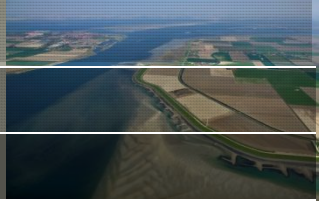
Deltares
Enabling Delta Life

Cities and their vulnerability to climate change

Marco Hoogvliet
Manager of Deltares' research program Resilient Cities

marco.hoogvliet@deltares.nl
+31 6 516 47 223
www.deltares.com

www.deltares.com



Deltares
Enabling Delta Life

Areas of expertise | Software | Academy | Facilities | About us | Contact

- Independent institute for Applied Science
- Not for profit
- ~800 employees
- Home base in the Netherlands
- Open source knowledge and software

Climate Adaptation

Consequences climate change far-reaching

Deltares is an independent institute for applied research in the field of water and subsurface with five areas of expertise.

Watch our introduction video

Flood Risk	Adaptive Delta Planning	Infrastructure	Water & subsoil resources	Environment

Deltares

Semantics of ‘vulnerability’ differ between scientific communities, and evolves

IPCC **integrative vulnerability concept** (IPCC 2007) →

‘Vulnerability is the outcome of an assessment that **integrates** biogeophysical and socio-economic **factors**’

1. **Exposure**
2. **Sensitivity**

} determine the potential **impact** of climate change

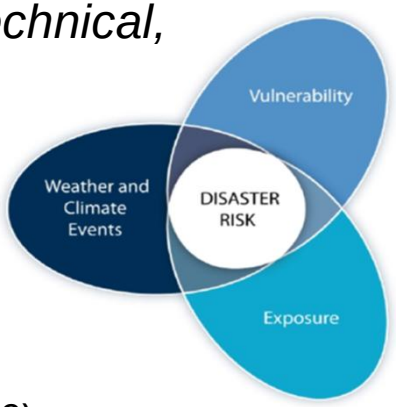
3. **Adaptive capacity** (i.e. the ability and means to cope with impacts)

***Socio economic resilience**: the capability of a society to **prevent** or **cope with** the impacts of climate change and sea-level rise, including technical, institutional, economic, and cultural ability*

Semantics don’t really matter for stakeholders

It boils down to **what/how to assess &**

which information to produce ?



IPCC SREX (2012)

Deltares

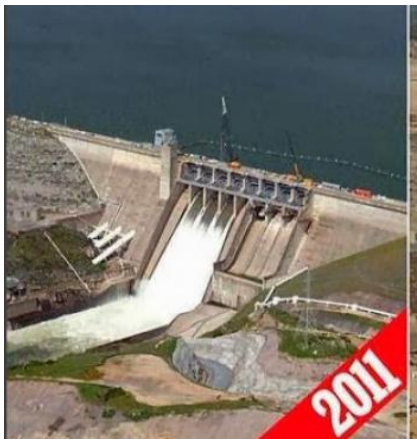
What to assess? – Vulnerability of…

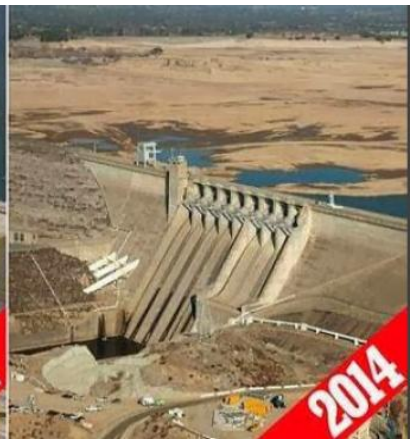
Deltares

Exposure to - Flooding (coastal, fluvial, pluvial, groundwater, …)

Deltares

Exposure to - Drought

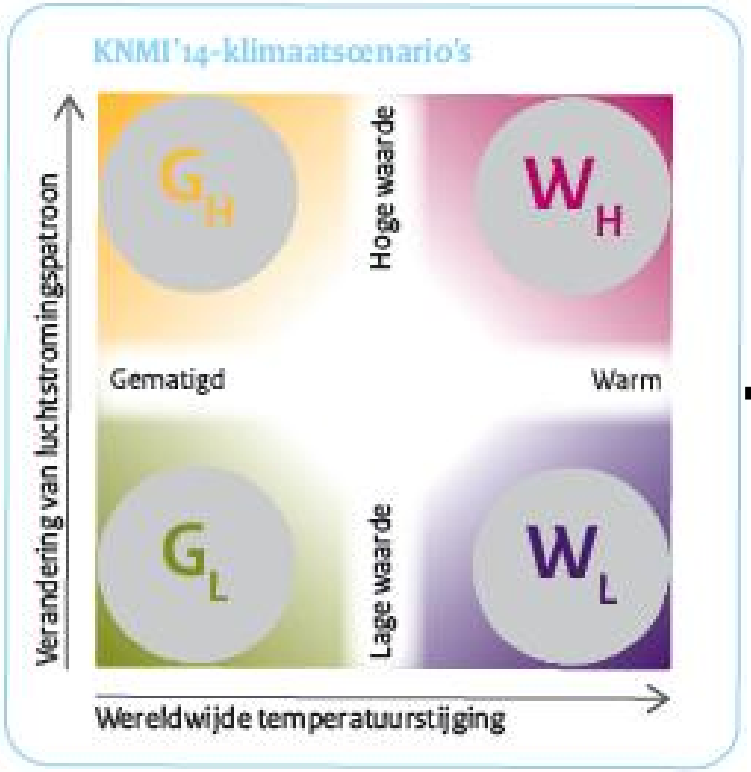


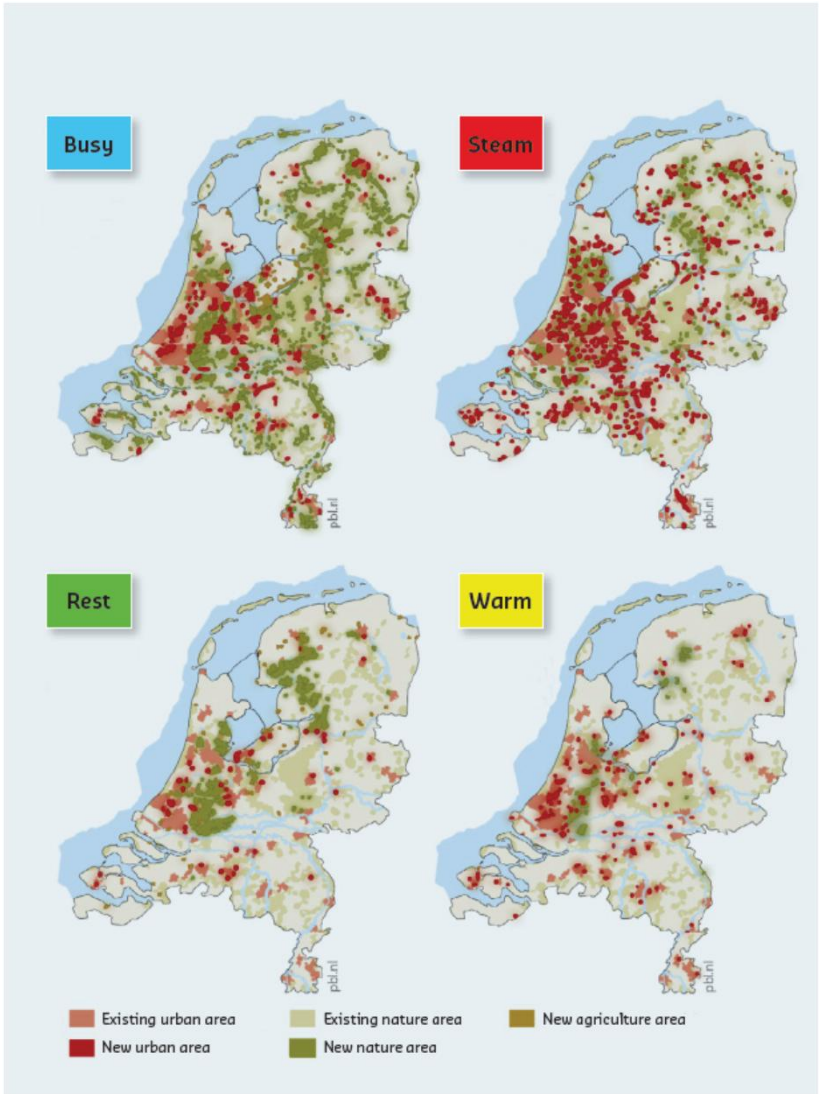


Deltares

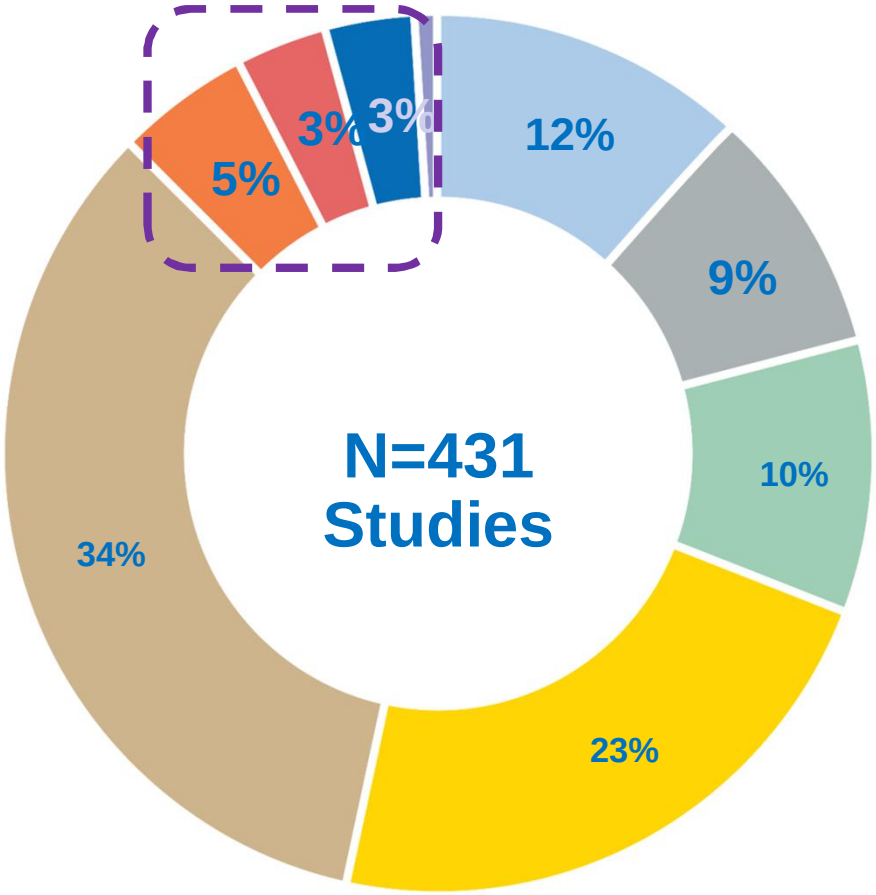
Exposure to - Heat

At least as important - Exposure to Socio Economic changes





Evaluation of vulnerability studies → Local (urban) scale under-represented



Source: De Groot - Reichwein and Masselink (2015)

34%	Region (supranational)
23%	Country
12%	World
10%	Region (subnational)
9%	Continent
5%	City
3%	Neighborhood
3%	Multiple
1%	Other

- National and regional governments are (2015) frontrunners in climate change impact studies
- Accurate vulnerability assessment on local level is **complex,** on many levels

Deltares

Estimates of impacts in damage (€), affected GDP and affected population

WORLD RESOURCES INSTITUTE

AQUEDUCT Global Flood Analyzer

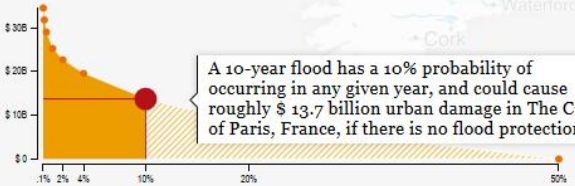
10 year protection

Type or select a country,

Flood Risk in The City of Paris, France

Urban Damage | Affected GDP | Affected Population

2010

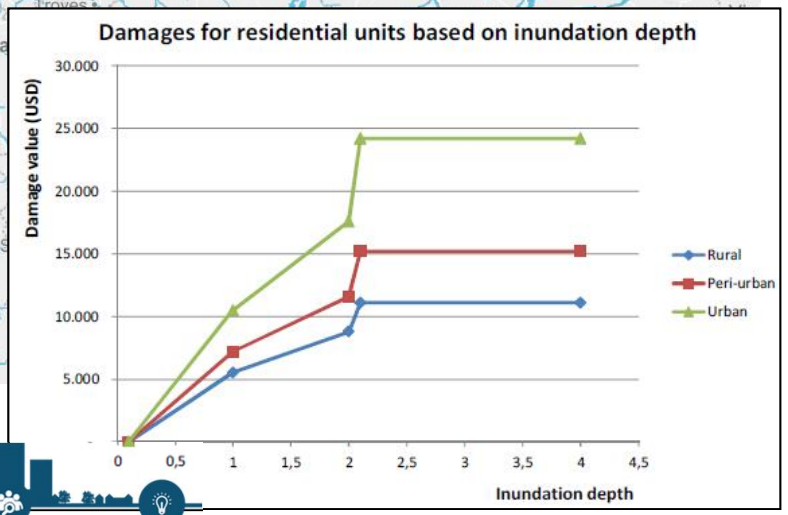


A 10-year flood has a 10% probability of occurring in any given year, and could cause roughly $ 13.7 billion urban damage in The City of Paris, France, if there is no flood protection

Annual Expected Urban Damage	$2.0B	Annual Avoided Urban Damage	$2.4B

2030 | Scenario A | Scenario B | Scenario C

Current Annual Expected Urban Damage	$2.0B
Increased Impact Due To Socio-economic Change	$586.1M
Increased Impact Due To Climate Change	$701.0M
2030 Annual Expected Urban Damage	$3.2B



http://floods.wri.org/#/

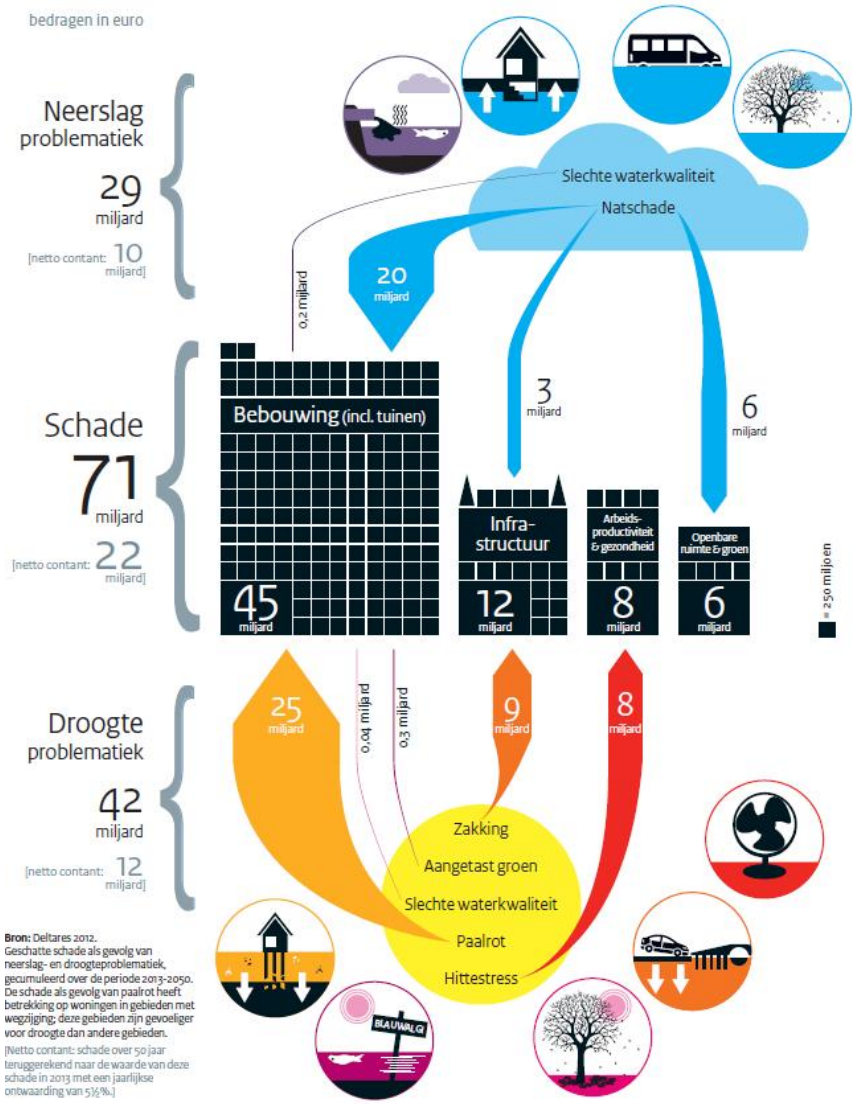
National scan of impacts (exposure + sensitivity) on local scale revealed…

Damage will run into billions, but **accuracy of estimates is low** (large range)

Mainly because **sensitivity is poorly known**

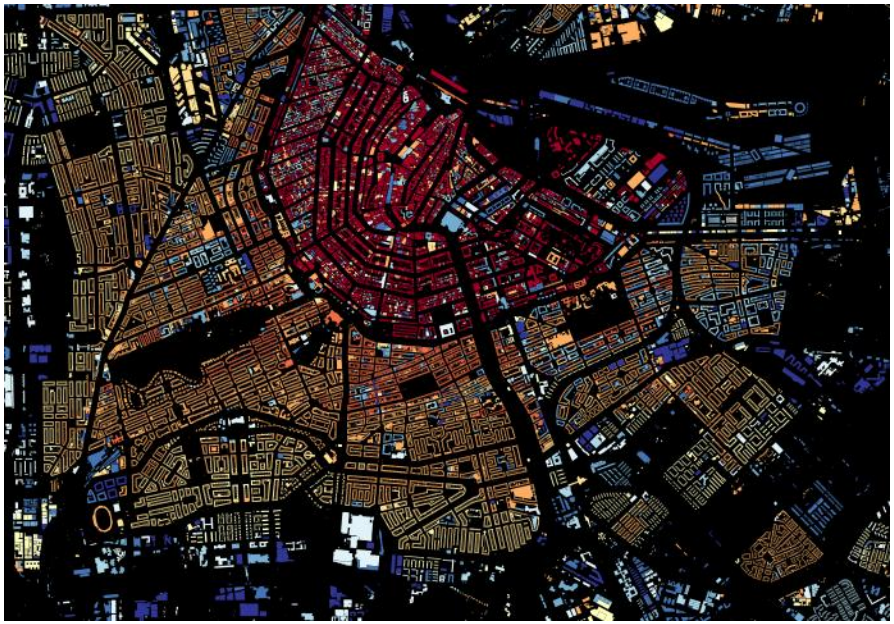
Accuracy is **more influenced by sensitivity information** than by exposure (climate) information

Dutch situation !



Deltares

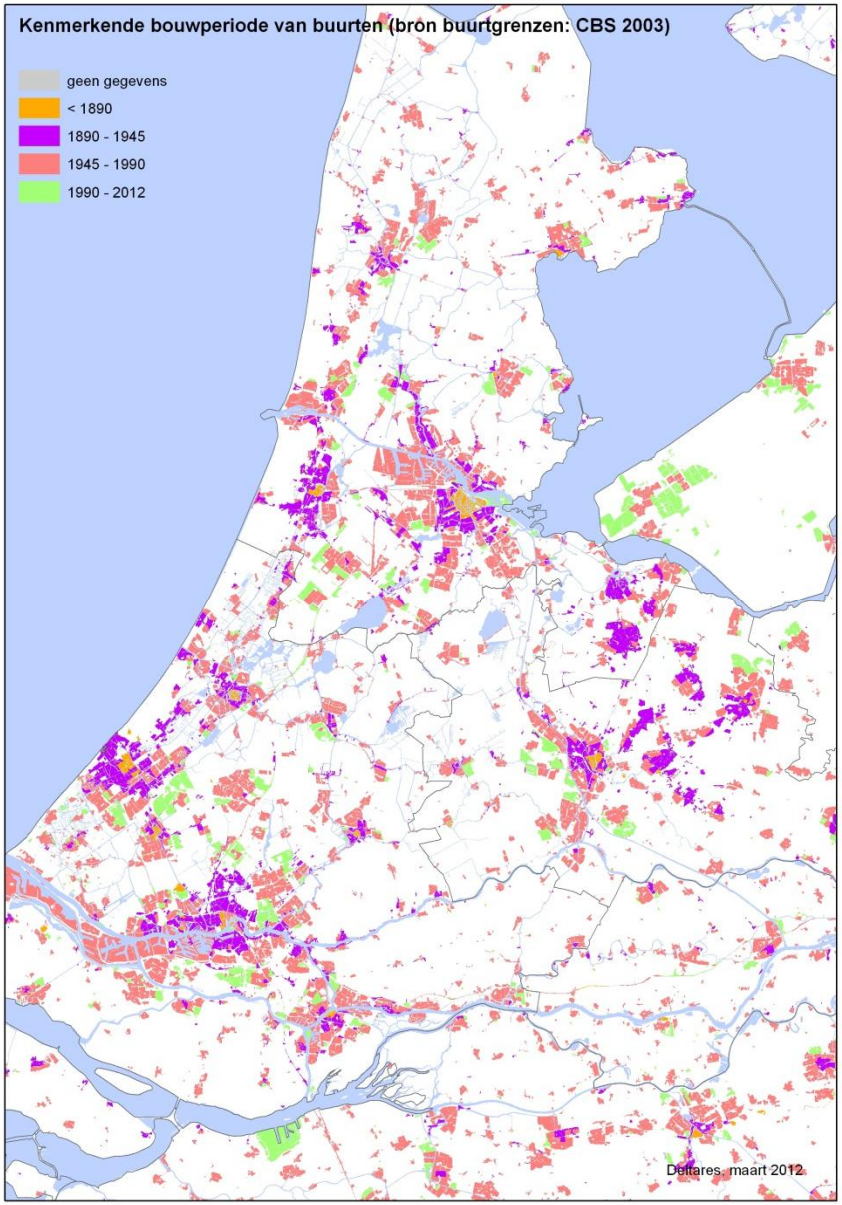
Sensitivity assessment → Urban Design and Construction assessment

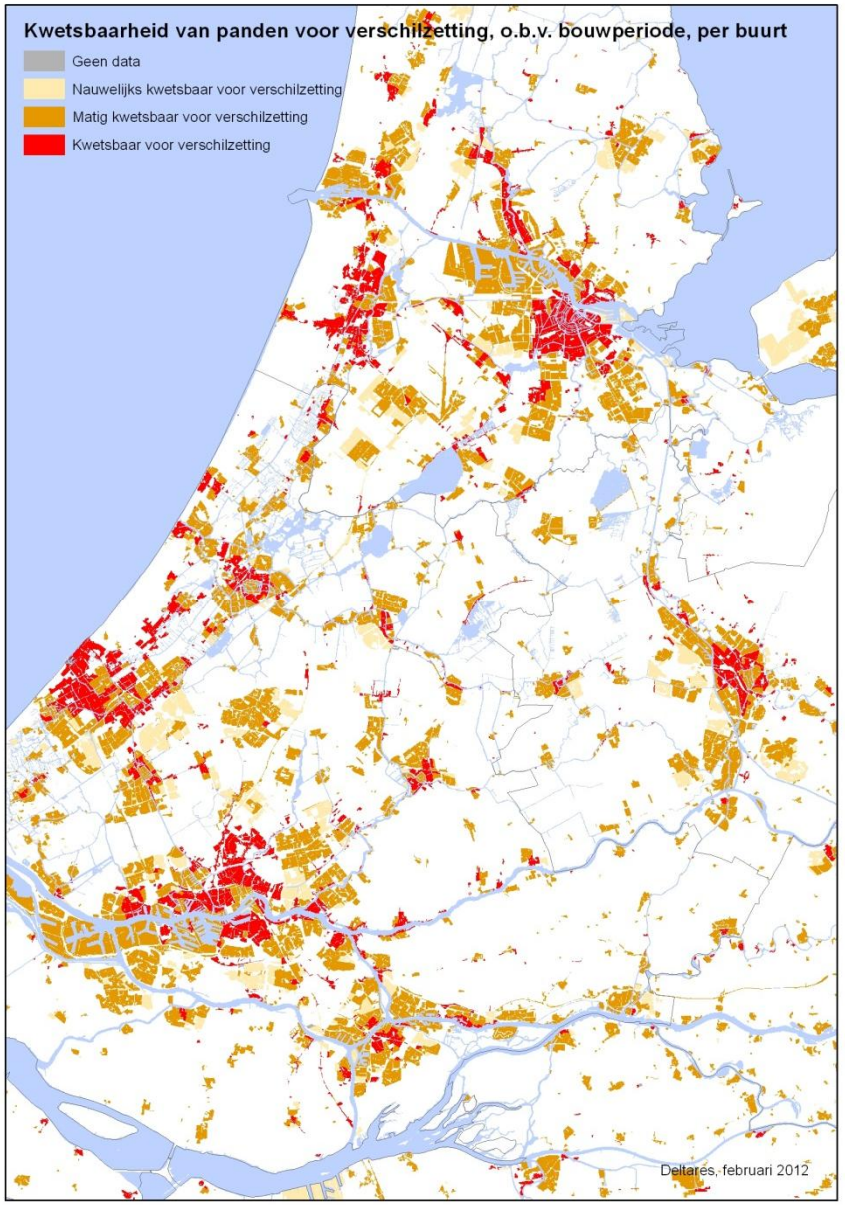


!

Deltares

Know urban area characteristics, thoroughly

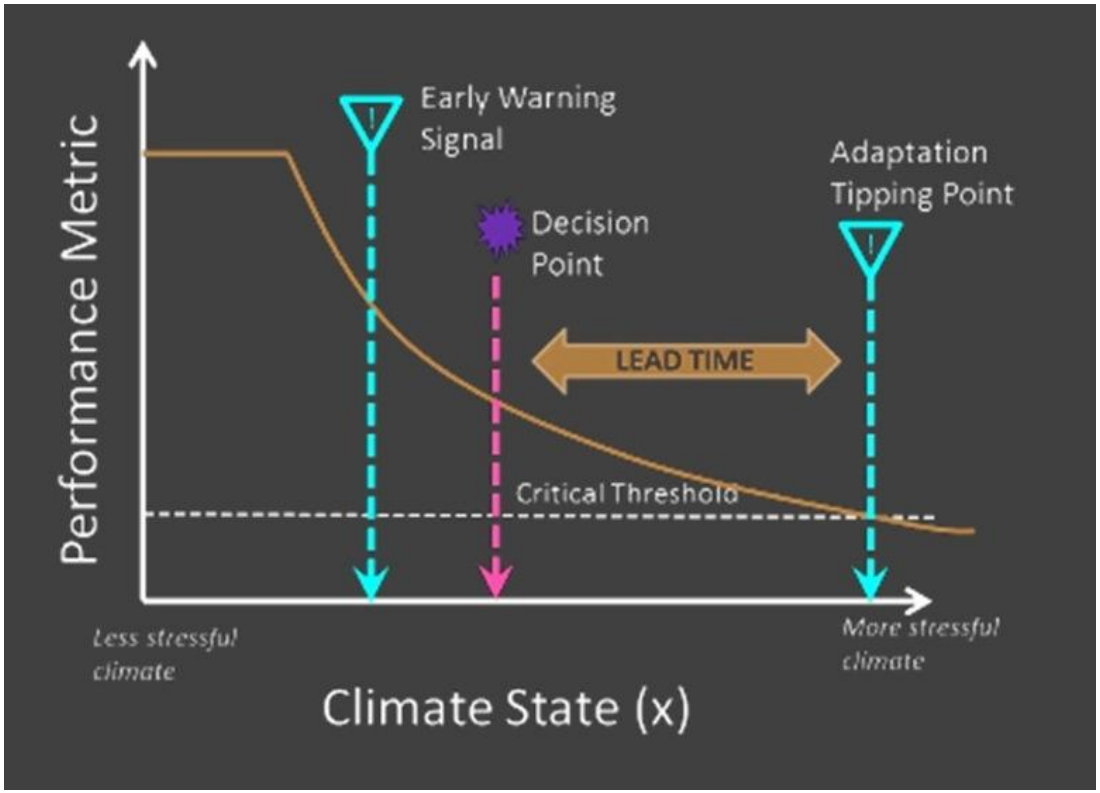




Understand effect of increased exposure on damage mechanisms

Deltares

Stresstest: increasing exposure leads to decreasing performance



Alas, performance does not always decrease gradual or noticeable

Tipping points can be reached suddenly

Especially because of increased dynamics, peaks in exposure

→ At least: **determine weak links** and **climate state at critical threshold**

What does it take to break? Not necessarily based on climate scenario's

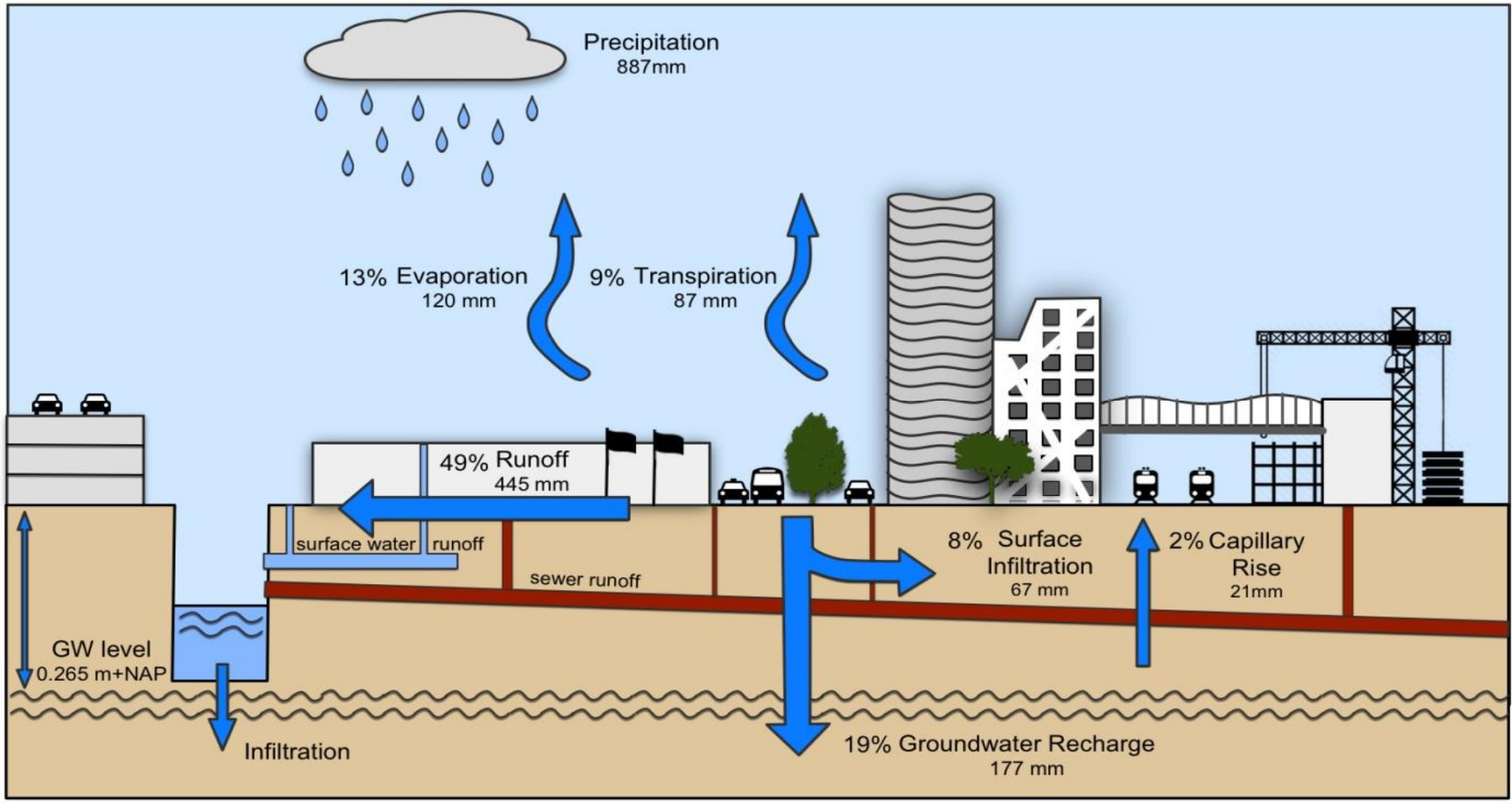
- physical
- functional
- normative
- …

→ Guide for Urban Climate Stress Test (Exposure + Sensitivity)

http://www.spatialadaptation.com/hulpmiddelen

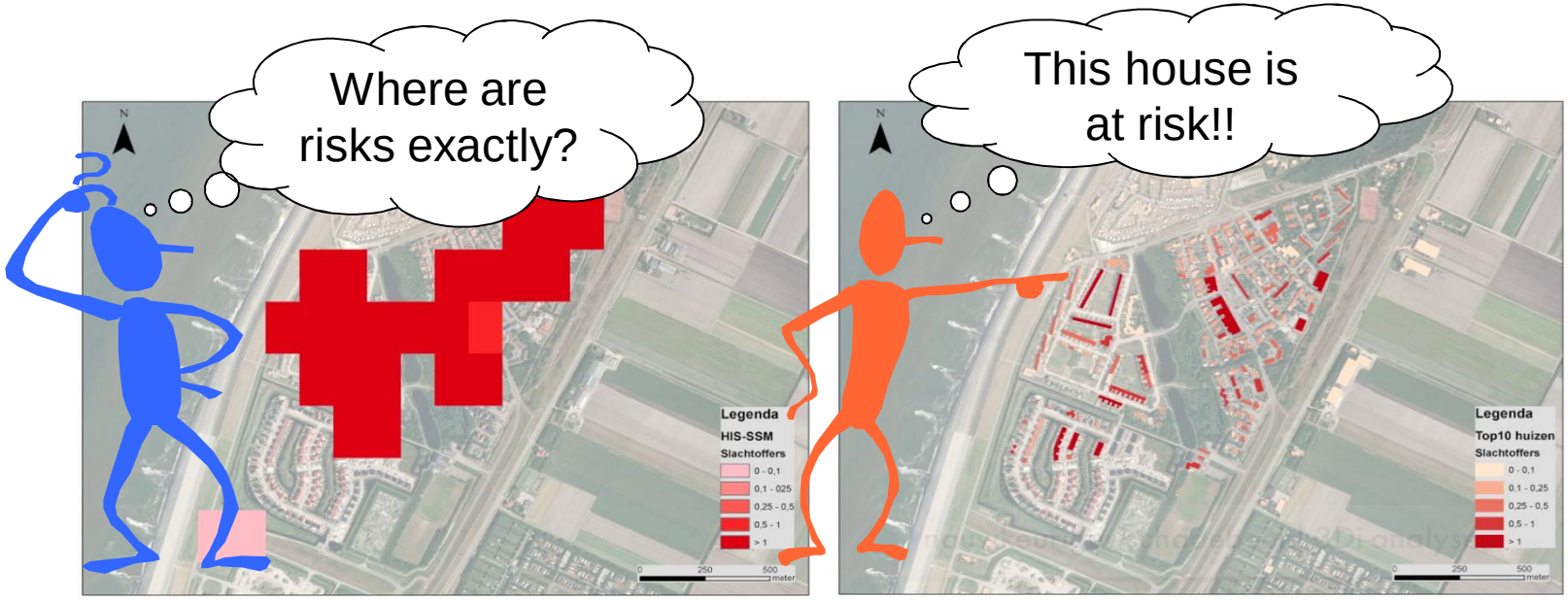
Deltares

First: stress test light with simple tools to identify (most) sensitive factors

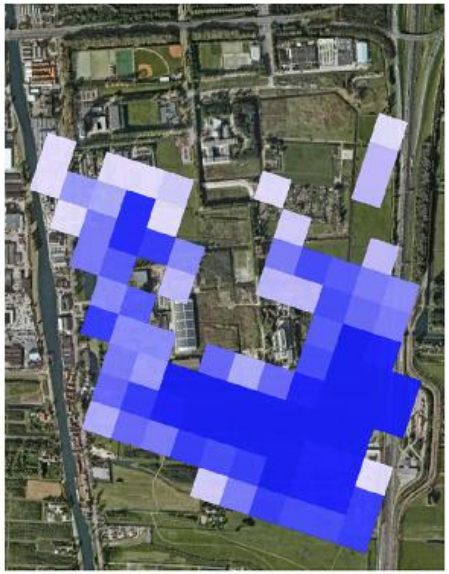


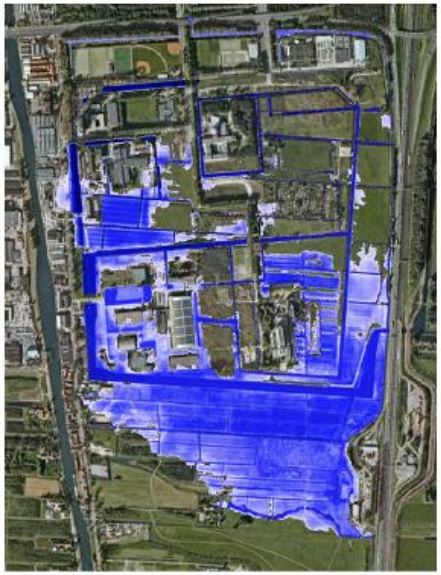
Deltares

Fast progress in high resolution flood & risk assessment



Standard resolution (100meter)

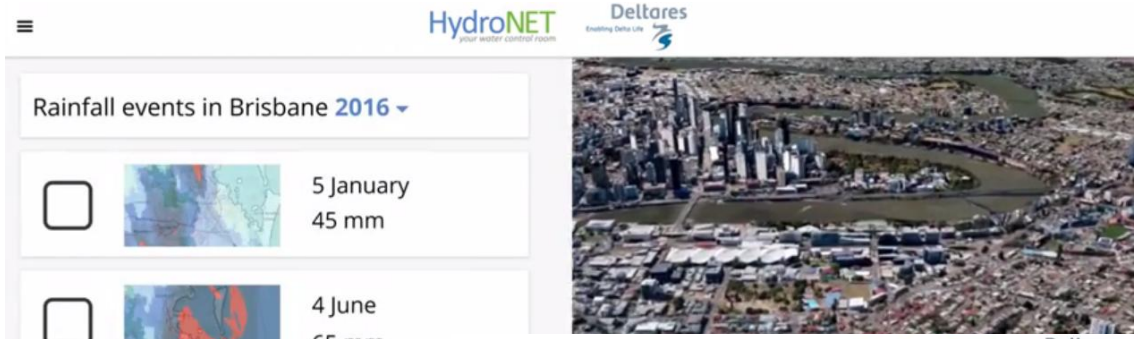


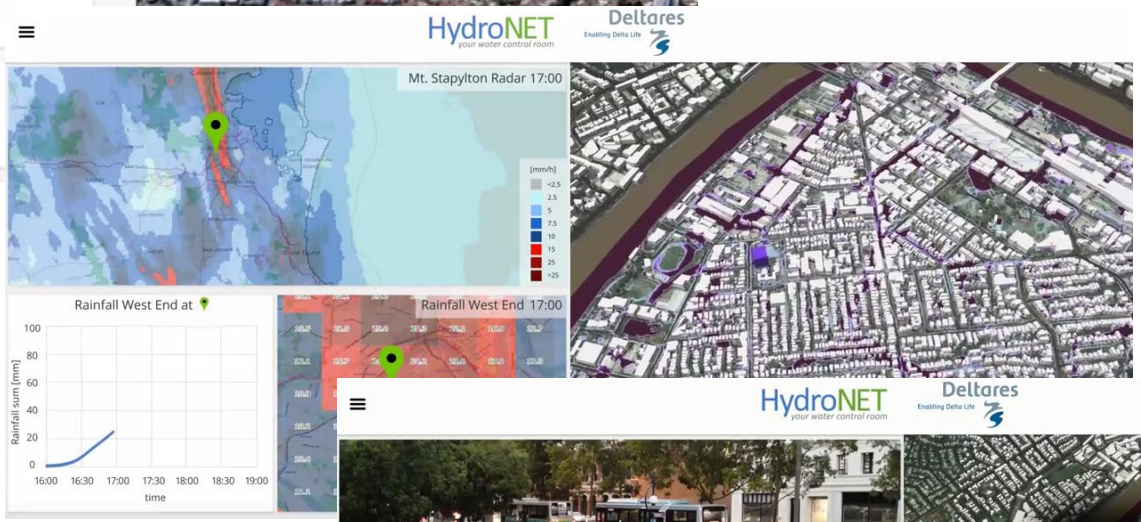


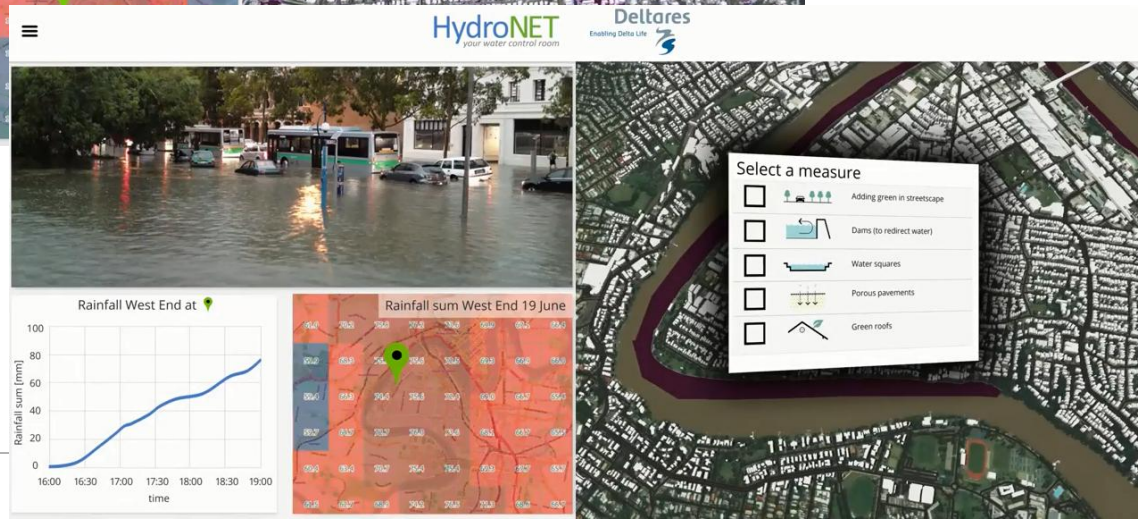
New standard resolution (up to 0,5m)

Deltares

Using different (real) events to assess effect of Exposure variations

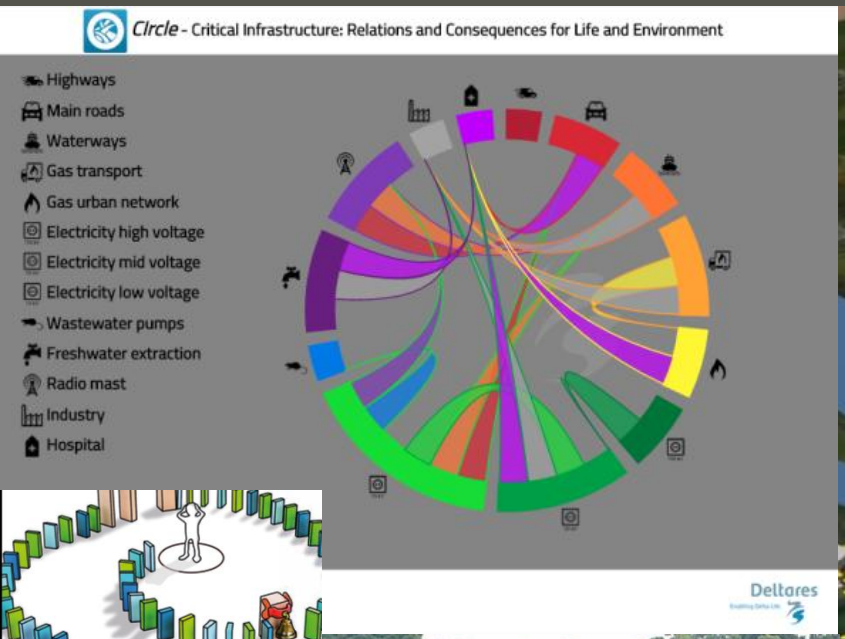


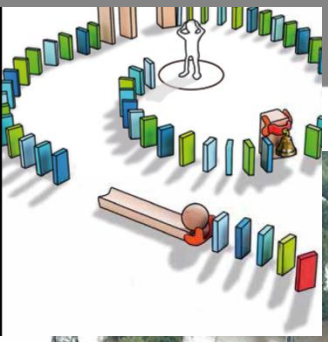


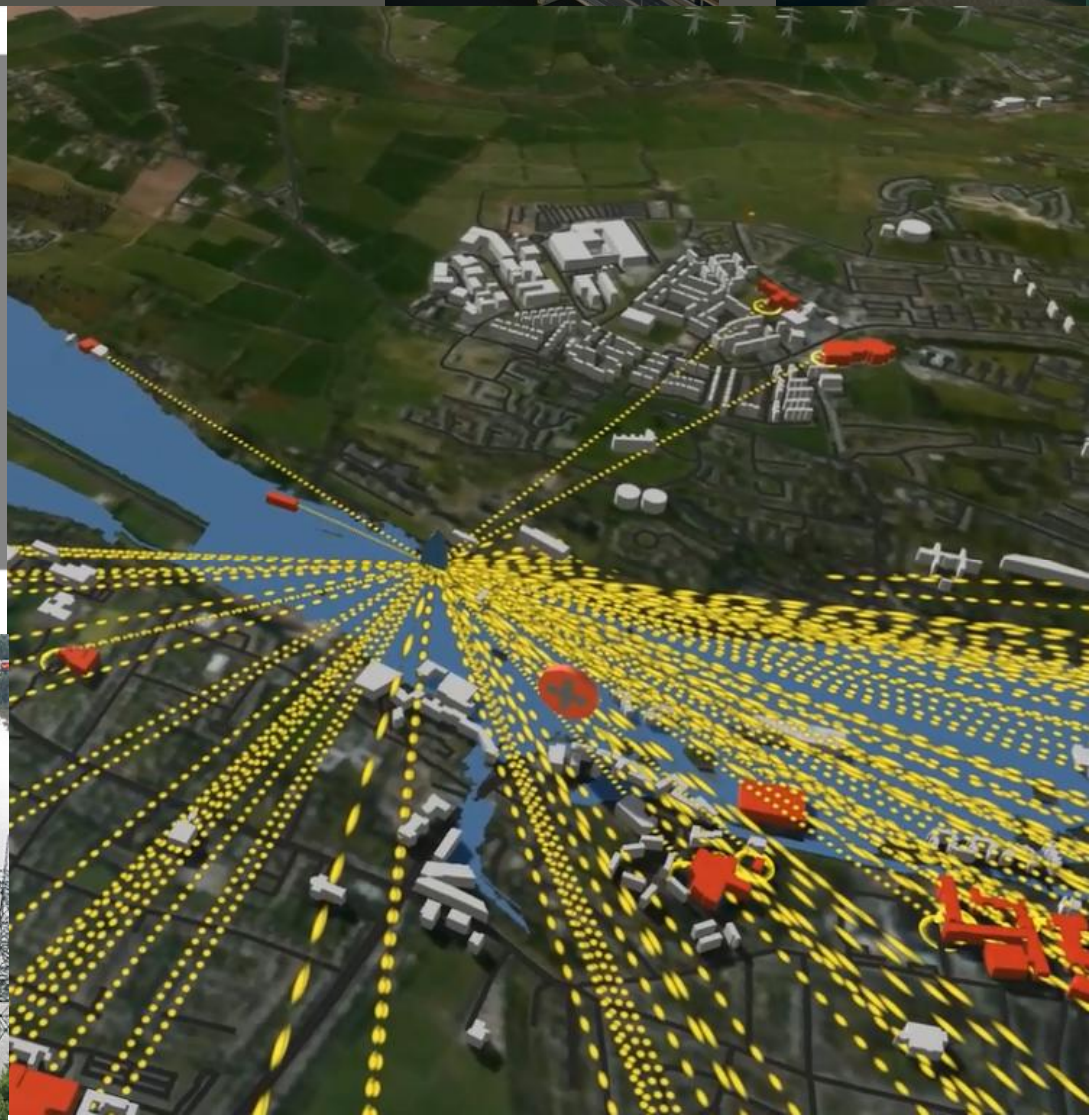


https://www.youtube.com/watch?v=kBCeQH4awmw

Participative identification of cascading failure of vital infra







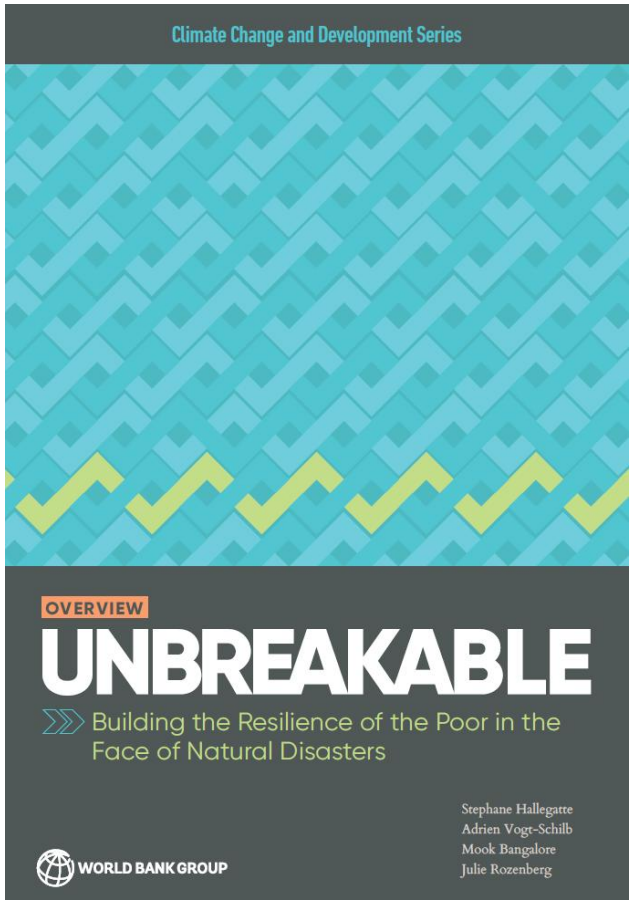
https://www.deltares.nl/nl/software/circle_vitale_infrastructuur/

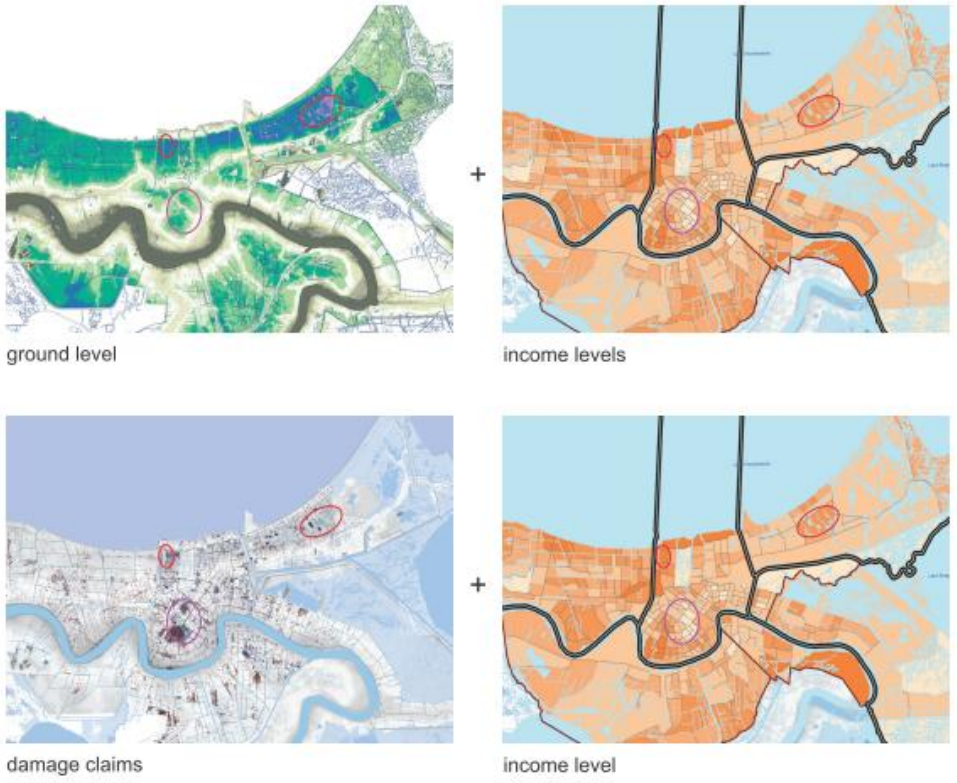
Joint system understanding → where do climate effects come in play?

Involving stakeholders and the public

Upstream retention, storage & (deep well) infiltration
New flood (water diversion) channels
Water pollution control laws (polluter-pays-principle)
Black water sewerage system construction & connecting buildings, households
Upstream diversion & detention basins
Waste (plastic, metal, organic) collection and recycling
Reduction industrial waste water discharge
Dredging of river bed & flood channels; improvement of dikes
Rainwater drainage/sewerage/canal construction
Regulate water extraction from surface water in upstream areas
River/canal storage and channel discharge capacity DKI
River/canal water quality
River/canal water resource
Removing constructions from river banks and flood plains; widening river bed & flood plains; 'Room for the River'
Jakarta Bay water quality
Jakarta Bay (Waduk retensi) sweet water resource
Waduk Rete nsi) resource
Trust of residents in government and planning
Sludge accumulation during flood
Pollution of shallow groundwater if infiltrated rainwater is not clean
Affordable alternative housing, with preservation of income (source) of residents
Fluvial flooding
Jakarta Bay (Laut) desalinization resource
Water purification to drinking water standard
Finding/creating space for pumps and polder-water-system elements
Include stormwater infiltration in urban planning
Polder systems with increased pump capacity (NCICD)
use of Piped water supply
Implementation of Water Allocation Master Plan ADB 2013
Revision of Bylaw No. 10/1998 on ground- and surface water tax collection and utilization
Superficial infiltration of CLEAN rainwater (green space, soil permeability enhancement, biopore cylinders, infiltration boxes & trenches & sewers, permeable pavement)
Increasing monsoon rains
Raise public awareness
(leakage) repair and maintance of piped water infrastructure & pumps
Early warning system
Damages / Loss of life
Subsidy system & regulation & guidelines to stimulate infiltration
Sea level rise & king tides
Stop groundwater use, spatially planned (vulnerable areas first) & in efficient order: 1) government & public buildings 2) industry 3) large private buildings 4) public & private housing
Water use reduction techniques (reduce, reuse, recycle)
Water demand DKI (1,44 million m3/day)
Pluvial flooding
Subsidence
use of Groundwater resource (0,7 million m3/day)
Water use measuring and pricing
Crisis management action plan & measures
NCICD outer sea wall B&C
Risk of groundwater nuisance due to rising groundwater level when extraction stops
Drought
Flood water reservoirs (near shore / on shore). Delayed discharge
Salinization of aquifers
use of Rainwater harvesting resource (building storage)
Make the capacity to deal with changing circumstances (RESILIENCE) an element in planning, design & construction of all urban renewal & substitution of built components and structures
Managed DEEP aquifer recharge DKI
Weight of urban construction and of land reclamation (local effect)
Uncontroled urbanization DKI
Coastal flooding
NCICD sea wall re-enforcement A
Natural aquifer recharge
(national) policy countering further growth of Jakarta
Planned urbanization (sprawl with sufficient piped water, drainage, sewers, parks)
Urbanization of aquifer supply infiltration area
Erosion
Excellerated discharge & decreased infiltration

Evaluate risks beyond plain damage to assets



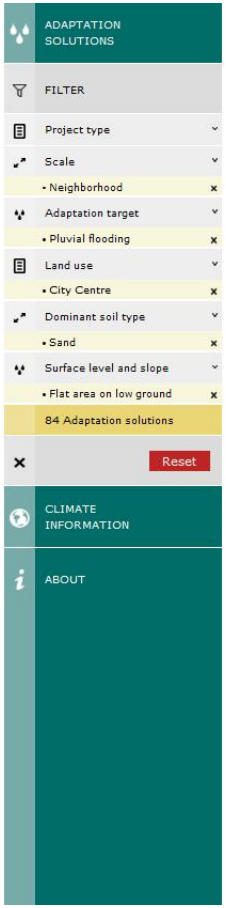


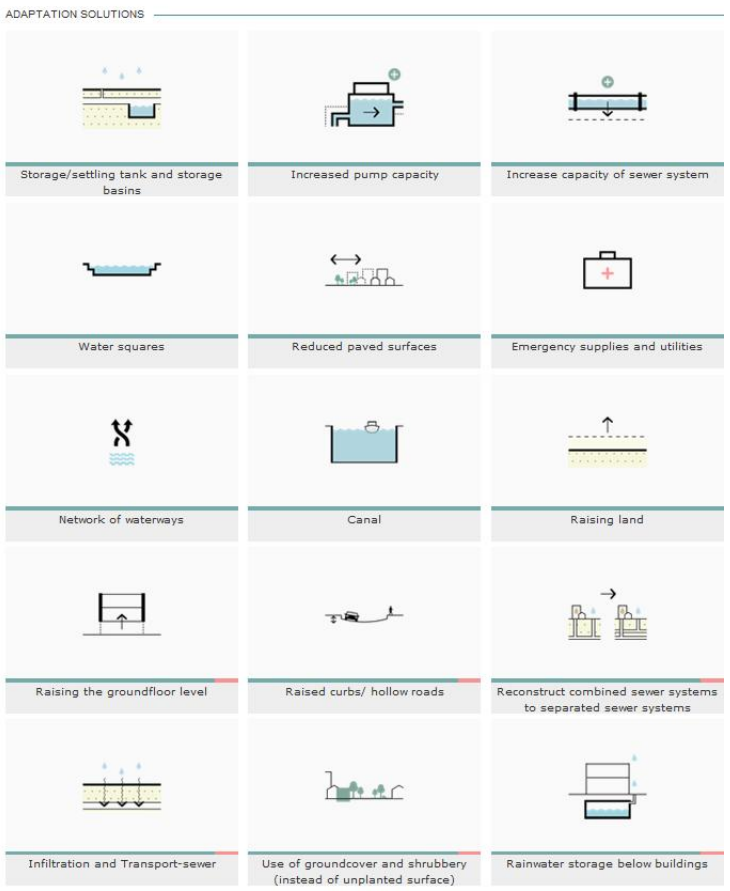
Including Adaptive Capacity or Socio-Economic Resilience in Risk Assessment **shifts adaptation investments**

https://openknowledge.worldbank.org/handle/10986/25335

Deltares

Lots of solutions, more coming, and tools to help you choose





www.climateapp.org

www.urbangreenbluegrids.com/design-tool/

Deltares

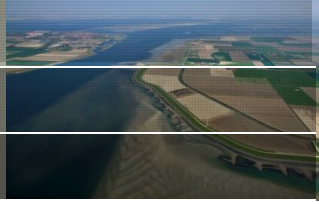
Work on concepts that combine goals, techniques, benefits and funds

adaptation
+
mitigation
+
resource efficiency
+
health & liveability

and attract cross sectorial co-investments

www.adaptivecircularcities.com

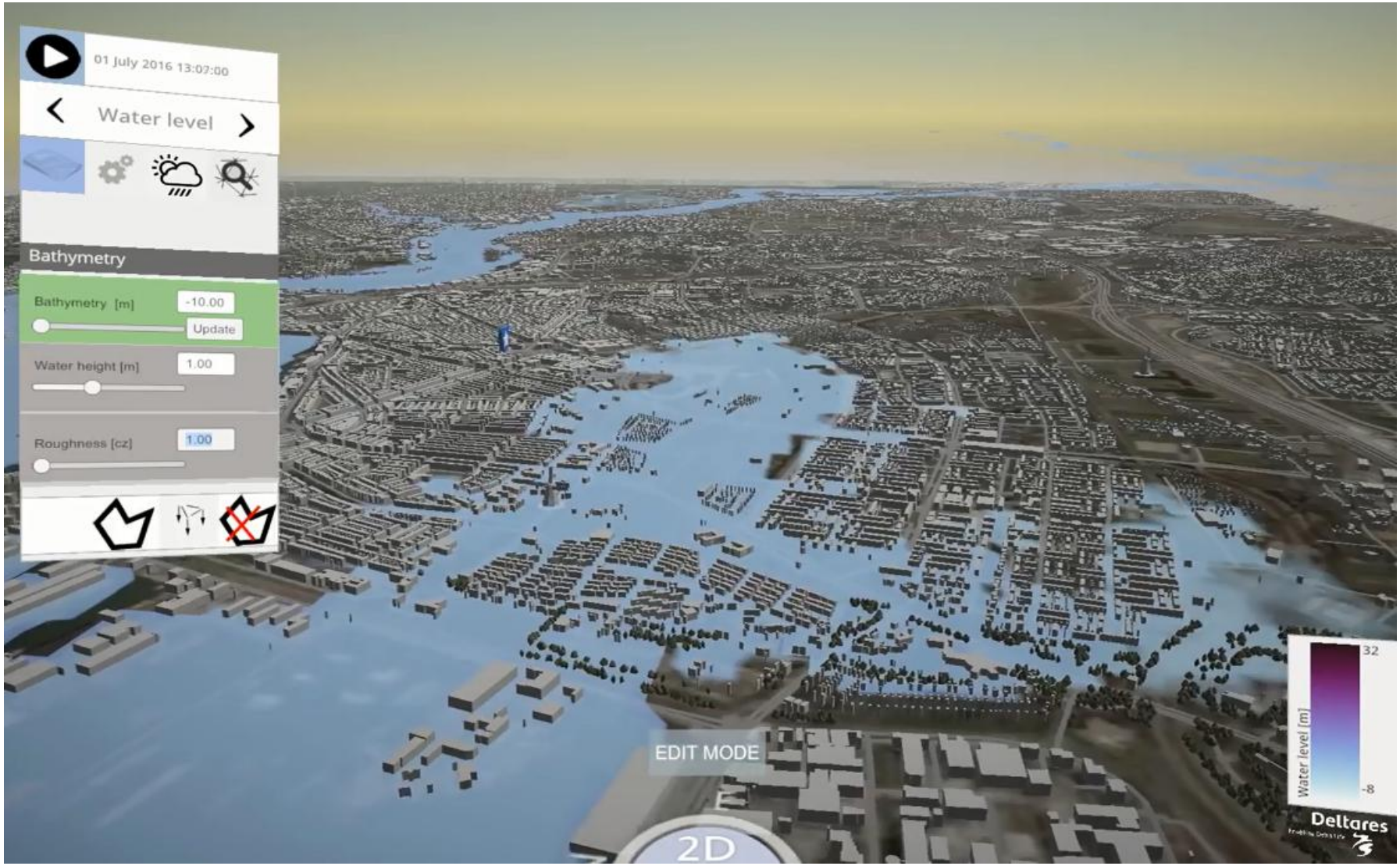
Deltares



Thank you for your attention

Deltares

interactive flood modelling and instant visualization of effects



Rotterdam-levee-intentionally-breached---3D-interactive-modelling-using-Delft3D-FM-Part-2.mp4

Deltares