Human-induced subsidence in urbanizing deltas and coastal zones

Policy brief and Sinking Cities II brochure

Cees van de Guchte & Kim van Nieuwaal

Workshop Japan and the Netherlands
Climate Adaptation and Resilience
Tokyo, Japan - 31 October 2019

DeltAlliance

Deltares

Delta Coalition

Nikkei Shimbun, 22 October 2019

室との絆育む

他国と良好な関係を深める国際親善は皇室が担う重要な役割の一つだ。とりわけ、各国の王室とは長い時間をかけて交流を深め、強い絆を築いてきた。各国で国王の世代交代も相次ぐ中、即位されたばかりの天皇陛下の「人脈」にも注目が集まる。

水問題 一緒に取り組む

オランダ　アレクサンダー国王

オランダでは2013年、高齢となったベアトリックス前女王の退位を受け、長男のウィレム・アレクサンダー国王が即位した。天皇陛下は国王と同世代で、これまでも親しい交流を重ねられてきた。

オランダのアレクサンダー国王（右から2人目）一家の案内で、王室馬車庫を見る天皇、皇后両陛下と愛子さま（2006年、アペルドールン）＝共同

代表的なのが安全な水の確保や治水といった水問題への取り組みだ。陛下は皇太子時代の07～15年に国連の「水と衛生に関する諮問委員会」の名誉総裁を務め、各国で講演などをされてきた。国王も06～13年に同委員会で議長を務め、共に水問題の解決に力を尽くしてきた間柄だ。

私的な交流も続いている。天皇、皇后両陛下と長女の愛子さまは06年に同国を訪れ、約2週間滞在された。皇后さまの療養も兼ねたもので、前女王の招待で実現した。両陛下は13年にも同国を訪れ、現国王の即位式に出席されており、皇后さまにとって11年ぶりの外国公式訪問となった。

同国は日本が江戸時代の鎖国中も交流した唯一の西洋の国。欧州の物流拠点としても重要で、多くの日本企業が進出するなど、歴史的に両国の関係は深い。ただ、第2次世界大戦中の戦争捕虜の取り扱いを巡り、戦後はオランダ国民に強い反日感情が残っていた。

00年に同国を訪問した上皇ご夫妻は戦争犠牲者の慰霊塔に献花し、元抑留者とも面会された。学生寮の窓越しに学生と歓談する姿なども同国民に好意的に受け止められ、同国の国民感情を和らげる契機になったとされる。

留学「生き方にプラス」

リザベス女王

皇室と英王室とのゆかりは深い。近代以降に来日した外国の王族は、1869年の英国第2王子エディンバラ公が最初とされる。昭和天皇は皇太子時代の1921年に英国をはじめ欧州各国を訪問し、上皇さまも19歳だった53年に昭和天皇の名代としてエリザベス女王の戴冠式に参列された。

天皇陛下は学習院大卒業後の83～85年に英オックスフォード大に留学し、18世紀のテムズ川の水運を研究。学生寮に寄宿し、初めてクレジットカードで買い物をしたり、パブでビールを飲んだりするなど、日本では経験できない自由な生活も楽しまれたという。後に回想録で「今日の私の生き方にどれだけプラスになっているか」とつづられた。

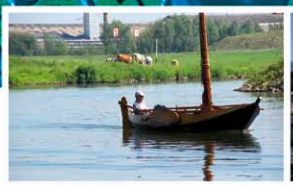
戦後、英国は皇族方の主要な留学先となっている。秋篠宮さまはオックスフォード大で動物学を専攻。長女の眞子さまはレスター大

ワンチュク国王

サウジアラビア　サルマン国王

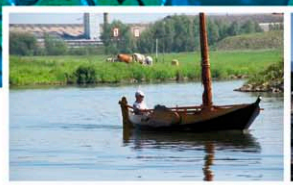
Johannis de Rijke, Colijnsplaat

Tokyo Metropolitan Government delegation in Dordrecht (NL), Sept. 2019

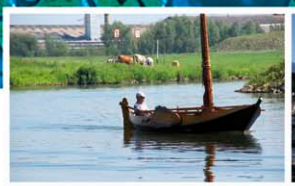


Delta Alliance Countries

Delta Alliance



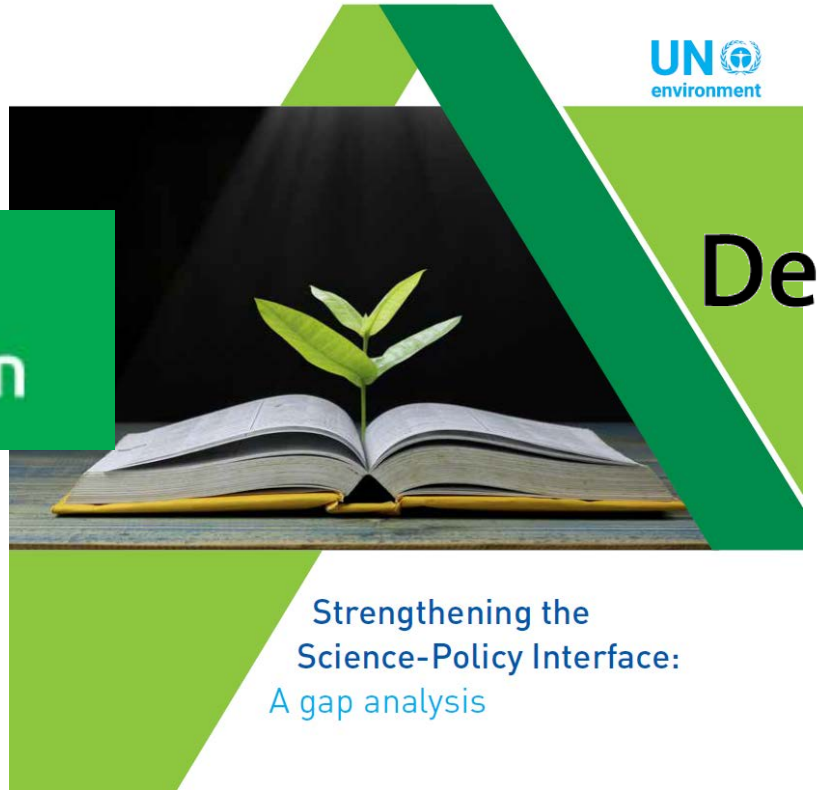
Delta Alliance & Delta Coalition



Bridging the gap for deltas

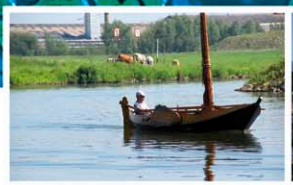
Policy network

Delta Coalition



Knowledge network

DeltAlliance



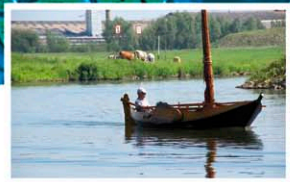
GLOBAL CENTER ON ADAPTATION

Challenge:

Leveraging deltas to address climate change

Deltas are areas where the impacts of climate change can exacerbate existing pressures from urbanization and pollution. But they are also places of opportunity that are often rich in social, economic and natural capital. The Global Center on Adaptation works with a global network with common interests in deltas to use these opportunities to address climate change challenges.

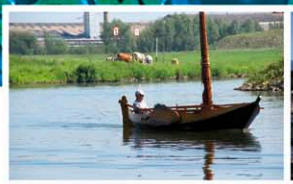
Delta Alliance is active participating organization of the Global Center on Adaptation



Current situation	Land and water use (occupation layer)	Infra-structure (network layer)	Natural Resources (base layer)	Governance	Resilience & Sustainability Indicator		
					Current	Moderate Scenario	Extreme scenario
Nile delta	--	0	-	0	-	-	--
Tana	-	-	0	-	-	-	--
Incomati delta	0	-	-	-	-	-	--
Zambezi	+	-	+	-	0	0	-
Ganges-Brahmaputra-Meghna delta	--	--	--	0	--	-	--
Yangtze delta	-	+	-	0	0	0	--
Ciliwung delta	--	--	--	-	--	--	-
Ayeyarwady	-	--	--	-	-	0	-
Mekong delta	0	0	-	0	0	+	0
Rhine-Meuse delta	+	++	0	+	+	0	-
Danube delta	+	+	+	0	+	0	0
California Bay-Delta	0	-	-	0	-	0	-
Mississippi River Delta	0	0	-	0	-	0	-
Parana	+	0	-	0	+	0	-

resilience/sustainability: *++(very good), + (good), 0 (medium), - (low), -- (very low)*

Available in december 2019 also: Assessment report on Ouémé Delta (Benin) and Volta Delta (Ghana)



Collaboration on subsidence between Coalition and Alliance

Delta Alliance

Policy brief
February 2019

Subsidence in urbanizing deltas and coastal zones

This policy brief describes the challenges and the actionable approaches to counteract human-induced land subsidence. Recommendations are made on policy and governance, technology, capacity building and financing aspects.

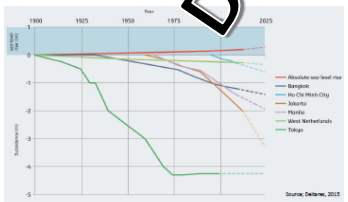
Subsidence is a huge challenge

Key messages

- There is abundant evidence that subsidence is a big challenge worldwide, especially in low-laying urbanizing deltas and coastal zones with deltaic subsoils; current observed subsidence rates in coastal megacities are in the range of 6-100 mm/year, while current global mean sea level rise is around 3 mm/year
- Without proper measures many coastal (delta) cities will be below sea level resulting in increased risk of flooding, loss of lives and significant economic losses in the form of structural damage and high maintenance costs, totalling billions of dollars per year
- The impacts of subsidence are further exacerbated by climate change, i.e. extreme weather events (short term) and rising sea levels (long term)
- Subsidence is a versatile, interlinked issue involving many policy sectors (e.g. water, infrastructure, housing, economy, spatial planning), and many stakeholders from local to national level; a ma[illegible] needed to deal with the complex and often 'hidden' but urgent threat of subsidence
- The good news is that it is possible [illegible] now to mitigate land subsidence, which will prevent worse impacts and much higher costs on longer

IPCC and OECD identified coastal cities a[illegible] deltas around the [illegible] vulnerable environments threatened by climate and human-induced changes. [illegible] increased hazard [illegible] risks for 0.5 billion people. Currently in many delta cities land subsidence ex[illegible] sea level ri[illegible] ten, due to excessive groundwater extraction related to rapid urbanization and p[illegible]ion growth. Current [illegible] absolute sea level rise is around 3 mm/year. However current observed subsiden[illegible] megacities are in the ra[illegible]6-100 mm/year and projections till 2025 expect similar subsidence rates [illegible]ending [illegible]ture measures.

Without change, more parts [illegible] Ho Chi Minh [illegible] Bangkok and numerous other delta (and coastal) cities will sink below sea level. Increased flooding and [illegible] other widespre[illegible]acts [illegible]nd subsidence result currently in damage of billions of dollars per year.



Subsided bridge in Jakarta

Subsurface connection problems by subsidence in the Netherlands

Subsidence for several coastal cities compared to absolute sea level rise in the same time period (please note that average subsidence values are presented as subsidence can differ considerably at local scale, depending on groundwater level and subsurface characteristics)

1

Delta Alliance

Oct 2019

Sinking cities II – example cases

A step-by-step approach to address land subsidence in urbanising deltas

In many coastal and delta cities land subsidence exceeds absolute sea level rise up to a f[illegible]ten. Without action, parts of Jakarta, Ho Chi Minh City, Bangkok and numerous other coastal cities will sink below s[illegible]ed flood risk and other widespread impacts of land subsidence result in damage totalling billions of dollars [illegible] cause of severe land subsidence is excessive groundwater extraction due to rapid urbanization and pop[illegible] A major rethink is needed to deal with the 'hidden' but urgent threat of subsidence, as well as more [illegible]port decision making.

In 2015, Deltares published the agenda-setting brochure 'Sinking Cities' to raise [illegible] subsidence and the associated damage. Although awareness on subsidence is increased, it is far from finished, as exem[illegible] frequent new discoveries of apparent new subsiding coastal cities. As there is a growing need in guidance this brochure pr[illegible]ensive and step-by-step approach to address land subsidence from the perspective of sustainable and resilient urban deve[illegible]ated by real life case study examples. The lessons learned from these experiences provide valuable information and inspira[illegible]decision makers and experts to address subsidence in urbanising deltas. It is expected that this guidance will further raise [illegible] contribute to lowering the threshold to act while acknowledging the progress made over the last years.

A step-wise approach is elaborated along the stages of the poli[illegible]cle. Clear steps that need to be taken. For each of the 6 steps identified, there are questions that need to be addressed, tec[illegible] an governance aspects that need to be considered to answer the questions, and products that form the outcome of the step to [illegible] a policy strategy (Table 1). This document offers guidance for the step-wise approach on land subsidence, by providing [illegible] for each of these steps. The Sinking Cities 2 brochure contributes to the ongoing awareness raising on land subsidence, wh[illegible]owing the progress made over the last years. It is expected that it will contribute to lowering the threshold to act and will [illegible]ch [illegible] land subsidence in more areas around the world. It offers a lead what to do next once a certain aspect is finalised.

Policy cycle	Questions to address	Step-wise approach		Products
		Technical aspects	Governance aspects	
Problem analysis	• How much subsidence is there? Are people aware of this? • What is impact of subsidence • What are the causes? • Who is involved and responsible?	1. Monitoring • Data collection • Review Assessment • Data analyses to disentangle subsidence causes	• Awareness raising • Stakeholder analysis • Identification of problem owners	• Subsidence map with current subsidence rates (+ sum) and impacts • Communication plan • Measuring plan and set-up • Subsidence database with publically available data • Subsidence map with causes of subsidence • Stakeholder mapping
Planning	• How much future subsidence is predicted? • What are most vulnerable areas? • What are possible measures? • What are the current and future impacts (quantified and monetised)?	3. Modelling • (Inverse) modeling to make predictions • Scenario constructions / analyses • Modelling / forecasting • Vulnerability assessment • Damage assessment 4. Measures - Cost-benefit analysis and decision support • Cost-benefit analyses / multi-criteria analysis of possible measures • Decision support system • Selection of (innovative) measures in an integrated multi-sectoral perspective	• Capacity building / education • Multi-sectoral planning, participation, stakeholder engagement and commitment • Political action, development of policy, strategy and legal instruments • Planning and design of buildings and infra-structure, incl. building code • Decision-making on implementation	• Subsidence map with future subsidence rates (+ sum) • Vulnerability map • Capacity building plan • Overview of possible measures • Subsidence impact map (current + future) • Decision support tools • Strategy and action plan (including selection of measures)
Implementation	• What will be done, how and when and by whom?	5. Measures - Implementation • Implementation of measures • Setup monitoring plan • Setting up pilot projects	• Multi-sectoral cooperation / organisational structure • Legal framework / operational procedures / guidelines • Enforcement of laws and regulations • Financing mechanisms / asset management	• Implementation plan (incl. organisation, operational procedures, legal aspects , financing, asset manage-ment) • Monitoring plan • Pilot sites
Evaluation	• Is the problem under control?	6. Monitoring and evaluation • Monitoring/remodelling • Setup evaluation plan • Compliance checking • Assessment and outlook • Exchange of knowledge and best practices	• Stakeholder evaluations • Public hearing	• Evaluation plan (technical and soc-economic) • Best practices • Knowledge exchange plan

Table 1. Integrated framework and stepwise approach addressing all aspects of subsidence, incorporating technical as well as governance aspects (Deltares, 2018)

1

Sinking cities

An integrated approach towards solutions

In many coastal and delta cities land subsidence exceeds absolute sea level rise up [illegible] factor of ten. Without action, parts of Jakarta, Ho Chi Minh City, Bangkok and nu[illegible]ther coastal cities will sink below sea level. Increased flooding and other widesp[illegible]s of land subsidence result in damage totalling billions of dollars per year. A major cau[illegible]r severe land subsidence is excessive groundwater extraction due to rapid urb[illegible]n and population growth. A major rethink is needed to d[illegible]'hidden' but urgent threat [illegible]bsidence. Deltares presents a comprehensive appro[illegible]ress land su[illegible]from the perspective of more sustainable and resilient [illegible]t.

There is abundant evidence th[illegible]bsi[illegible] detrim[illegible]l [illegible]ll increase in the near future, causes major problems worldwid[illegible] making it nec[illegible] to address subsidence related problems now.

- In many coastal megacities ar[illegible]l land subsidence increases flo[illegible]quency, inundation depth and du[illegible]with floods causing major economic dama[illegible]loss of lives. Land subsidence results in s[illegible]ant economic losses in the form of structural damage and high maintenance costs. This effects roads and tran[illegible]portation networks, hydraulic infrastructure, su[illegible] as river embankments, sluice gates, flood[illegible] and pumping stations -, sewage systems, b[illegible] and foundations. The total damage wor[illegible] is estimated at billions of dollars annually.
- Because of ongoing urbanization a[illegible]tion growth in delta areas, in particular [illegible]asta-cities, there is, and will be, more [illegible]velop-ment in subsidence-prone area[illegible]ly.
- Th[illegible]cts of subsidence are further exacerbated b[illegible]weather events (short term) and rising [illegible]g term).

Subsidence is an issue that involves many policy complex technical aspects and governance embedment. There is a need for an integrated proach in order to manage subsidence and to evelop appropriate strategies and measures that are effective and efficient on both the short and long term. Urban (groundwater management, adaptive flood risk management and related spatial planning strategies are just examples of the options available. The figure below illustrates the current subsidence problems related to socio-economic development and climate change.

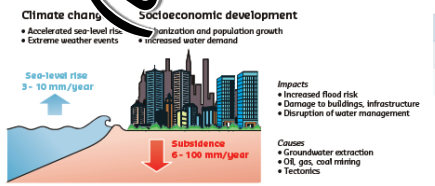


Figure 1. Land subsidence from a multi-sectoral perspective

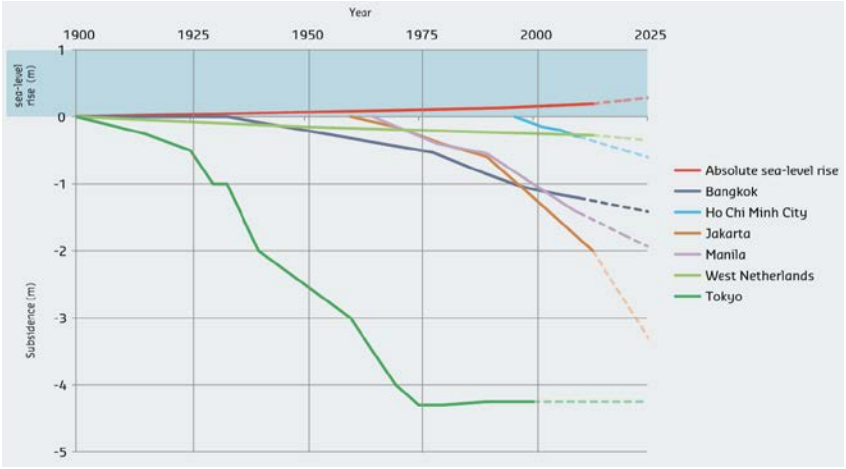
Draft for DC Tokyo

Forthcoming

(update 2015)

Human-induced land subsidence is a big challenge worldwide especially in low-laying urbanizing deltas and coastal zones

- 6-100 mm/year, while global mean SLR is around 3 mm/yr
- Damage is totalling billions of dollars per year
- Impacts are further exacerbated by climate change (extreme events + SLR)



Policy brief

- Describes the challenges and the actionable approaches to counteract human-induced land subsidence
- Recommendations are made on policy and governance, technology, capacity building and financing aspects

Sinking Cities II brochure (supporting the policy brief)

- Step-by-step approach illustrated by real life example cases

Policy brief

Policy and governance aspects of subsidence

- Subsidence is not mentioned in the global agendas and often also not addressed in national or local policy agendas
- Subsidence is often a ‘hidden’ policy issue, not fully recognized or acknowledged
- In many subsidence prone areas there is no comprehensive subsidence strategy and approach, no multi-sectoral cooperation, no legal framework nor specific instruments, which hampers setting of clear policy targets and implementation of measures to mitigate subsidence
- An organisational structure with clear roles and responsibilities regarding subsidence issues is often non-existent or not sufficient, thus undermining planning and action

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Policy brief

Comprehensive approach towards solutions

Integrated framework and stepwise approach (6 steps) addressing most relevant aspects of subsidence, incorporating technical as well as governance aspects

Policy cycle	Questions to address	Step-wise approach		Products
		Technical aspects	Governance aspects	
Problem analysis	• How much subsidence is there? Are people aware of this? • What is impact of subsidence • What are the causes? • Who is involved and responsible?	**1. Measuring** • Measurement data collection • Impact assessment **2. Mechanisms** • Data analyses to disentangle subsidence causes	• Awareness raising • Stakeholder analysis • identification of problem owners	• Subsidence map with current subsidence rates (+ sum) and impacts • Communication plan • Measuring plan and set-up • Subsidence database with publically available data • Subsidence map with causes of subsidence • Stakeholder mapping
Planning	• How much future subsidence is predicted? • What are most vulnerable areas? • What are possible measures? • What are the current and future impacts (quantified and monetised)?	**3. Modelling** • (Inverse) modelling to make predictions • Scenario constructions / analyses • Modelling / forecasting • Vulnerability assessment • Damage assessment **4. Measures - Cost-benefit analysis and decision support** • Cost-benefit analyses / multi-criteria analysis of possible measures • Decision support system • Selection of (innovative) measures in an integrated multi-sectoral perspective	• Capacity building / education • Multi-sectoral planning, participation, stakeholder engagement and commitment • Political action, development of policy, strategy and legal instruments • Planning and design of buildings and infra-structure, incl. building codes • Decision-making on Implementation	• Subsidence map with future subsidence rates (+ sum) • Vulnerability map • Capacity building plan • Overview of possible measures • Subsidence impact map (current + future) • Decision support tools • Strategy and action plan (including selection of measures)
Implementation	• What will be done, how and when and by whom?	**5. Measures - implementation** • Implementation of measures • Setup monitoring plan • Setting up pilot projects	• Multi-sectoral cooperation / organisational structure • Legal framework / operational procedures / guidelines • Enforcement of laws and regulations • Financing mechanisms / asset management	• Implementation plan (incl. organisation, operational procedures, legal aspects , financing, asset management) • Monitoring plan • Pilot sites
Evaluation	• Is the problem under control?	**6. Monitoring and evaluation** • Monitoring remodelling • Setup evaluation plan • Compliance checking • Assessment and outlook • Exchange of knowledge and best practices	• Stakeholder evaluations • Public hearing	• Evaluation plan (technical and soc-economic) • Best practices • Knowledge exchange plan

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Policy brief

Recommendations

Technology

- Knowledge agendas and collaborative research on subsidence
- Systematic monitoring
- Artificial groundwater recharge

Policy and governance

- Clear policy framework and appropriate legislation on subsidence
- Multi-sectoral cooperation, joint policy development, coordination and participation
- Future proof decisions enabled by evidence-based decision support models and tools

Capacity building

- Awareness raising and need assessments on subsidence knowledge
- Training programs, workshops, seminars and conferences
- Community of practice on subsidence mitigation (from planning to implementation)

Finance

- Assessments of main financial risks and costs/benefits
- Financing mechanisms and innovative financial instruments
- Integrated economic assessment framework for land subsidence

Sinking Cities II brochure

A step-by-step approach to address land subsidence in urbanising deltas

- Illustrated by real life example cases
- Lessons learned and recommendations for each step

Step 1. Measuring subsidence (example case Ganges–Brahmaputra–Meghna delta and Dhaka, Bangladesh)

Step 2. Understanding subsidence Mechanisms (example case Jakarta, Indonesia)

Step 3. Modelling land subsidence (example case the Mekong Delta, Vietnam)

Step 4. Measures - Cost-benefit analysis and decision support (example case Gouda, The Netherlands)

Step 5 Implementation of measures (example case Bangkok)

Step 6. Monitoring and evaluation of land subsidence (example case Shanghai, PRC)

Subsidence in Dutch national Climate Effect Atlas

Klimaateffectatlas

VIEWER KAARTVERHALEN OVER DE ATLAS PARTNERS HELPDESK FAQ Zoeken

Home › Viewer

Overstroming | Wateroverlast | Droogte | Hitte

Download | Gidsmodellen voor landschapstypen | Zoek gemeente

Klimaateffecten — Selecteer scenario: Huidig | 2050WH

- Tekort oppervlaktewater extreem droog jaar ✓ ✓
- Tekort oppervlaktewater gemiddeld jaar ✓ ✓
- Gemiddelde Laagste Grondwaterstand ✓ ✓

Gevoelige functies en ruimtelijke kenmerken

- Signaalkaart bodemdaling mei15-mei18
  - Weinig daling
  - Significante daling eerste helft periode
  - Significante daling tweede helft periode
  - Significante daling
  - Veel daling

Klik hier voor het kaartverhaal droogte


Two dominant frames (cf. De Boer & Wardekker, 2010)

Risk Avoidance

"To prevent damage and climate risks to society"

Opportunity

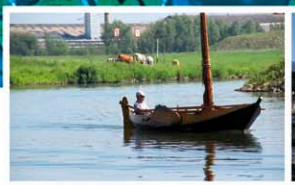
"To realize resilient, sustainable and innovative businesses and cities"

Two dominant frames

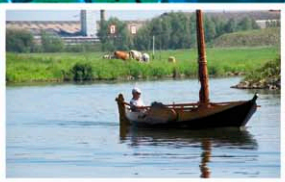
Risk Avoidance	Opportunities
Reductionistic	Integrated holistic
Technical engineering (controlling the water)	Systems approach (using nature, living with water)
Quantification of risks and uncertainties	Creating support through design and visualization
Are measures cost effective?	Is there support for measures? Can they be financed?

Minimizing risks

Maximizing opportunities, value creation



Delta Commisson 2008



Delta Programme

One Aim:

- Keeping NL a good, safe and attractive place to live and work for present and future generations (→ 2100, long term perspective)

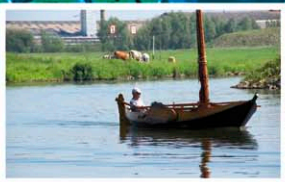
Two Goals:

- Safe, now and in the future (2050-2100)
- Fresh water supply guaranteed, also in dry periods

Three Basic values:

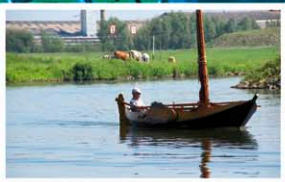
- Solidarity, Flexibility and Sustainability

Not in answer to a disaster, but in advance, to be prepared or avoid it

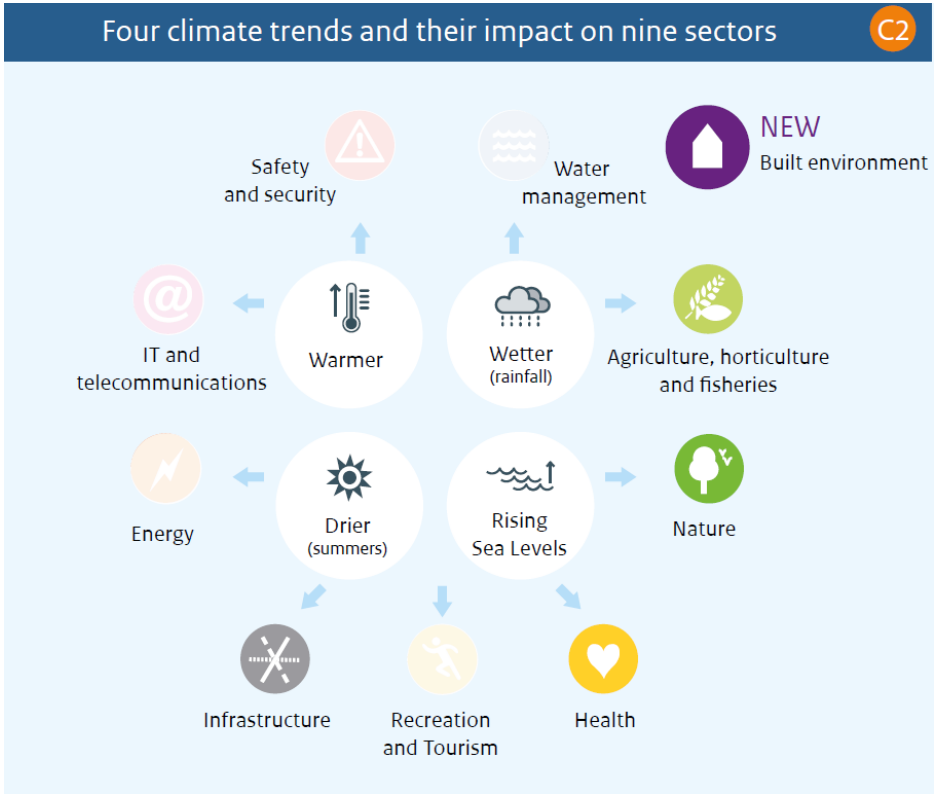


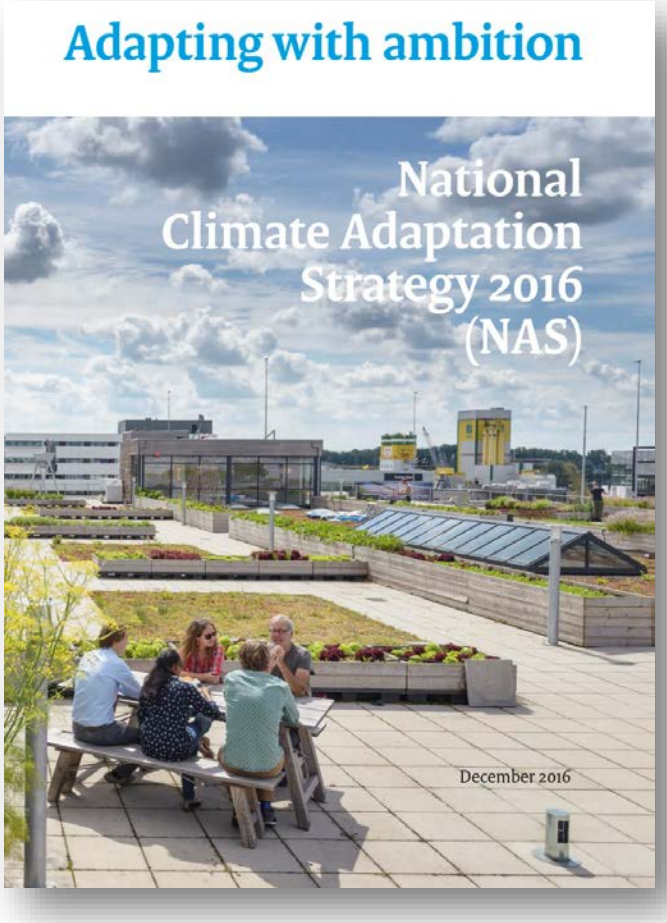
Some lessons learned

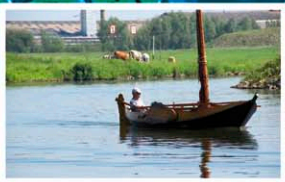
- Establish the network on the ground, with those that do the actual work. Make them feel part of the family
- Make the connection with identity and let others shine
- A frontperson that is both powerful (stay in control) and accessible (make connections)
- Secure the funds
- It’s not just threats, it’s above all about opportunities
- Secure the knowledge base and work interdisciplinary
- Be innovative / flexible in organizing (e.g. collaboration with NAS)



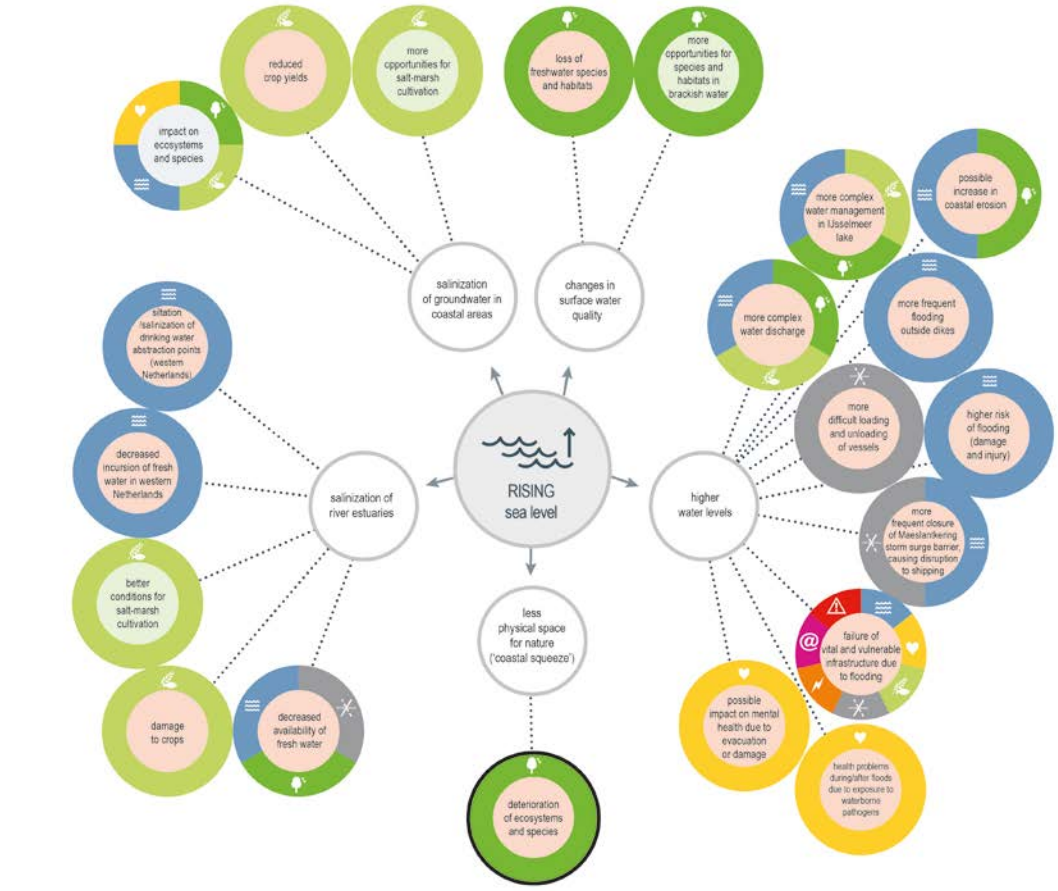
National Adaptation Strategy of The Netherlands







NAS NL: effects sea level rise



English_Bollenschema_zeespiegel_V18C_UP, februari 2018

National Climate AdaptationStrategy (NAS)

Climate trends, climate impacts and consequences for sectors

Climate trend

Climate impact

Implications for sectors

Sectors

- Water and spatial management
- Nature
- Agriculture, horticulture and fisheries
- Health
- Recreation and tourism
- Infrastructure (air, road, rail, water)
- Energy
- IT and telecommunications
- Safety and security

Impact

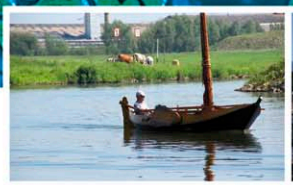
- Medium to marked effect: this decade
- Marked effect: this century

Nature of effect

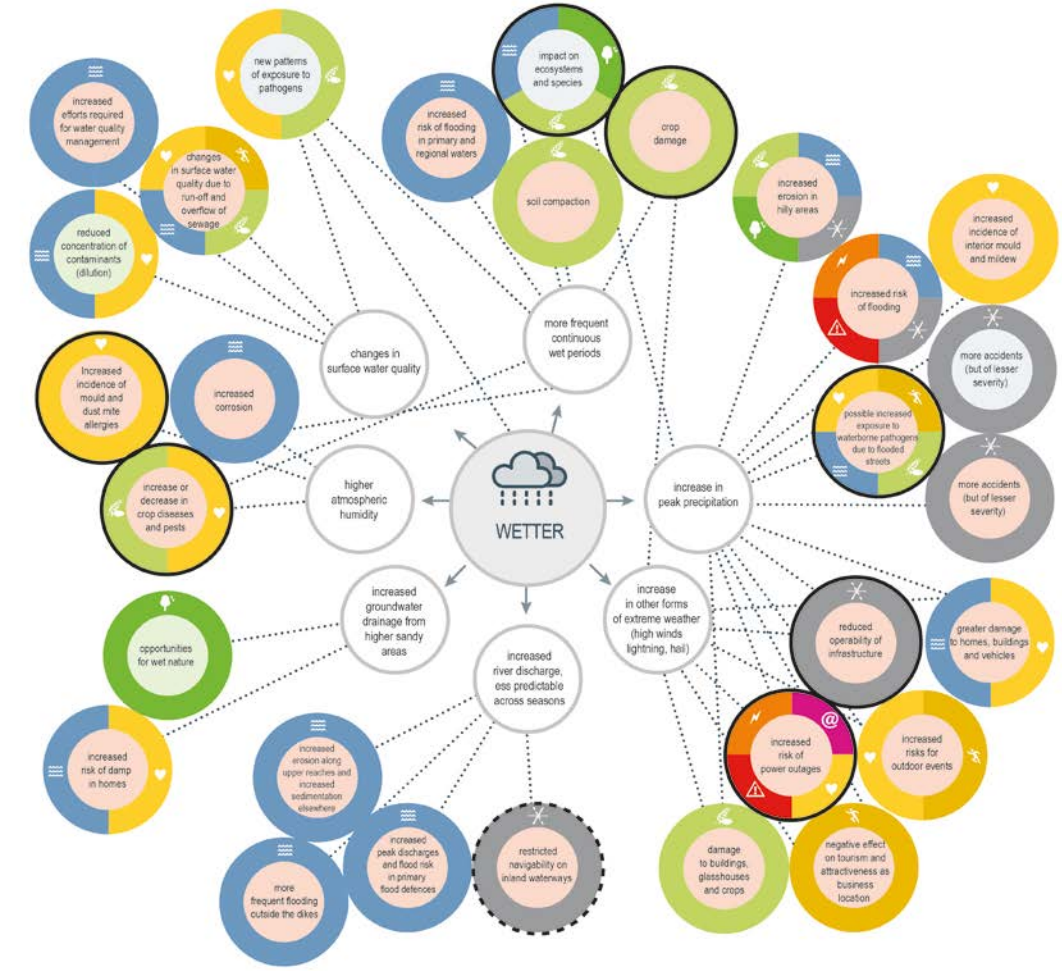
- Effect is an opportunity
- Effect is a threat
- Unclear whether effect is an opportunity or a threat

source:
- PBL, Aanpassen met beleid klimaatverandering klimaatverandering ('Adapting to climate change'), 2013
- PBL, Aanpassen aan klimaatveranderingklimaat-verandering ('Adapting to climate change'), 2015
- NAS workshop sessions, 7 June, 1 September and 12 October 2016

Disclaimer: These diagrams offer a simplified and incomplete representation of the actual situation. In the interests of clarity, not all components of the known causal relationships are shown.
F.M. Scientific check on this version



NAS NL: effects wetter



English_Bollenschema_wetter_V18C_UP, februari 2018

National Climate AdaptationStrategy (NAS)

Climate trends, climate impacts and consequences for sectors

Climate trend

Climate impact

Implications for sectors

Sectors

- Water and spatial management
- Nature
- Agriculture, horticulture and fisheries
- Health
- Recreation and tourism
- Infrastructure (air, road, rail, water)
- Energy
- IT and telecommunications
- Safety and security

Impact

- Medium to marked effect: this decade
- Marked effect: this century

Nature of effect

- Effect is an opportunity
- Effect is a threat
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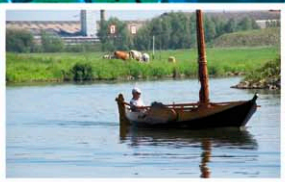
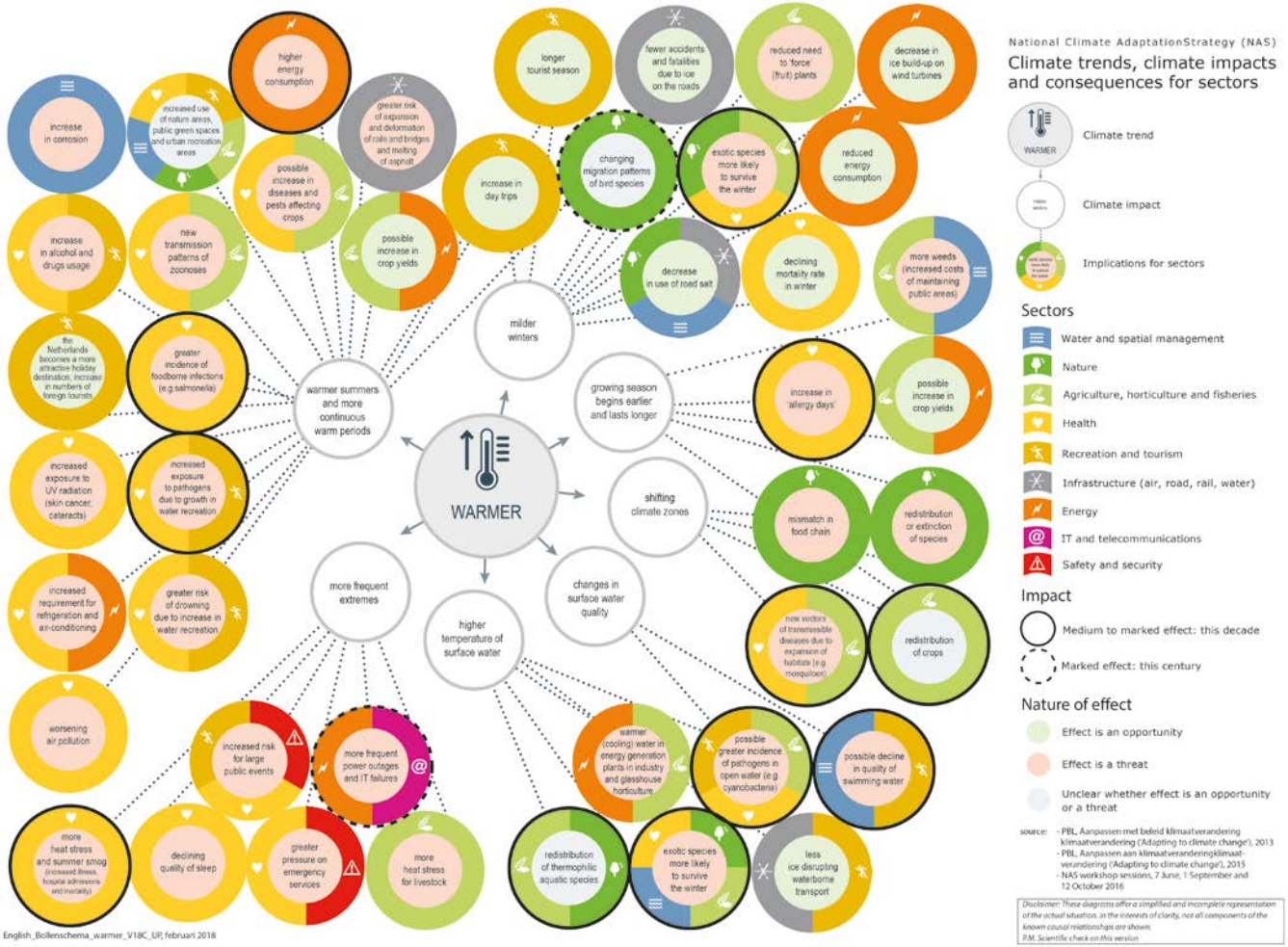


NAS NL: effects warmer



National Climate AdaptationStrategy (NAS)

Climate trends, climate impacts and consequences for sectors

WARMER — Climate trend

Climate impact

Implications for sectors

Sectors

- Water and spatial management
- Nature
- Agriculture, horticulture and fisheries
- Health
- Recreation and tourism
- Infrastructure (air, road, rail, water)
- Energy
- IT and telecommunications
- Safety and security

Impact

- Medium to marked effect: this decade
- Marked effect: this century

Nature of effect

- Effect is an opportunity
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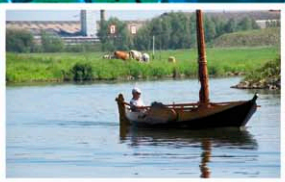

NAS NL: effects drier

English_Boilenschema_droger_V18C_UP, februari 2018

National Climate AdaptationStrategy (NAS)

Climate trends, climate impacts and consequences for sectors

DRIER — Climate trend

Climate impact

Implications for sectors

Sectors

- Water and spatial management
- Nature
- Agriculture, horticulture and fisheries
- Health
- Recreation and tourism
- Infrastructure (air, road, rail, water)
- Energy
- IT and telecommunications
- Safety and security

Impact

- Medium to marked effect: this decade
- Marked effect: this century

Nature of effect

- Effect is an opportunity
- Effect is a threat
- Unclear whether effect is an opportunity or a threat

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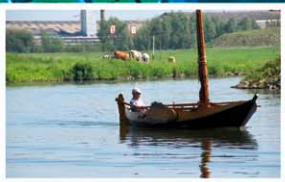
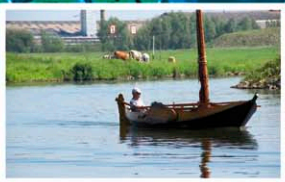
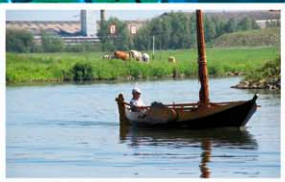


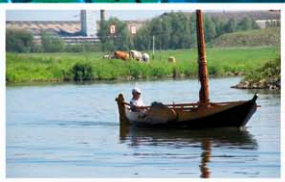
The Dutch delta

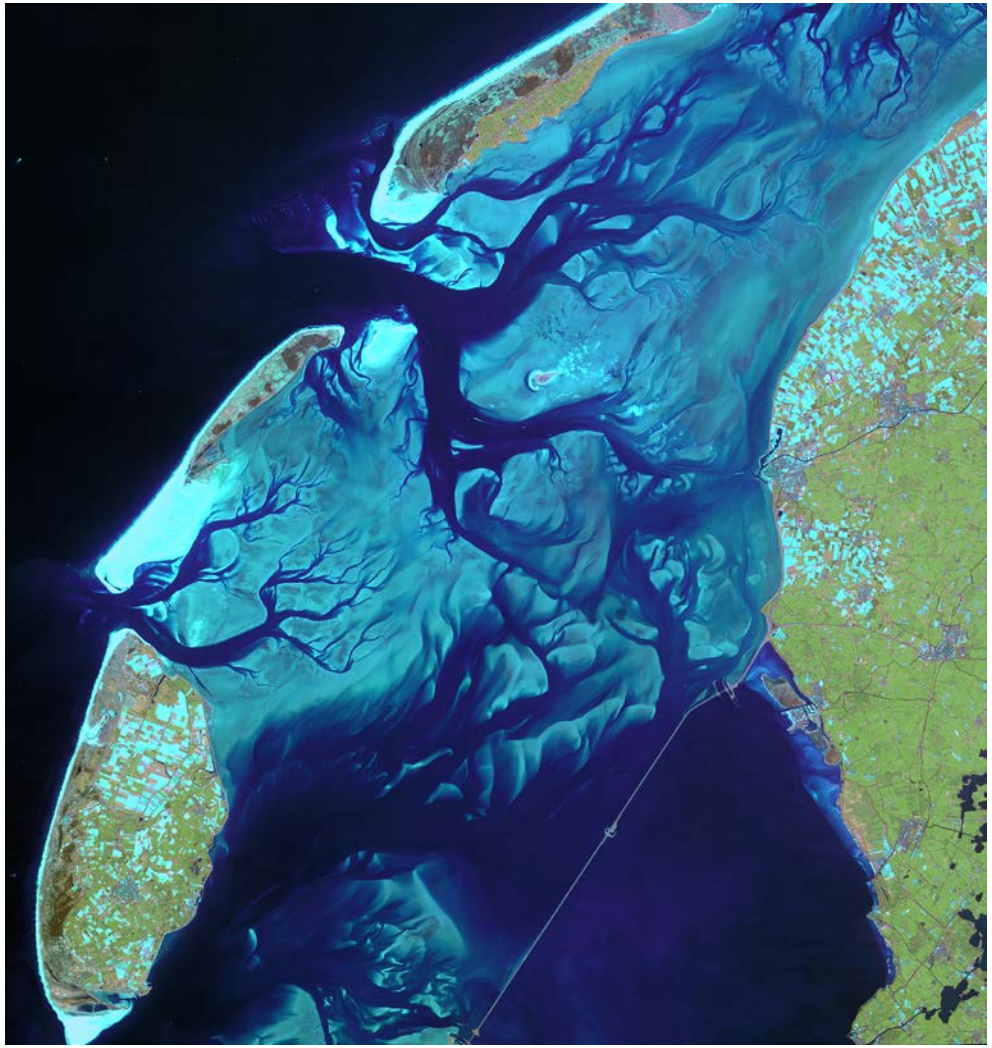


The Dutch delta works



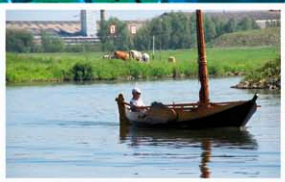
Paradigm shift: room for the river

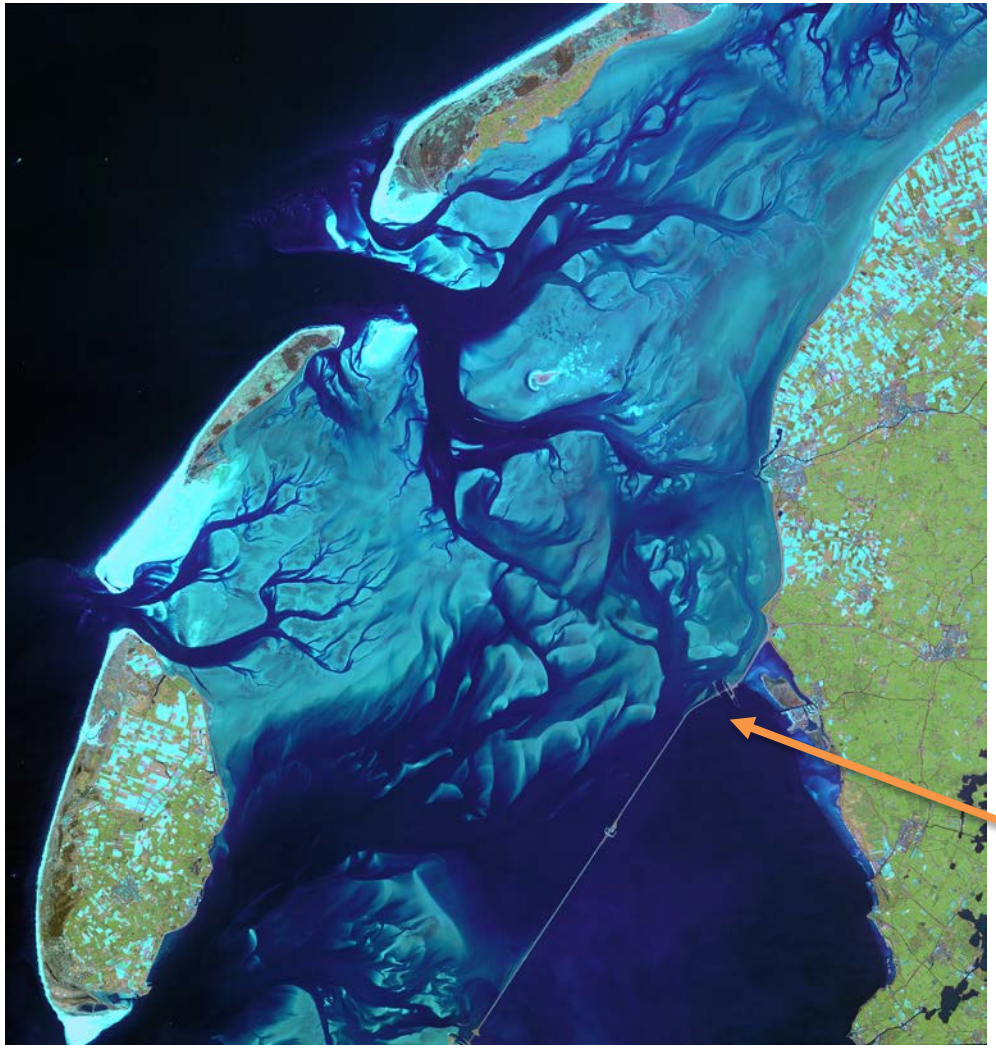




The Dutch Wadden Sea

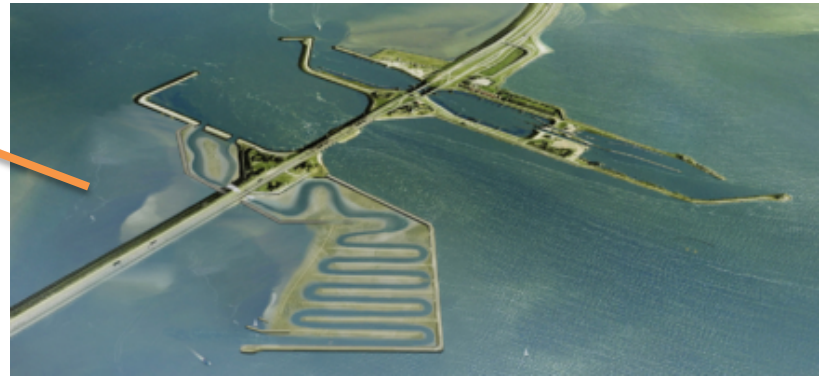
Western part of the UNESCO World Heritage Site, with Afsluitdijk visible at the bottom

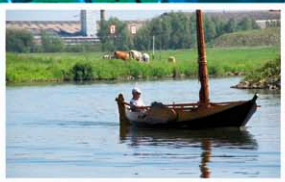




The Dutch Wadden Sea

Fish Migration River





Delta Knowledge Management components

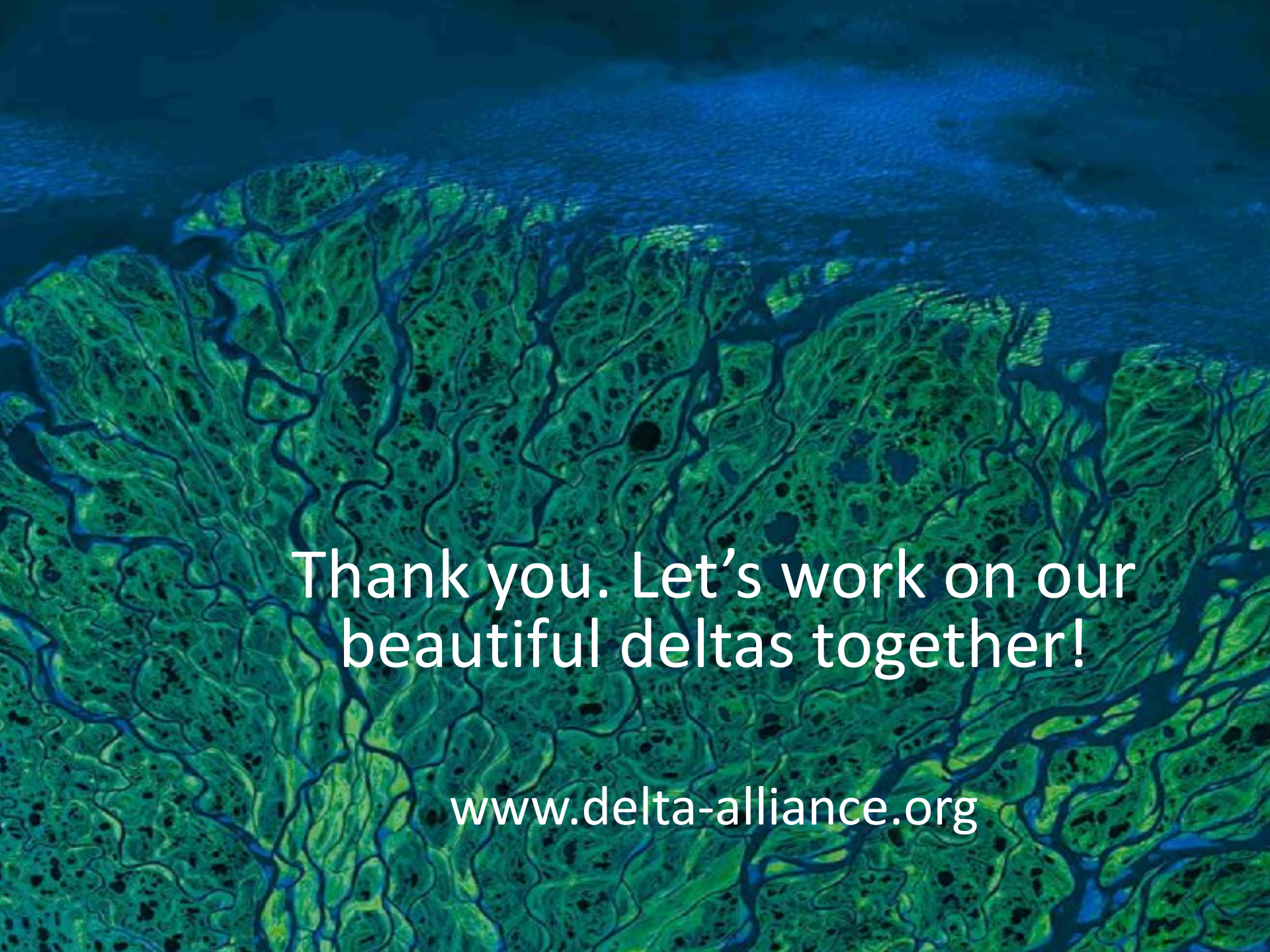
Organization & management	Data sharing agreement	Independent lead or broker (delta wing)	Establishing a user community	Long term Funding & arrangement
User interfaces and services	Static impact maps	Online webviewer	Tailored services, apps, and storylines	Project appraisal & screening
ICT infrastructure	Local database	Online database (knowledge portal)	Data access (downloads & data services)	Spatial Data Infrastructure
Climate impact data	NWRD, Meta Model	Nationwide Climate risk assessments	Mainstreaming in implementing agencies	Regular updating of meta model and NCVA
Basic climate data	Using IPCC for projections	Model selection, downscaling, bias correction	Indicator generation for specific users	Regular updating of indicators

Steps towards climate adaptation information services for BDP2100

Building the *climate adaptation services chain* in Bangladesh

(CAS work in progress)

Climate Adaptation Services


Thank you. Let's work on our beautiful deltas together!
www.delta-alliance.org