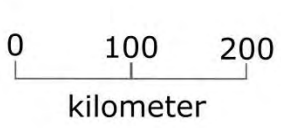


6. Lower Pliocene (n_2^1)

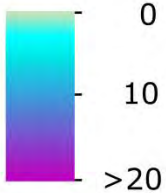


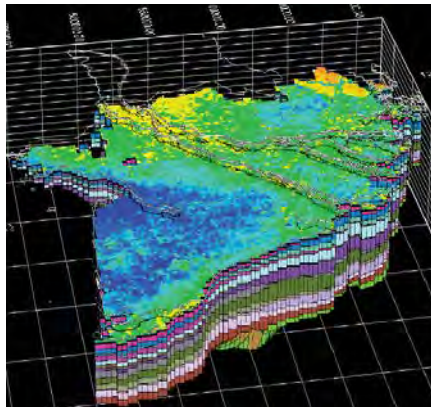
7. Upper Miocene (n_1^3)





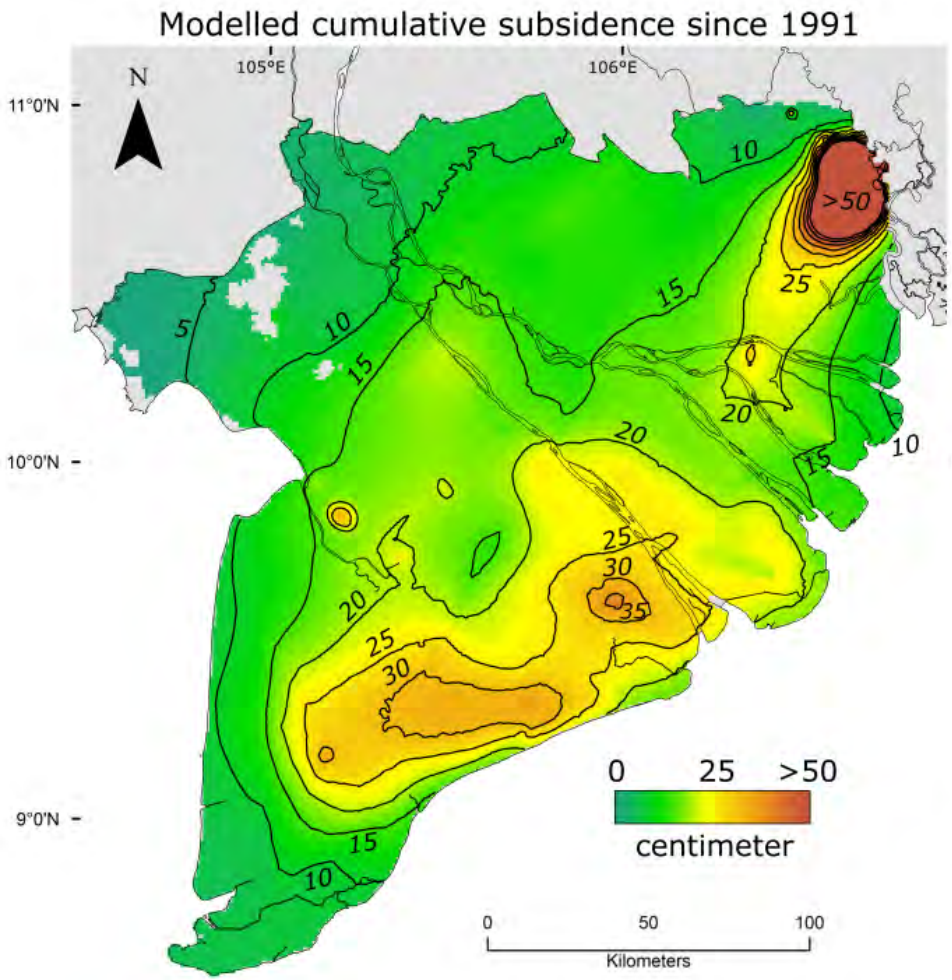
Legend
Drawdown (m)

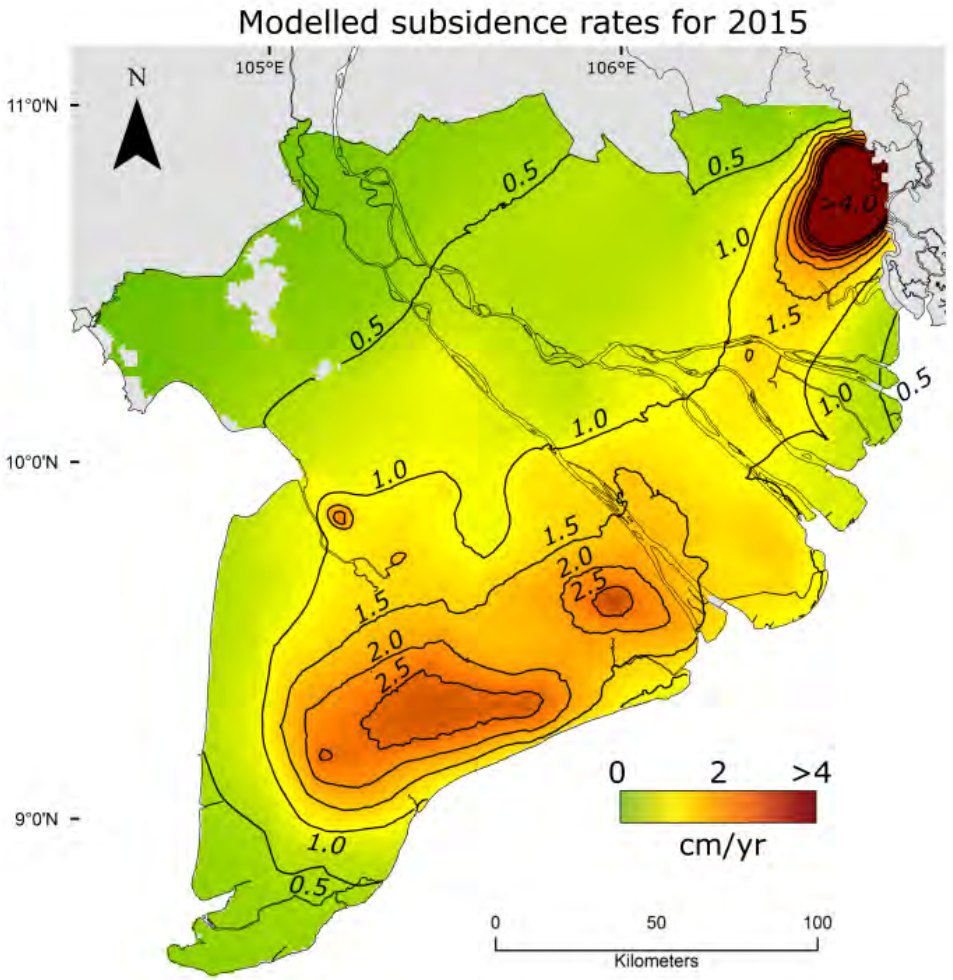




Minderhoud et al., 2017

Berekende bodemdaling door groundwateronttrekking

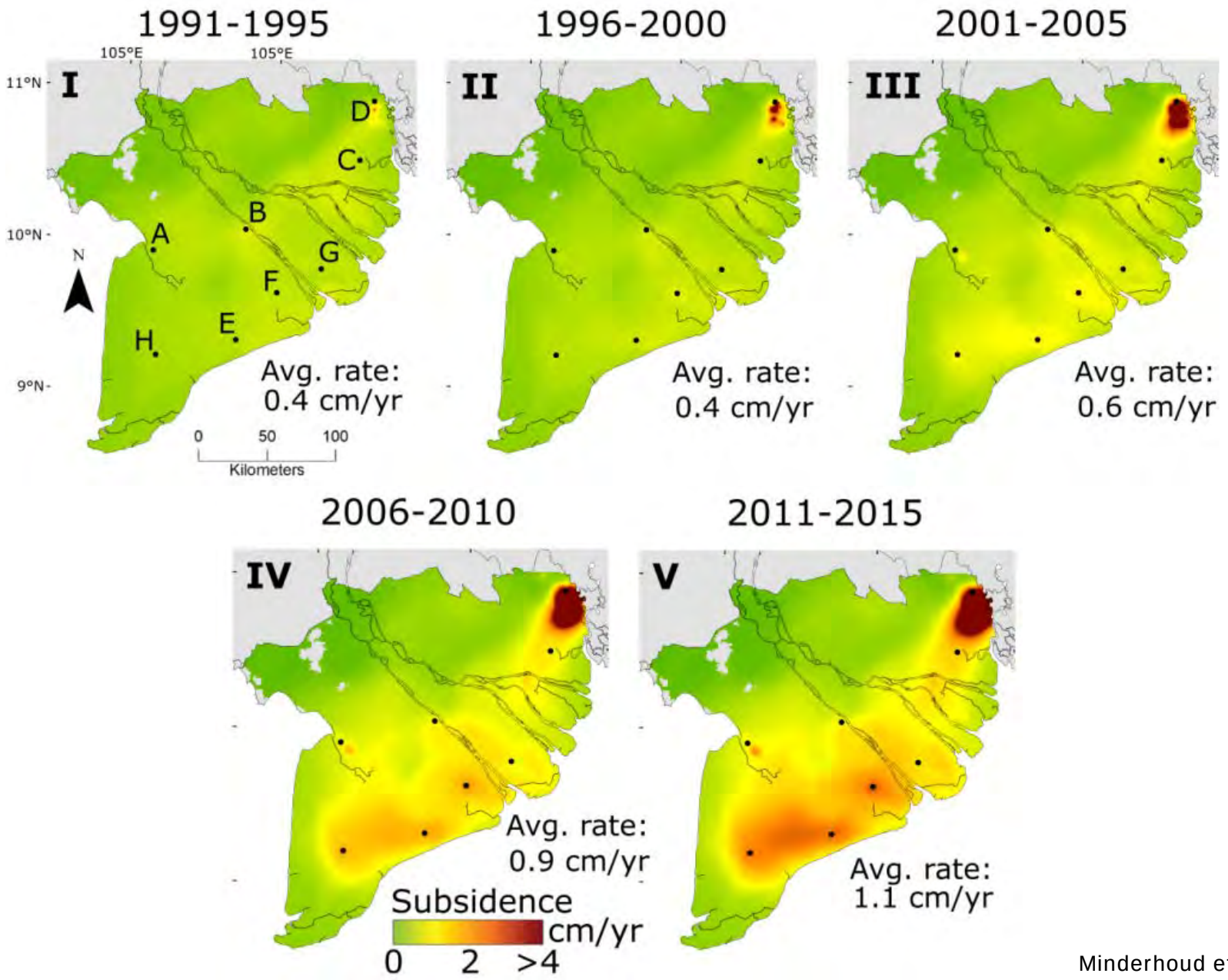




Bodemdalingsnelheden liggen veel hoger dan absolute zeespiegelstijging!

Minderhoud et al., 2017

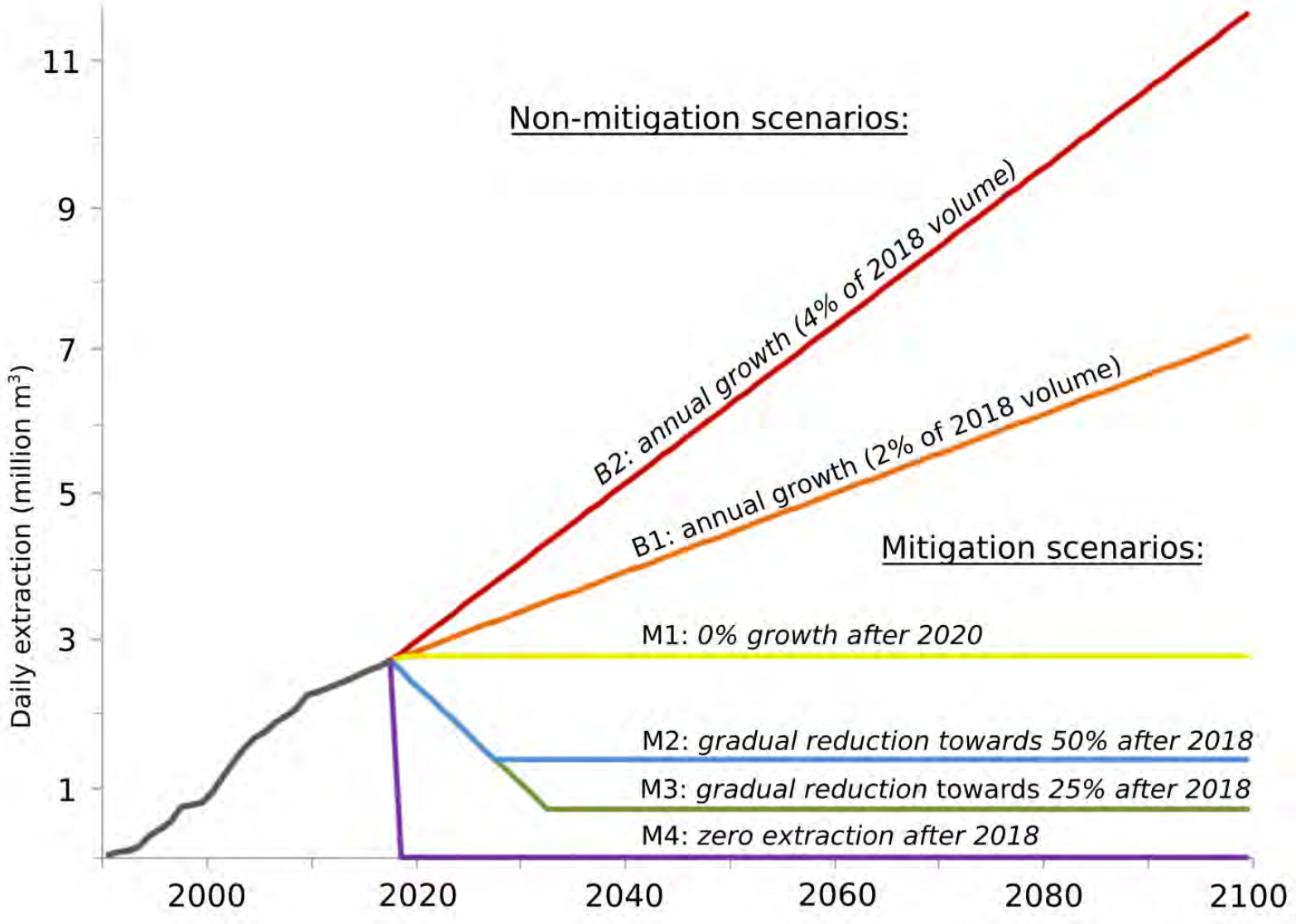
Bodemdaling is aan het versnellen!



Minderhoud et al., 2017

Hoe ziet de toekomst eruit?

Verschillende scenarios van grondwateronttrekking



Minderhoud et al., in review

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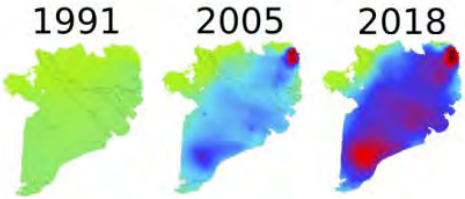
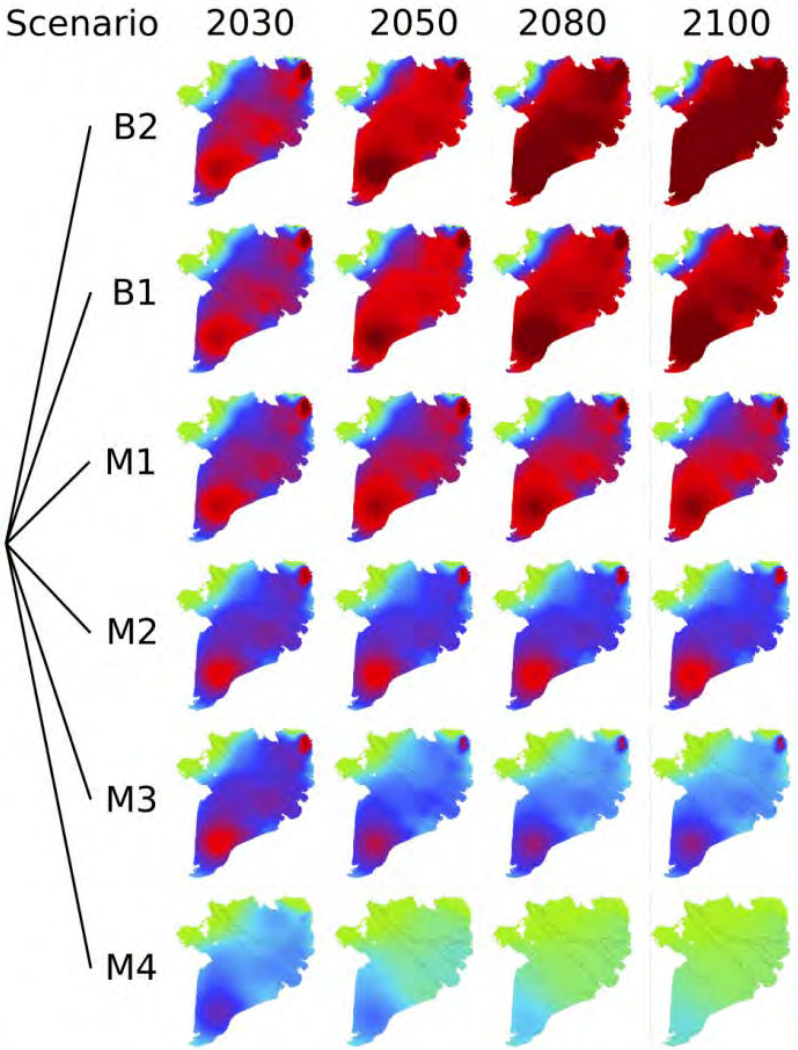
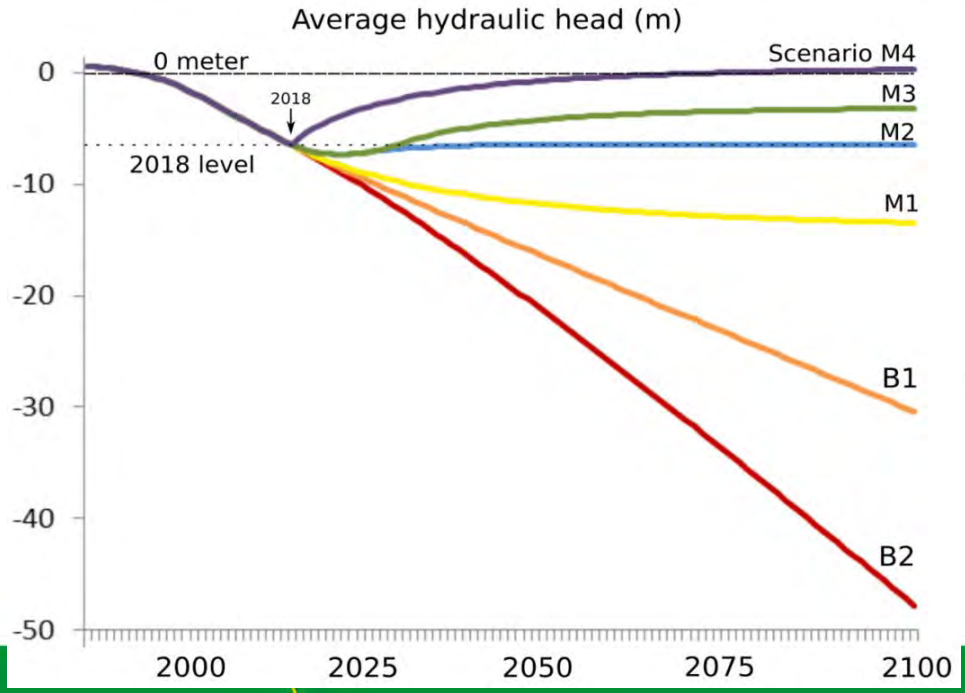
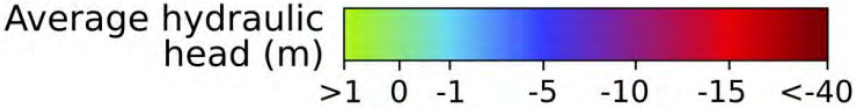
Grondwaterstand









Minderhoud et al., in review Future Deltas

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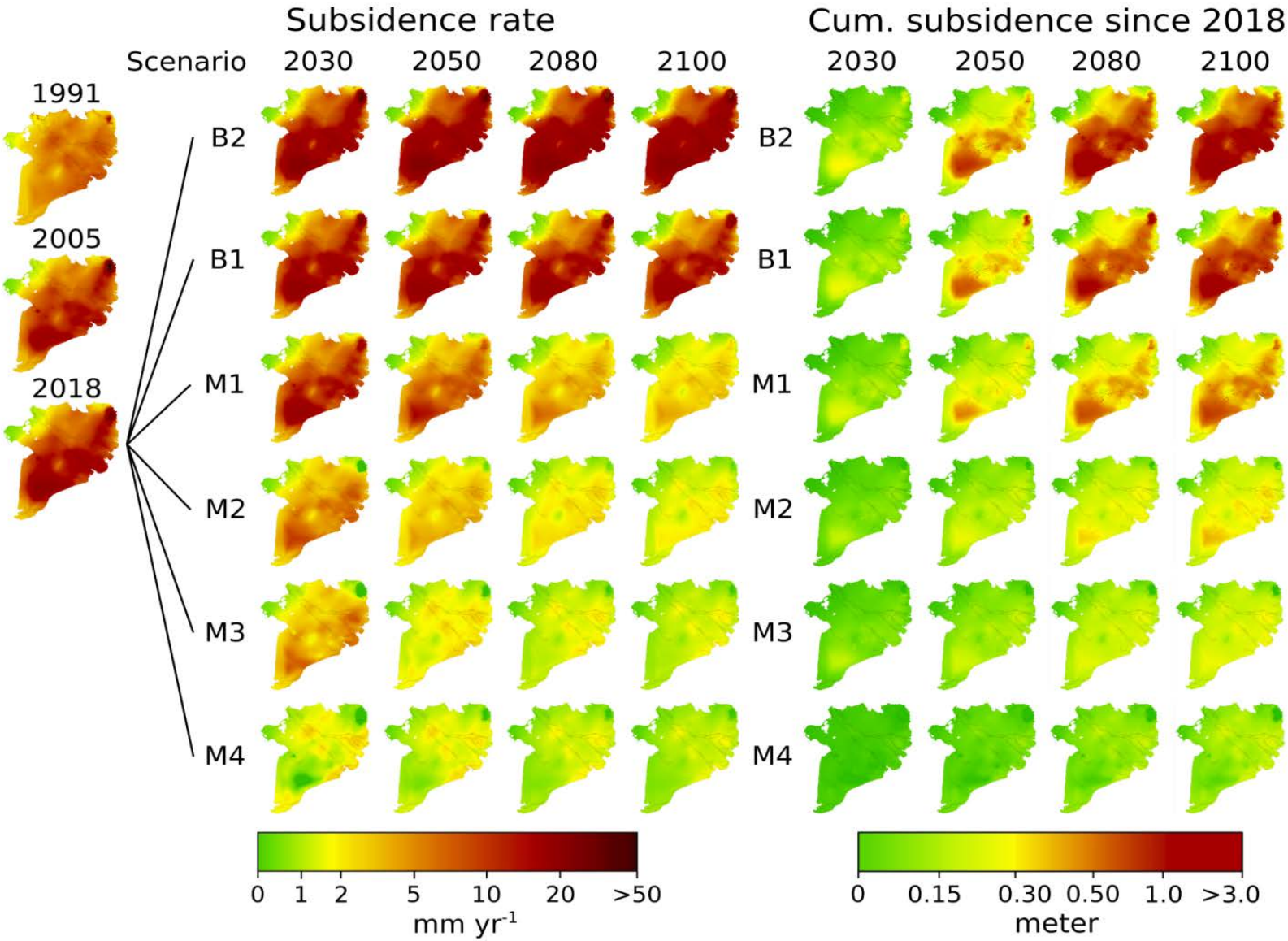
Toekomstige bodemdaling



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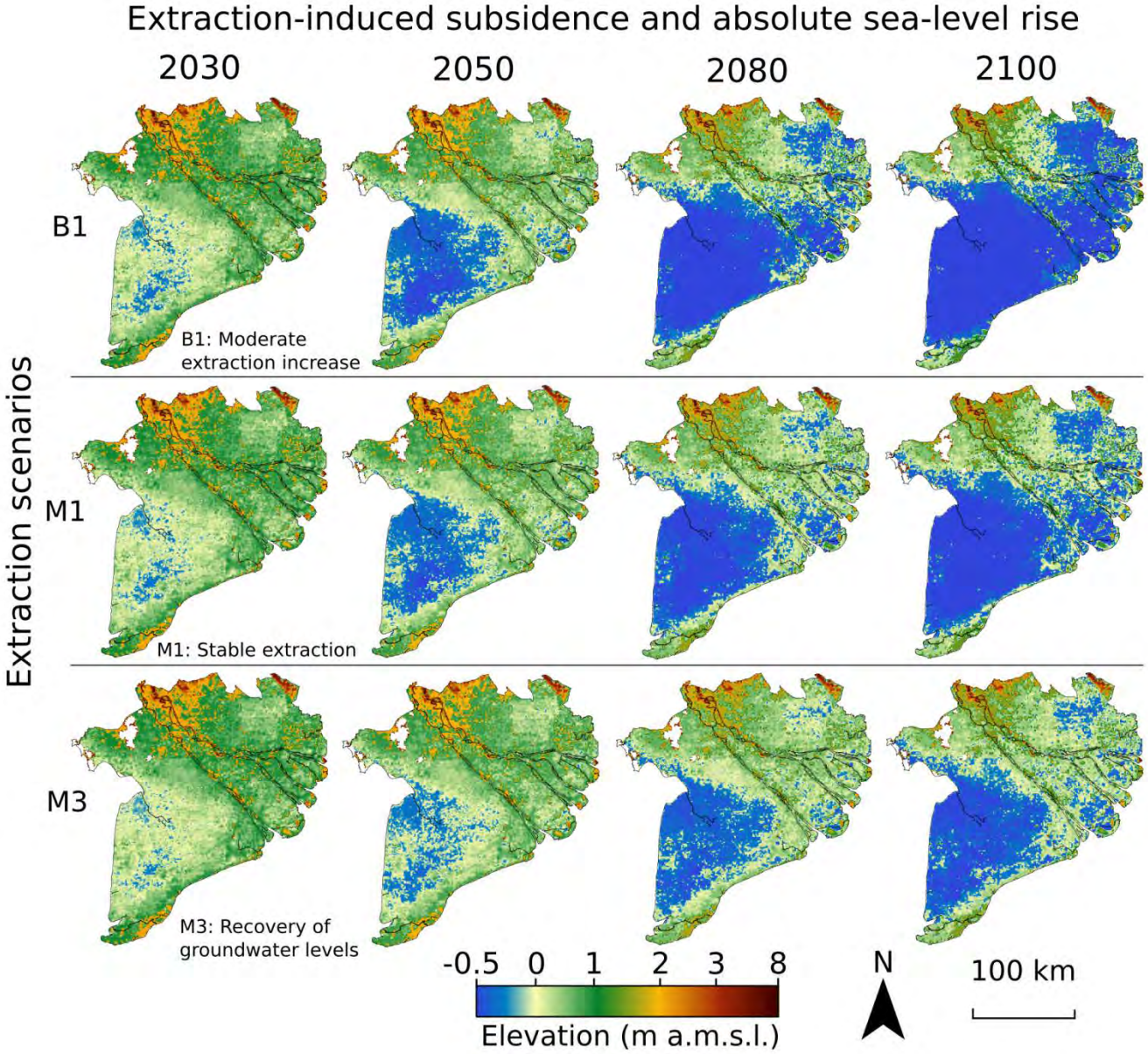
Hoe ziet de toekomst eruit?



Minderhoud et al., 2020

Selectie media impact van het onderzoek afgelopen jaar

VN EXPRESS INTERNATIONAL
The most read Vietnamese newspaper
News Business Travel Life Sports Video Perspectives
News
Mekong Delta closer to sea than previously thought: study
By Minh Nga

nrc.nl
Mekongdelta ligt lager dan gedacht
Geografie De kans op overstromingen in Vietnam is groter dan gedacht. Bestaande risicomodellen gaan uit van onnauwkeurige gegevens.
Anne Marlene 29 augustus 2019 Leestijd 2 minuten

SCIENTIFIC AMERICAN
SCIENCE MIND HEALTH TECH SUSTAINABILITY EDUCATION VIDEO PODCASTS BLOGS PUBLICATIONS
CLIMATE
New Elevation Measure Shows Climate Change Could Quickly Swamp the Mekong Delta
A surprise revelation means 12 million Vietnamese may need to retreat

28 August 2019
Subsidence research reveals other urgent problem
Elevation of sinking Mekong Delta wrongly estimated for decades
The Vietnamese Mekong Delta is on average just 80 centimetres above the local
ENVIRONMENT

Trouw
OPINIE RELIGIE&FILOSOFIE DUURZAAMHEID&NATUUR
Bodemdaling is niet alleen in Nederland een probleem. In Vietnam lopen 18 miljoen mensen gevaar

ADVANCES
10.000.000 copies in 14 languages world-wide
Delta Danger

GEOGRAPHY
Delta Danger
Newly calculated elevation means millions of residents may need to leave Vietnam's Mekong Delta
A stunning 12 million people could be forced to retreat from rising seas in Vietnam's Mekong Delta within half a century. Geographer Philip Minderhoud and his colleagues at Utrecht University in the Netherlands arrived at this conclusion

Impact in Vietnam

Press conference at the Embassy in Hanoi (24 Oct 2019)

Prime-time 20:00 news on VTV1

Presentation at Vietnam Ministry (MONRE)

Hoofdconclusie

De versnellende bodemdaling in de Mekong delta wordt voornamelijk veroorzaakt door grondwateronttrekking

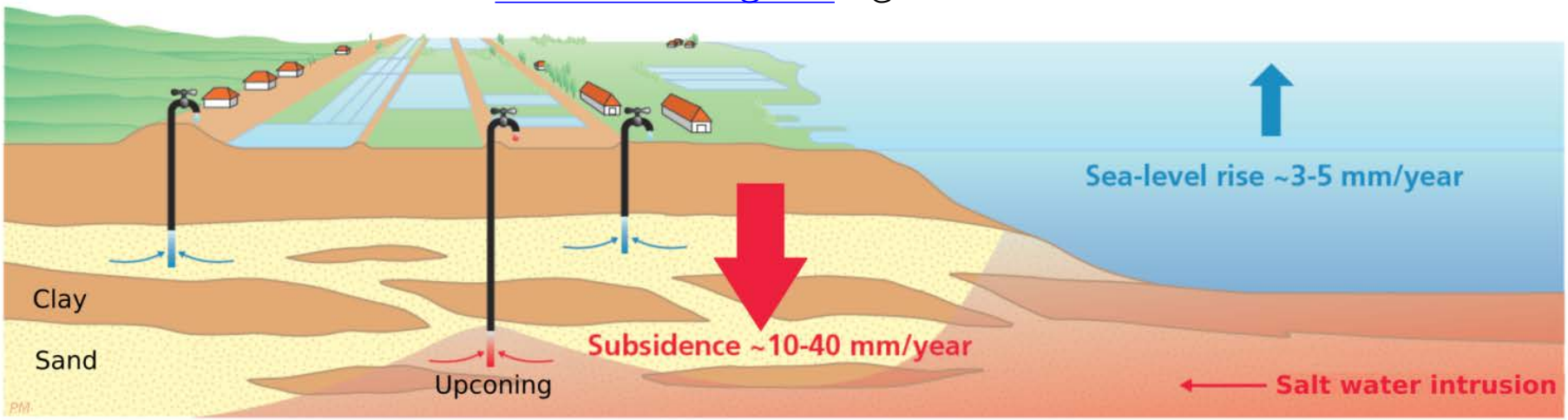
Grondwater is niet gratis in delta je betaal ervoor met hoogte

Het drastisch terugbrengen van de grondwateronttrekking is van levensbelang voor de delta

“Mijn hartelijke dank gaat uit naar alle leden van de Hofvijverkring. Dankzij de financiele support van de Hofvijverbeurs kon ik het afgelopen jaar een groot aantal international bezoeken en wetenschappelijke samenwerkingen aangaan waar ik nu de vruchten van pluk. Blijf gezond!”

Philip

P.S.J.Minderhoud@uu.nl / @deltasubsidence



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Wetenschappelijke referenties om verder te lezen:

Minderhoud, P. S. J, Middelkoop, H., Erkens, G., Stouthamer, E., 2020: Groundwater extraction may drown mega-delta: projections of extraction-induced subsidence and elevation of the Mekong delta for the 21th century, Environmental Research Communications, https://doi.org/10.1088/2515-7620/ab5e21

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Minderhoud, P. S. J., Coumou, L., Erkens, G., Middelkoop, H., Stouthamer, E., 2019: Mekong delta much lower than previously assumed in sea-level rise impact assessments, Nature Communications, 10, 3847, https://doi.org/10.1038/s41467-019-11602-1

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Minderhoud, P. S. J., Erkens, G., Pham Van, H., Bui Tran, V., Erban, L.E., Kooi, H., Stouthamer, E., 2017: Impacts of 25 years of groundwater extraction on subsidence in the Mekong delta, Vietnam, Environ. Res. Lett., 12, 6, https://doi.org/10.1088/1748-9326/aa7146 (open access)

Zoccarato, C., Minderhoud, P. S. J., Teatini, P., 2018: The role of sedimentation and natural compaction in a prograding delta: insights from the mega Mekong delta, Vietnam, Sci. Rep. 8, 11437, https://doi.org/10.1038/s41598-018-29734-7 (open access)