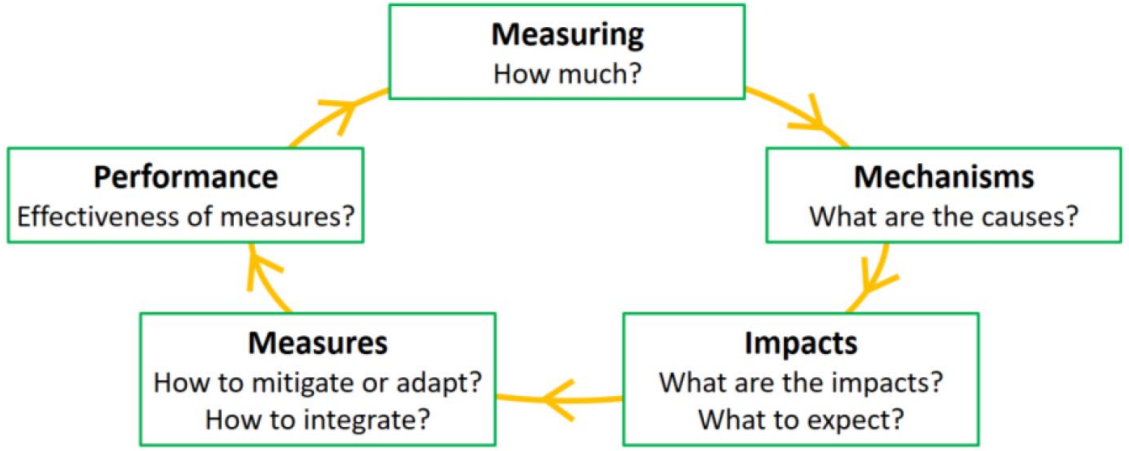
WP 1: “Meten en Monitoren”

… van bodemdaling op locale en regionale schaal,
… met hoge ruimtelijke en temporele resolutie,
… geïntegreerd met geofysische modellen,
… uitgesplitst naar oorzakelijk mechanisme, en
… met link naar zeespiegelvariatie



Uitdagingen Meten en Monitoren

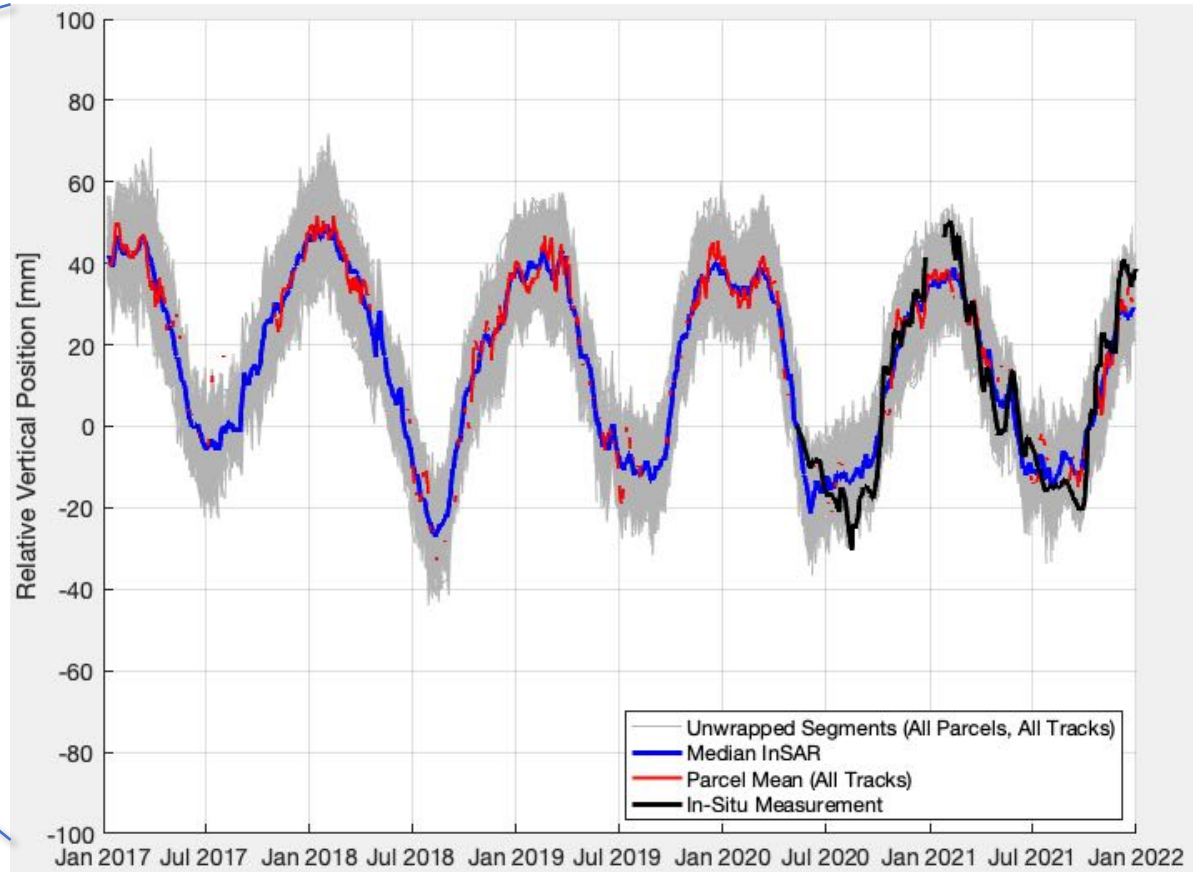
- Voor het veenweide-gebied konden we nog niet gebiedsdekkend bodembeweging meten
- Van gemeten bodembeweging wisten we niet in welke rol verschillende oorzakelijke mechanismen spelen
- Voor de wijdschalige component van het herstel van isostatisch evenwicht (GIA) wisten we nog onvoldoende wat de invloed was voor Nederland

Werkpakketten

- WP1.1 **Geodesie** : gebruik maken van satelliet radar metingen om beweging slappe bodem te kunnen meten
- WP1.2 **Data-assimilatie en ontrafeling** : inverse-modellering van oorzaken voor bodemdaling door natuurlijke oorzaken en menselijk handelen
- WP1.3 **Bodembeweging door isostasy** : schatting van de GIA bodembewegingscomponent, vnml uit historische grondwaterstandsdata

WP 1.1 InSAR geodesie

Philip Conroy, Simon van Diepen, Freek van Leijen, Ramon Hanssen



- InSAR werkt over veenweide
- Nieuw kinematisch model
- Opschalen naar Groene Hart

- Conroy et al, 2023a, Bridging Loss-of-Lock in InSAR Time Series of Distributed Scatterers, *IEEE TGRS*, accepted for publication, 1/11/2023
- Conroy et al, 2023b, SPAMS: A New Empirical Model for Soft Soil Surface Displacement Based on Meteorological Input Data, *Geoderma*, accepted for publication 20/10/2023

WP 1.2 Ontrafelen en parameteriseren van het totale bodemdaling signaal

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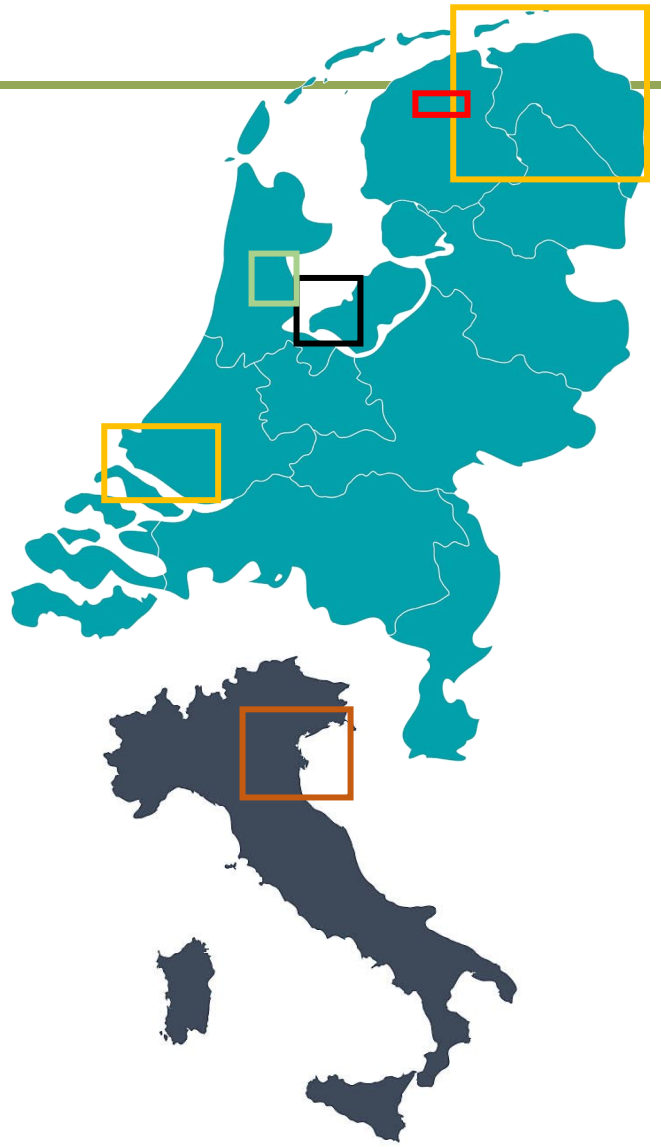
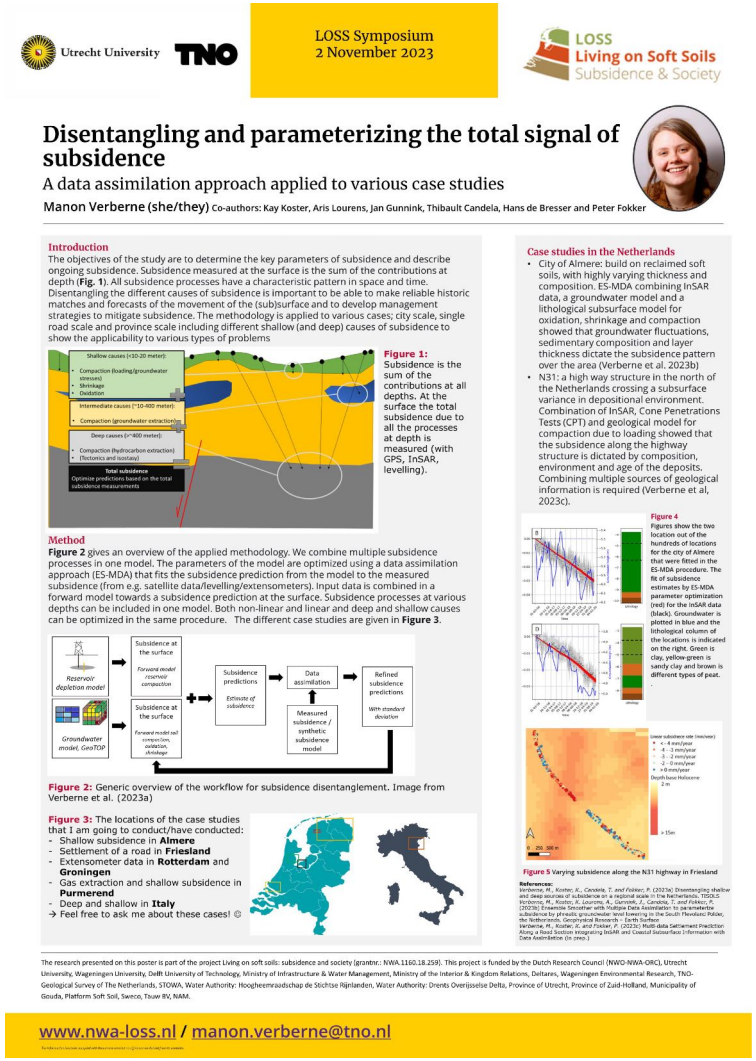
Living on Soft Soils
Subsidence & Society

Manon Verberne, Peter Fokker



Toegepast op:

- **Almere** → shallow background subsidence
- **Friesland** → compaction of highway structure
- **Rotterdam and Groningen** → intermediate depth
- **Purmerend** region → shallow and deep
- **Emilia-Romagna** → off shore gas, groundwater extraction and soft soils



Utrecht University TNO

LOSS Symposium
2 November 2023

LOSS Living on Soft Soils Subsidence & Society

Disentangling and parameterizing the total signal of subsidence

A data assimilation approach applied to various case studies

Manon Verberne (she/they) Co-authors: Kay Koster, Aris Lourens, Jan Gunnink, Thibault Candela, Hans de Bresser and Peter Fokker

Introduction

The objectives of the study are to determine the key parameters of subsidence and describe ongoing subsidence. Subsidence measured at the surface is the sum of the contributions at depth (**Fig. 1**). All subsidence processes have a characteristic pattern in space and time. Disentangling the different causes of subsidence is important to be able to make reliable historic matches and forecasts of the movement of the (sub)surface and to develop management strategies to mitigate subsidence. The methodology is applied to various cases; city scale, single road scale and province scale including different shallow (and deep) causes of subsidence to show the applicability to various types of problems

Figure 1: Subsidence is the sum of the contributions at all depths. At the surface the total subsidence due to all the processes at depth is measured (with GPS, InSAR, levelling).

Method

Figure 2 gives an overview of the applied methodology. We combine multiple subsidence processes in one model. The parameters of the model are optimized using a data assimilation approach (ES-MDA) that fits the subsidence prediction from the model to the measured subsidence (from e.g. satellite data/levelling/extensometers). Input data is combined in a forward model towards a subsidence prediction at the surface. Subsidence processes at various depths can be included in one model. Both non-linear and linear and deep and shallow causes can be optimized in the same procedure. The different case studies are given in **Figure 3**.

Figure 2: Generic overview of the workflow for subsidence disentanglement. Image from Verberne et al. (2023a)

Figure 3: The locations of the case studies that I am going to conduct/have conducted:
- Shallow subsidence in **Almere**
- Settlement of a road in **Friesland**
- Extensometer data in **Rotterdam** and **Groningen**
- Gas extraction and shallow subsidence in **Purmerend**
- Deep and shallow in **Italy**

→ Feel free to ask me about these cases!

Case studies in the Netherlands

- City of Almere: build on reclaimed soft soils, with highly varying thickness and composition. ES-MDA combining InSAR data, a groundwater model and a lithological subsurface model for oxidation, shrinkage and compaction showed that groundwater fluctuations, sedimentary composition and layer thickness dictate the subsidence pattern over the area (Verberne et al. 2023b)
- N31: a high way structure in the north of the Netherlands crossing a subsurface variance in depositional environment. Combination of InSAR, Cone Penetrations Tests (CPT) and geological model for compaction due to loading showed that the subsidence along the highway structure is dictated by composition, environment and age of the deposits. Combining multiple sources of geological information is required (Verberne et al, 2023c).

Figure 4 Figures show the two location out of the hundreds of locations for the city of Almere that were fitted in the ES-MDA procedure. The fit of subsidence estimates by ES-MDA parameter optimization (red) for the InSAR data (black). Groundwater is plotted in blue and the lithological column of the locations is indicated on the right. Green is clay, yellow-green is sandy clay and brown is different types of peat.

Figure 5 Varying subsidence along the N31 highway in Friesland

The research presented on this poster is part of the project Living on soft soils: subsidence and society (grantnr.: NWA.1160.18.259). This project is funded by the Dutch Research Council (NWO-NWA-ORC), Utrecht University, Wageningen University, Delft University of Technology, Ministry of Infrastructure & Water Management, Ministry of the Interior & Kingdom Relations, Deltares, Wageningen Environmental Research, TNO-Geological Survey of The Netherlands, STOWA, Water Authority: Hoogheemraadschap de Stichtse Rijnlanden, Water Authority: Drents Overijsselse Delta, Province of Utrecht, Province of Zuid-Holland, Municipality of Gouda, Platform Soft Soil, Sweco, Tauw BV, NAM.

www.nwa-loss.nl / manon.verberne@tno.nl

WP 1.3 – Grondwater dataset

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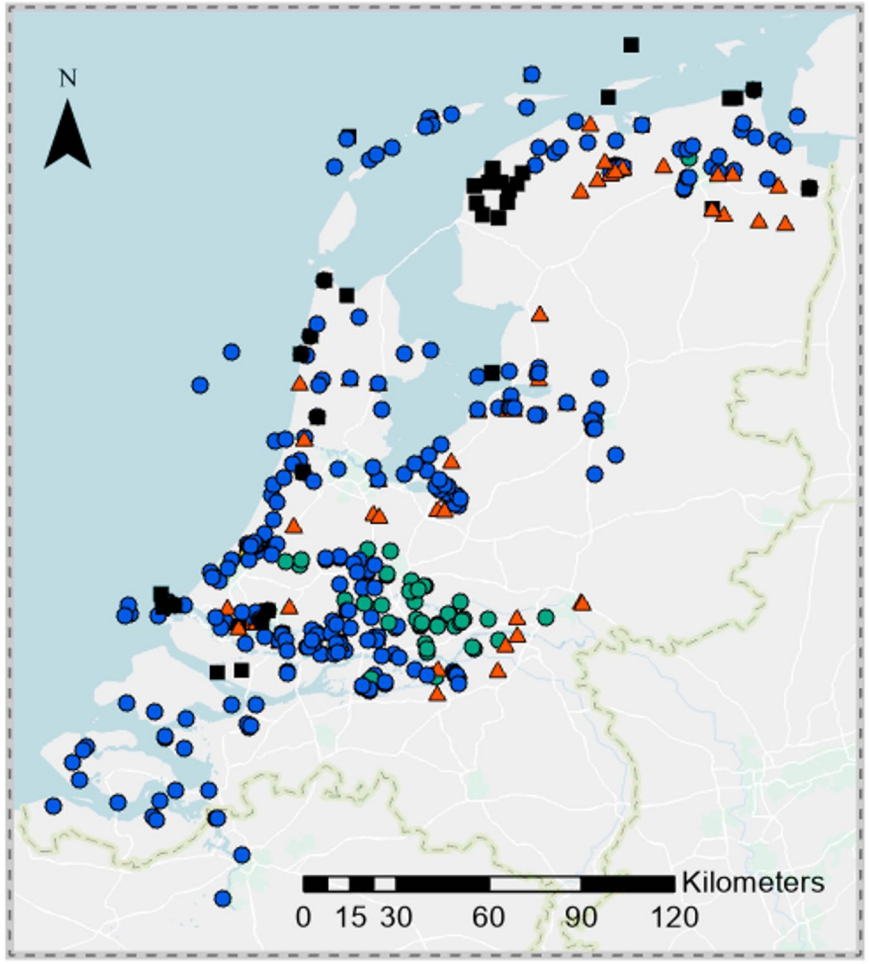
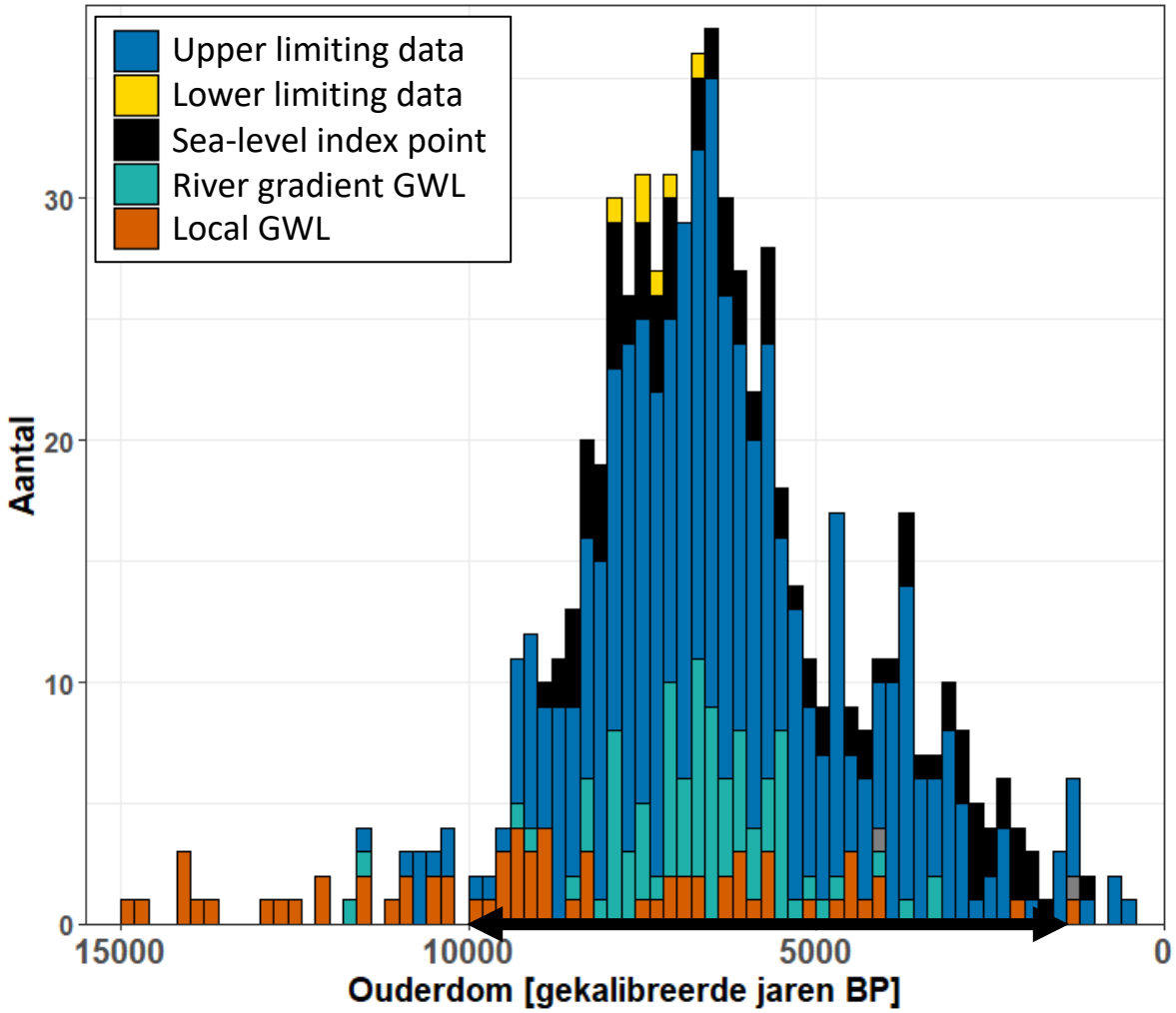
Kim de Wit, Kim Cohen





WP 1.3 – Grondwater dataset

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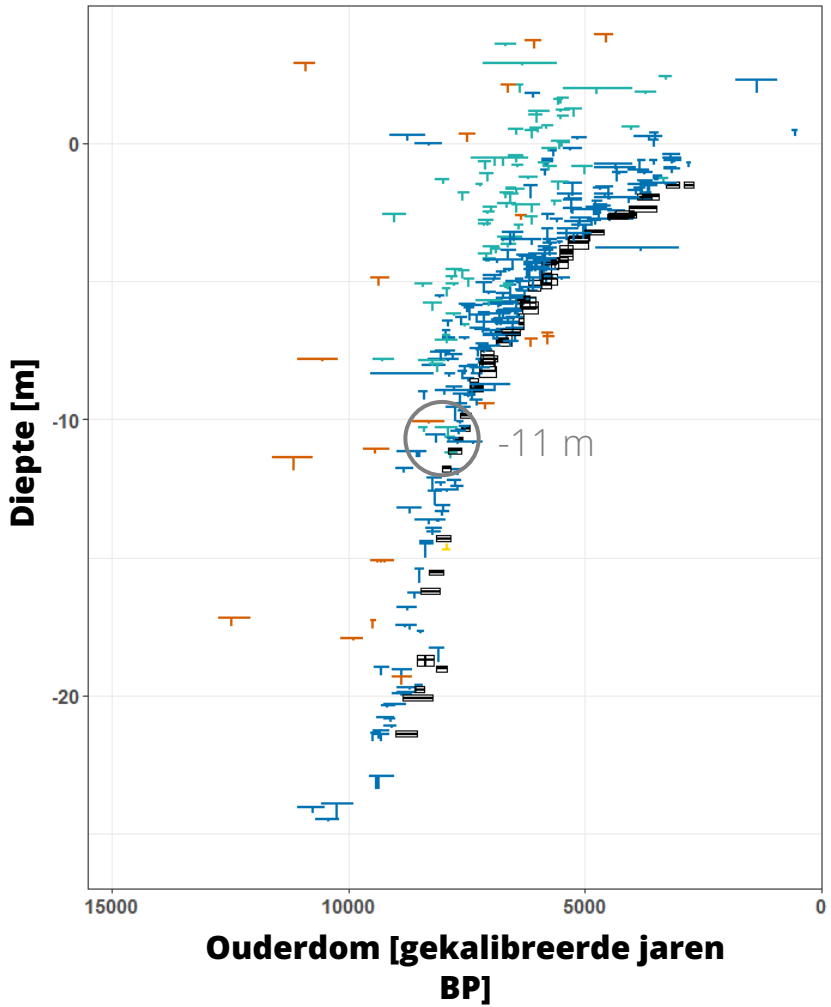
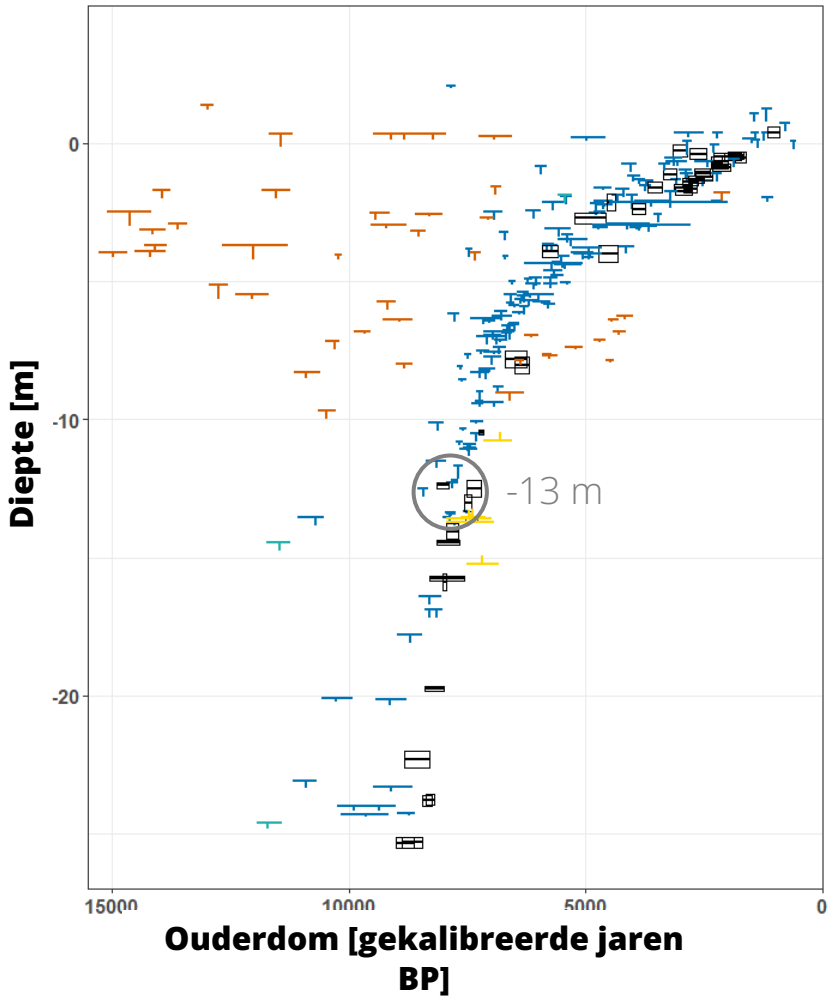
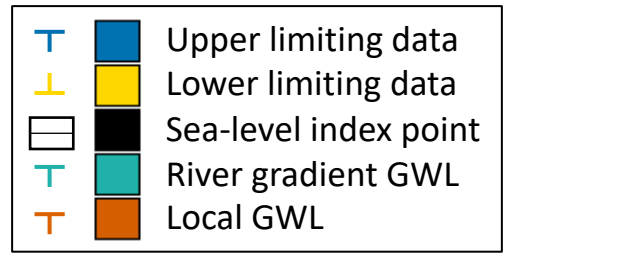
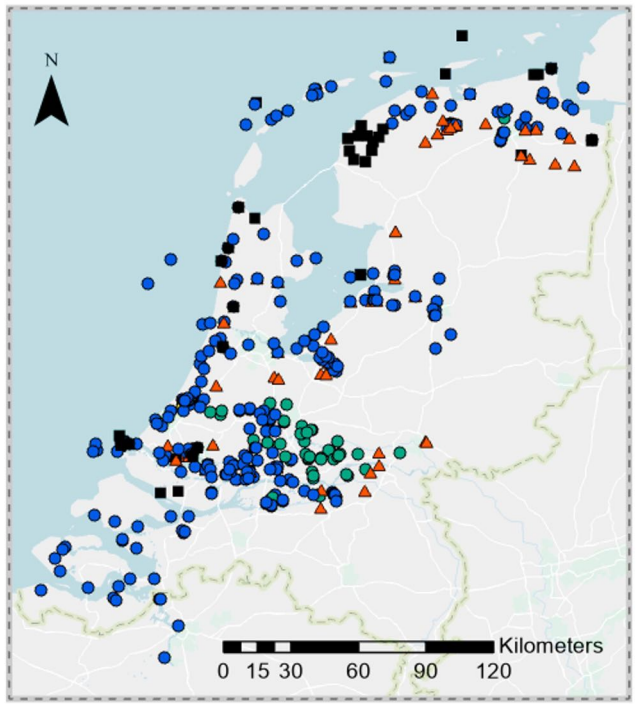
Zuid-Nederland



Noord-Nederland







LOSS WP 3 – impact analysis

Structure and overall aim of the workpackage

Living on soft soils – subsidence & society

Annual Symposium, 2 November 2023

Hans-Peter Weikard, Wageningen University

Structure of WP 3: Impact Analysis

WP 1 What's happening? (measurement)

WP 2 And why? (understanding processes)

WP 3 What should we do? (decision support)

WP 4 What can we do? (scenario development)

WP 3.1 Forecasting of land subsidence (Deniz Kılıç)

WP 3.2 Impacts on buildings and infrastructure (Alfonso Prosperi)

WP 3.3 Impacts on agriculture and overall assessment

(Dewy Verhoeven)

Impact analysis

Aim of the research

Impact analysis for decision making

Physical impacts

- Impacts of what ⟶ scenario analysis
- What kind of impacts ⟶ on buildings, infrastructure, agricultural yields

The meaning of physical impacts

- Importance of (physical) impacts
  - Who is impacted?
  - How much?
  - When?

Welfare analysis

- Cost-Benefit Analysis for the scenarios defined and optimized pathways

WP 3.1
Modelling alternative mitigation pathways to subsidence

LOSS Symposium

2 November 2023

Deniz Kılıç, Utrecht University

d.kilic@uu.nl

Modelling alternative mitigation pathways to subsidence

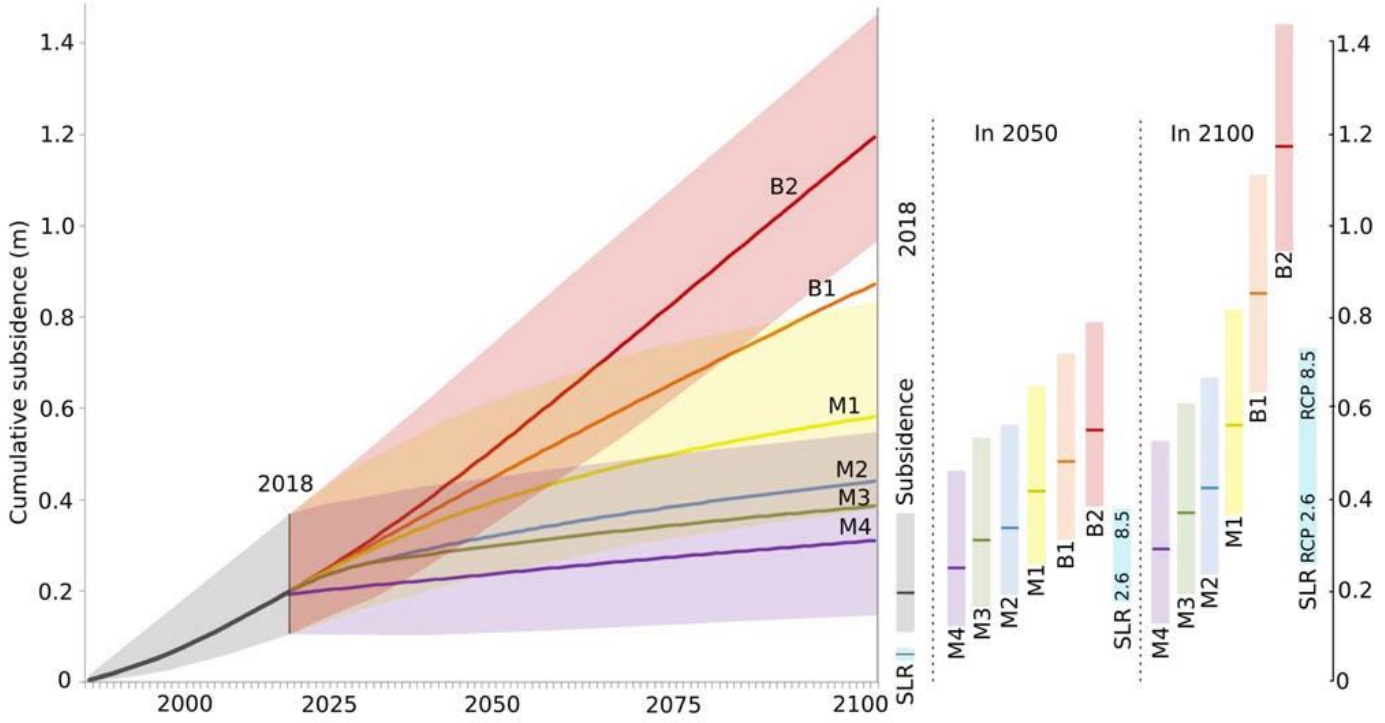


Figure: An example of future cumulative land subsidence in the Mekong delta under various mitigation scenarios (Minderhoud et al., 2020)

Research Question: Can we evaluate the impact of specific mitigation and adaptation strategies against land subsidence in the Netherlands using a 3D predictive modelling over 100-year timeframe?

Goal: Quantify the long-term impact of counter measures on land subsidence and peat oxidation through a 3D predictive modelling; Provide valuable data-driven insights to stakeholders through a series of 'what if?' scenario analysis.

Methods:

Atlantis forward model (Bootsma et al., 2020)

Fragility curves for urban damage assessment (Prosperi et al., 2023)

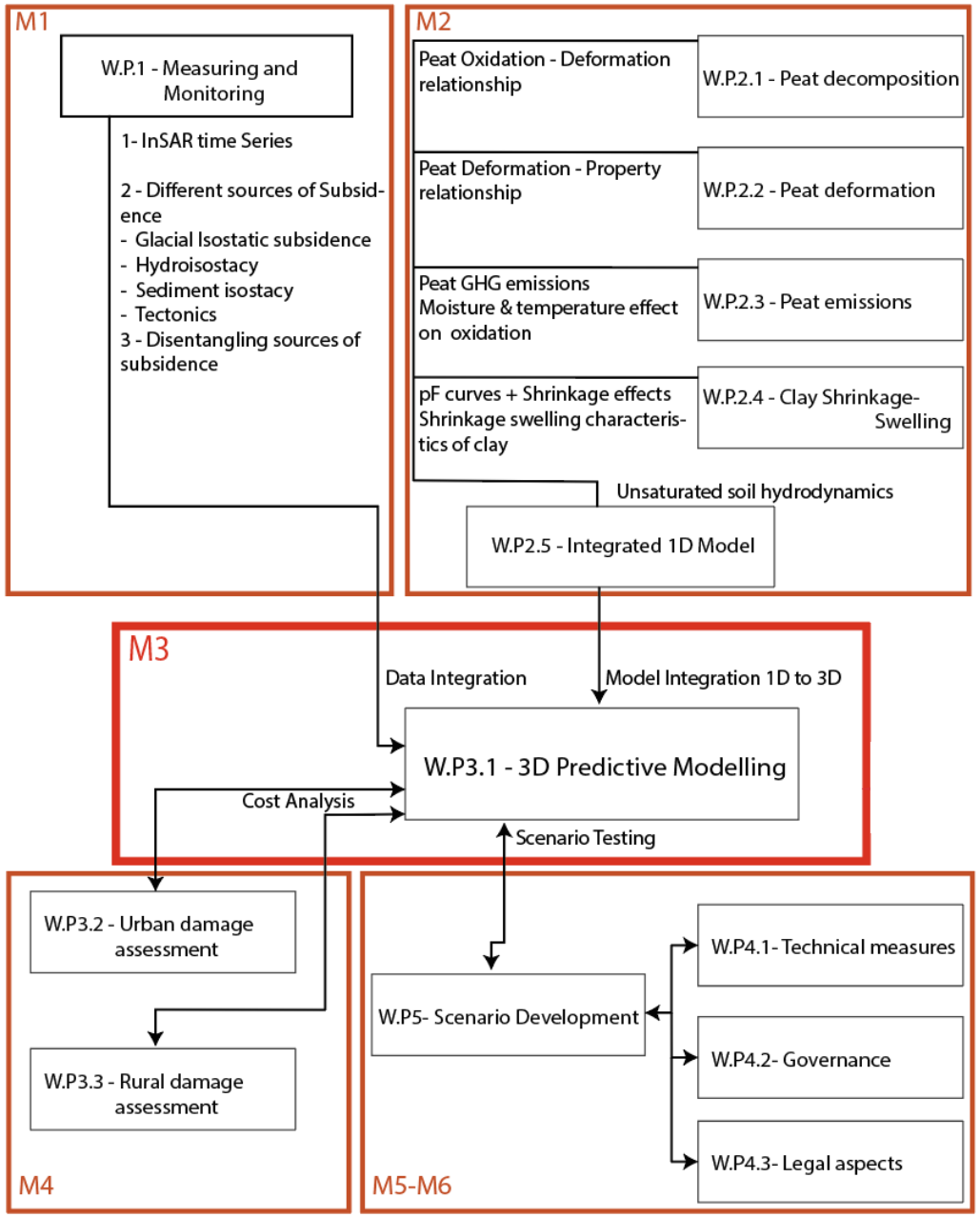
Analytical solution for rural damage assessment (Verhoeven et al., Submitted)

Scenario analysis on measures

IPCC Climate Change Scenarios (KNMI, 2023)

Societal Cost-Benefit Analysis (Boardman et al., 2001)

NWA-LOSS WP3.1: 3D Predictive Modelling



Research steps

1. Model development
2. Data integration & Process improvements
   - Sensitivity analysis
   - Calibration, Data assimilation
3. Damage Module Development (1D to 3D)
   - Numerical/Empirical fragility functions for **urban area damages**
   - Analytical solution for **rural area damages**
   - Quantifying the damages associated with land subsidence and GHGs emissions in the Netherlands
4. Baseline scenario development (Business-as-usual)
5. Alternative futures (scenarios) to mitigate the land subsidence
   - **Societal cost-benefit analysis**
6. Quantification of **the extent of GHG emissions** due to peat oxidation

Integrated Spatial Data/Modelling Framework (The Work Package 3.1 – M3)

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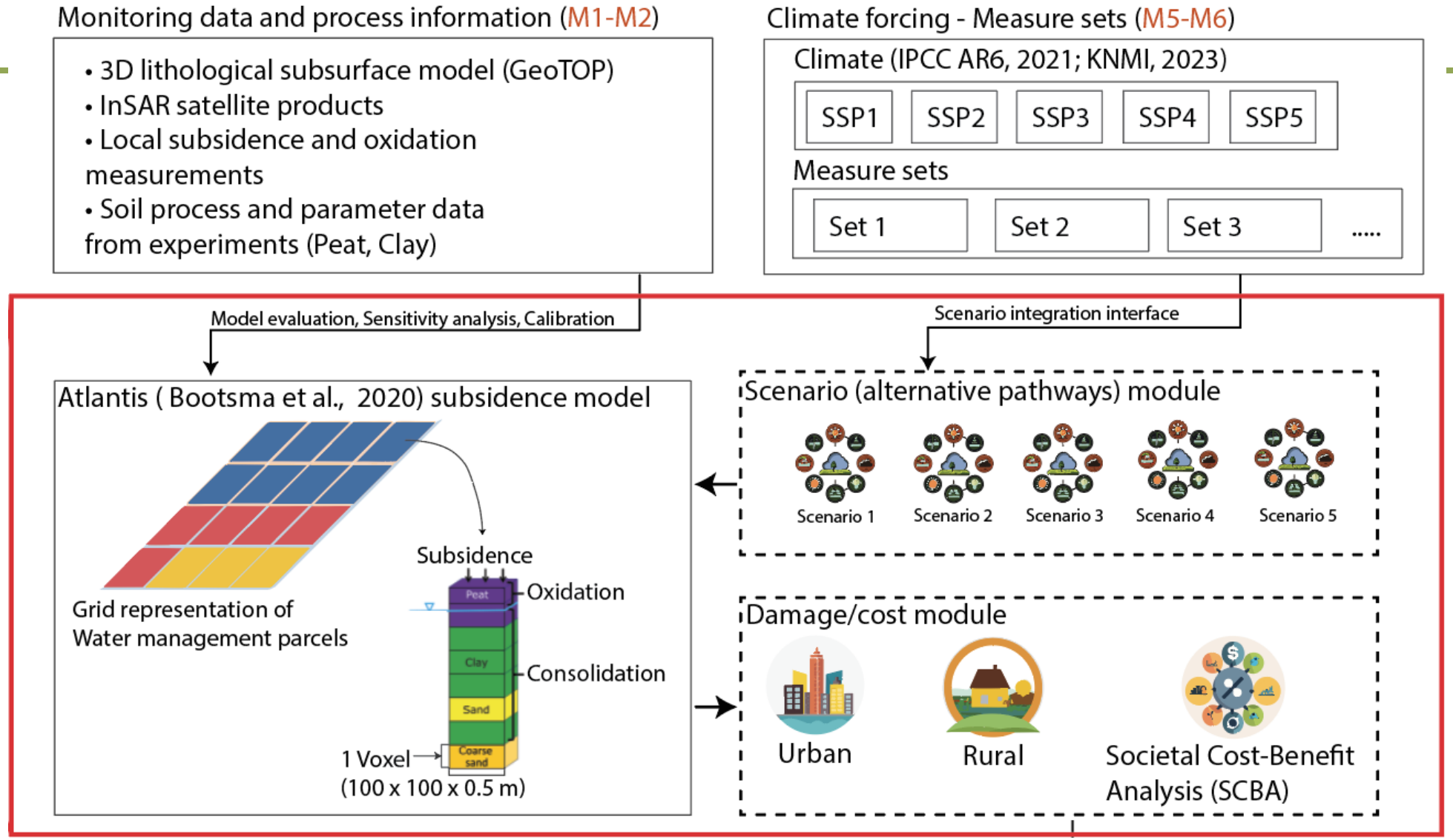

Expected Outputs...

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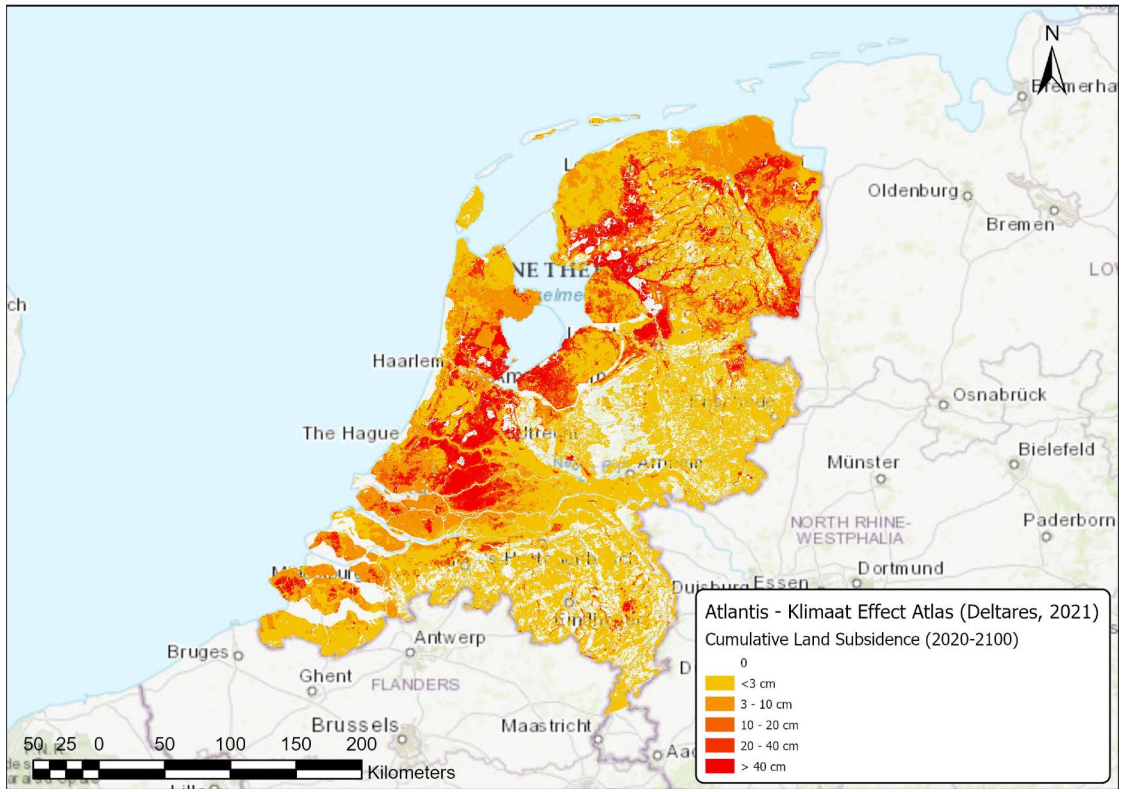
Land subsidence rates (in cm/year)

Damage assessment (in EUR) in rural and urban areas



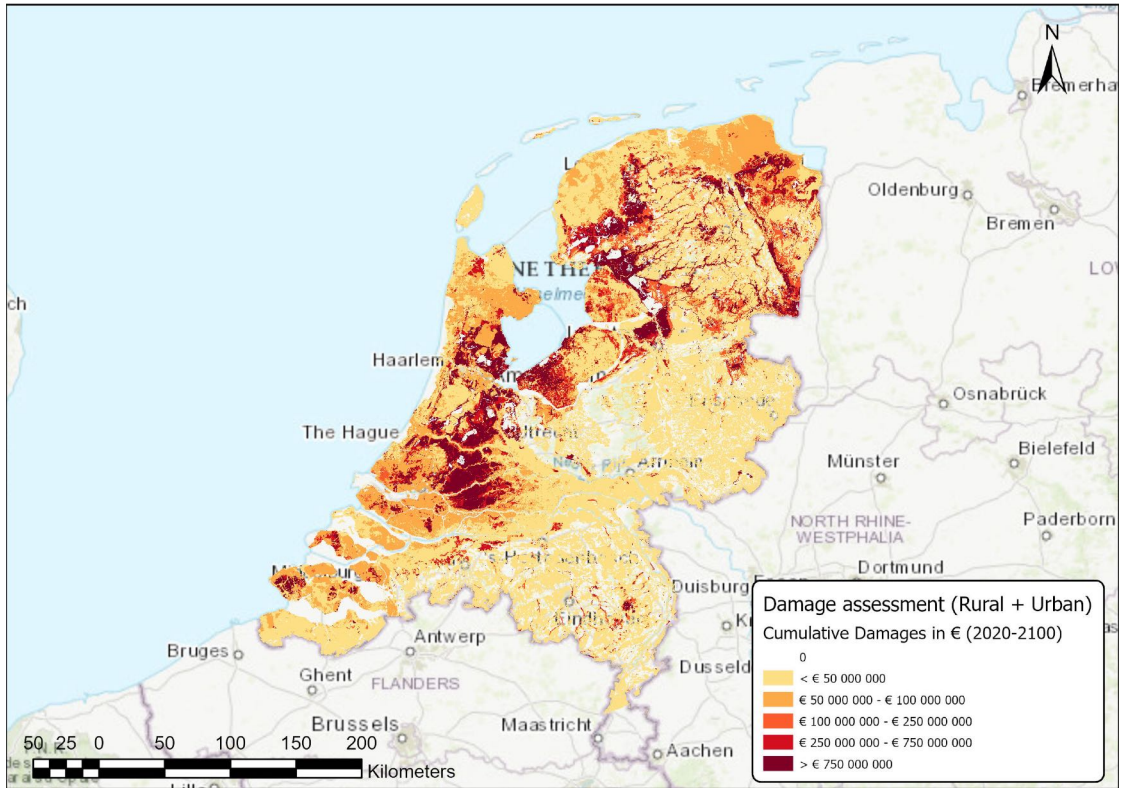


Figure: Example output maps for demonstration purposes based on Klimaat Effect Atlas (2021)

WP 3.2
Assessing damages to buildings and infrastructure

LOSS Symposium

2 november 2023

Alfonso Prosperi

A.Prosperi@tudelft.nl

Supervisor

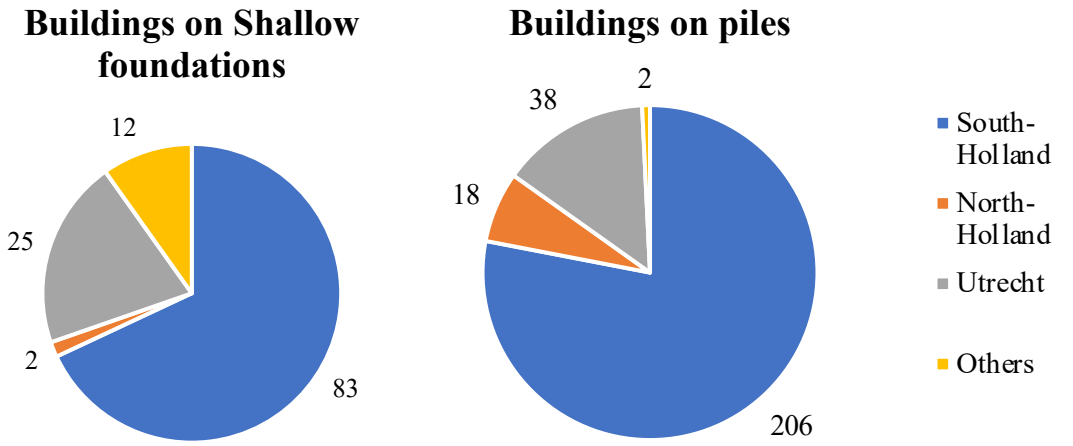
Dr. ir. Mandy Korff, Deltares and TU Delft

Prof. Dr. ir. Jan Rots, TU Delft

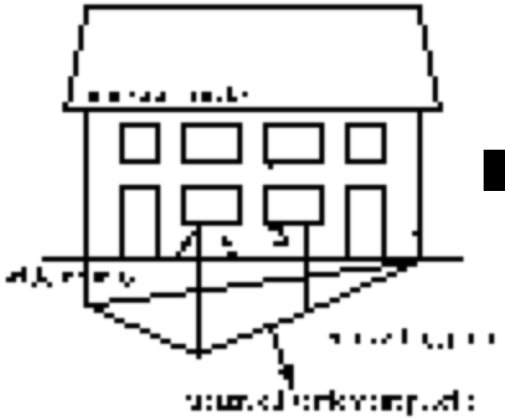
Empirical fragility functions

386 field surveys over different Dutch provinces were collected.

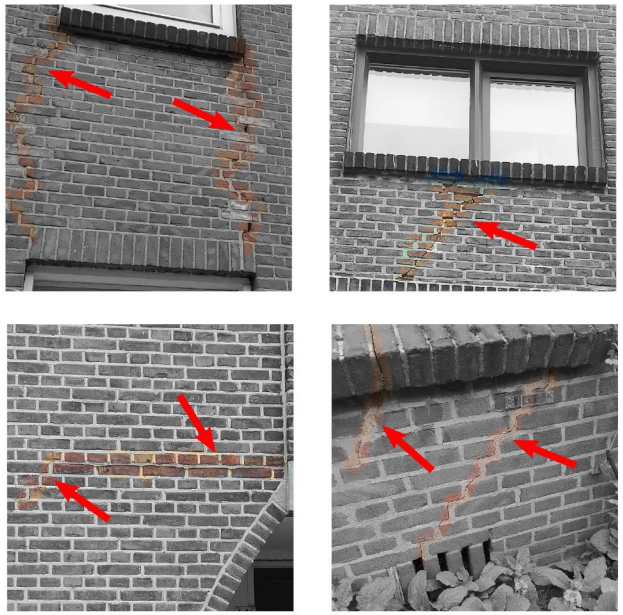
The collected information was used to develop empirical-based **fragility functions**.

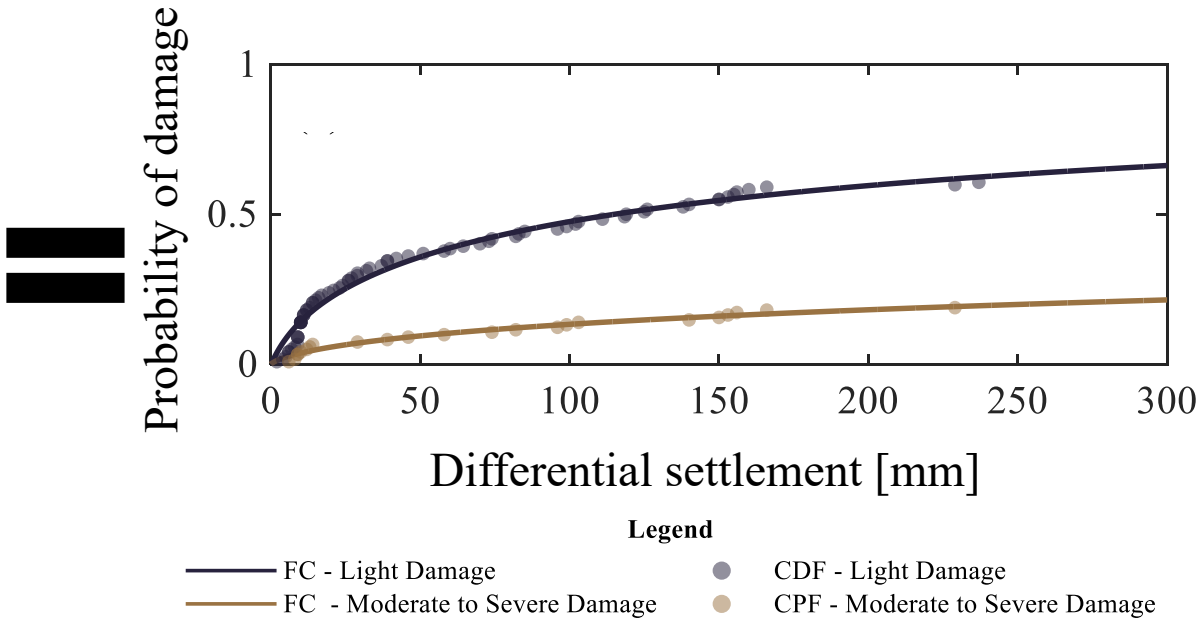


Measured deformation of the building



Damage reported in field surveys



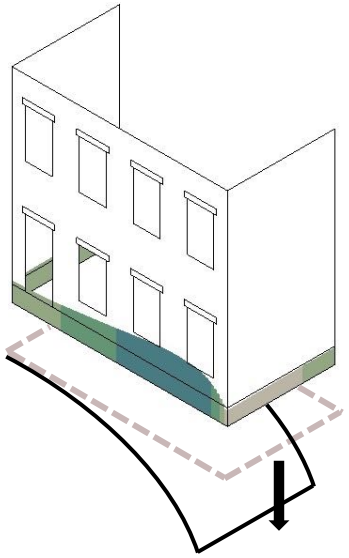


Numerical simulations

Reality
Monument ID: 11994

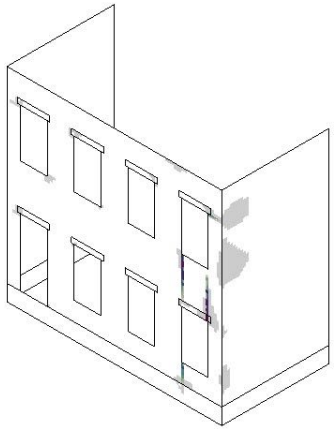
Source: https://commons.wikimedia.org/wiki/File:RM11994_Delft_-_Oude_Delft_81.jpg

Model



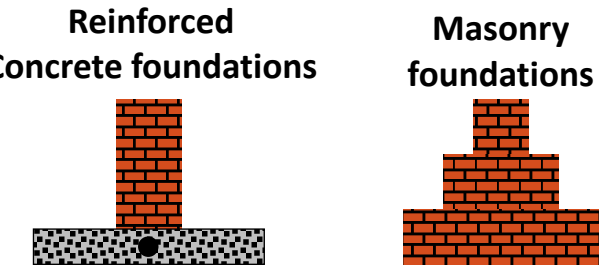
A settlement action is applied to model the subsidence occurrence

Results



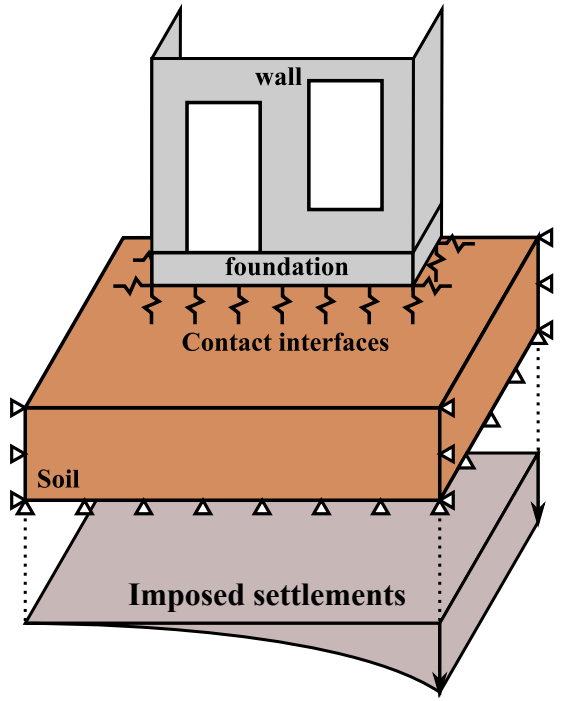
Crack patterns

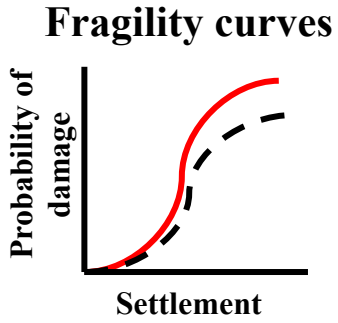
- **Buildings with longer façades are more vulnerable than shorter ones**, if the height is the same;
- Buildings on **reinforced concrete foundations are less vulnerable** to subsidence than the ones on masonry foundations;
- **The shape of the settlement actions strongly influences the results**;

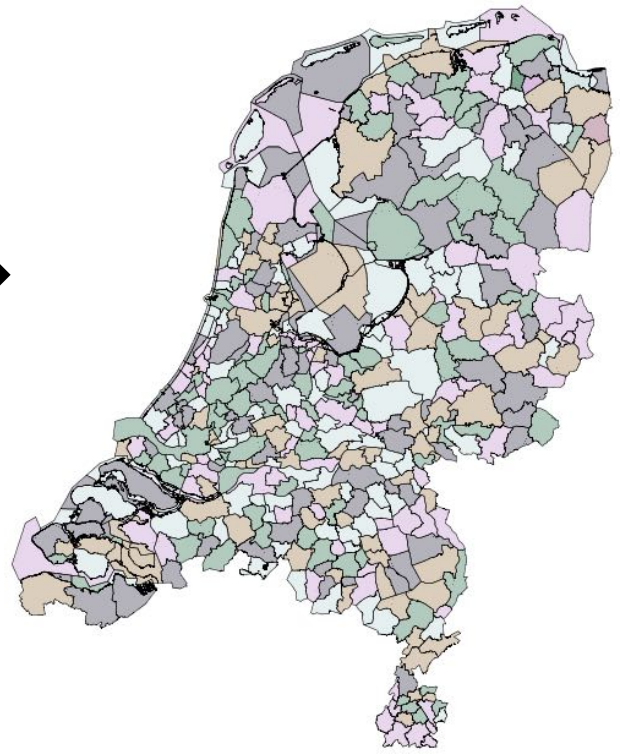


Using the numerical (and empirical) fragility functions to assess damage and losses

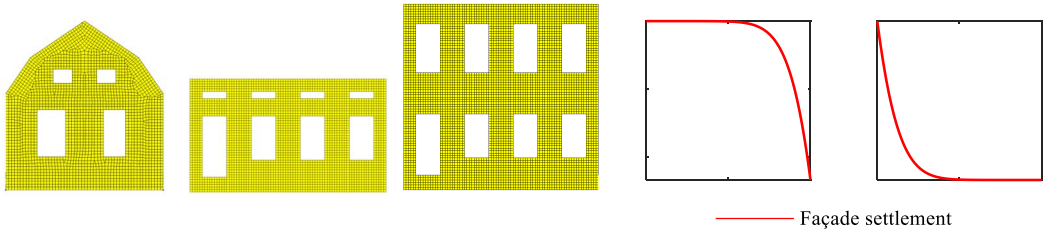
Numerical models to obtain fragility functions







Models that include the variability of the structural features and of the settlements



Disclaimer: The results of this slide are not based on any calculation and just serve for illustration purposes.

WP 3.3
Afweging maatschappelijke kosten en baten van aanpak bodemdaling veenweidegebieden

LOSS Symposium

2 november 2023

Dewy Verhoeven

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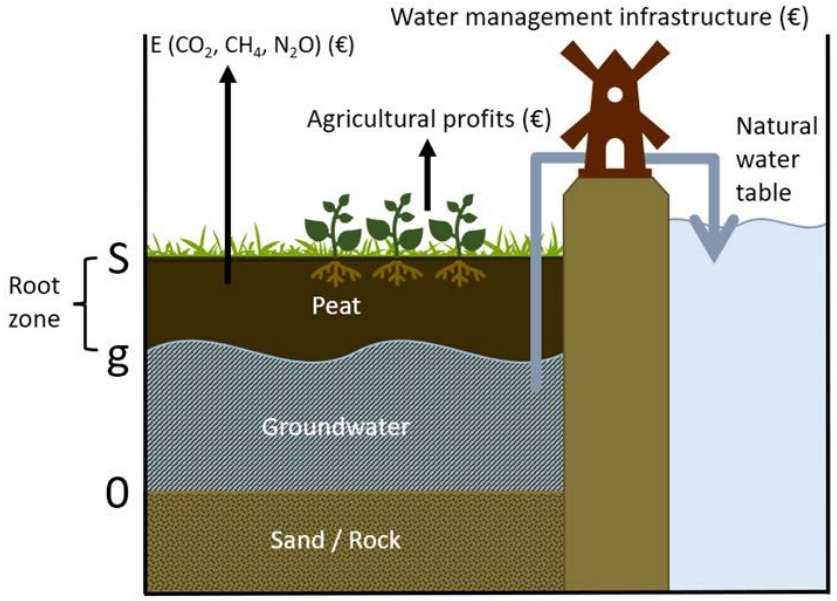
Supervisors

Dr. Hans-Peter Weikard - WUR

Dr. Suphi Sen - WUR

Optimalisatiemodel bodemdaling veenweiden

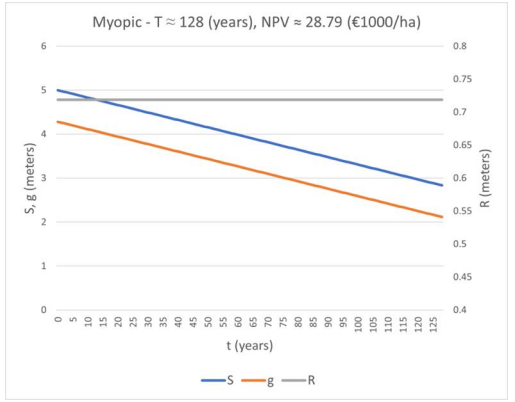
- Beleidskeuzes bodemdaling nu zijn afweging tussen maatschappelijke kosten en baten in het heden, de nabije en de verre toekomst.
- Model integreert bodemdaling en peilbeheer met waardering maatschappelijke effecten (landbouw, waterbeheer en klimaat) op lange termijn.
- Toekomstige effecten verdisconteerd.
- Berekent optimaal beleidspad (maximale netto contante waarde van maatschappelijke effecten).



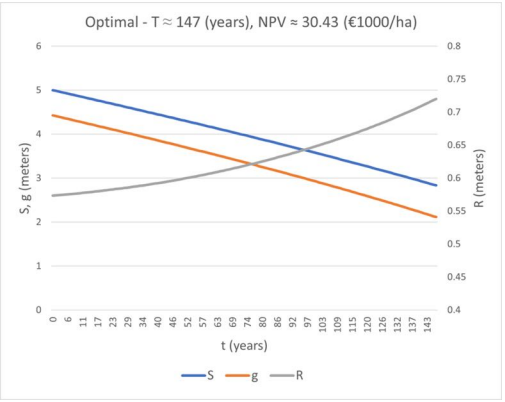
Basismodel: veenexploitatie en beheerkosten

- Enkel landbouwopbrengsten en beheerkosten
- Vergelijking kortzichtig vs toekomstgericht beleid
- Conclusies:
  - Peilindexatie negeert kosten voor toekomstige generaties
  - Maatschappelijk wenselijk om waterpeilen op te hogen zelfs zonder meewegen klimaateffect
  - Negeren toekomstige effecten leidt tot significante welvaartsverliezen.

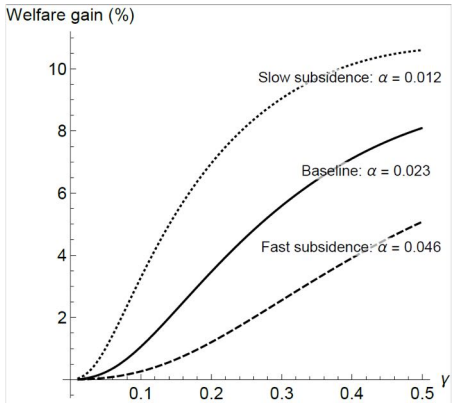
Kortzichtig



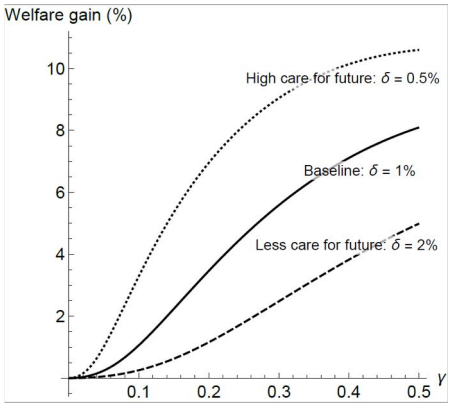
Toekomstgericht



Dalingssnelheid(α)

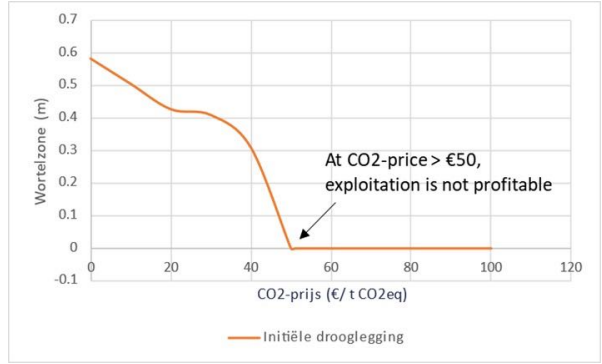


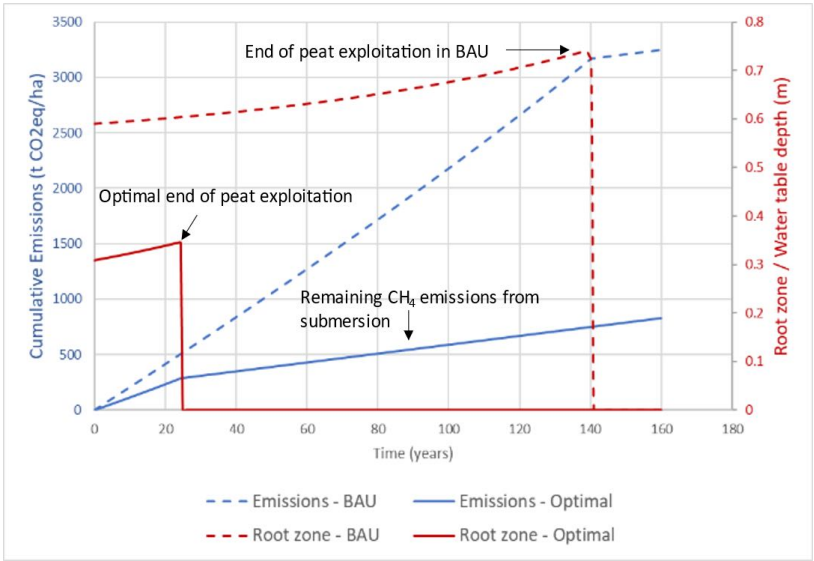
Discontovoet (δ)



Uitbreiding model: Emissies/klimaatkosten

- Waardeert klimaatkosten uitstoot CO_2, CH_4 (en N_2O) volgens SCC-methode (CO_2-prijs)
- Vergelijking scenario's in simulaties:
  - BAU: Klimaateffecten genegeerd in besluitvorming, enkel financiële effecten
  - Sociaal optimum: Klimaateffecten meegewogen
- Voorlopige resultaten:
  - Ook bij relatief lage CO_2-prijs levert peilverhoging en verkorting exploitatieperiode als veenweide welvaartswinst op.
  - Uitstoot CH_4-prijs bij vernatting heeft beperkt effect.
  - Onder realistische aannames (bijv. hogere CO_2-prijs), klimaatkosten vaak te hoog voor rendabele drooglegging veenweide.
- Ruimtelijke toepassing





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sterke samenwerking

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Ministerie van Binnenlandse Zaken en Koninkrijksrelaties

PROVINCIE UTRECHT

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HOOGHEEMRAADSCHAP DE STICHTSE RIJNLANDEN

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Tauw

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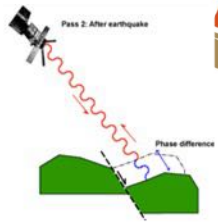
Work Package 4 – Maatregelen, governance benaderingen en juridisch kader

Aanpak



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WP1

Meten & monitoren
Hoeveel?

Mechanismen
Oorzaken?

WP2

Gevolgen
Wat zijn de gevolgen?
Wat nog te verwachten?

WP3

Maatregelen
Welke?
Hoe te integreren?

WP4

Effectiviteit
Gewenste effect?
Neveneffecten?

WP4

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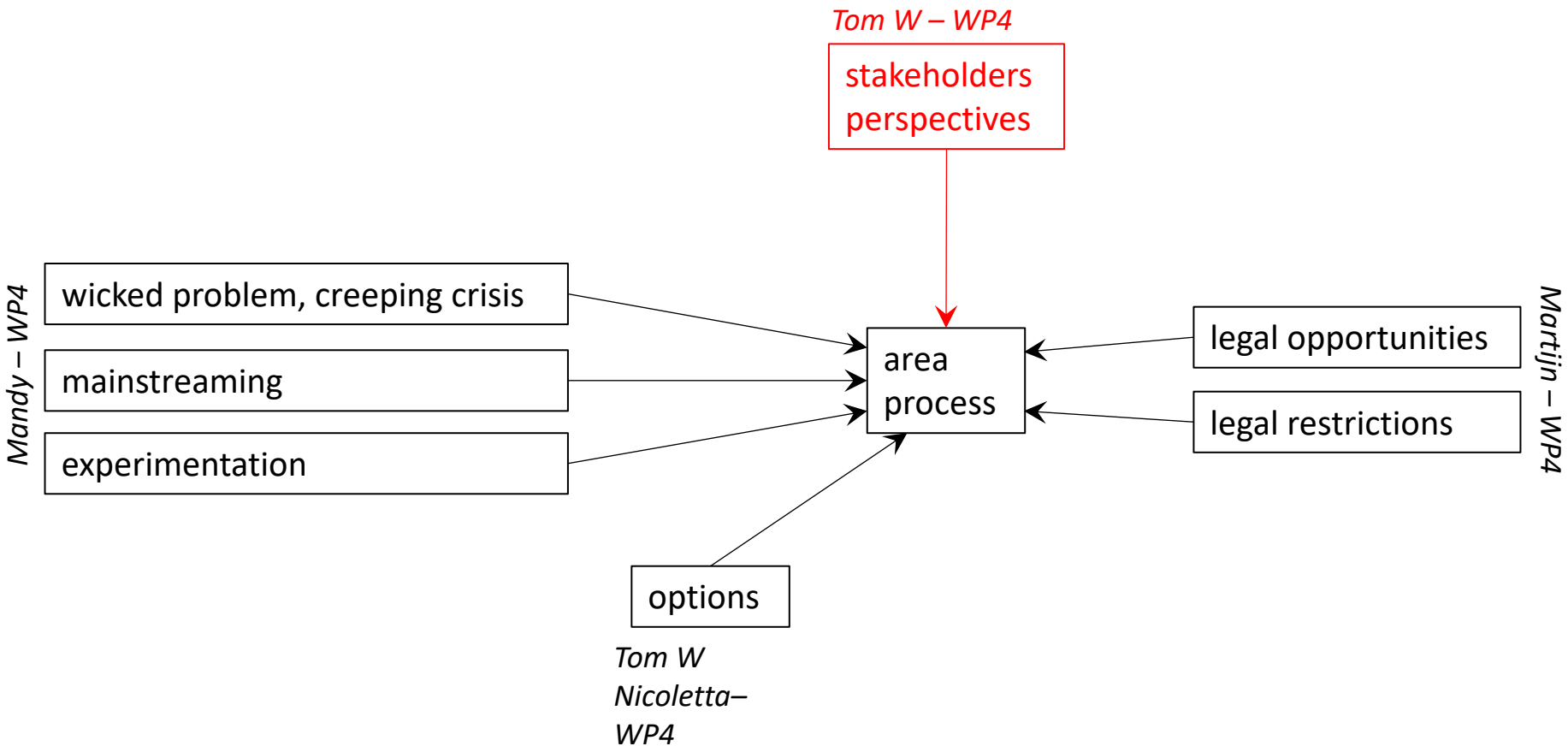
- WP4.1: Maatregelen om bodemdaling aan te pakken (mitigatie, aanpassing, compensatie)
- Stedelijk gebied – Nicoletta
- Landelijk gebied – Tom
- WP4.2: Beheer bodemdaling in de Nederlandse veengebieden - Mandy
- WP4.3: Juridische aspecten bodemdaling: verantwoordelijkheden en aansprakelijkheid – Martijn

=>algemeen en gebiedsgericht

=>gericht op het vergroten van de oplossingsruimte én het in kaart brengen van de grenzen aan deze oplossingsruimte

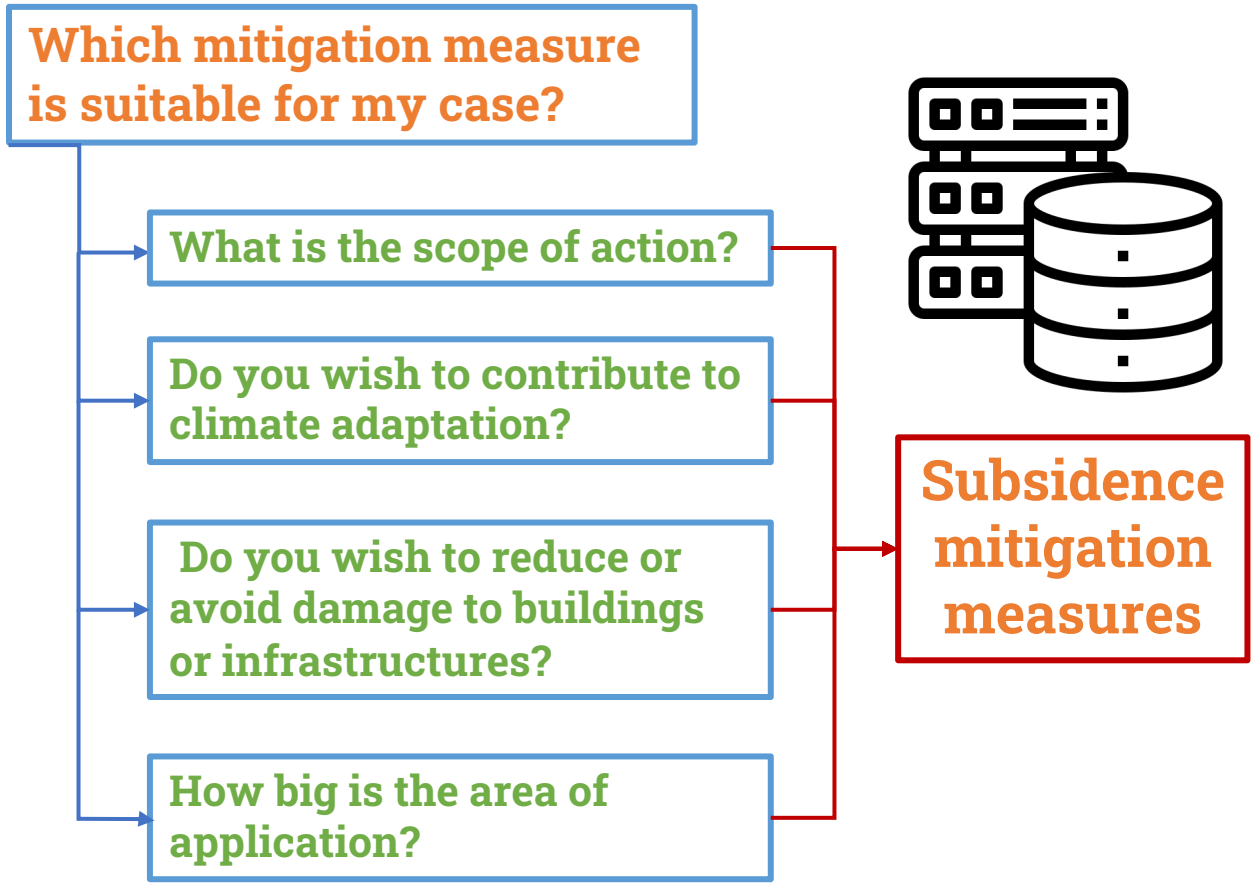
Area process and central role WP4



WP4.1: Measures to address land subsidence (mitigation, adaptation, compensation) – urban areas

Mitigation and prevention of subsidence in cities

- **Mitigation – Prevention – Adaptation**
  → *Glossary of terms*
- There are **no standard methods for choosing** subsidence mitigation measures in urban areas
  → *Guidelines (grouping)*
- There are **no (standard) methods** to determine **the effectiveness** of mitigation measures
  → *Guidelines (effectiveness)*



Nappo & Korff, Preprint. Technical methods for reducing land subsidence and its impacts in urban areas.

WP4.1: Measures to address land subsidence (mitigation, adaptation, compensation) Rural area – Tom

Transitie Landelijk Gebied

- Rijkdom aan keuzes voor diverse contexten
  - fysisch milieu, sociale context, management van onzekerheden
- Vertaling naar handvatten voor gebiedsprocessen
  - natuurlijke variatie, perspectieven

		number	groundwater level	land subsidence	GHG emissions	available water quantity	water quality	fertilization (N and P deposition)	population meadow birds	disease risk	technical feasibility	economic viability	food production	land use elsewhere	recreation	historical landscape conservation	viability in the long term?
technical measures	trench infiltration	1	+	-	?	--	0	0	+	+	+	++	0	0	0	+	-
	subsoil irrigation and drainage (SSI)	2	+	-	-	-	0	0	+	0	+	+	0	0	0	+	0
	pressurizing SSI	3	++	--	--	-	0	0	+	0	++	0	0	0	0	+	+
	high ditch water level	4	+	-	-	-	0	0	+	0	+	0	-	0	0	+	-
	dynamic ditch water level	5	+	-	-	-	0	0	+	0	+	+	0	0	0	+	-
	clay-in-peat	6	0	?	?	0	0	0	0	0	?	?	0	0	0	+	?
	mineral cover	7	0	-	-	0	0	0	?	0	+	-	+	0	0	+	+
	acidification	8	0	-	-	0	-	0	-	0	+	?	0	0	0	+	-
	salinization	9	0	-	-	+	-	0	-	0	+	0	0	0	0	+	0
paludiculture	cattail	10	I	--	L	+/-	+/-	0	?	+	+	?	-	+	?	-	+
	reed	11	I	--	L	+/-	+/-	0	?	+	+	?	-	+	?	-	+
	azolla	12	I	--	?	+/-	+/-	0	?	+	?	?	+	0	-	-	?
	wild rice	13	I	--	?	+/-	+/-	0	?	+	?	?	+	0	?	-	?
	elephant grass	14	++	--	-	+/-	+/-	0/-	?	0	?	?	-	+	?	-	+
	willow	15	++	--	-	+/-	+/-	0/-	-	0	?	?	-	+	?	-	+
	cranberry	16	++	--	-	-	+	-	-	0	?	?	+	0	+	-	+
	water buffalo	17	+	-	-	-	0	0	0	0	?	?	-	0	+	-	?
	food forest	18	++	--	-	-	+	-	-	0	+/-	?	+	0	+	-	+
	black alder	19	++	--	--	-	+	-	-	0	+	?	-	+	+	-	-
	peat moss cultivation	20	++	--	--	-	++	--	+?	0	?	?	-	+	?	-	+
alternative	semi-natural meadows	21	+	-	-	-	+	-	++	0	+	0	-	+	+	+	0
	greenhouses	22	+	0	-	-	+	-	--	0	+	+	++	0	--	-	0
	solar panels	23	+	-	-	-	+	-	--	0	+	+	--	+	--	-	--
	urban area	24	+	0	-	-	+/-	-	--	0	+	+	--	+	-	-	+
nature	ombrotrophic mire	25	++	R	S	+/-	++	--	+/-	0	?	0	--	+	++	0	+
	minerotrophic fen	26	I	R	S	+	+/-	--	+/-	0	+	0	--	+	++	+	+
	riparian forest	27	+	R	S	+	++	--	-	0	+	0	--	+	++	0	+

WP4.2: Governance of land subsidence in the Dutch peatlands - Mandy

Transformatief bestuur voor duurzaamheidsvraagstukken in relatie tot landgebruik

met bodemdaling in het westelijk veenweidegebied als empirische casus

Living on soft soils – subsidence & society

Mandy van den Ende
Dr. Dries Hegger
Dr. Heleen Mees
Prof. Peter Driessen
Copernicus Instituut voor Duurzame Ontwikkeling, Universiteit Utrecht

1] Wat suggereert het water- en bodem sturend principe?

= transformatie / systeemverandering

<u>Economische belangen van gevestigde partijen zijn leidend, al het andere is volgend</u>

<u>Water- en bodemsysteem is leidend, al het andere is volgend</u>

Focus op de korte termijn

Focus op de lange termijn

‘Strijden tegen’

Alles kan overal: maakbaarheid

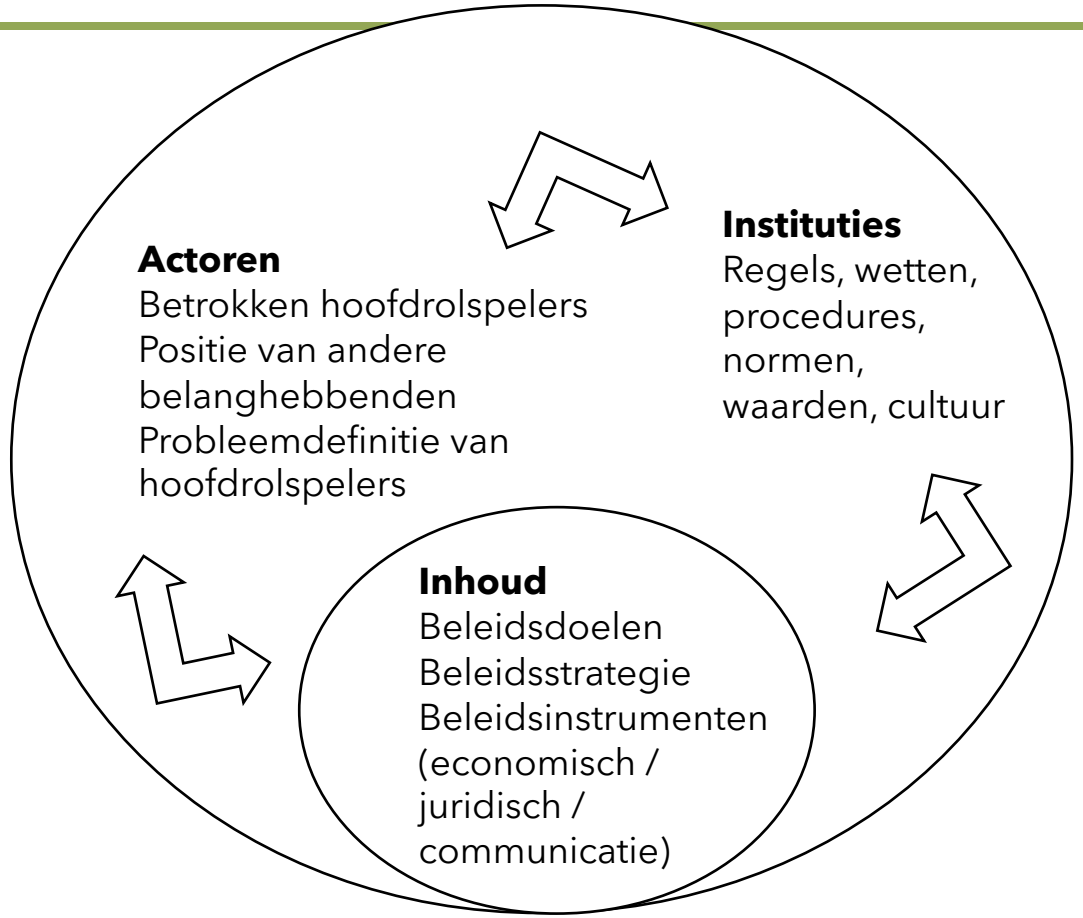
‘Samenwerken met’

Niet alles kan overal: prioriteit

Dominantie, controle

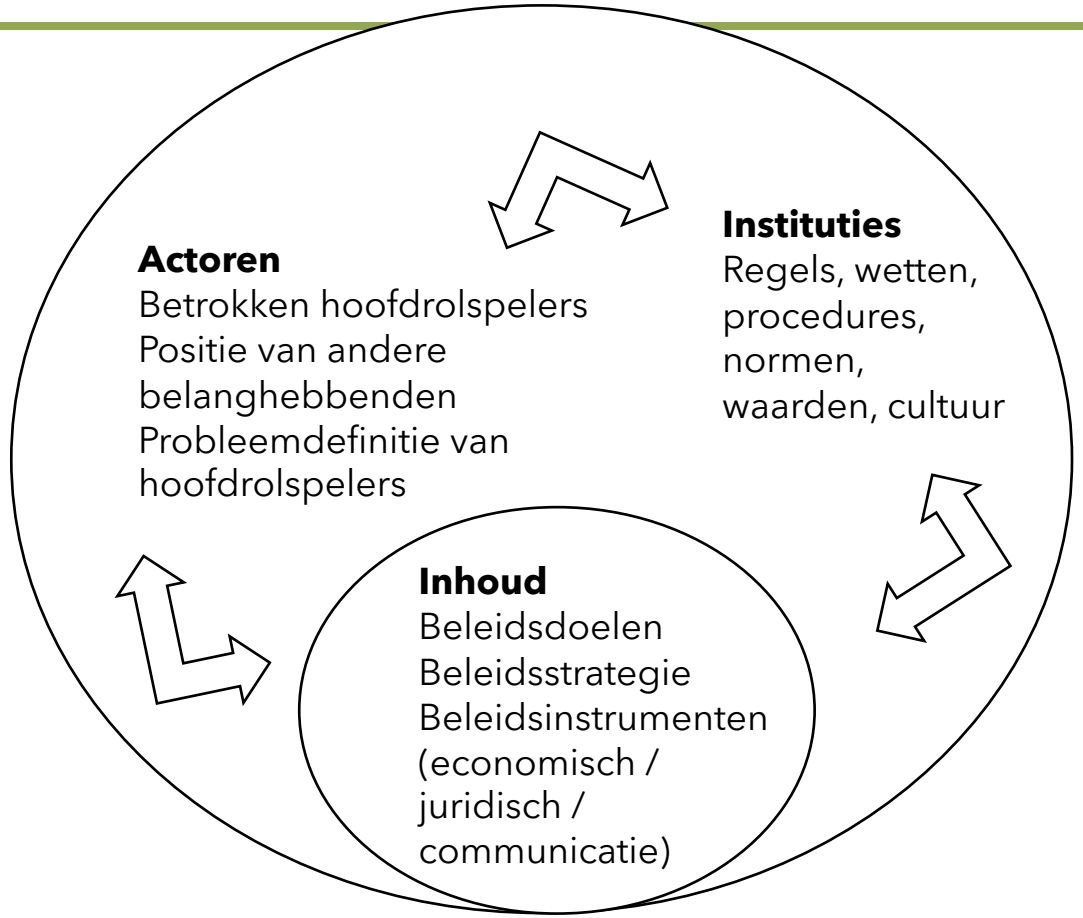
Bescheidenheid, veerkracht

2] Governance aanpakken…



"The ensemble of actors, institutions and content"
(Driessen et al., 2012, p.144)

2] … verschillende voorkeuren, aannames, belangen hebben [1/2]…



Water- en bodemsysteem is leidend, al het andere is volgend

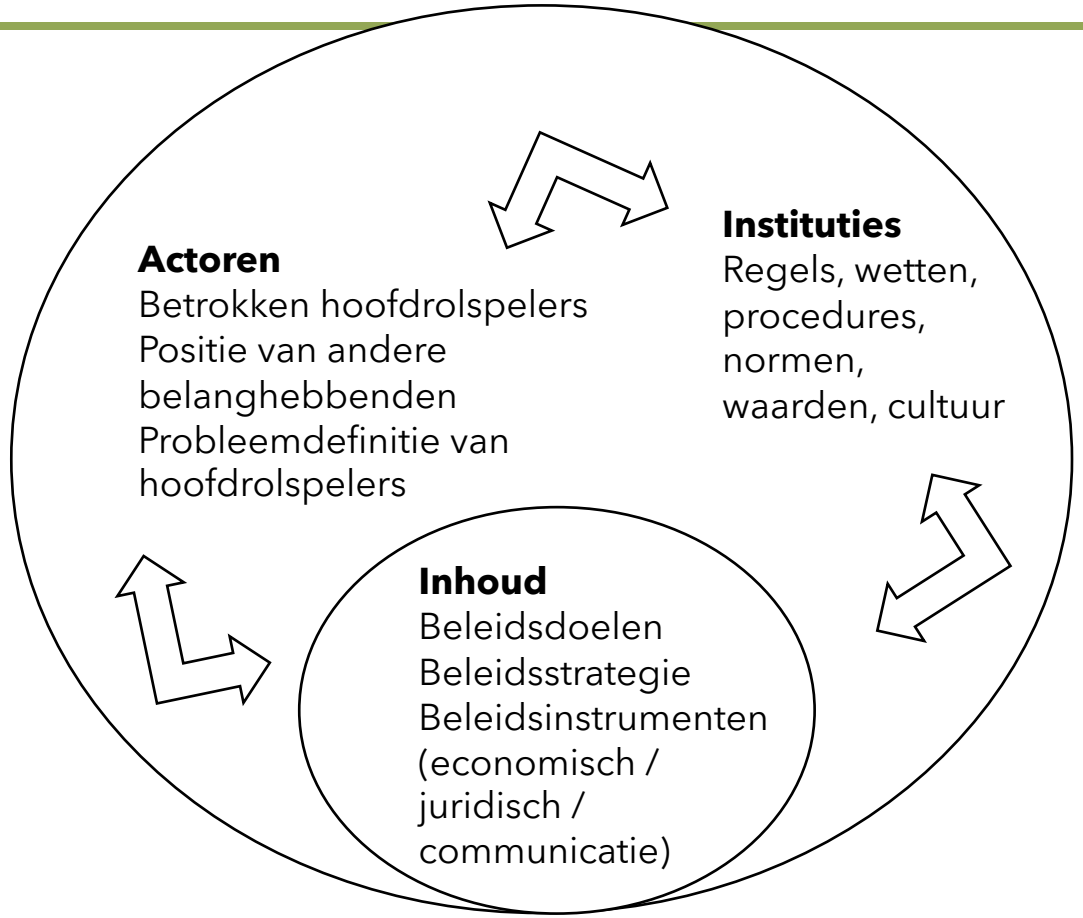
Focus op de lange termijn

Niet alles kan overal: prioriteit

'Samenwerken met'

Bescheidenheid, veerkracht

2] … verschillende voorkeuren, aannames, belangen hebben [2/2]…



<u>Economische belangen van gevestigde partijen zijn leidend, al het andere is volgend</u>

Focus op de korte termijn

‘Strijden tegen’

Alles kan overal: maakbaarheid

Dominantie, controle

3] … en op basis daarvan kiezen voor maatregelen die bijdragen aan transformatieve verandering…

<u>Water- en bodemsysteem is leidend,</u>
<u>al het andere is volgend</u>

Focus op de lange termijn

‘Samenwerken met’

Niet alles kan overal: prioriteit

Bescheidenheid, veerkracht

<u>Technische maatregel</u>
- Waterinfiltratiesystemen
- **Verhoging slootwaterpeil**
- Klei in veen
- Funderingen
- Dammen, dijken
- Lichtgewicht ophoogmateriaal

<u>Alternatieve gewassen / vee</u>
- Lisdodde
- **Cranberry**
- Water buffel

<u>Alternatief landgebruik</u>
- Zonnepanelen
- Drijvende woningen
- Lokale voedselcooperaties
- **Natuur**

<u>Grote</u> beschikbare oplossingsruimte: diversiteit aan maatregelen, incl. low-tech/planning

2] … of voor maatregelen die het huidige landgebruikssysteem in stand houden (in strijd met het water- en bodem sturend principe!)

<u>Economische belangen van gevestigde partijen zijn leidend, al het andere is volgend</u>

Focus op de korte termijn

‘Strijden tegen’

Alles kan overal: maakbaarheid

Dominantie, controle

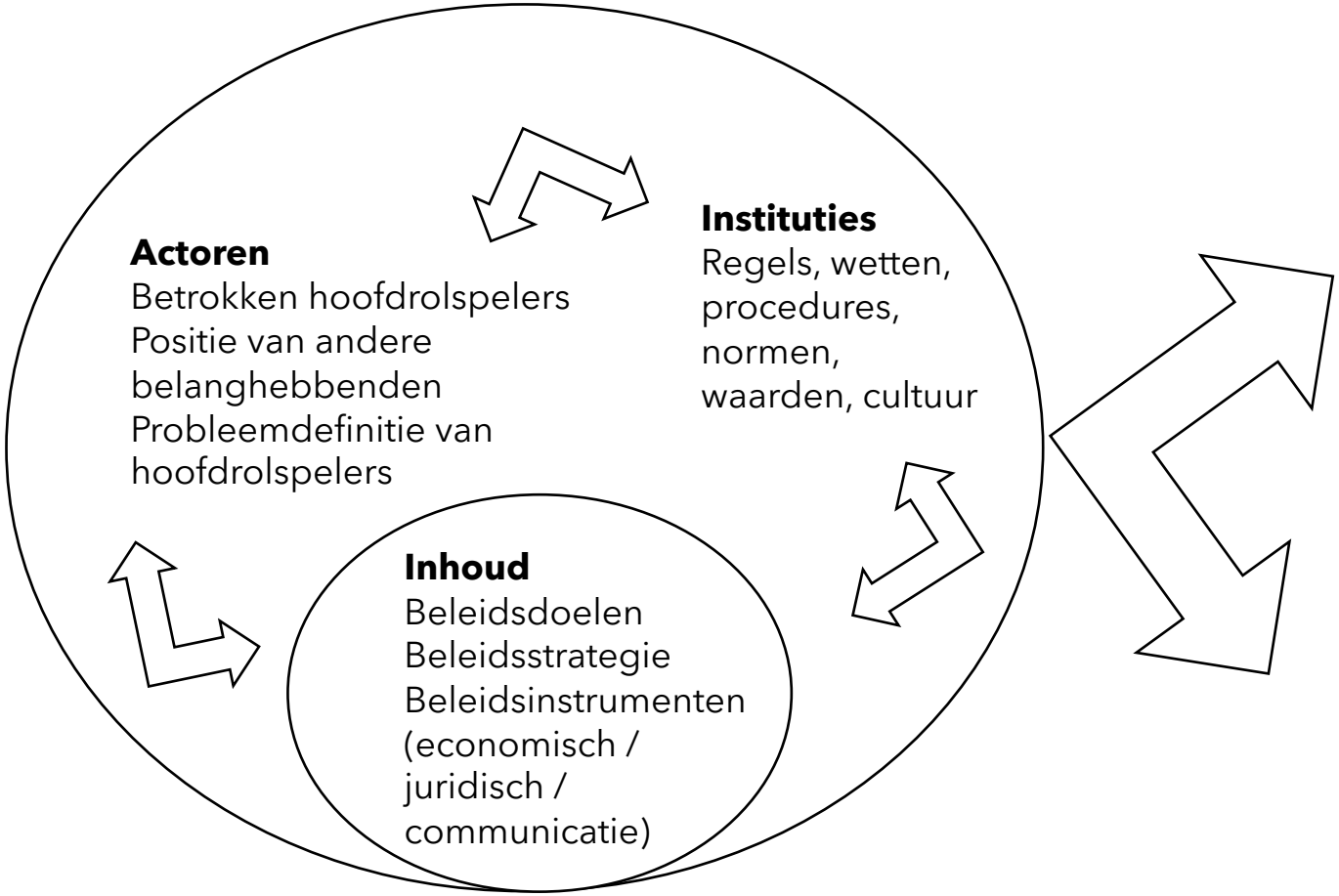
<u>Technische maatregel</u>
- **Waterinfiltratiesystemen**
- **Verhoging slootwaterpeil**
- **Klei in veen**
- Funderingen
- Dammen, dijken
- Lichtgewicht ophoogmateriaal

<u>Alternatieve gewassen / vee</u>
- Lisdodde
- Cranberry
- Water buffel

<u>Alternatief landgebruik</u>
- Zonnepanelen
- Drijvende woningen
- Lokale voedselcooperaties
- Natuur

<u>Beperkte</u> beschikbare oplossingsruimte: techno-fix dominant

3] Onderzoek naar de potentie van drie bestaande governance aanpakken (experimenteren, beleidsintegratie, responsibiliseren) om bij te dragen aan systeemverandering



Dank voor uw aandacht!

Posterpresentatie: het transformatief potentieel van *experimenteren*

Contact: m.a.vandenende@uu.nl of
https://www.linkedin.com/in/mandyvandenende/

Publicatie in wetenschappelijk tijdschrift:

- Van den Ende M.A., Hegger D.L.T., Mees H.L.P., Driessen P.P.J. Wicked problems and creeping crises: A framework for analyzing governance challenges to addressing environmental land-use problems (2023) Environmental Science and Policy, 141, pp. 168 – 177.

Media:

- Gevraagd: politieke moed voor het vinden van een oplossing voor het veenweidegebied. Want één waarmee alle betrokkenen worden geholpen, bestaat niet Friesch Dagblad, 10 juni 2023

WP4.3: Legal aspects of soil subsidence: responsibilities and liability - Martijn

Utrecht University

CENTRE FOR
WATER, OCEANS AND
SUSTAINABILITY LAW

Hoe kan het omgevingsrecht bijdragen aan een doeltreffende inzet van taken en bevoegdheden door overheden voor de aanpak van bodemdaling in het landelijke en stedelijke veengebied?

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Bodemdaling als maatschappelijke én juridische opgave

- (Oorzaken van) bodemdaling hebben verschillende nadelige gevolgen in het landelijk gebied: broeikasgasuitstoot, verminderde waterkwaliteit, natuurschade
- (Oorzaken van) bodemdaling leiden in stedelijk gebied tot schade aan funderingen, bebouwing en infrastructuur
- Juridische verplichtingen in het landelijk gebied: terugdringen van broeikasgassen, verbeteren van waterkwaliteit, beschermen van Natura 2000-gebieden
- Juridische verplichtingen in het stedelijk gebied: beperkte overheidszorg voor schade aan funderingen en wateroverlast

Knelpunten en oplossingsrichtingen voor een doeltreffende aanpak van bodemdaling

- Eén concrete, nationale doelstelling voor bodemdaling
- Specifieke beleidskaders voor de aanpak van bodemdaling
- Rekening houden met korte én lange termijn
- Samenhang van beleid
- Doorwerking van beleid

Een doeltreffende uitoefening van taken en bevoegdheden voor de aanpak van bodemdaling

- Maatregelen en (juridische) instrumenten
- Instrumenten voor doorwerking van beleid: instructieregels, reactieve interventies
- Instrumenten voor de aanpak van bodemdaling:
- *Waterbeheer:* peilbesluit, peilafwijkvergunning
- *Ruimtelijk:* ver- en geboden, vergunningplichten en voorschriften in omgevingsplan en -verordening

Nadelige gevolgen van maatregelen voor de aanpak van bodemdaling en nadeelcompensatie

- Financiële schade voor agrariërs: wanneer moet landbouwschade gecompenseerd worden?
- Nadelige gevolgen voor de fysieke leefomgeving: afname van bergingscapaciteit, nadelige effecten voor weidevogels

Work package 2

Symposium
Living on Soft Soils: Subsidence & Society
2 November 2023

Mariet Hefting

BODEMDALING

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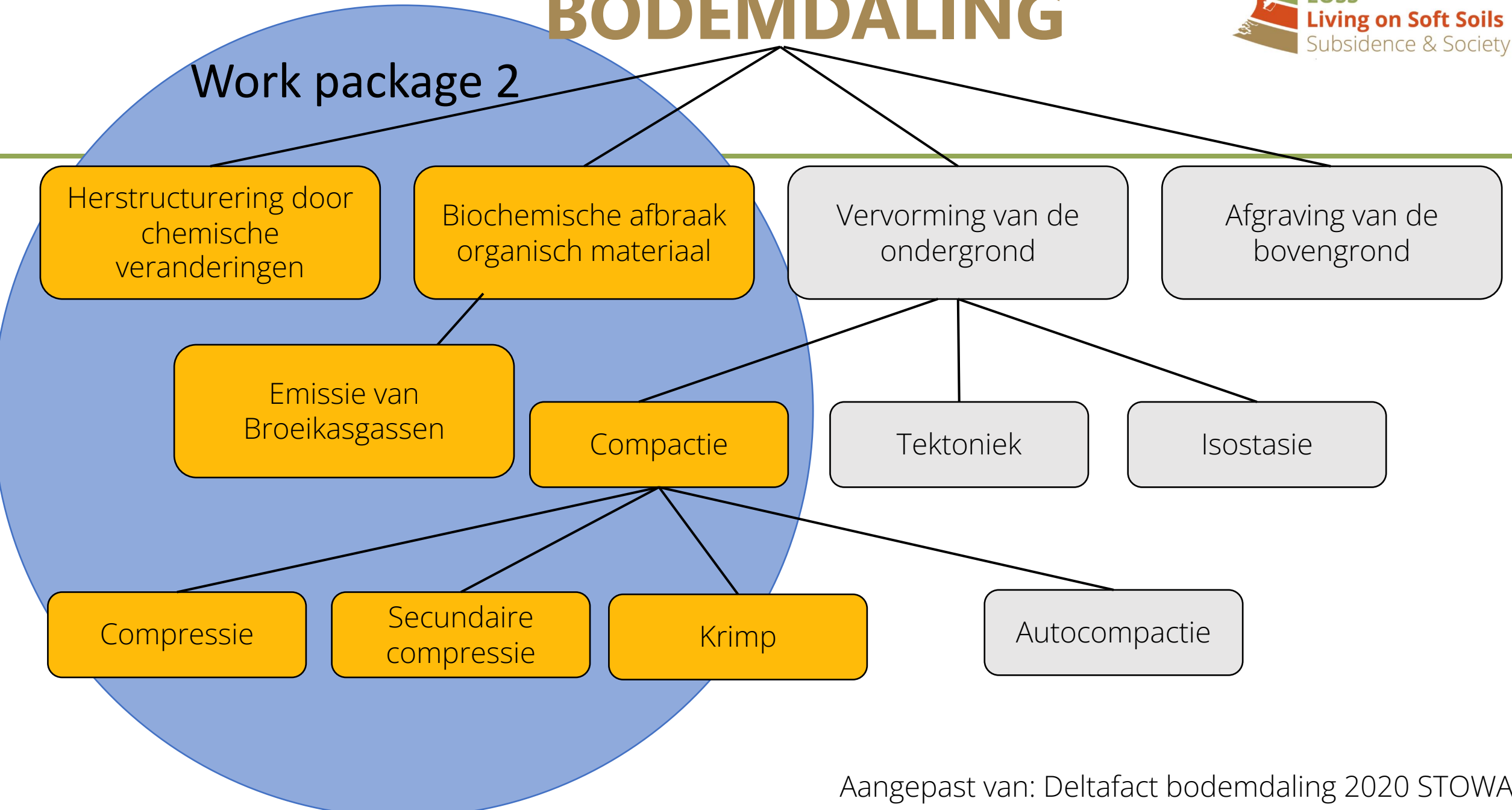

Aangepast van: Deltafact bodemdaling 2020 STOWA

WP2.1 *Duygu Tolunay:* De rol van microbiële veenafbraak in bodemdaling

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Utrecht University

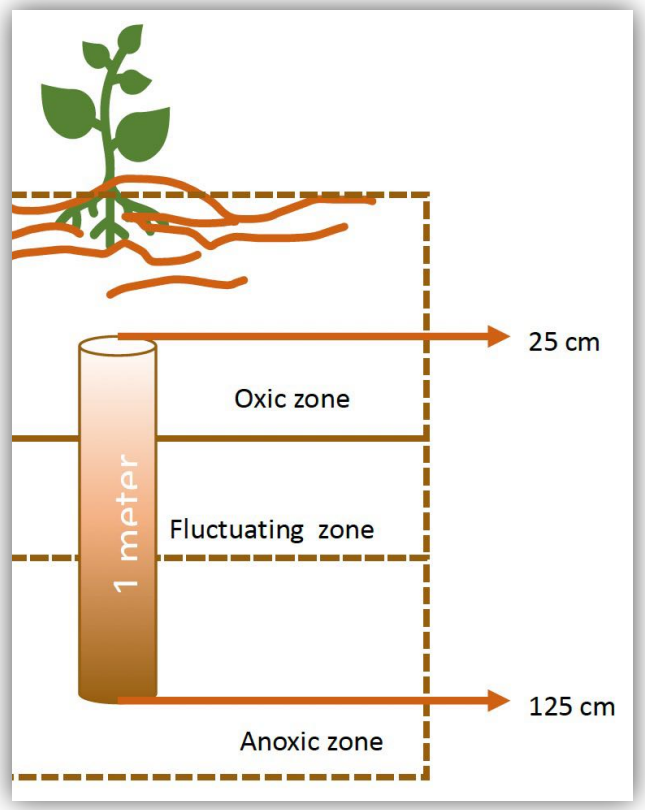
DECOMPOSITION RATES: Oxische en anoxische afbraaksnelheden in botanisch verschillende veengebieden

DRIVER: SUBSTRATE: Effect van het substraat op microbiële activiteit, diversiteit en dichtheden

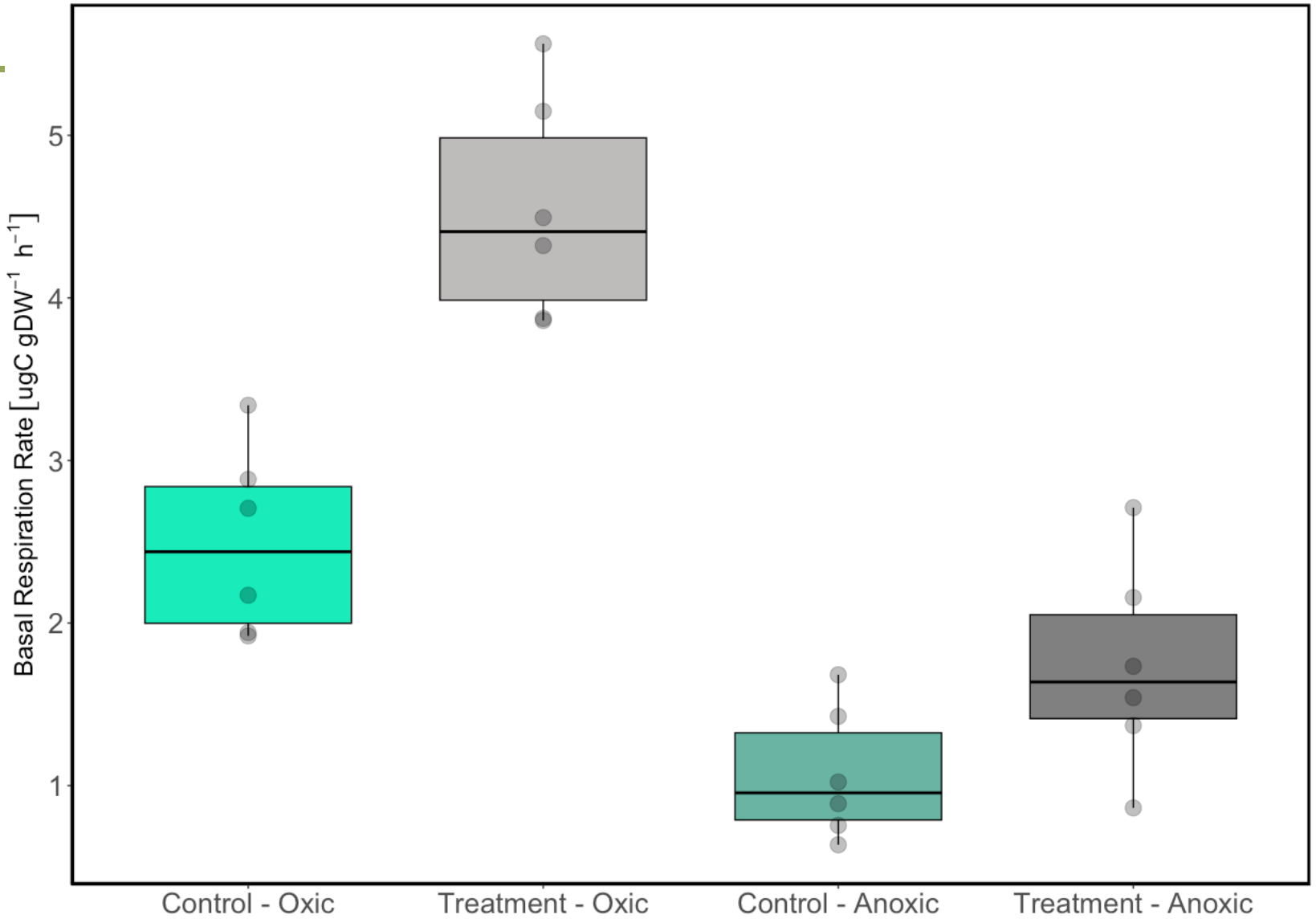
DRIVER: PORE-WATER: Effect van sulfaat en ijzer op microbiële afbraak

INTERACTION: BIOLOGY AND PHYSICS: De interactie van microbiële afbraak met fysische bodemdalings-mechanismen

OOGST van OMGEKEERDE VEENKERNEN



WP 2.1: Duygu Tolunay
Microbial Respiration (CO_2 production) (Assendelft)



After one-year field incubations:

- ~~Flipped cores respires more both~~ under water saturated and oxic conditions
- **Anoxic Samples:** easily degradable carbon source and potential iron and sulphate reduction
- **Oxic Samples:** oxygen boosts degradation of fresh peat material
- Conclusion: Restoration of peatlands takes longer and legacy effect continues after a year

WP2.2:Pepijn van Elderen Sturende processen van kruip in organische bodems

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- Review paper: link tussen de processen die viskeuze compressie veroorzaken in klei en veen > decompositie !
- De relatie tussen organische stof (verlies) & volume afname klei/veen> database samendrukingstesten
- 1D modellering
- Het CT-scan project.

Nationaal park De Weerribben, Overijssel, Nederland
Bron: Staatsbosbeheer

WP2.2: Kruip in veen

Pepijn van Elderen

Universiteit Utrecht

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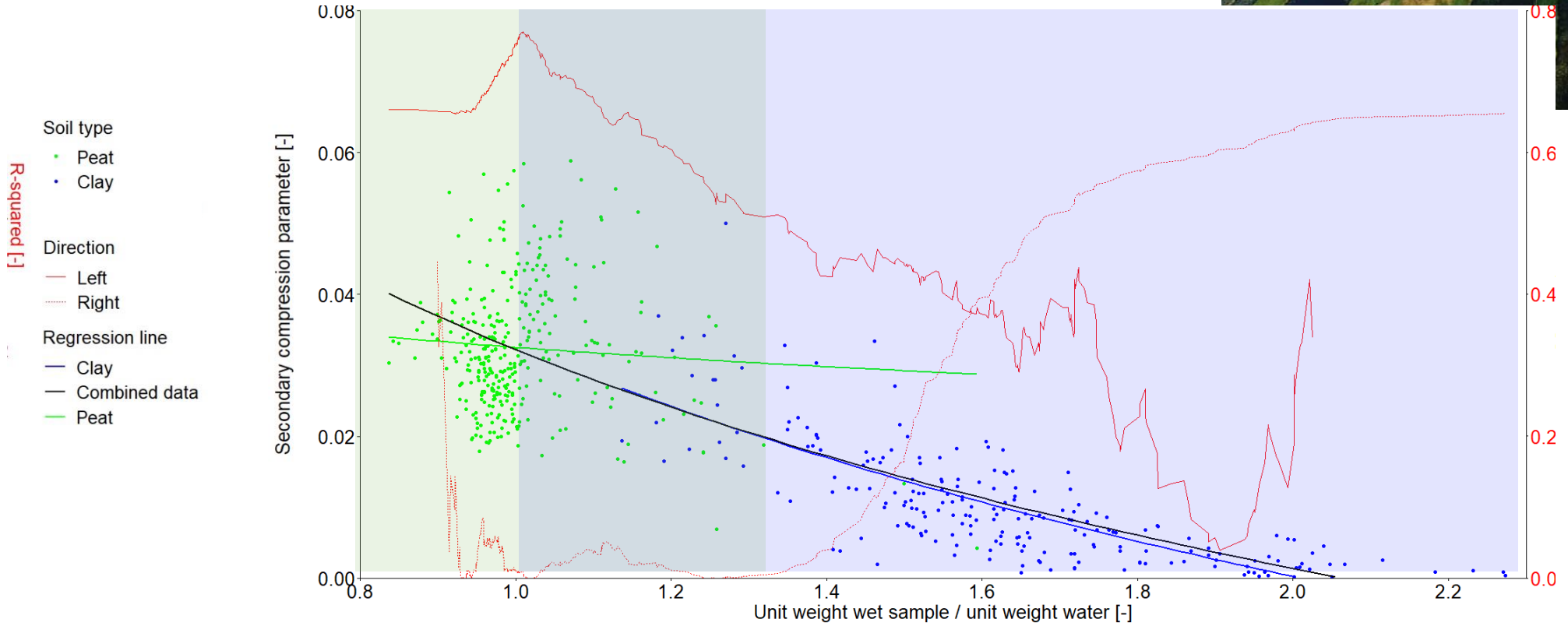
Geotechnische database analyse:



WP2.2: Kruip in veen

Pepijn van Elderen

Universiteit Utrecht

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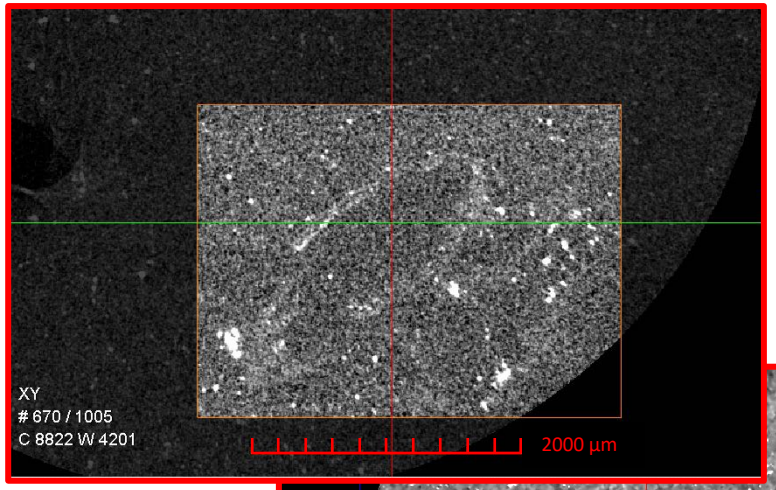
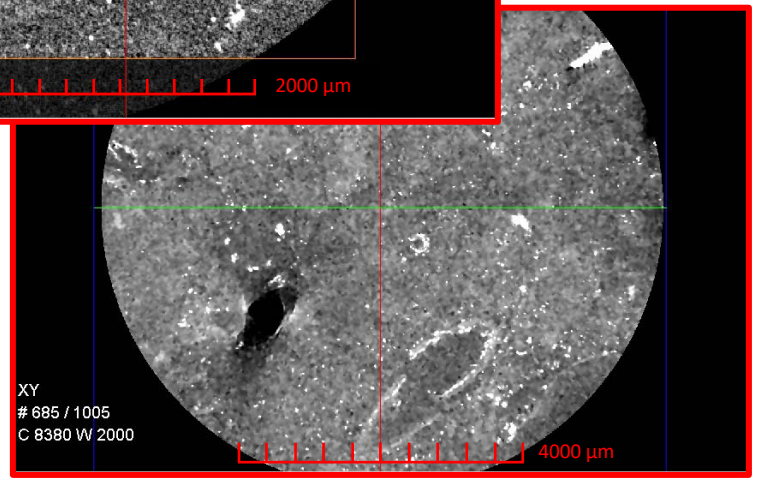
CT structuur analyse

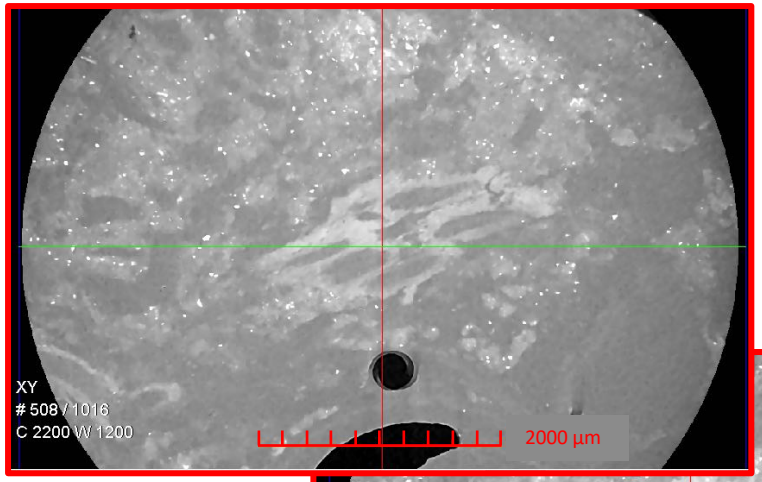
16 µm →



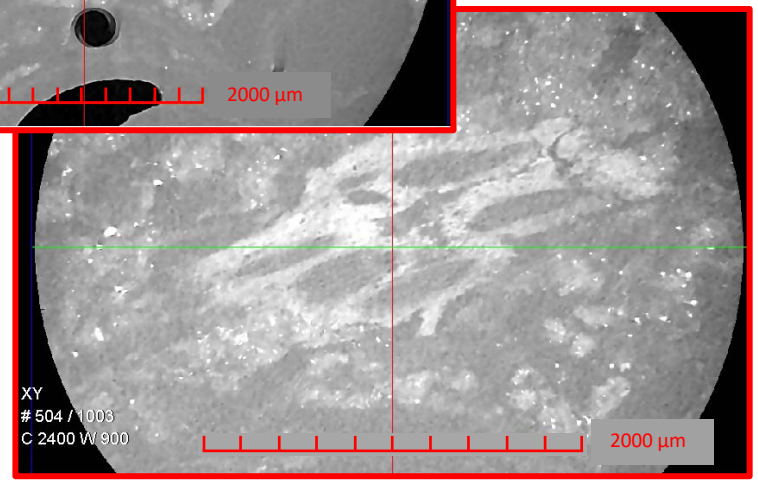
8 µm →



8 µm →



4 µm →



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WP2.3 Erne Boldeau

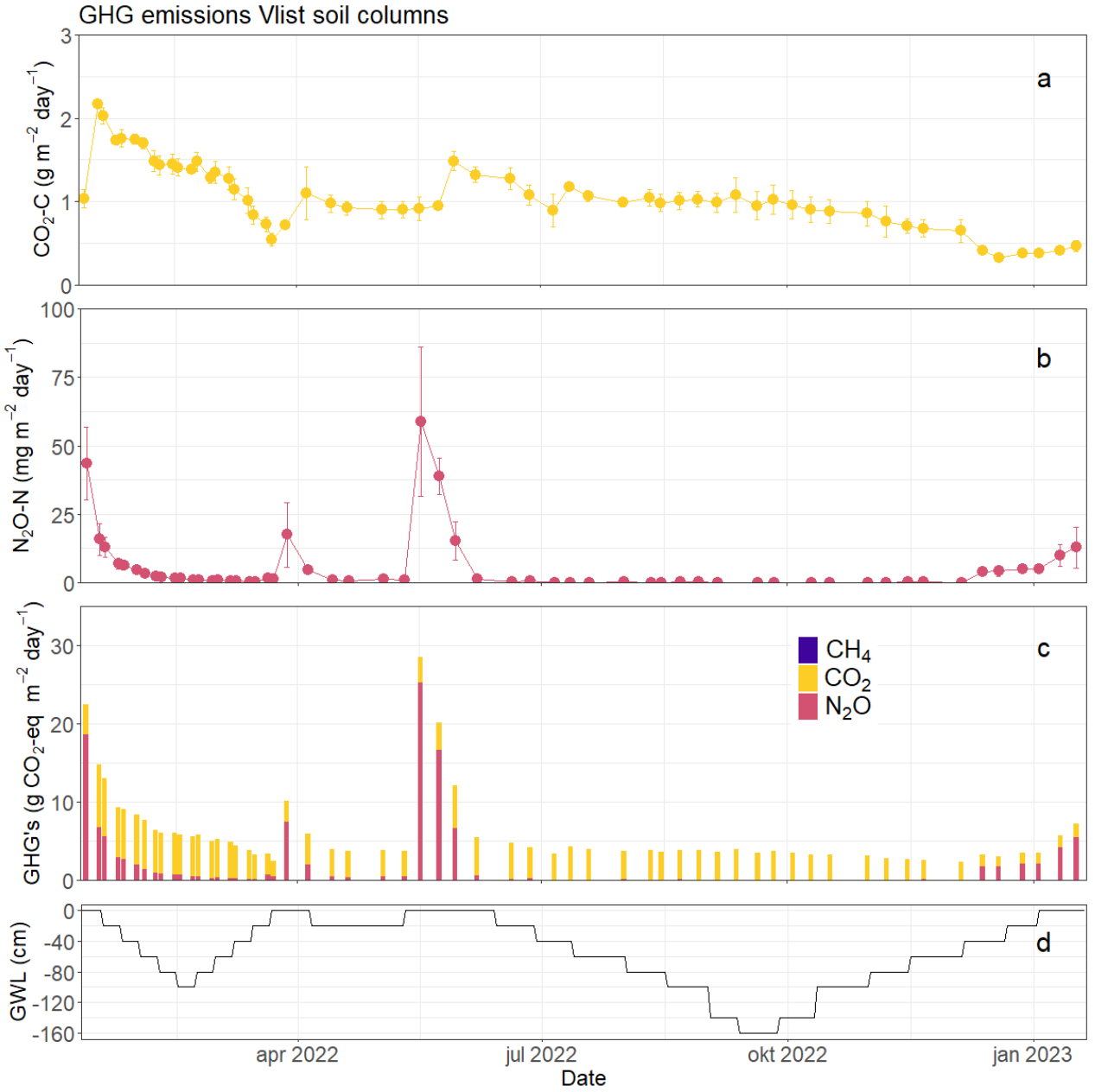
Effecten van grondwaterstrand & bemesting / beweiding op CO_2 en N_2O emissies uit veenweide

- Grote veenkolommen in lab: broeikasgasemissies en volumeverandering van veen
- Veldexperiment Zegveld, effecten grondwaterpeilverhoging op N_2O emissies, aanbreng van verschillende mesttypen:
  - *scheidingsproducten van drijfmest,*
  - *vaste mest*
  - *kunstmest*
  - *beweiding: / urineplekken, mestflatten en vertrapping*
- Komende maanden in een labexperiment interactie tussen vocht- en temperatuureffecten op veenrespiratie.

WP 2.3: Erne Blondeau

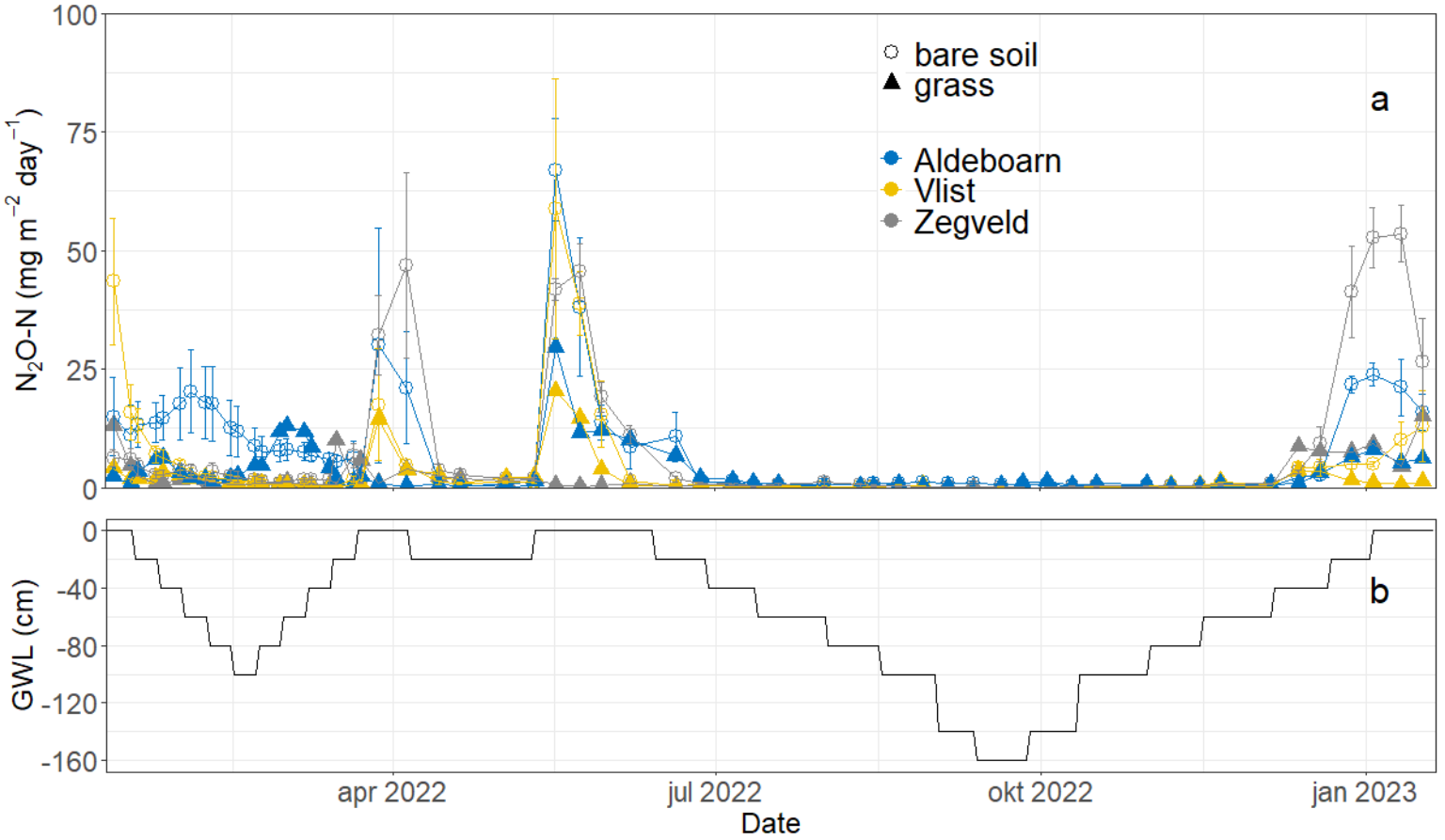
Geïncubeerde veenkolommen <u>zonder</u> graszode:

trade-off tussen CO_2 en N_2O



WP 2.3: Veldsituatie?

Geïncubeerde veenkolommen met (onbemeste) graszode



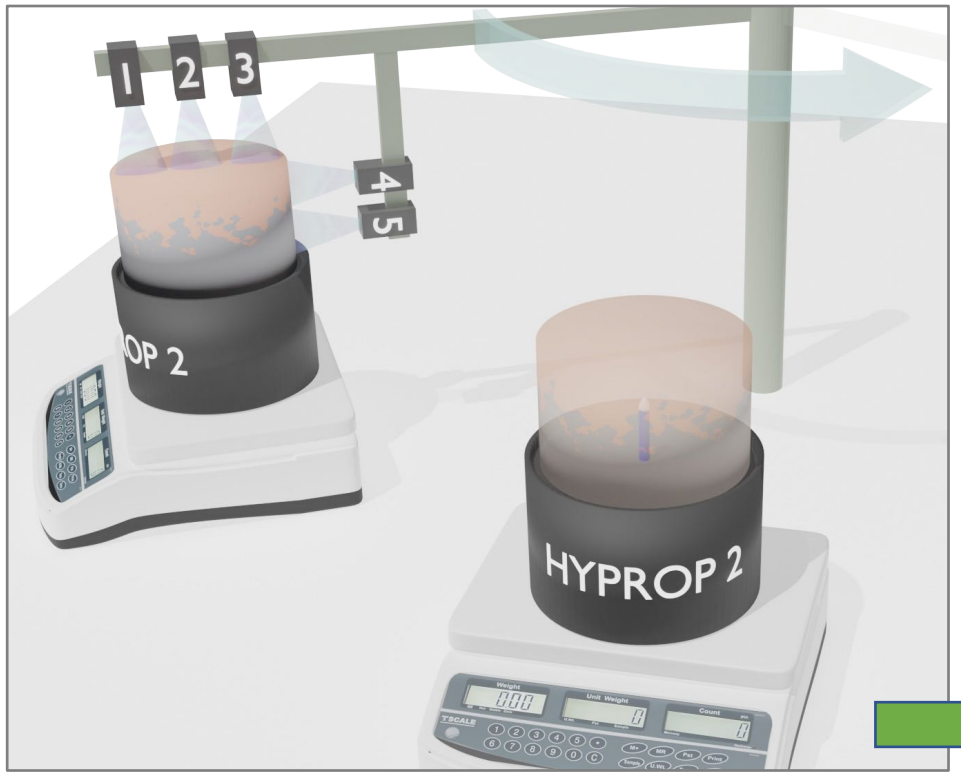
Voortgang 2.4 Bente Lexmond

- Krimpgedrag van bijna 30 monsters beschreven
- Grootste krimp tijdens de eerste fase van drogen
- Monsters uit verzadigde zone irreversibele krimp niet in de GW fluctuatie zone
- **Data van veldmetingen en labproeven gecombineerd gebruikt om bodemdaling Oostvaardersplassen te schatten (focus poster)**.

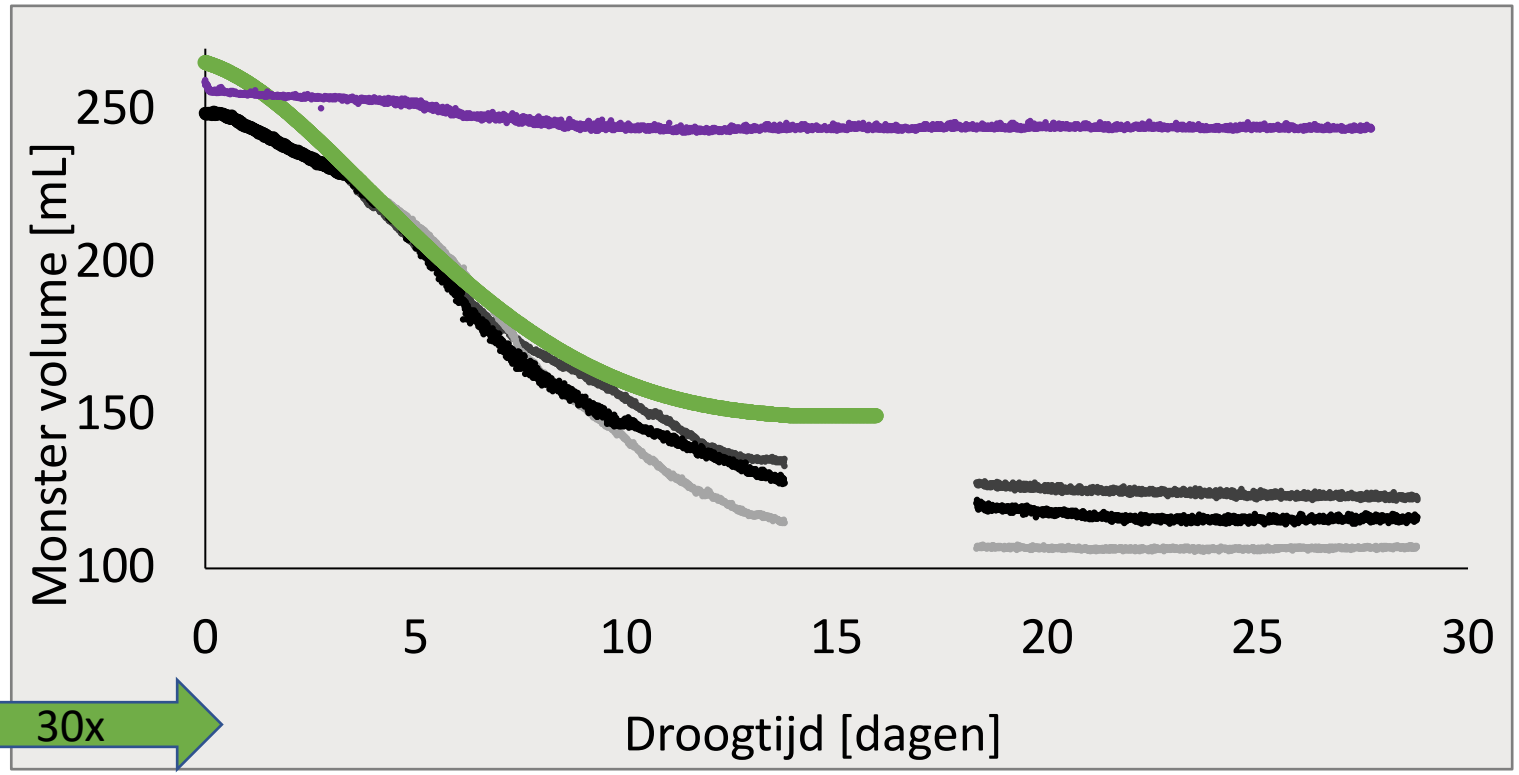
Nu metingen om dit te bevestigen.

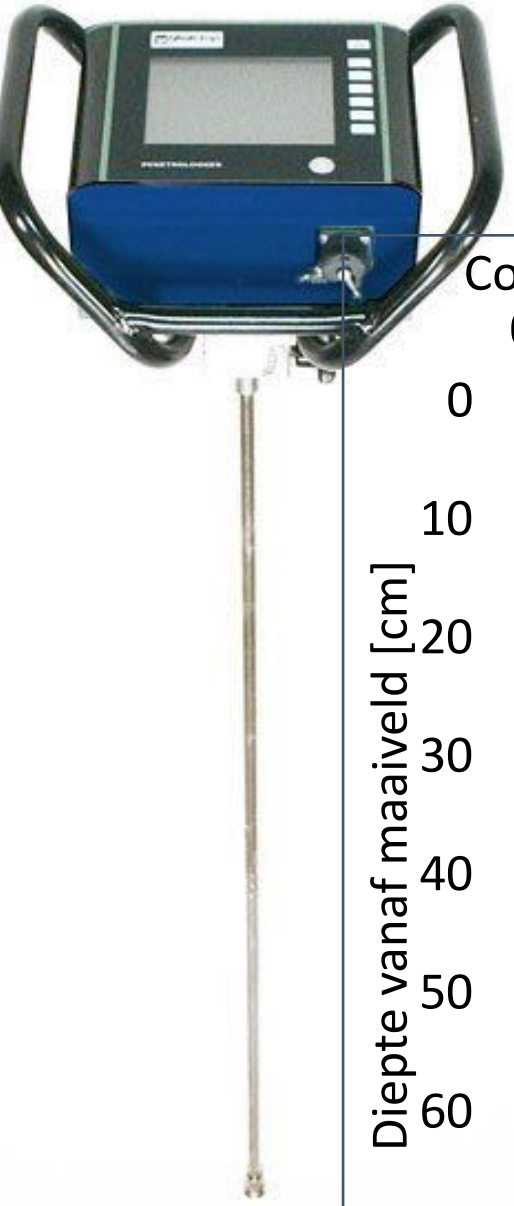
- Planning: modelleren, lab experimenten relatie extensometer data.

Update WP2.4: Bente Lexmond Klei-krimp



30x





WP 2.4: Case study: Oostvaardersplassen

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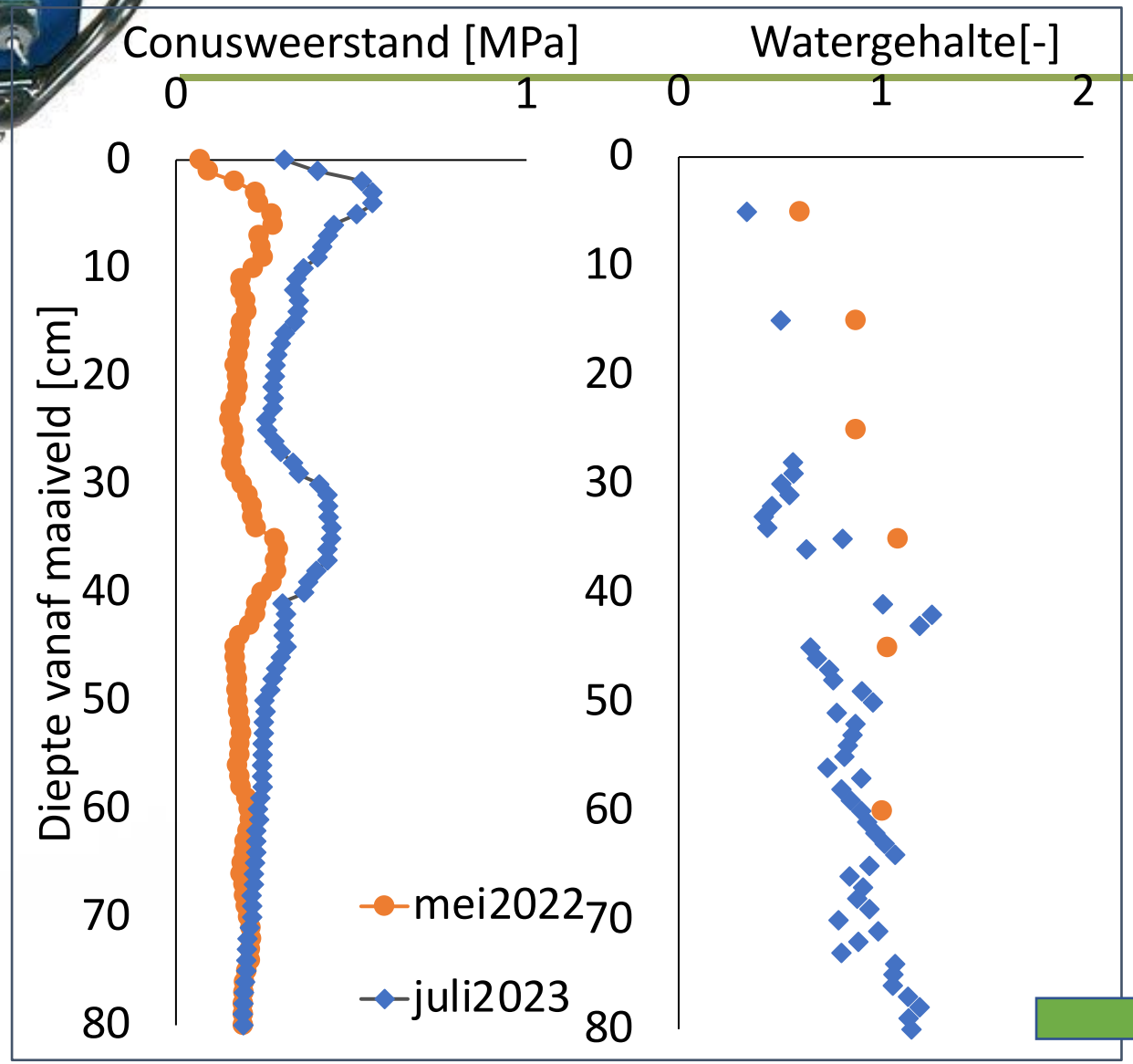

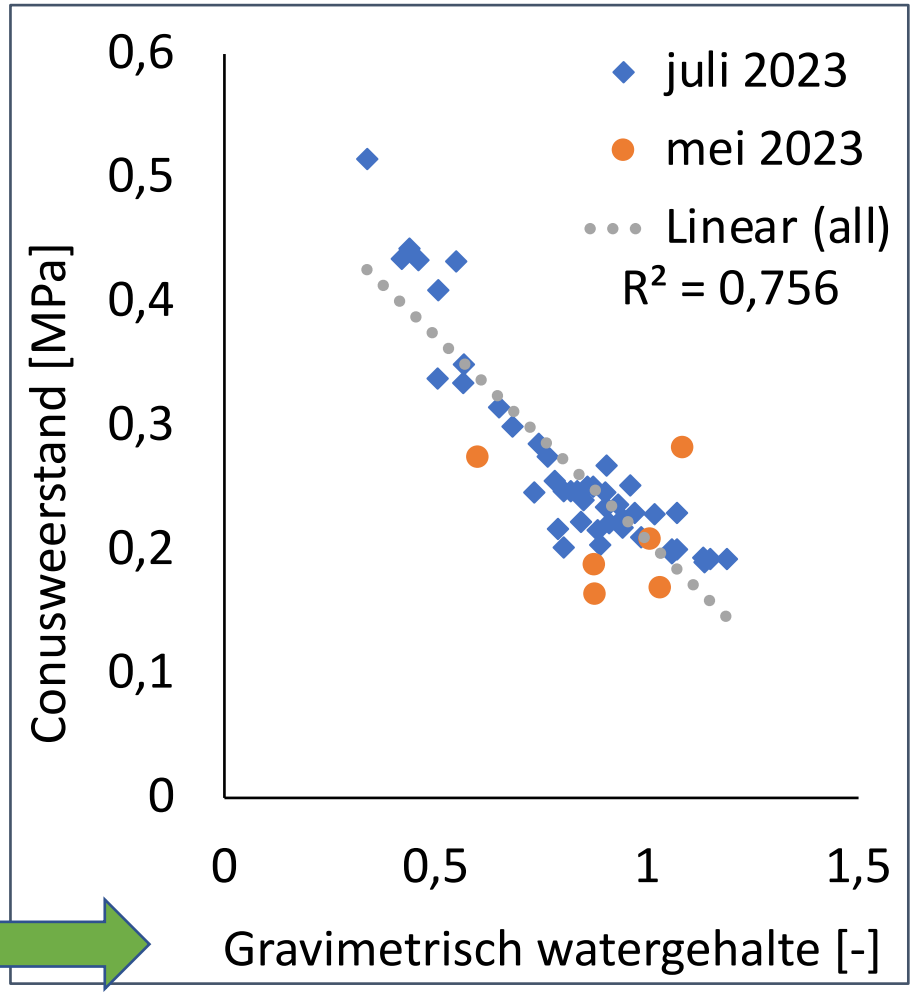

TISOLS
Tenth International Symposium on Land Subsidence
The Netherlands

United Nations Educational, Scientific and Cultural Organization
Intergovernmental Hydrological Programme

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How to reach societal impact with land subsidence research

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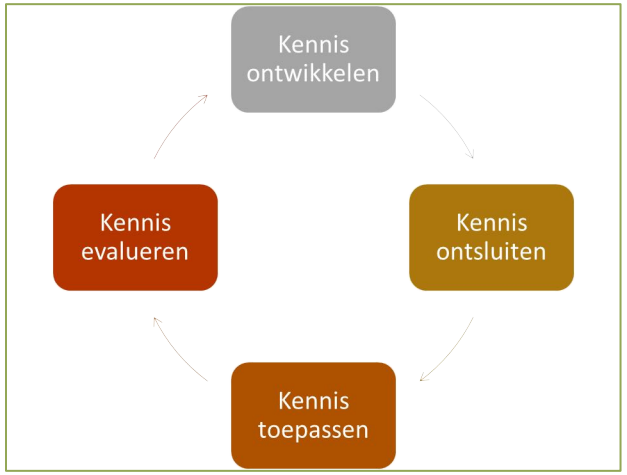
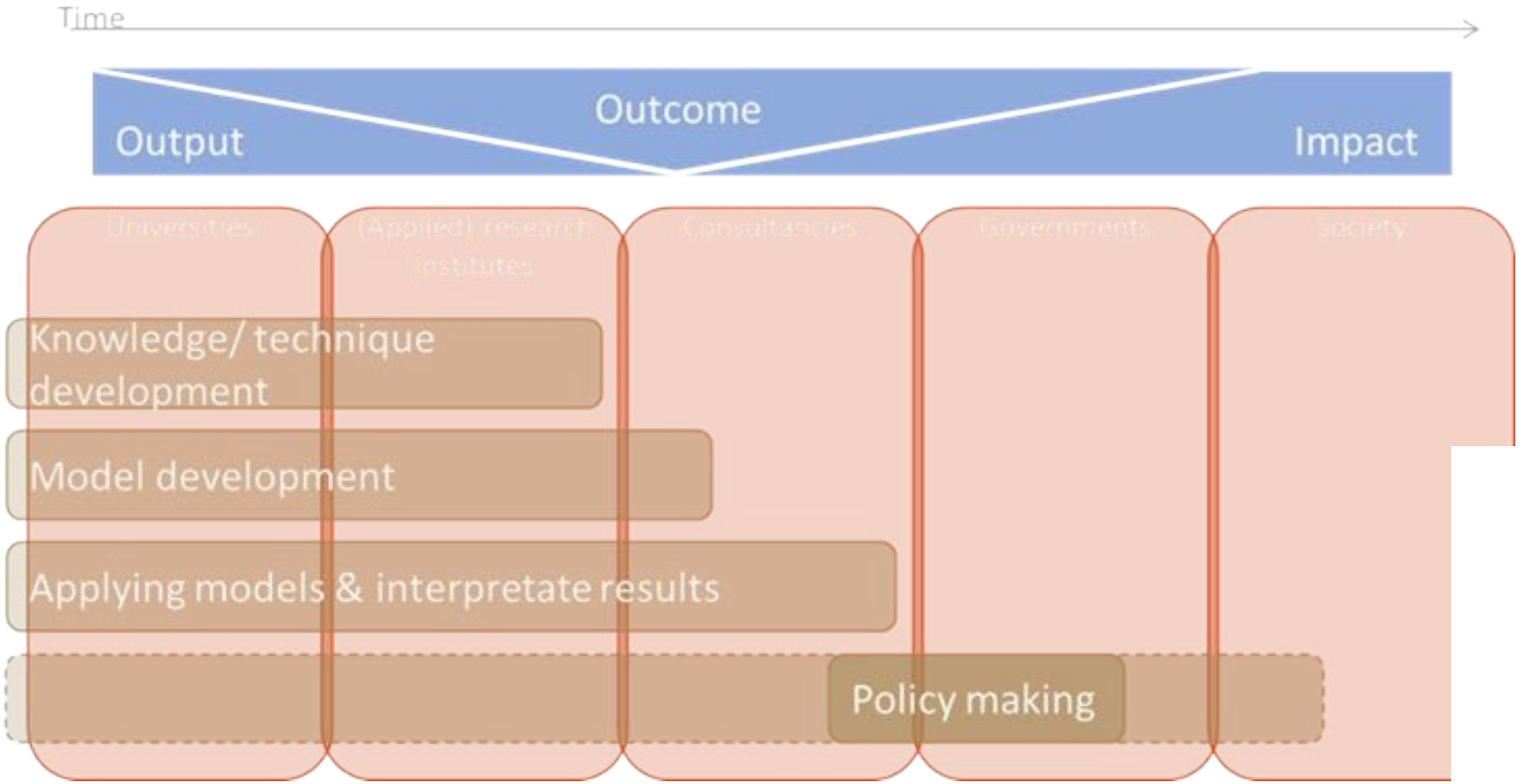
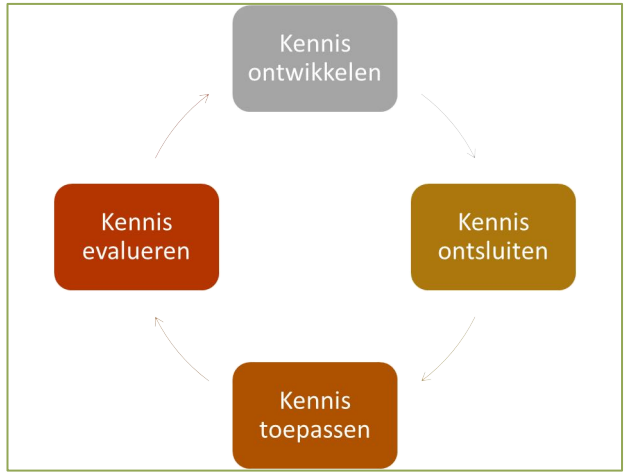
Introduction

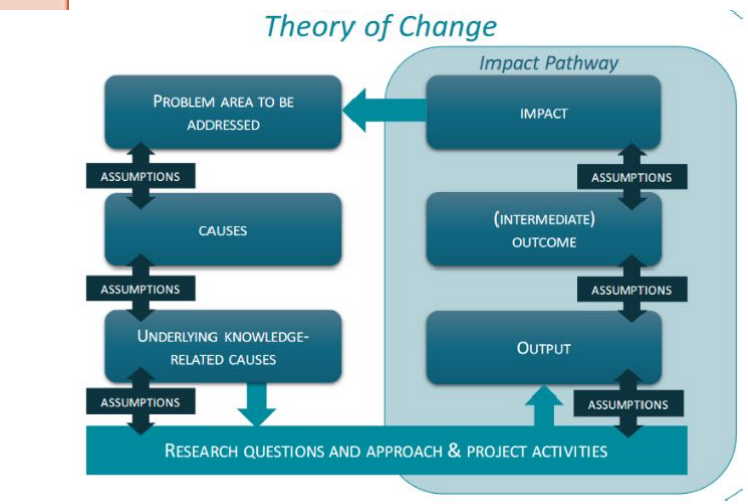
Many low-lying river deltas, home to over 500 million people, host vast areas of intensely used land surface that are subsiding due to natural causes and human-induced activities. The physical consequences of subsidence are manifold: relative shallowing of groundwater tables, salinization of ground and surface water, emission of greenhouse gasses (GHG), damage to buildings and infrastructure, and increased flood risk, flood water depth and flood duration. For delta societies this leads to serious economic loss through reduced agricultural yields, arable land loss, rising costs of maintenance and repair of lost assets, and forced sectoral divestments. For the Netherlands, economic damage of progressive subsidence could add up to 22 billion Euros by 2050 with continuing current policy (Van den Born et al. 2016).

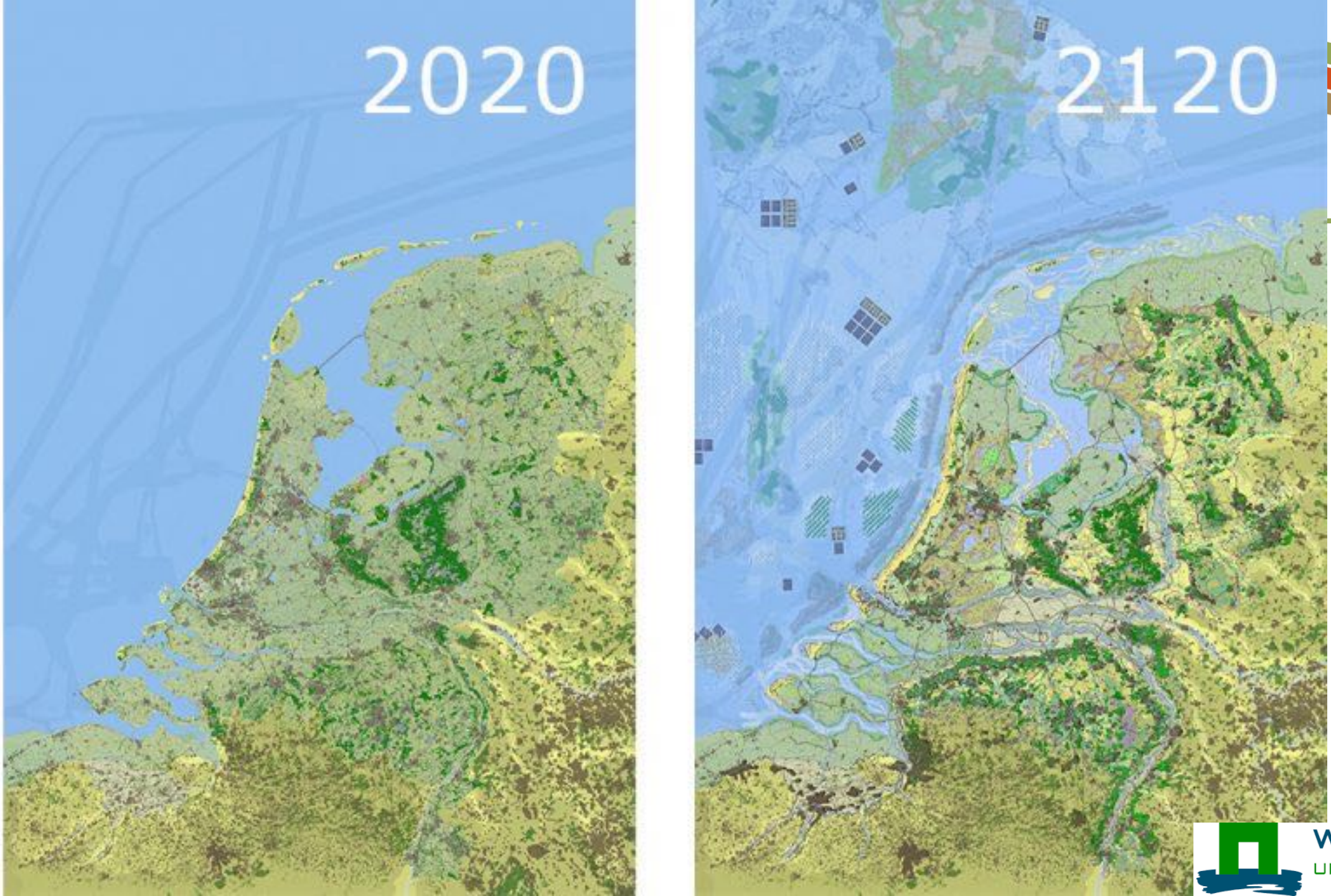


WP5:
knowledge utilization and entrepreneurship









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WAGENINGEN
UNIVERSITY & RESEARCH

Vijf mogelijke/plausibele toekomsten

1. Geen ingrijpen in bodemdaling
2. Klimaatneutraliteit in het veenweidegebied (klimaatwet)
3. Schade aan gebouwen, infrastructuur en openbare ruimte zo veel mogelijk vermeden
4. Bodemdaling nog maximaal 3 mm per jaar (cf. Rli, 2020)
5. Geen door menselijk handelen geïnduceerde bodemdaling

N.B. Toekomsten verschillen in mate van inzet op mitigatie, adaptatie en compensatie

Universiteit Utrecht

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Towards a sustainable future scenario and pathways for subsidence in the Netherlands (LOSS: WP 5)

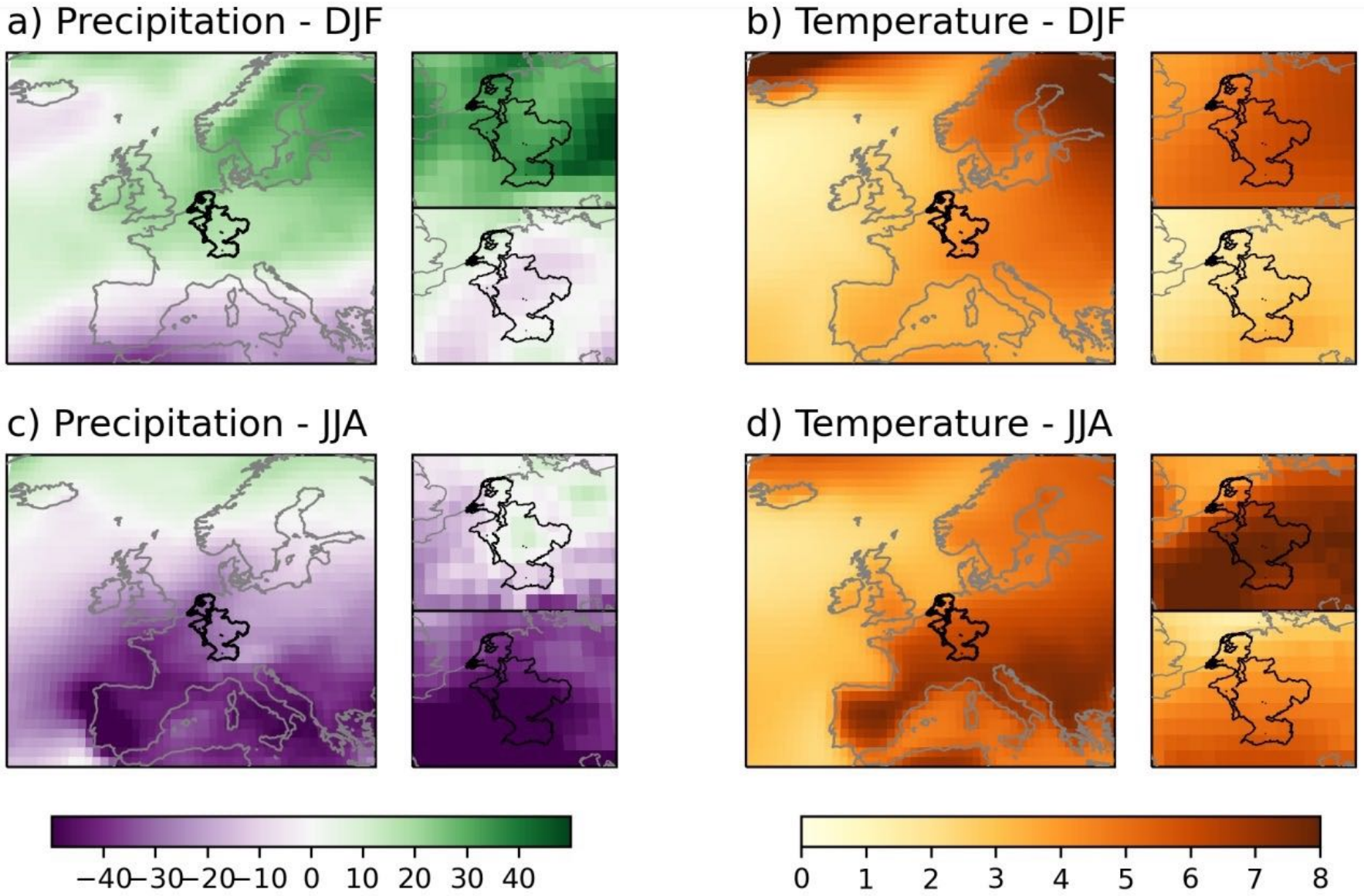
M.Hammad*, E. Stouthamer*, G. Erkens*

*Department of Physical Geography, Faculty of Geosciences, Utrecht University,

Winter

(2100)

Summer



Highest trend

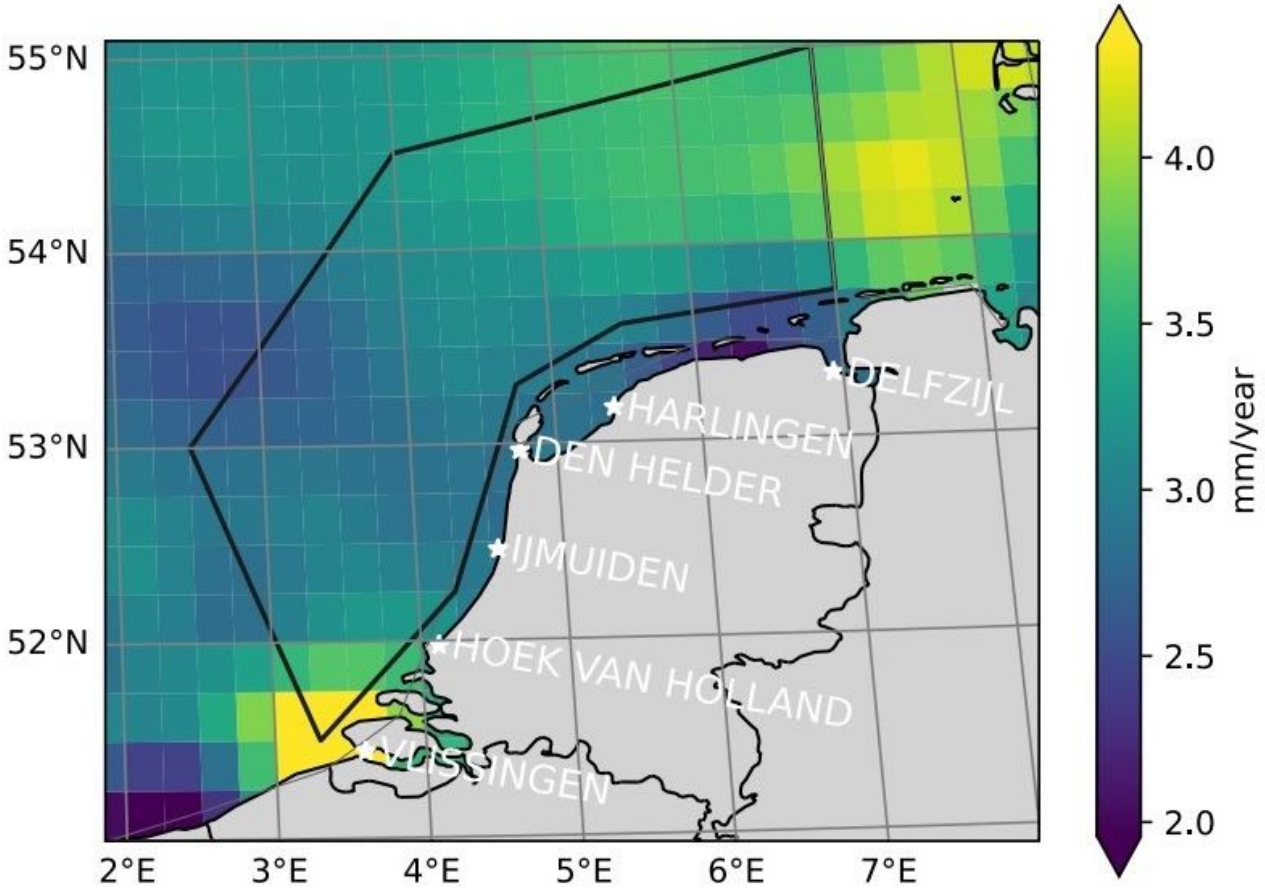
Lowest trend

Highest trend

Lowest trend

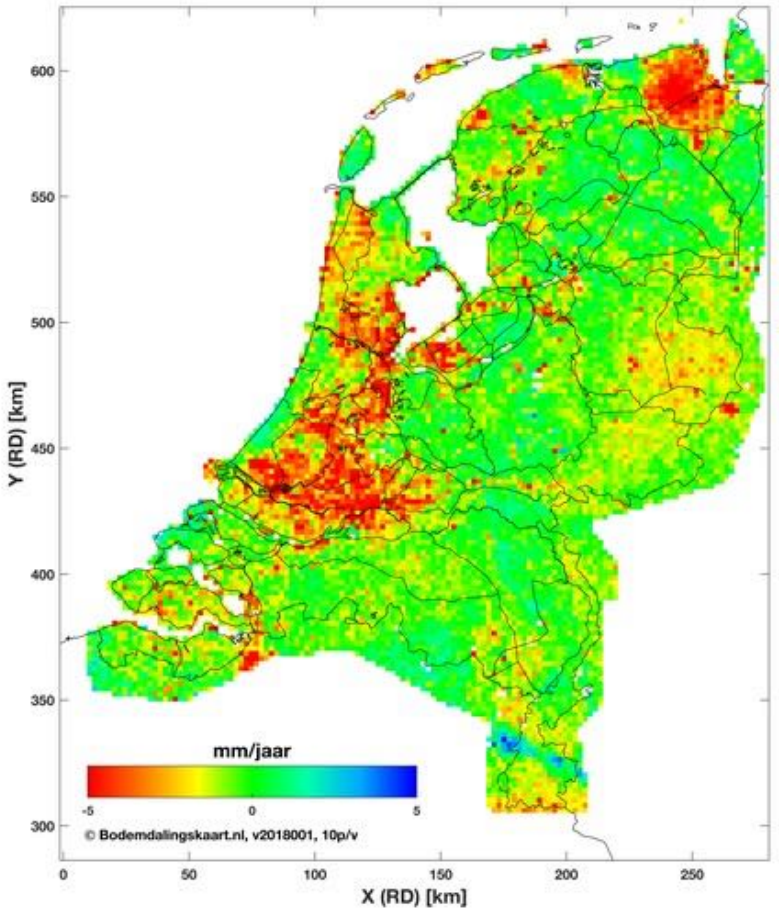
Large panels: CMIP6 multi-model mean projected regional climate change in Europe for SSP5-8.5 in 2100 (ΔGSAT = 4.0 C), for (a,c) precipitation [%], (b,d) 2 m temperature (C), and (a,b) in the winter season (DJF), (c,d) in the summer season (JJA). Small panels show the models with the largest and smallest trend in NL+RM region (in black) [KNMI'23].

Absolute sea level rise



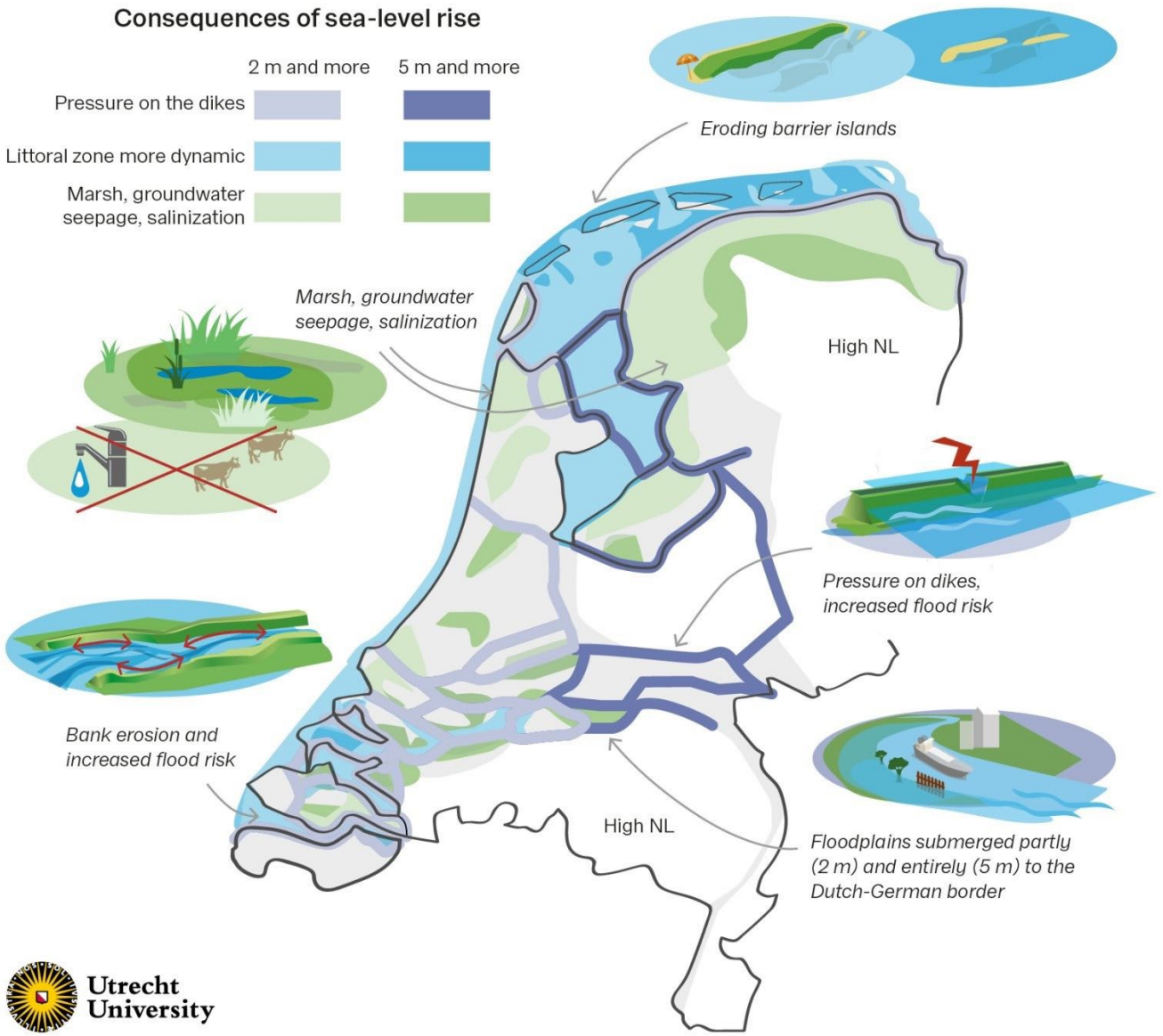
Linear fit to the sea level from satellite altimetry over the period 1993-2021 (The locations and names of the 6 main tide gauges are in white) [KNMI'23].

Subsidence rate



Subsidence rate in the Netherlands. [Bodemdalingskaart 2.0]

Relative sea level rise (absolute sea level rise + subsidence) consequences



LIVING ON SOFT SOIL "LOSS" PROJECT

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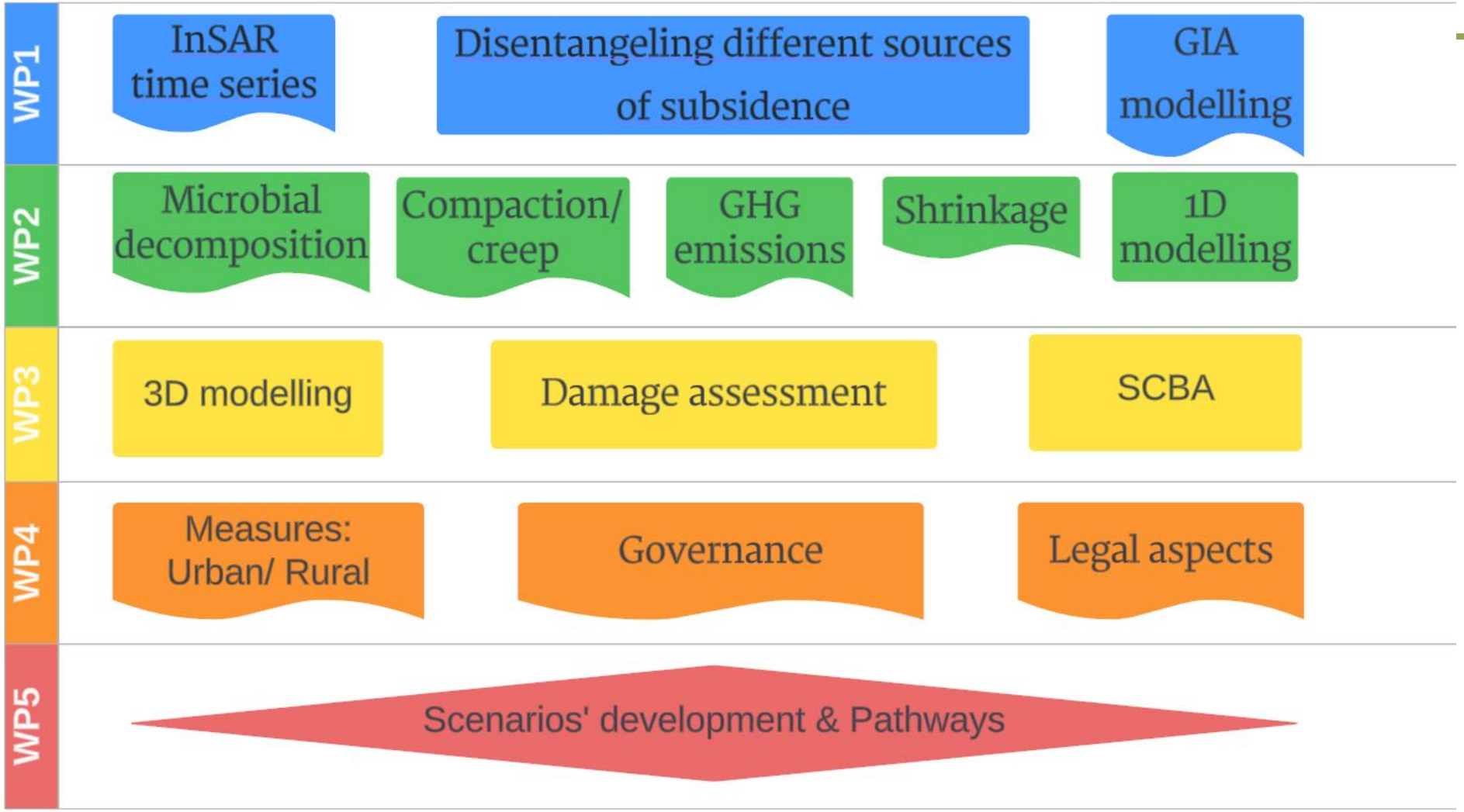
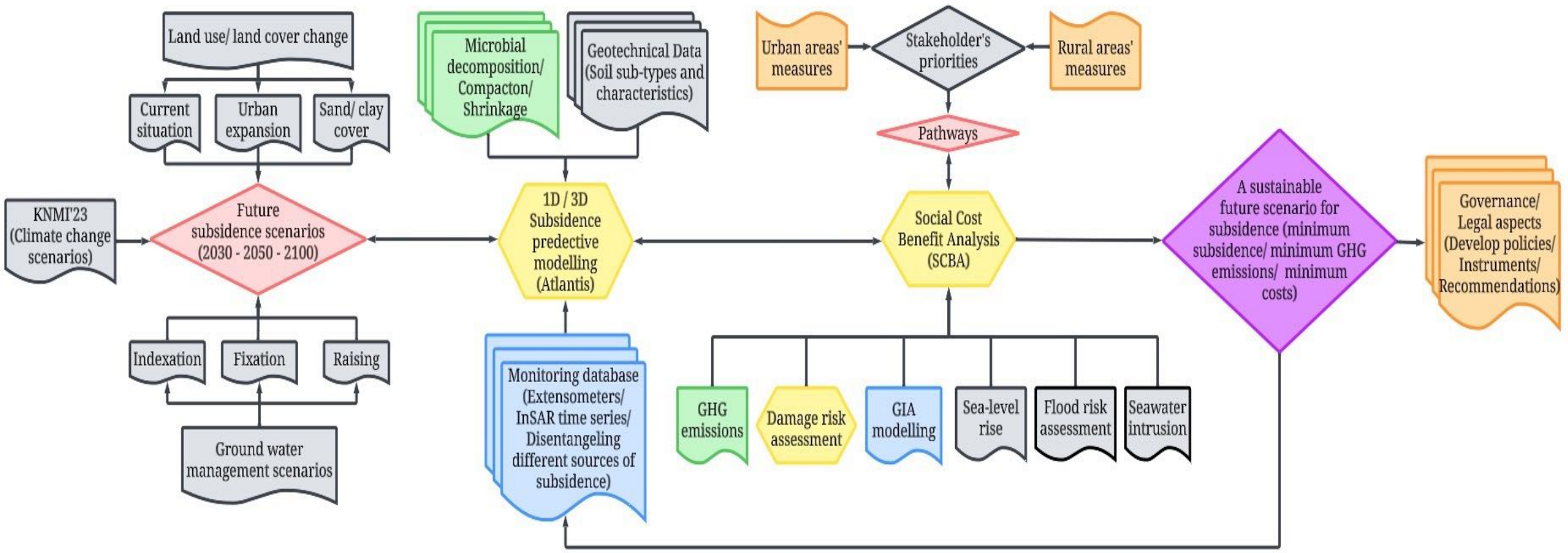
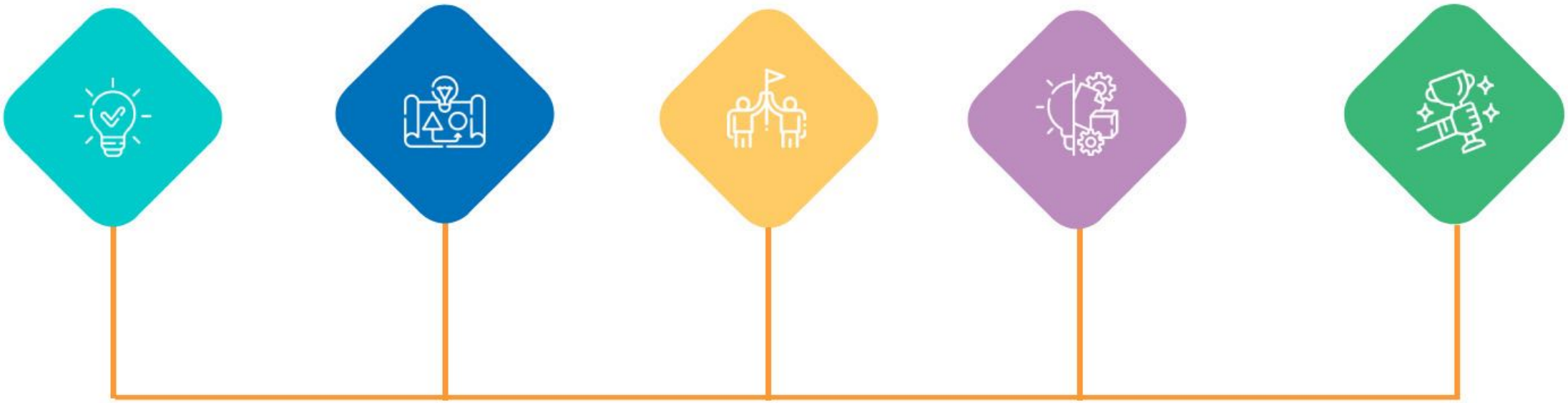


LIVING ON SOFT SOIL "LOSS" PROJECT



The workflow of the LOSS project (blue: WP1, green: WP2, yellow: WP3, orange: WP4, red: WP5 and grey: external resources) to reach a sustainable future scenario for subsidence (purple).

SHALLOW SUBSIDENCE SCENARIO DEVELOPMENT
WP.5



STEP 01

DEFINE THE SCOPE AND OBJECTIVES

STEP 02

IDENTIFY KEY DRIVERS AND UNCERTAINTIES

STEP 03

STATISTICAL ANALYSIS AND MODELING

STEP 04

SCENARIO CONSTRUCTION AND ANALYSIS

STEP 05

PREPARE FINAL MAPS AND DEVELOP PATHWAYS AND RECOMMENDATIONS

Thank you!

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