

Urban Retrofitting of BGI

Water Sensitive Cities 2019

Interreg

North Sea Region
BEGIN

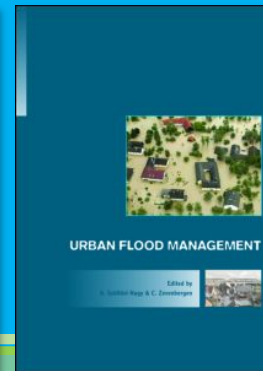
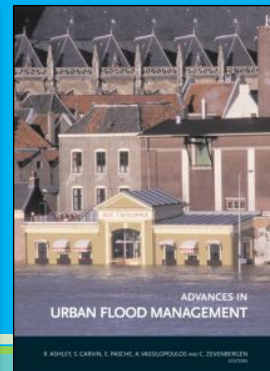
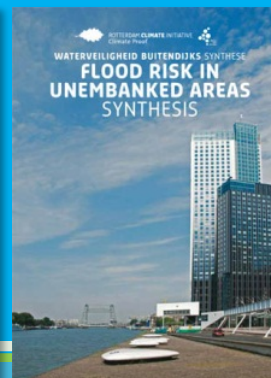
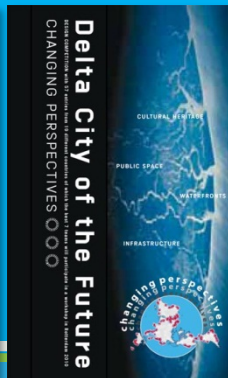
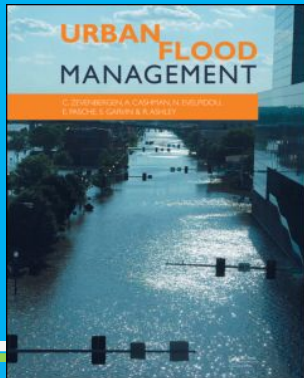


Dr. William Veerbeek

European Regional Development Fund

EUROPEAN UNION

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Theory & Application: lecture & field trip



5 July: Lecture (13:45-16:30)



16 July: Field Trip (9:30-16:00)

Lecture outline

1. Water and Cities: The Challenges

- Challenges;
- Goals and assessment;

2. Adaptation Opportunities: The issue of scale and time

- System's perspective;
- Measures for different scale levels;
- Temporal dimension;

3. Opportunistic adaptation

- Asset management perspective;
- Lifecycle approach;
- Definition;

4. Applications: example from Rotterdam

- Climate change scenarios: the impacts;
- Lifecycles: estimating future opportunities;
- Future challenges;

Water and Cities: The Challenges

“The Usual Suspects”



Urbanisation



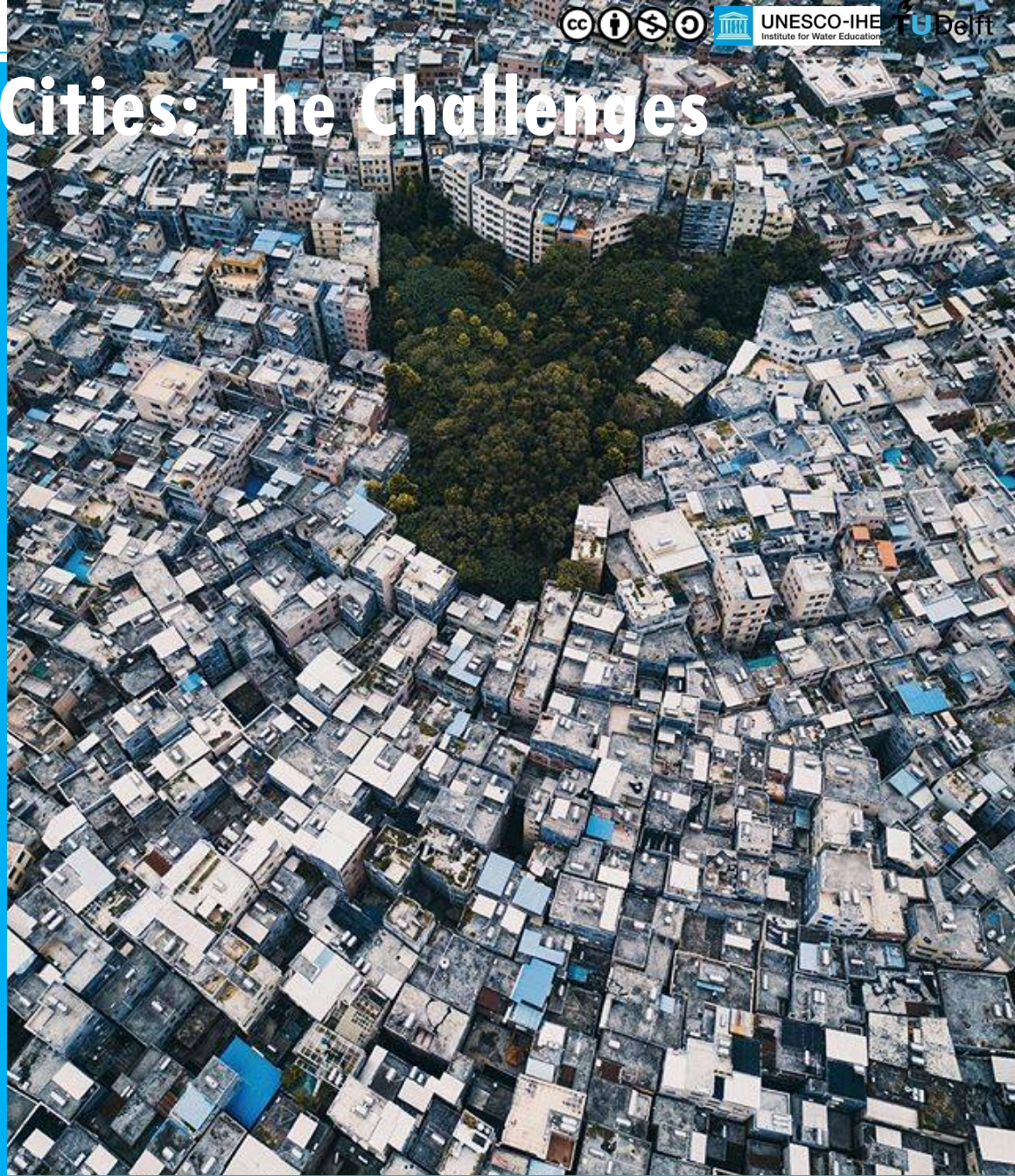
Climate Change

Water and Cities: The Challenges

- Growth in housing, population, and the economy will put **increasing demand on water supply and wastewater services** while (often) **putting more people/assets at risk** (exposure).

Water and Cities: The Challenges

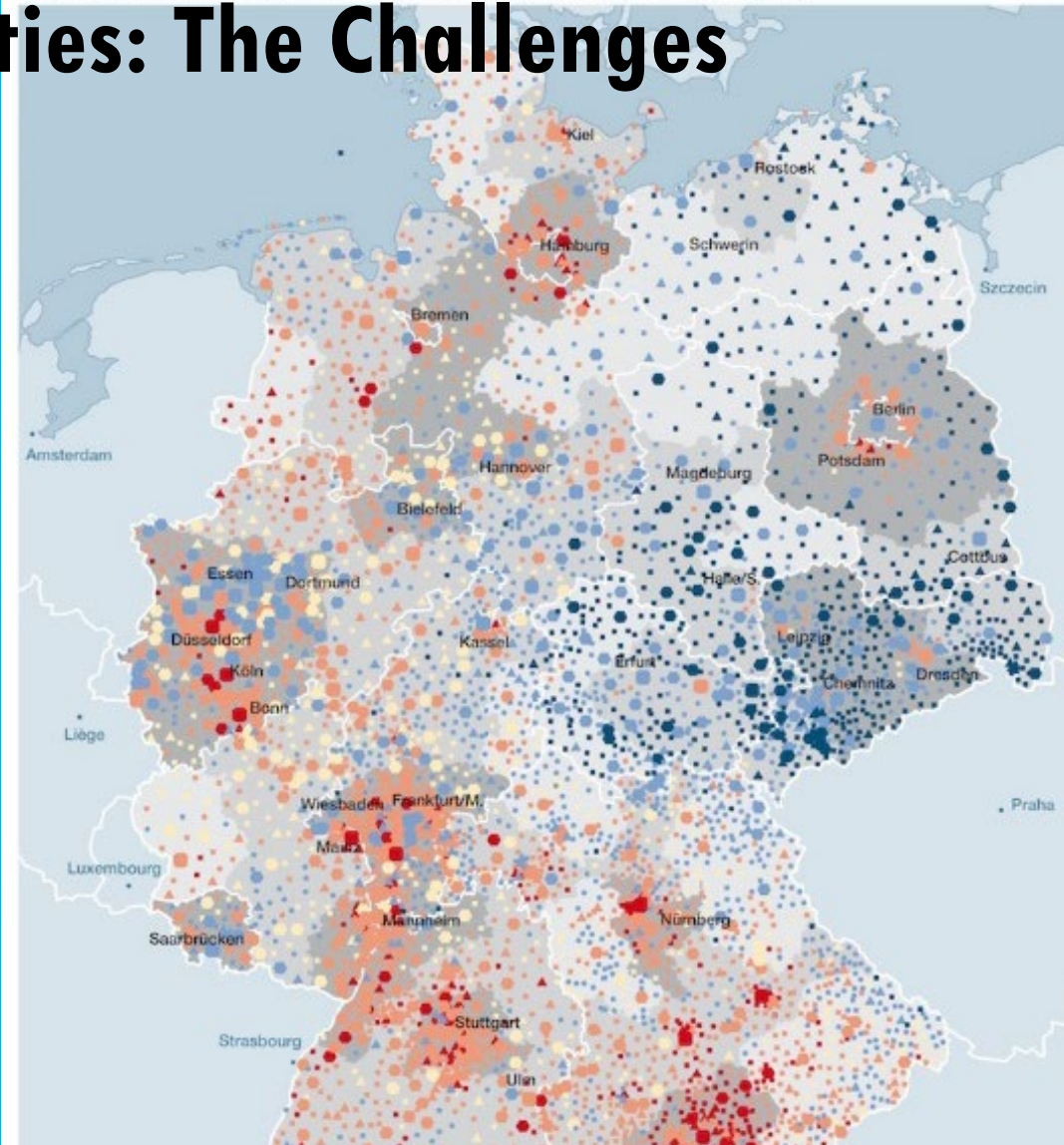
- Lower overall drainage capacity;
- Limited space for peak storages;
- High dependency on piped-drainage system;
- Poor quality runoff;
- Little evapotranspiration;
- Large volumes of wastewater
-



Urban villages in Guangzhou, China

Water and Cities: The Challenges

Shrinking cities: What's the issue?



Shrinking cities Germany 2002-2007. BBR, 2009

Water and Cities: The Challenges

- Growth in housing, population, and the economy will put **increasing demand on water supply and wastewater services** while (often) **putting more people/assets at risk** (exposure).
- Climate change is predicted to create **hotter, drier summers and wetter winters. Extreme weather events** are on the rise. This brings implications for water availability, quality and increased risks of flooding.

What are additional drivers in future urban water management?

Challenges: Additional drivers

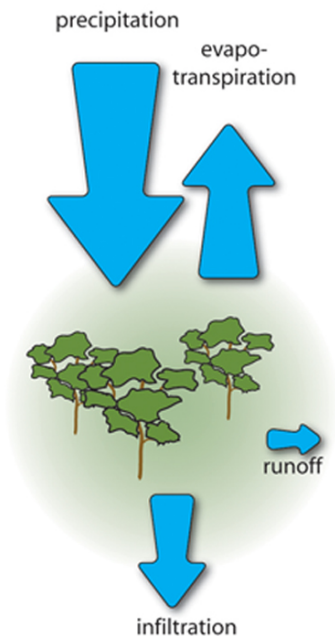
- The **increasing cost of water** means that affordability of water is becoming more of an issue.
- **Rising environmental standards.** For example, the cost of implementing the EU Water Framework Directive.
- **Rising consumer expectations** about having choice over prices paid and services received.
- **Increasing expectations in relation to livability**, i.e. availability of green/blue in city;
- **Aging (water) infrastructure, increasing failure, substandard performance;**
- **Financing** the changes that are required to regenerate cities and **improve buildings and infrastructure.**

Water and Cities: The Goals

WSUD: Restoring the 'normal' water balance in the city

***Virtual water: water that is 'embedded' in products we use**

natural water balance



Key:

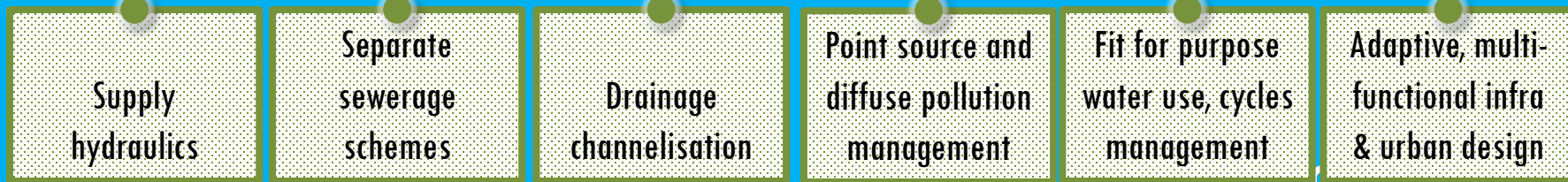
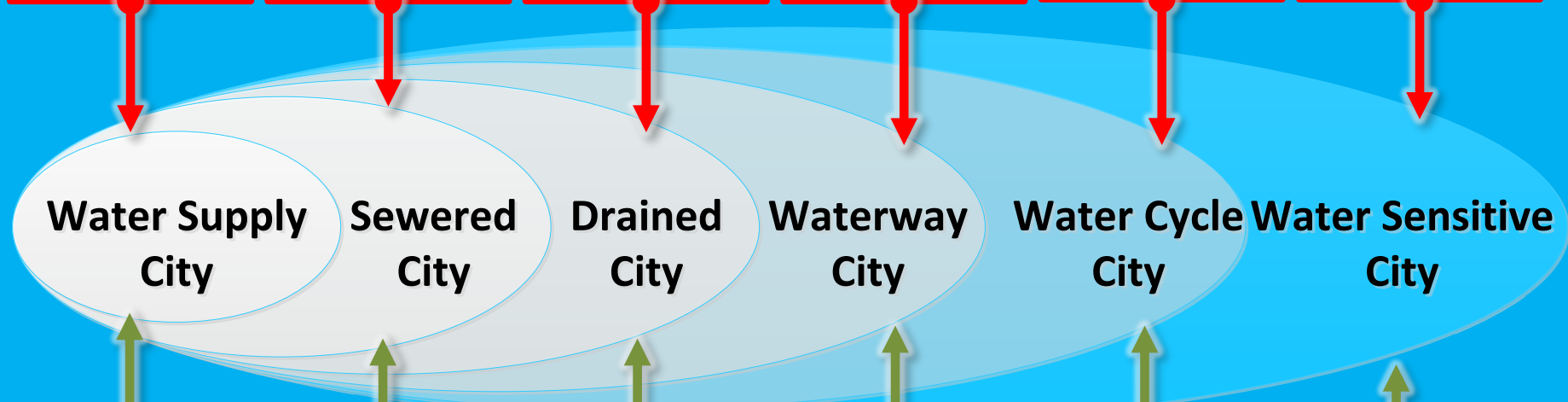
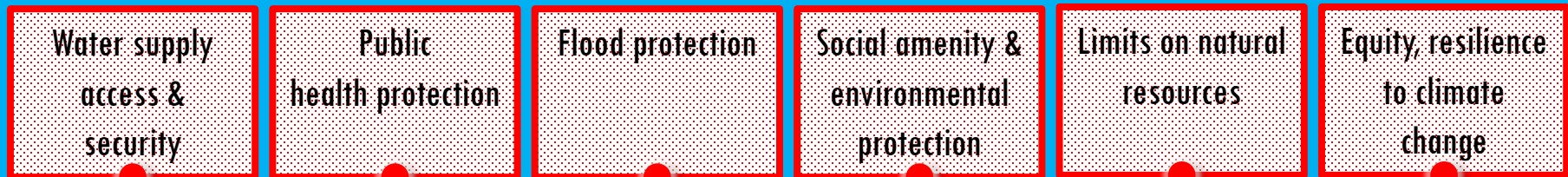


Huban & Wong, 2006

Transitioning to the Water Sensitive City (WSC)

Wong & Brown, 2008

CUMULATIVE SOCIO-POLITICAL DRIVERS

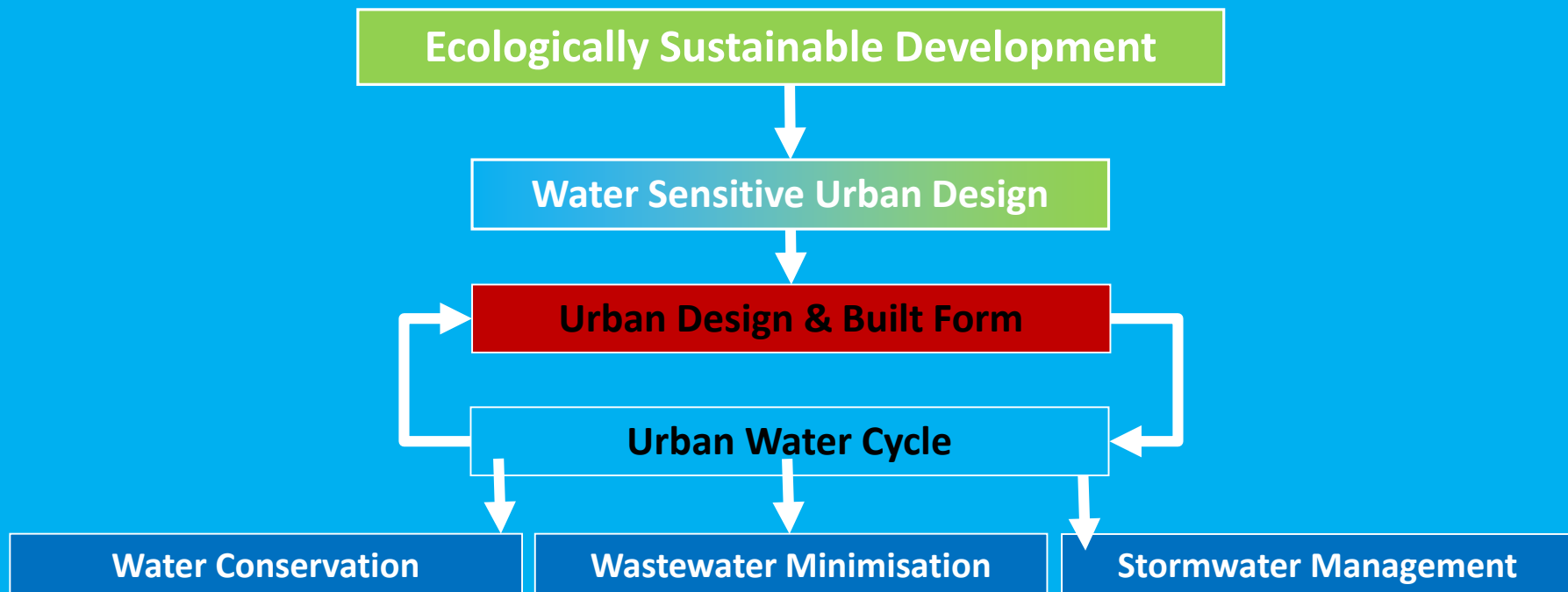


SERVICE DELIVERY FUNCTIONS



WSUD: Definitions

- The **integration of urban planning** with the management, protection and conservation of the **urban water cycle** that ensures that urban water management is sensitive to natural hydrological and ecological processes (EU flood resilient cities)



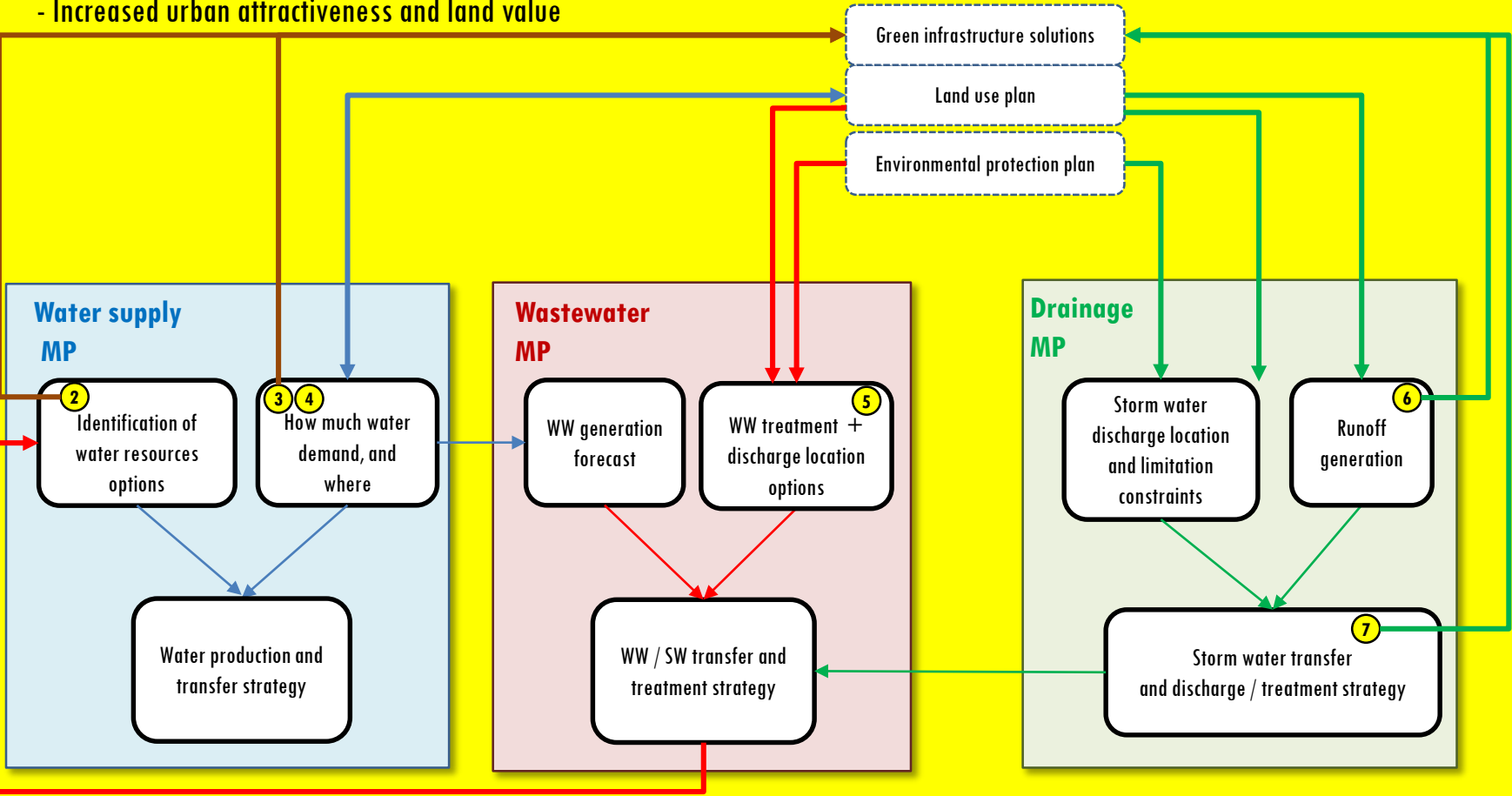
WSUD: Proposed Approach

Components:

Objectives:

- Provision of basic municipal services objectives
- Protection of environmental, recreational and cultural values
- Increased urban attractiveness and land value

Urban development plan



① : treated water reuse
 ② : stormwater capture

③ : storm / grey water reuse
 ④ : water demand management

⑤ : localized WWT systems

⑥ : retrofit SUDS
 ⑦ : Filtration through vegetation

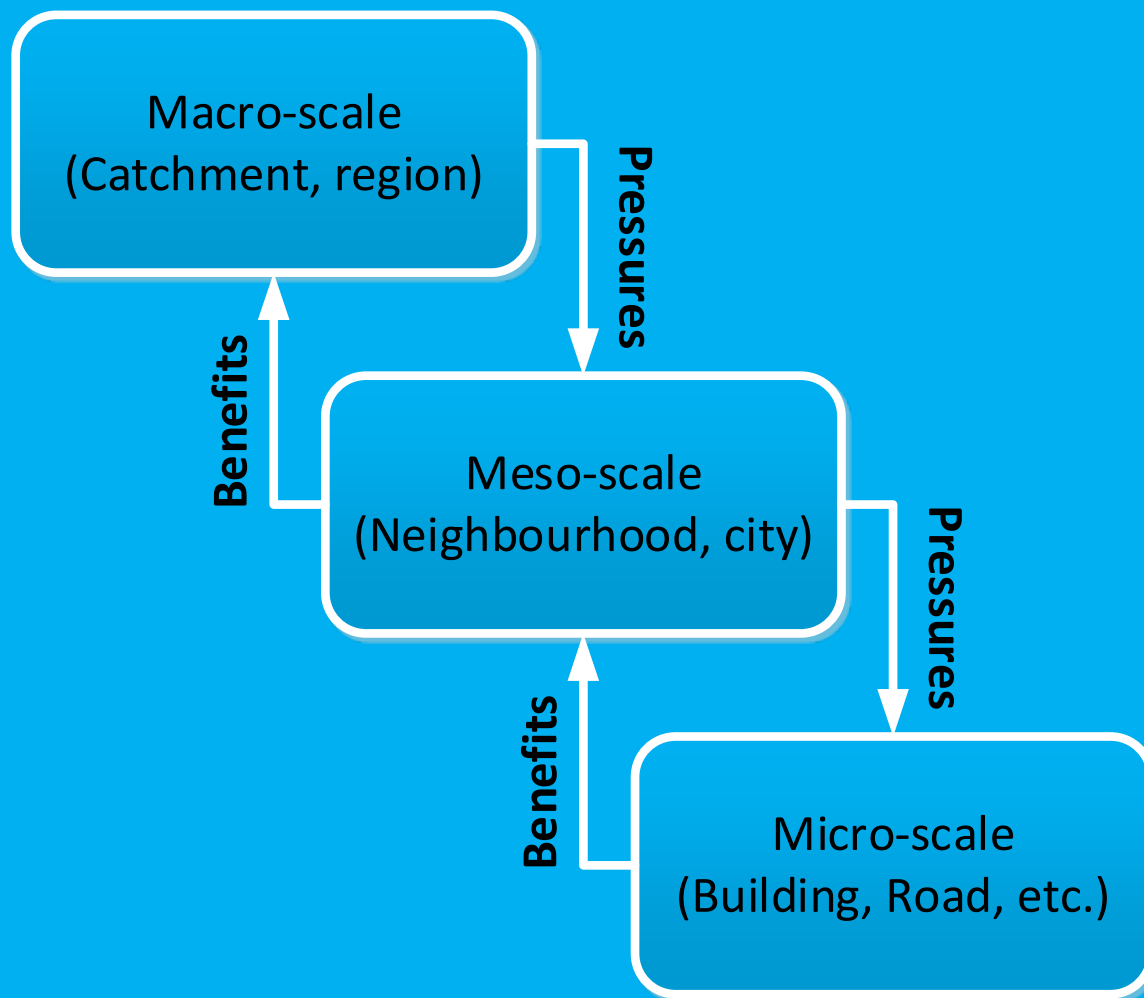
Adaptation opportunities and Scale

Urban water management: a systems' perspective

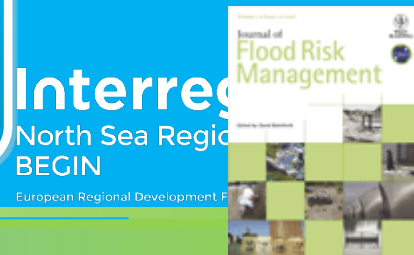
- Interaction of within and between components;
- Inheritance of water related pressures across scales;
- Inheritance of water related benefits across scales;

Adaptation opportunities and Scale

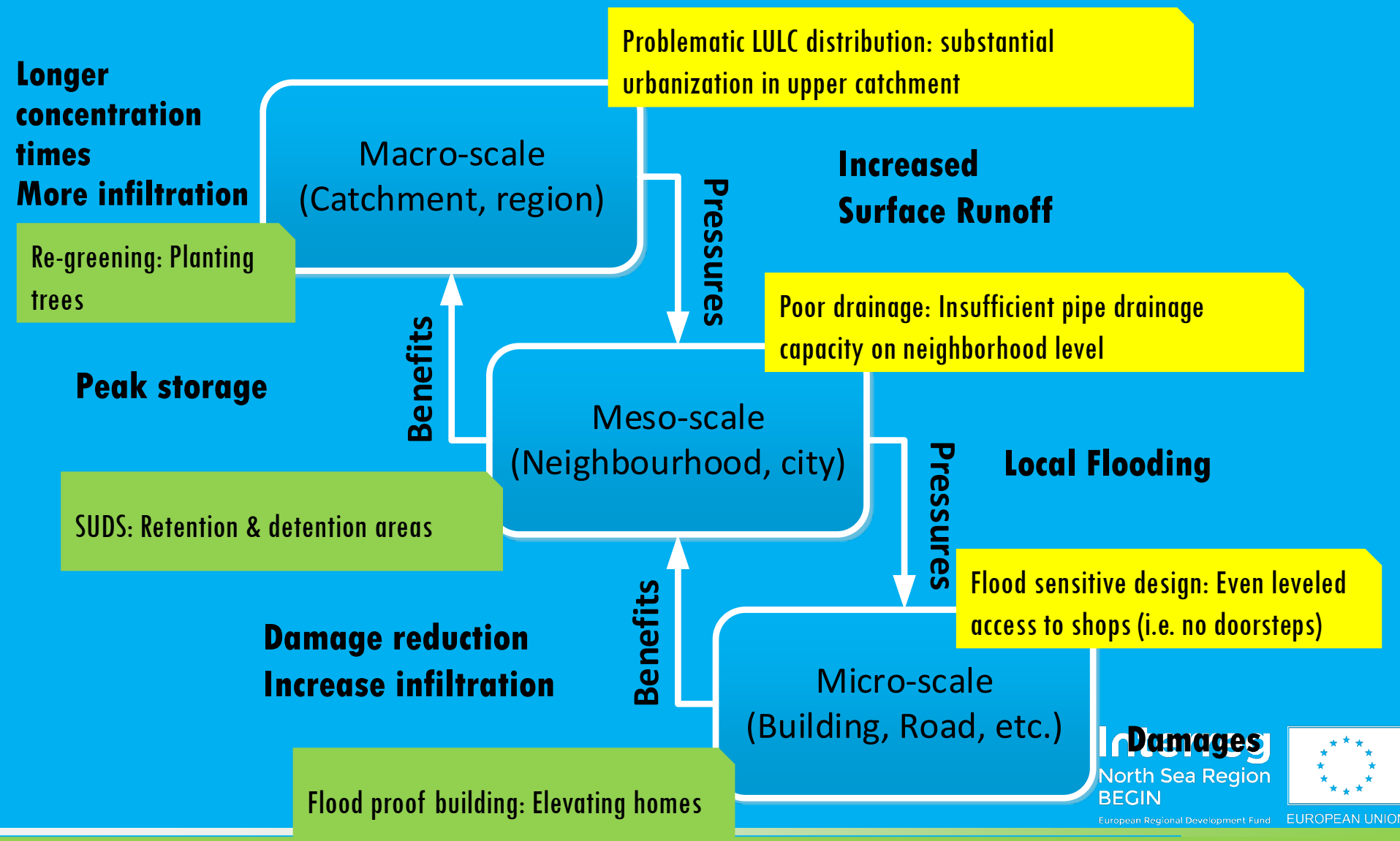
Example: flood risk propagation across scales



Zevenbergen et al, 2008



Adaptation opportunities and Scale



Adaptation opportunities and Scale

Adaptation on building level

Micro-scale
(Building, Road, etc.)

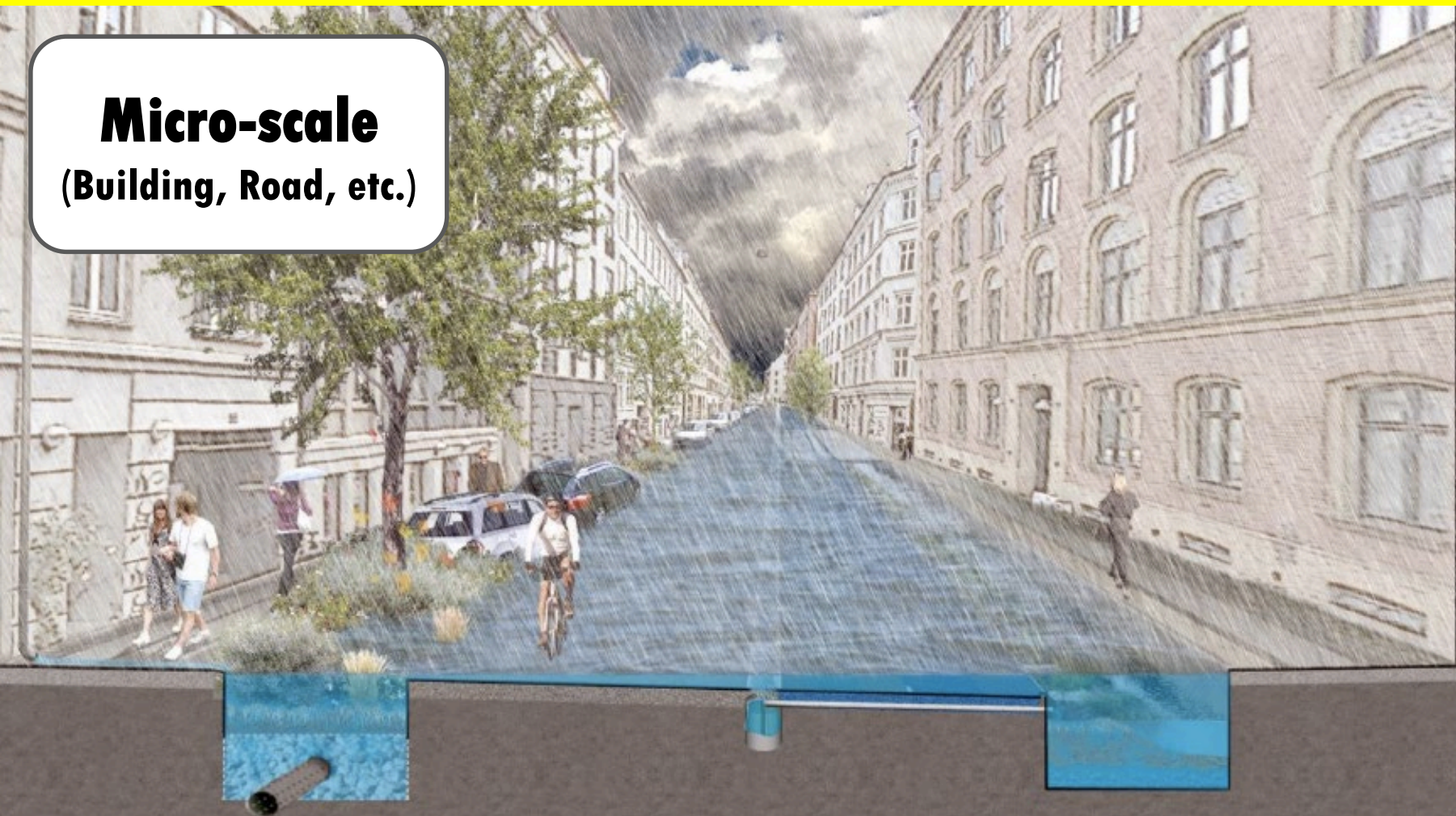
- buildings outside floodzone
- basement apartment
- elevated
- above shops
- on grade



Adaptation opportunities and Scale

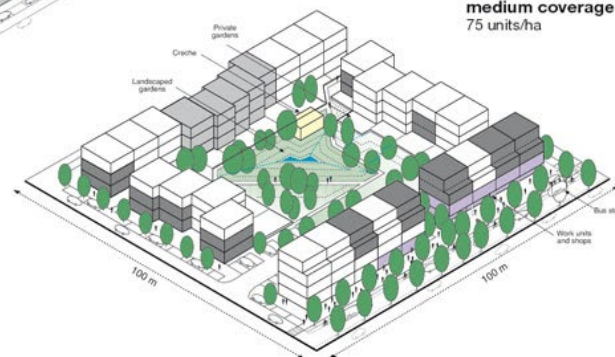
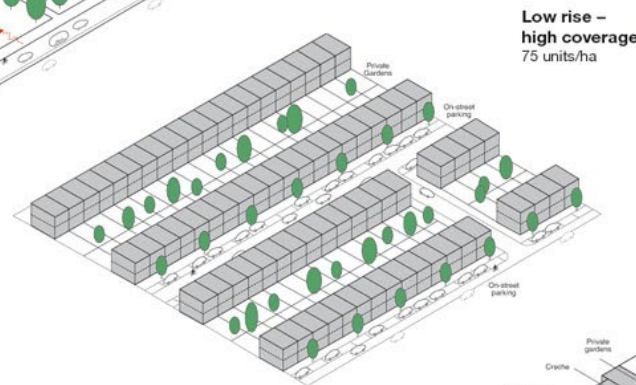
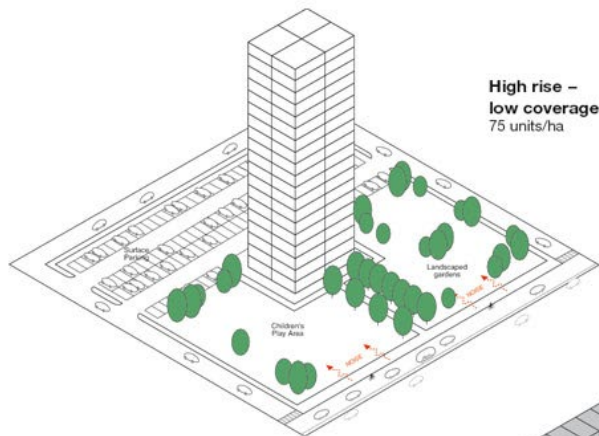
Adaptation on street level

Micro-scale
(Building, Road, etc.)



Adaptation opportunities and Scale

Adaptation on block level



Key
Target a mix of activities
Include a variety of house types

- Community facilities
- Shops and workspaces
- Maisonettes
- Houses
- Apartments

Different urban typologies for the same density (75 units/ ha)

Meso-scale
(Neighbourhood, city)

Adaptation opportunities and Scale

What WSUD principles does this park include?

Storm water management: storage, infiltration, treatment, reuse, controlled discharge peak flows, increasing evapotranspiration

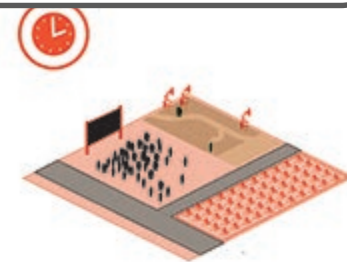
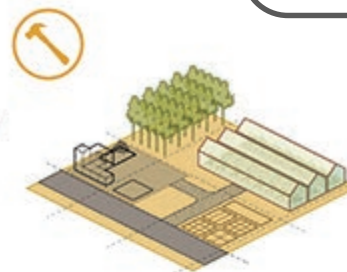


Qunli Stormwater Wetland Park by Turenscape

Adaptation opportunities and Scale

Adaptation on patch level

Meso-scale
(Neighbourhood, city)



COMMUNITY OPEN SPACES
LANDSCAPES FOR RECREATION, SOCIAL LIFE, AND SMALL-SCALE FOOD CULTIVATION

- Playgrounds
- Neighbourhood parks
- Sports fields
- Plazas
- Recreation centres
- Trails/Greenways
- Urban gardens
- Farmers markets
- Cemeteries (existing)

ECOLOGICAL LANDSCAPES
MEADOWS AND FORESTS THAT PROVIDE HABITAT AND OTHER ENVIRONMENTAL BENEFITS

- Nature parks
- Industrial nature parks
- Rapid reforestation
- Successional road
- Roads to rivers

BLUE+GREEN INFRASTRUCTURES
LANDSCAPES THAT CAPTURE STORMWATER AND CLEAN AIR

- Large lake
- Smaller retention ponds
- Infiltration parks
- Swales & Infiltration medians
- Road-side pond (along wide roads)
- Green industry buffer
- Carbon forest

WORKING + PRODUCTIVE LANDSCAPES
LANDSCAPES THAT GENERATE NEW KNOWLEDGE, GROW ENERGY AND FOOD, AND CREATE NEW URBAN EXPERIENCES

- Research landscape
- Urban farm
- Aquaculture and hydroponics
- Algae-culture
- Homesteads
- Campgrounds

TRANSITIONAL LANDSCAPES
TEMPORARY LANDSCAPES THAT CLEAN SOIL AND ENABLE NEW FORMS OF SOCIAL LIFE AND CREATIVE DISPLAYS

- Event landscapes
- Remediation fields or forests
- Art-scapes
- Urban meadows

Adaptation opportunities and Scale

Adaptation on regional level

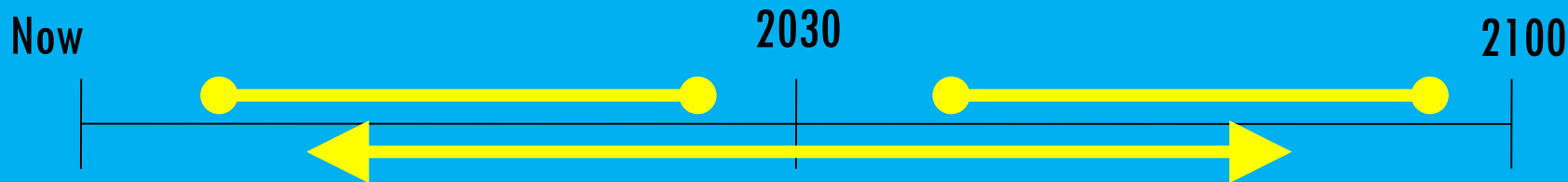
Often policy related or very large infrastructural works (e.g. dams)

Macro-scale
(Catchment, Region)

Tree planting programme Beijing-Tianjin

Adaptation opportunities and Time

Adaptation: a temporal challenge

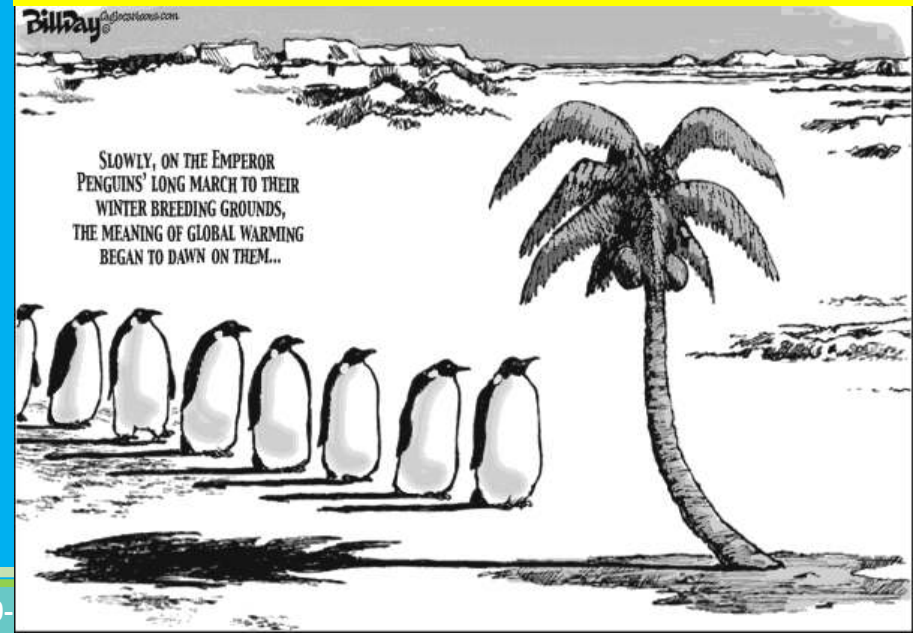


Aligning short-medium & long term

Opportunism?



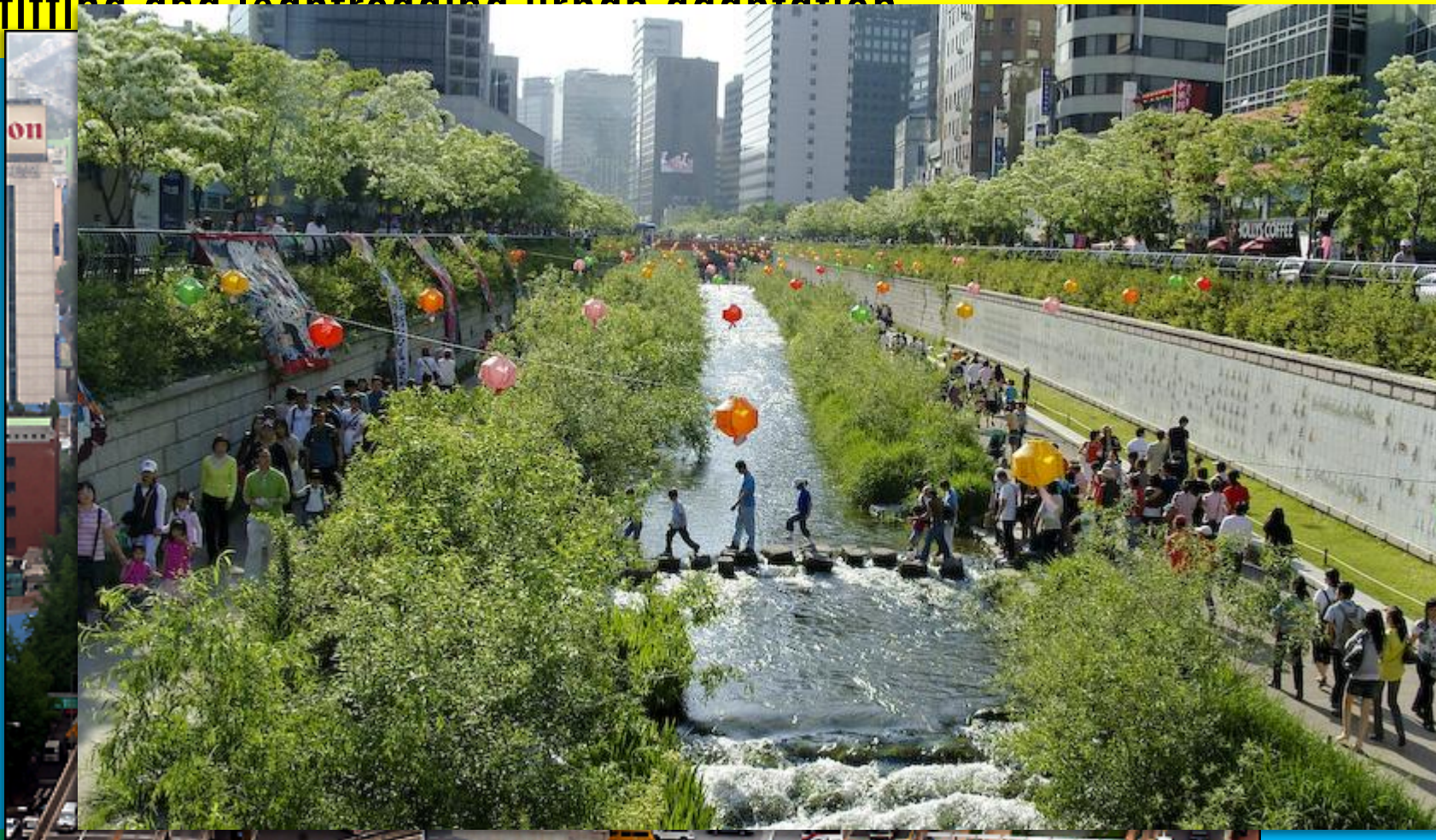
Utopianism?



Adaptation opportunities and Time

Retrofitting and leapfrogging urban adaptation

Environmental degradation



Economic Development

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e2- Seoul-The stream of consciousness

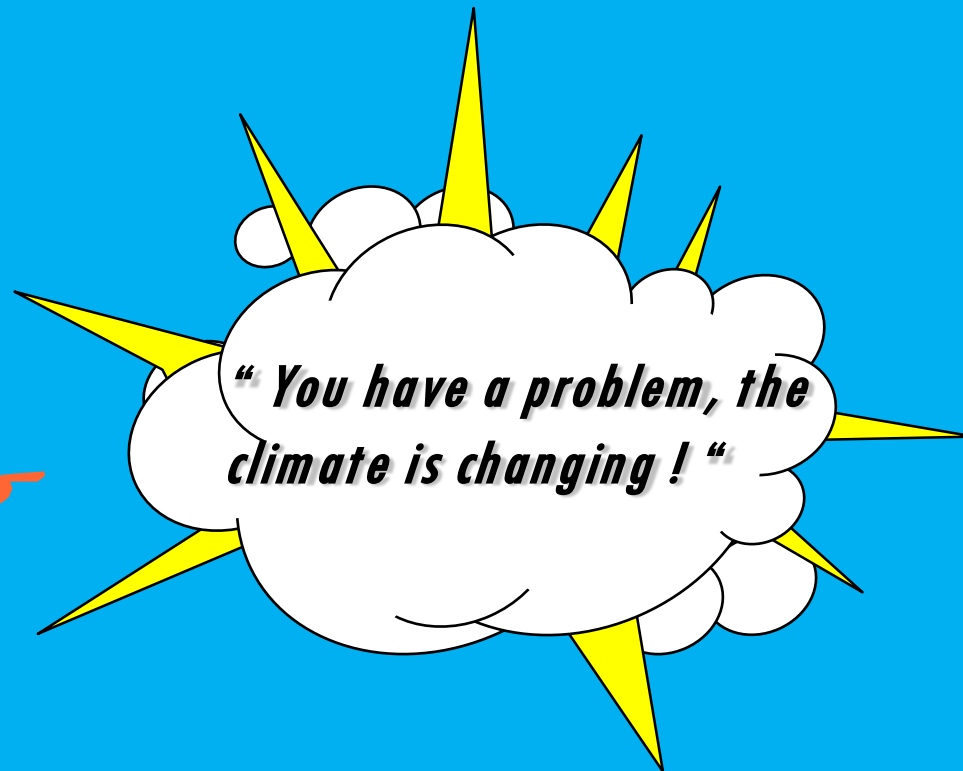
On vimeo.com

narrated by **brad pitt** director **tad fettig**

Adaptation Challenges in Time



Hydrologist



Decision maker

Adaptation Challenges in Time



Hydrologist

“ How much....? ”



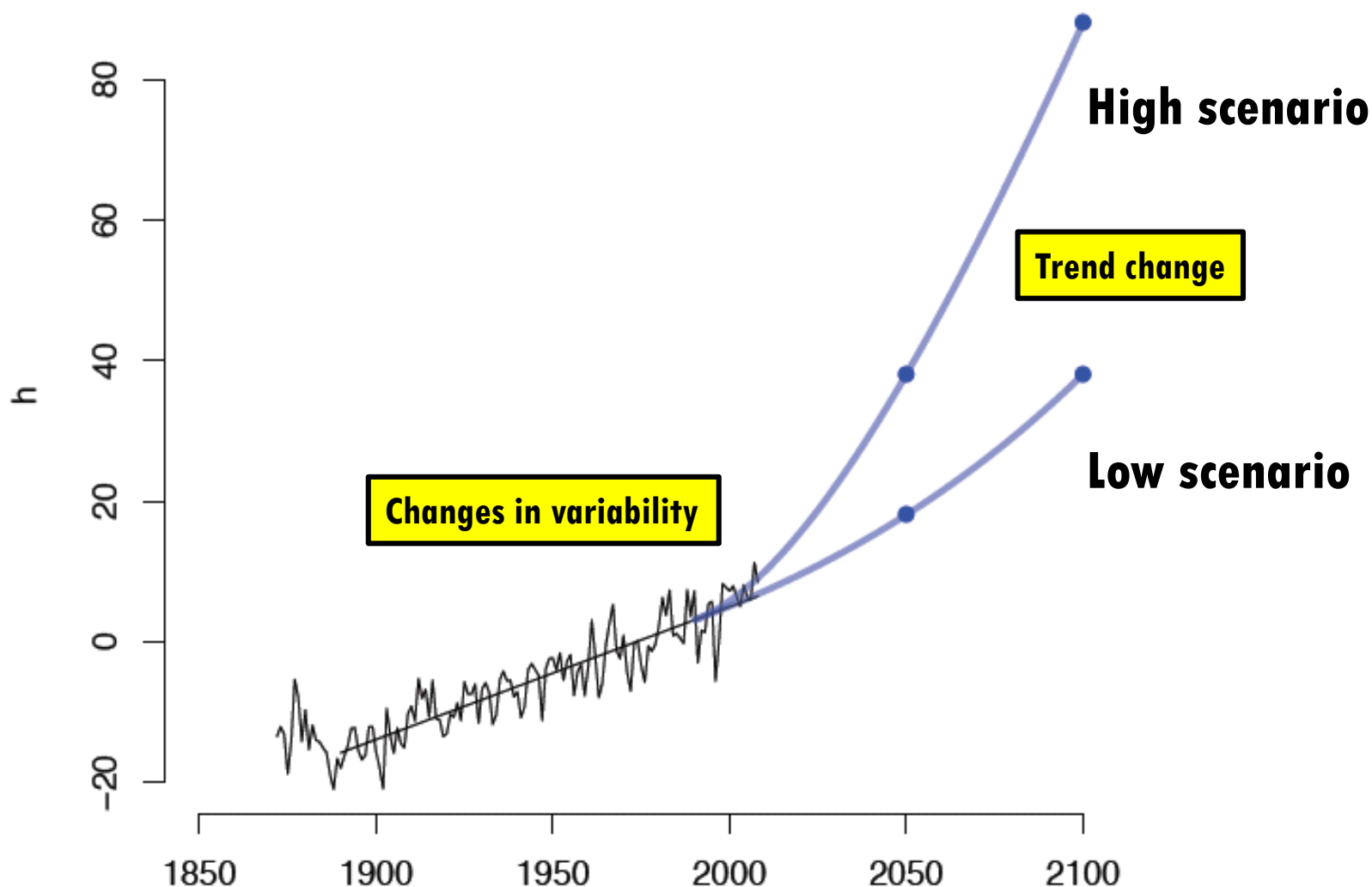
Decision maker

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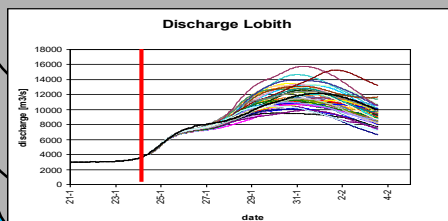
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Climate variability vs. climate change



Adaptation Challenges in Time

“How much....?”



Hydrologist

Decision maker

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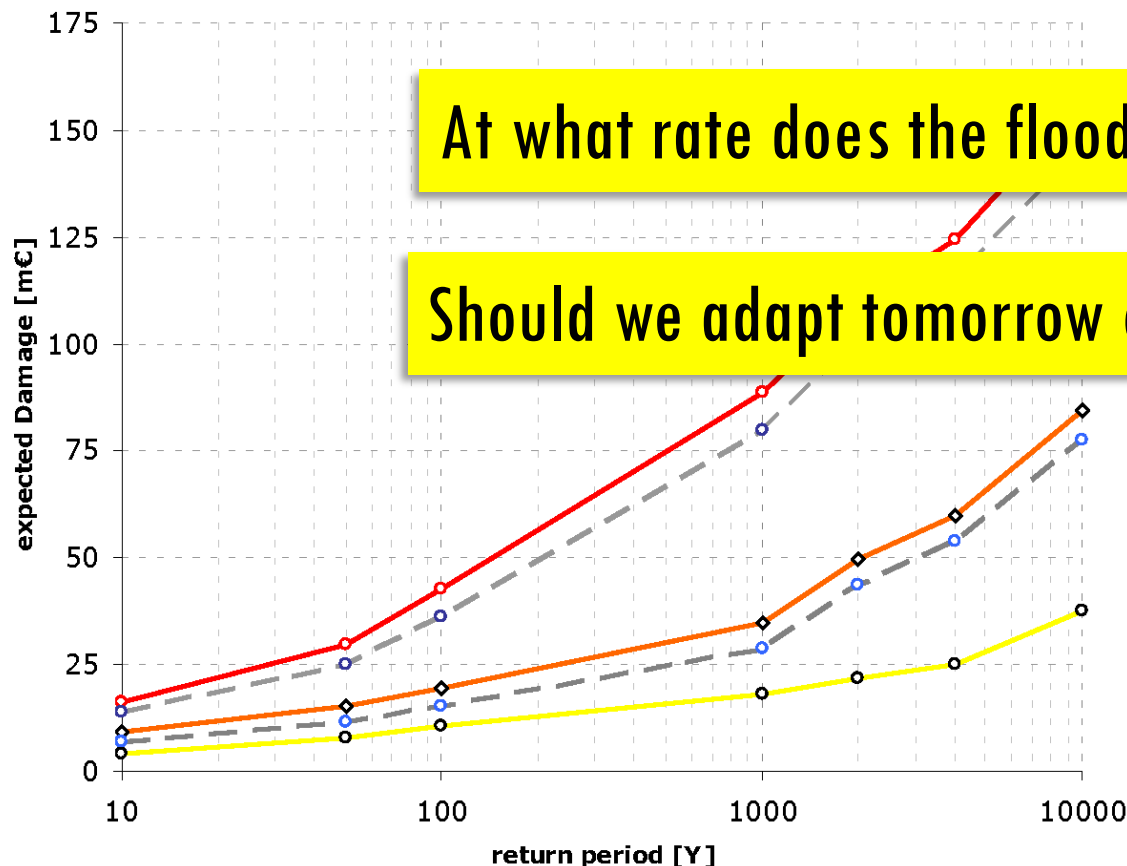


Planning for “the future”



Adaptation opportunities and Time

CC-induced flood damage increase in unembanked areas



At what rate does the flood risk change?

Should we adapt tomorrow or can we wait?

- Current
- 2100 Veerman
- 2100 Closable but open
- ◇ 2050 G+
- 2050 Closable but open

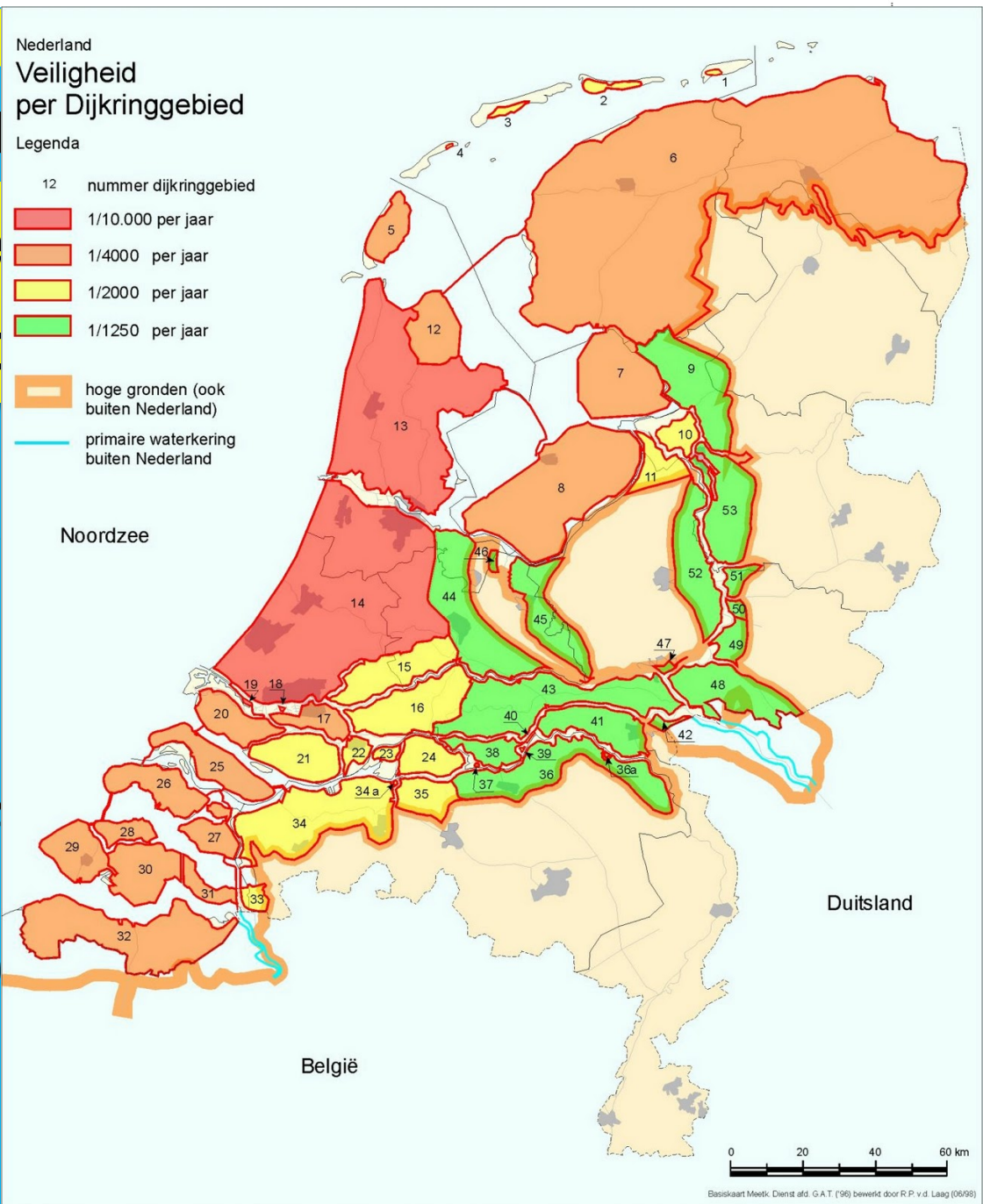
Opportunistic Adap

...or, how can we
existing renewal

Can we achieve/maintain

- Climate change
- Aging infrastructure
- Changing expectation end user

*desired level of service, a standard

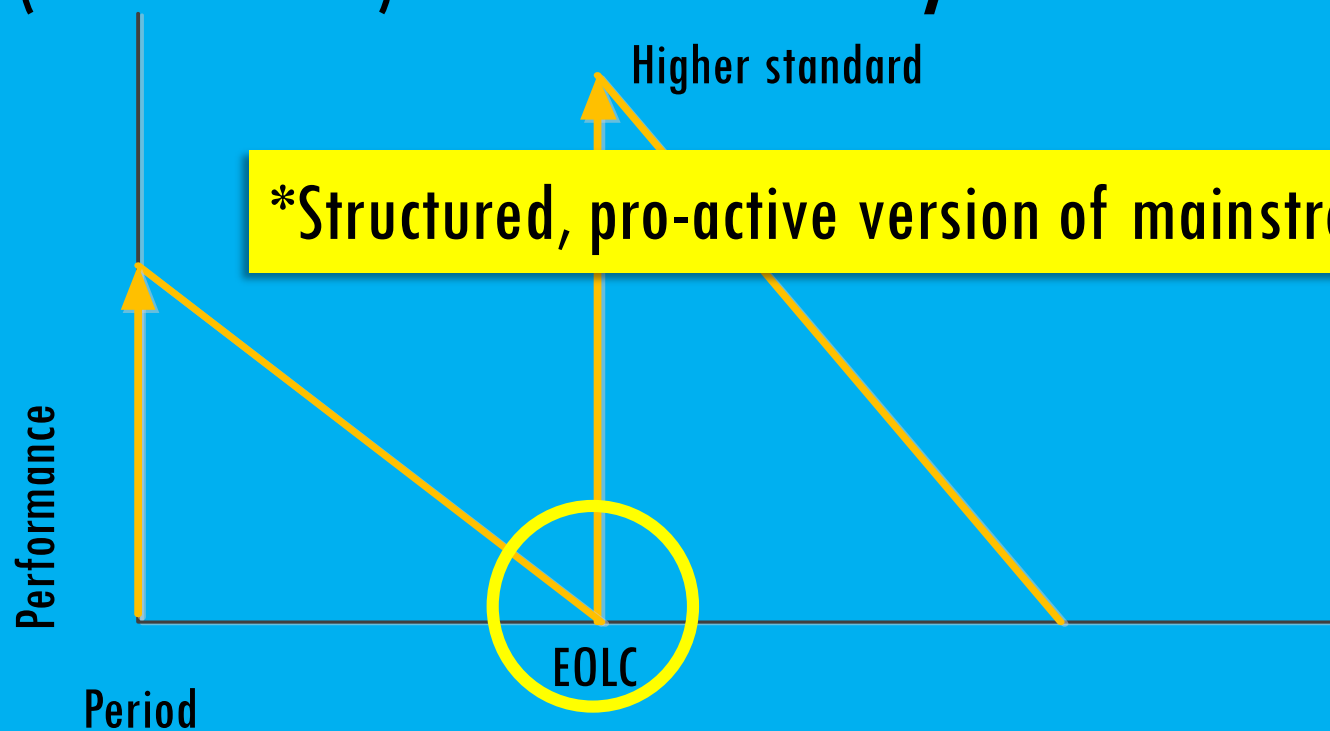


Opportunistic adaptation: adapting at EOLC

Introduce higher standard at the End of Lifecycle (EOLC)

Opportunistic adaptation*:

Upgrading standards/protection level at the time of **major renewal** (rehabilitation) or **maintenance cycles**



Adopting an Asset Management perspective

Assets:

- Something **you** own that has **value**;
- There can be assets that gain value over **time**...or lose value over time;

Asset Management:

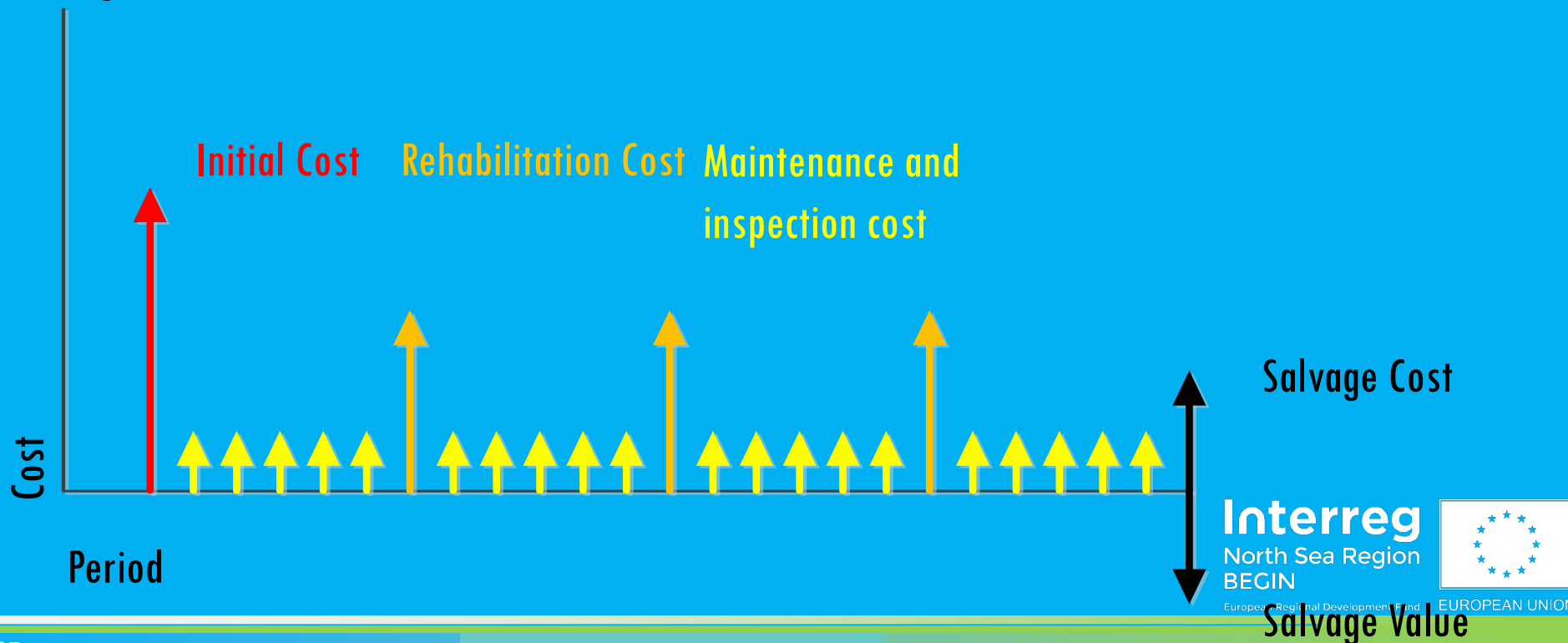
An ongoing process of **maintaining, upgrading, and operating** physical assets **cost effectively**, based on a continuous **physical inventory** and **condition assessment**

Adapting over time

Assessing the lifecycle: lifecycle costs

A method of calculating the cost of a system over its entire life span:

- Initial costs
- Operational costs (future rehabilitation costs, maintenance, monitoring/inspection)
- Salvage costs

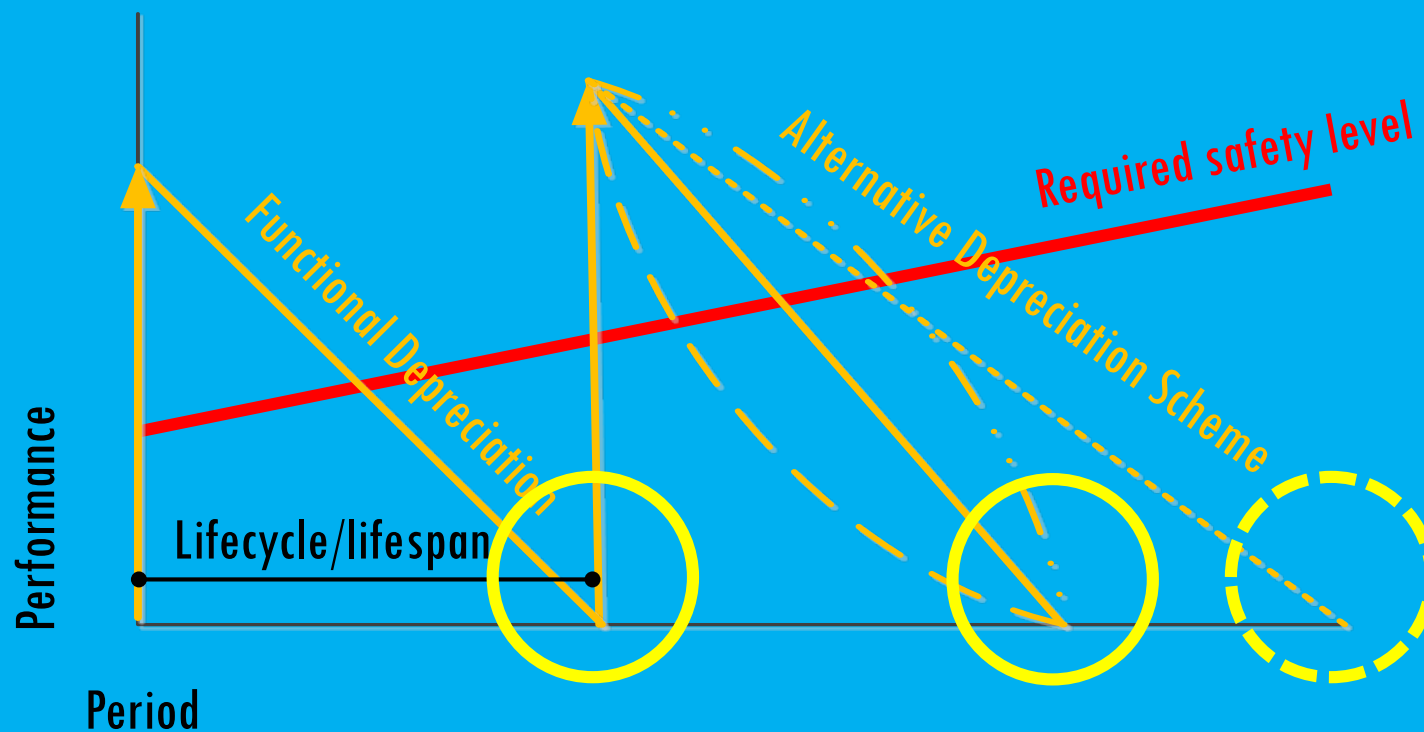


Adapting over time

Depreciation: how the assets is evaluated over time

Rehabilitation strategy:

- Cost vs rehabilitation performance period
- Cost vs performance progression (i.e. functional depreciation)



Opportunistic adaptation: adapting at EOLC

Assessing the age of your assets: Construction year



Opportunistic adaptation: adapting at EOLC

Estimating lifespan of different assets classes

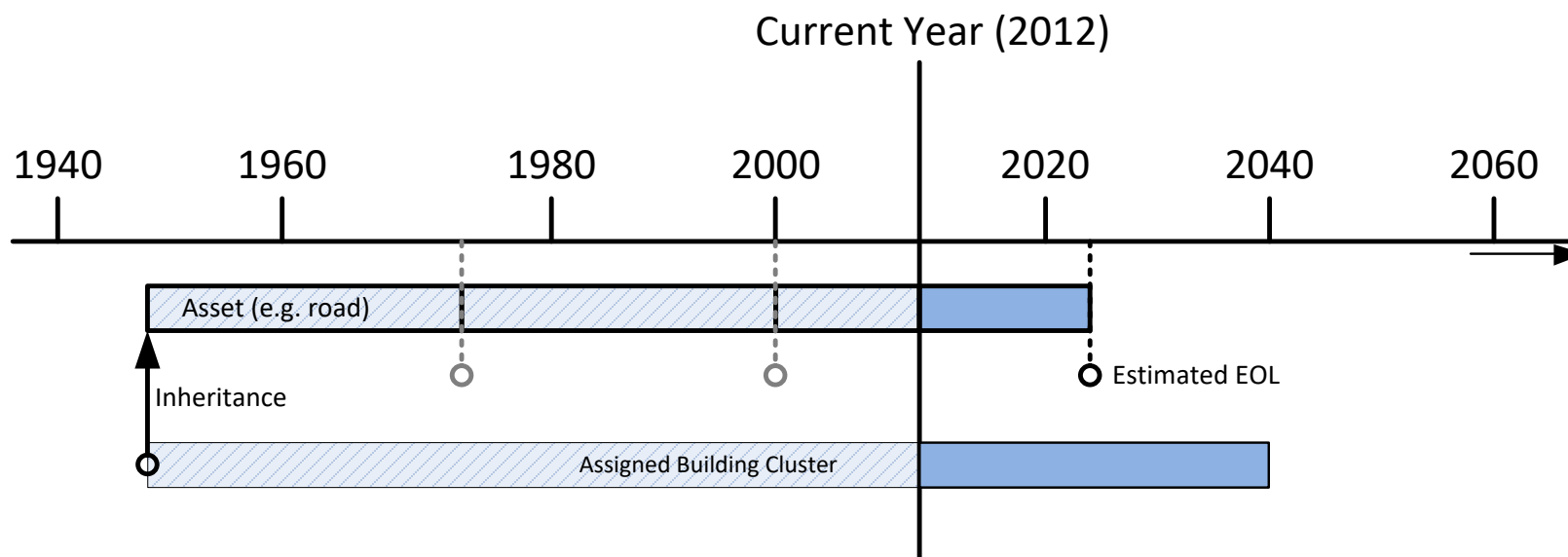
Asset	Estimated lifespan [Y]
Housing	25-150
Roads	5-30
Storm drains	40-100
Bridges	30-50
Dikes, Dams, etc.	25-50
Playgrounds	10

- Large variation within and between comparable asset classes;
- Regional differences;
- Often based on haphazard maintenance/renewal schemes

Opportunistic adaptation: adapting at EOLC

Assessing estimated EOLC

Estimated construction year of assets within the study including inherited construction years for infrastructure, public space and utilities)



Rotterdam South: An urban case study



Rotterdam 1990: A city with difficulties

Rotterdam on top of every “bad” statistics list:

- Economy: Poor population, poorly educated;
- Economy: Low-tech, mid-tech industry;
- Social: High crimes, no go areas;
- Social: Immigration, cultural segregation;
- Assets: Aging housing stock, much social housing;
- Assets: Bad public spaces, unsafe, dirty, unmaintained areas;
- Environment: Badly polluted (port, industry);
- Etc. etc. etc.

On top of that...

PRECIPITATION



WATER CHALLENGES

RIVER DISCHARGES



GROUNDWATER



SEA LEVEL RISE



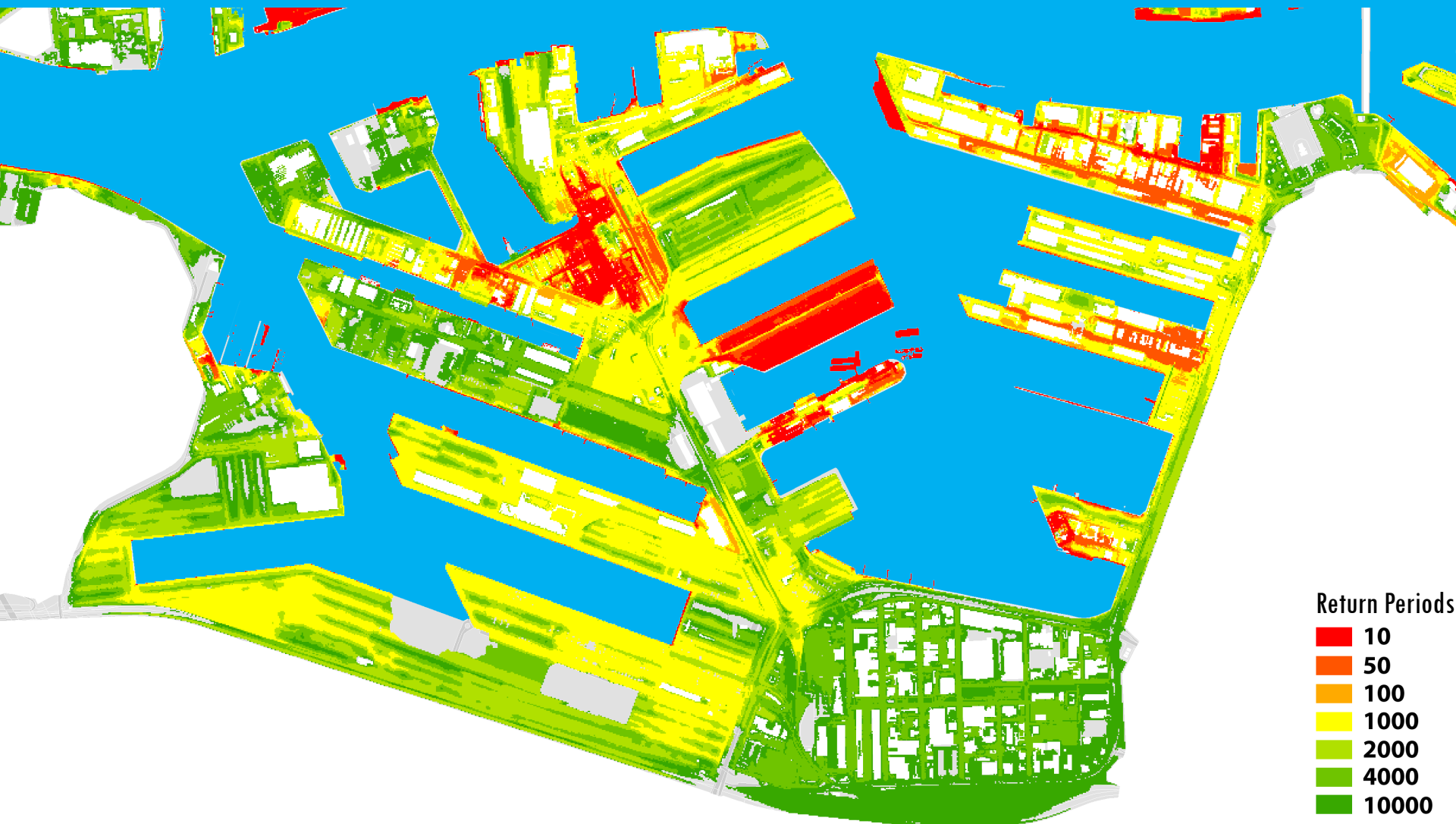
Rotterdam South: An urban case study

Estimated flood extent based on current probability distribution



Rotterdam South: An urban case study

Flood extent for different return periods



4. Applications: example from Rotterdam



4. Applications: example from Rotterdam



Rotterdam South: An urban case study

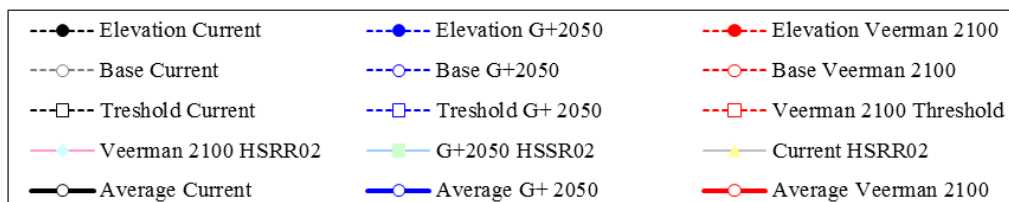
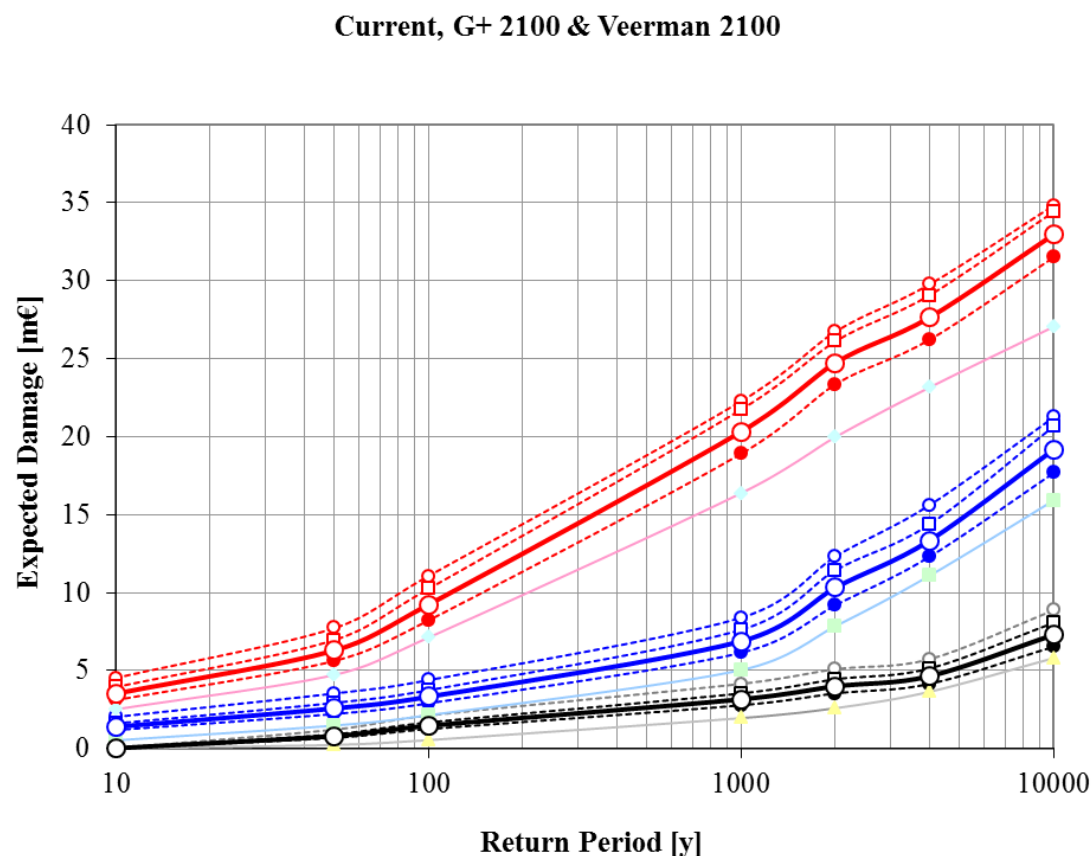
Estimated flood extent for different return periods



Rotterdam South: An urban case study

Expected flood damages to residential properties:

- Significant increase for 2 climate change scenarios;
- Moderate & extreme CC-scenarios are for 2100



Rotterdam South: An urban case study

Expected flood damages to residential properties:



3,45 m + NAP (4000Y flood)

1000Y flood in 2050

500Y flood in 2100

3,00 m + NAP (25/50Y flood)

10Y flood in 2050

Annual flood 2100
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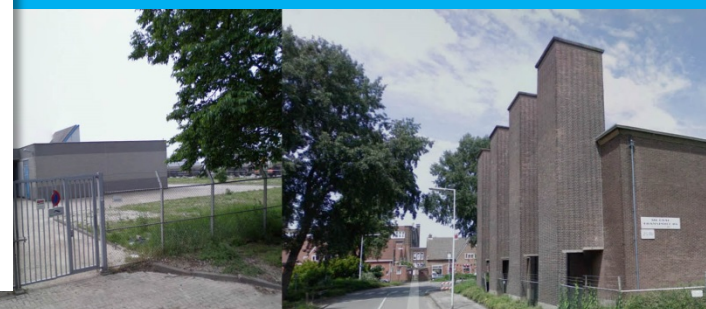
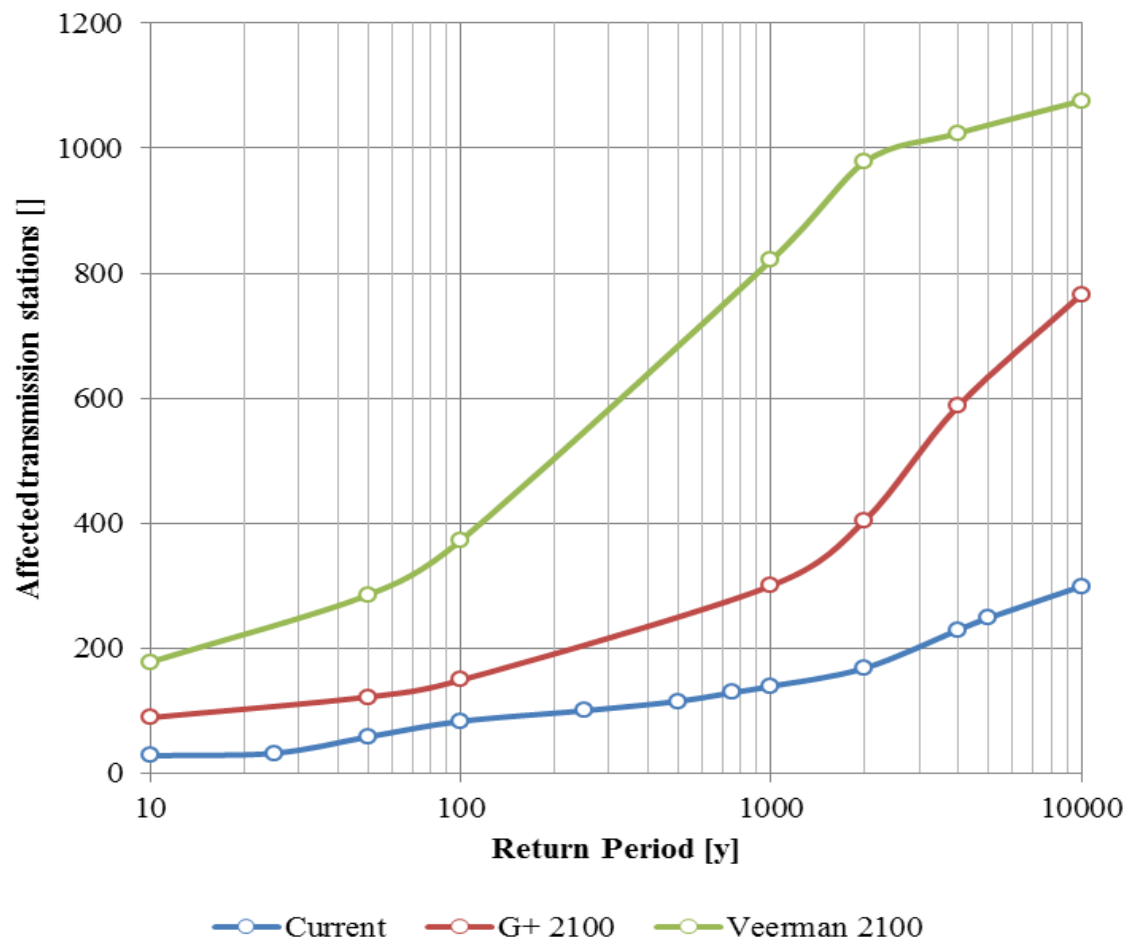


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Actual flood entry heights

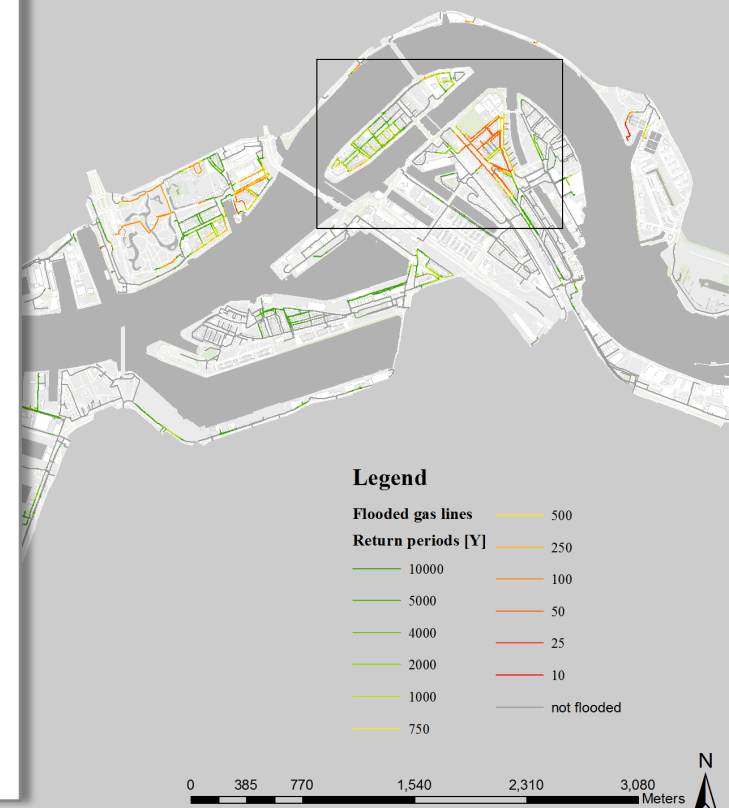
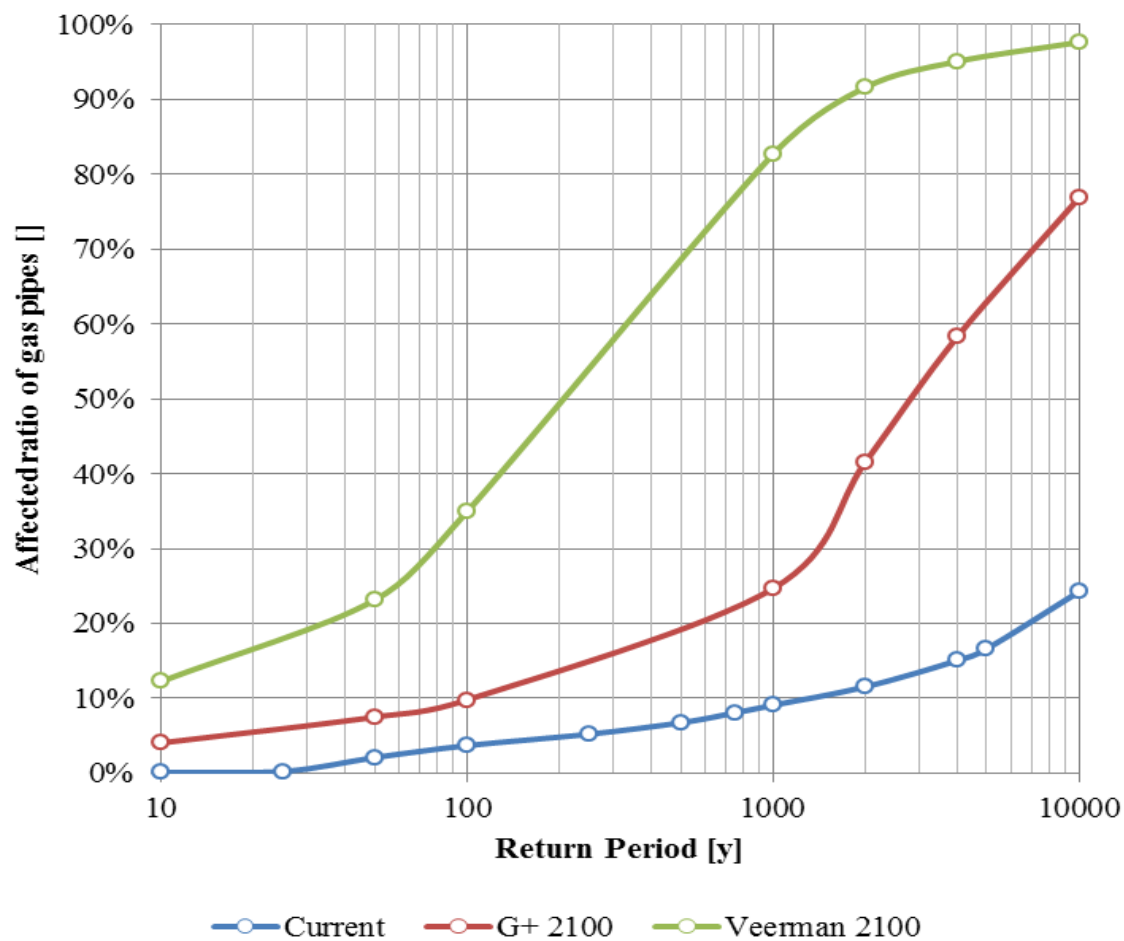
Rotterdam South: An urban case study

Utilities: transmission stations (1244, 299 exposed current)



Rotterdam South: An urban case study

Utilities: gas supply pipes (173km, 41km exposed current)



Rotterdam South: An urban case study

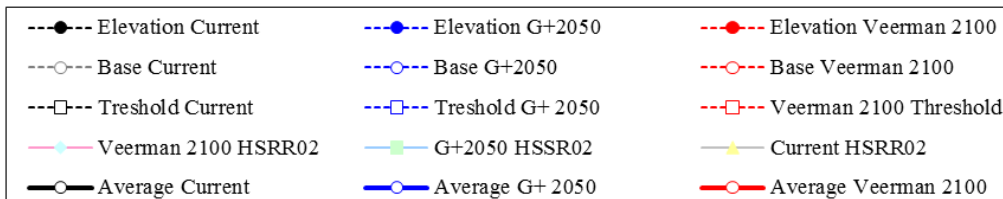
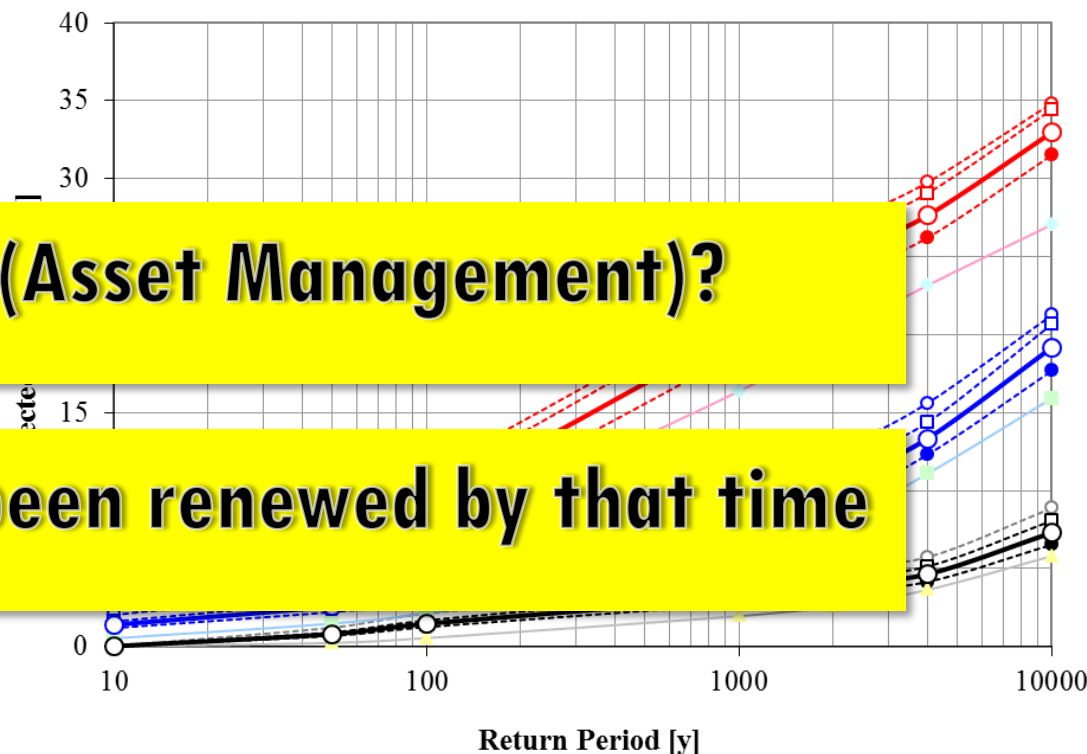
Expected flood damages to residential properties:

- Significant increase for 2 climate change scenarios;
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What's the issue here (Asset Management)?

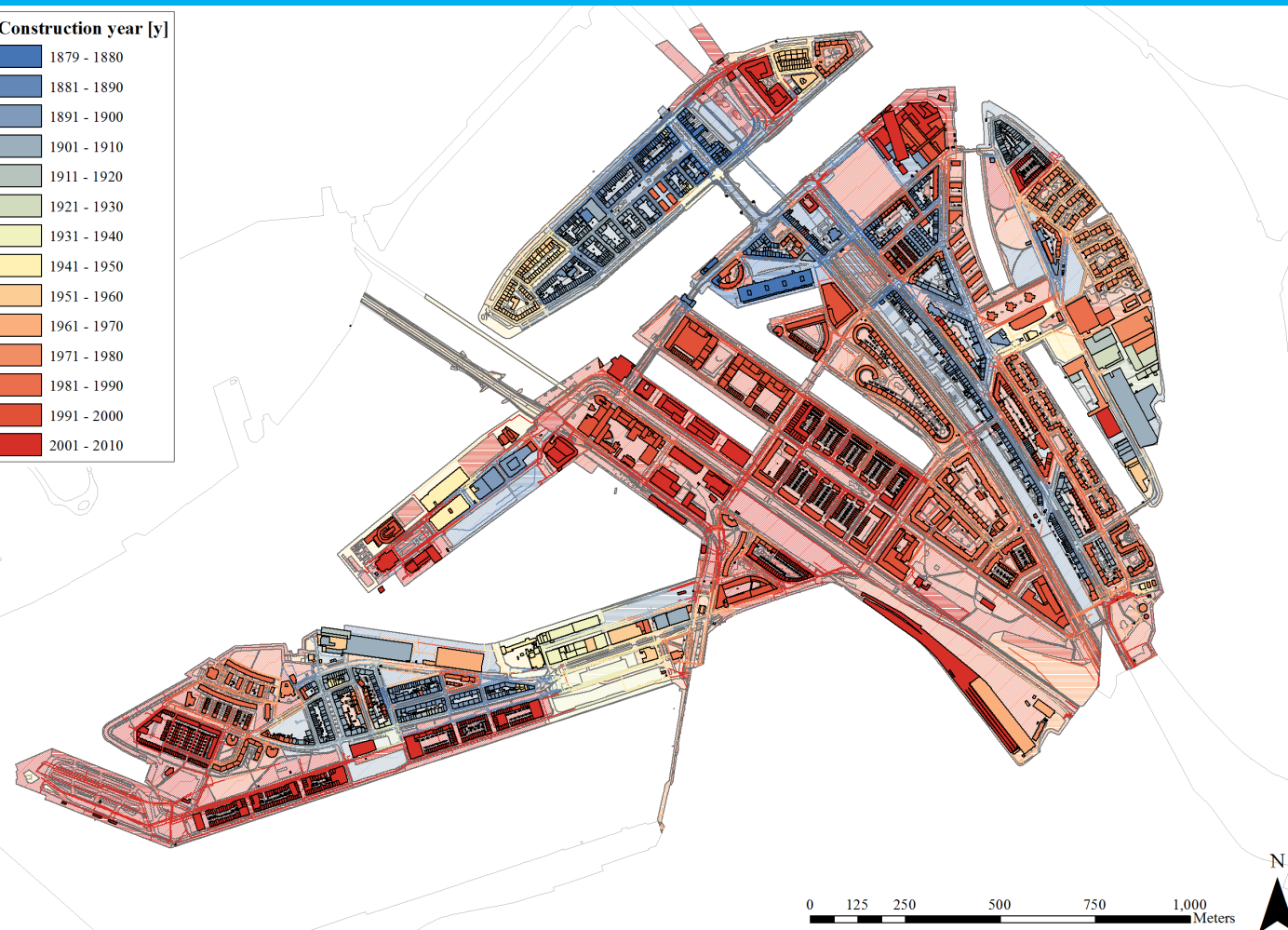
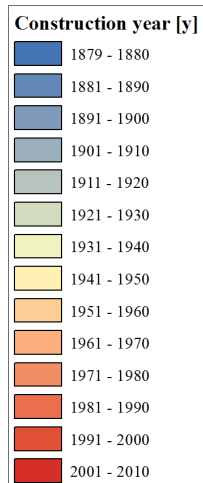
Houses have already been renewed by that time

Current, G+ 2100 & Veerman 2100



Rotterdam South: An urban case study

Estimated construction year of assets within the study including inherited construction years for infrastructure, public space and utilities)

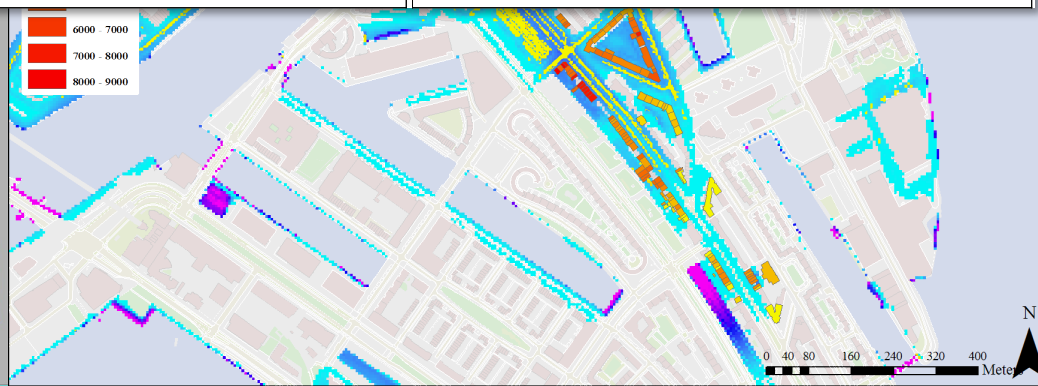
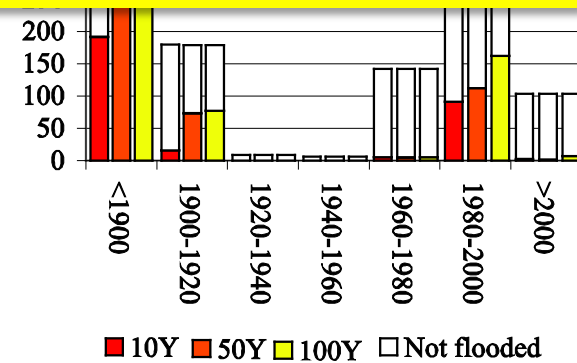
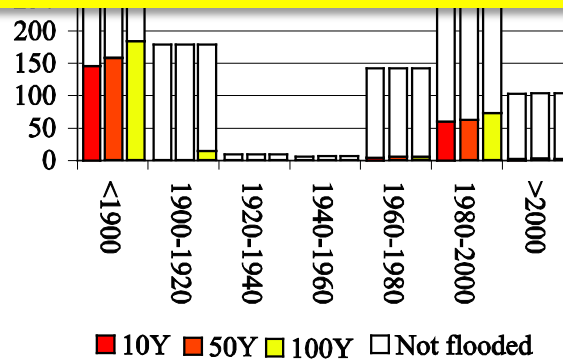
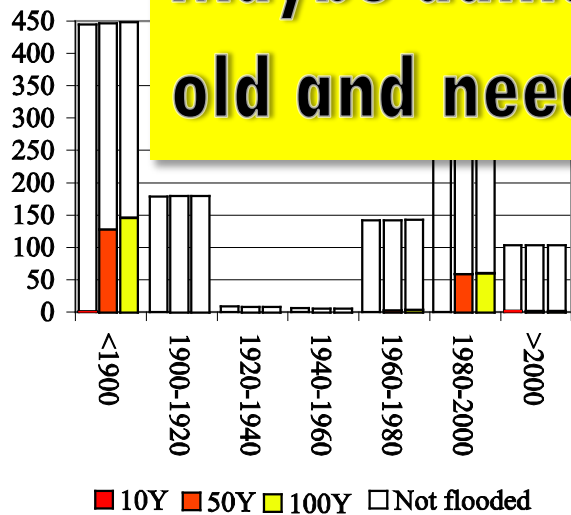


Feyenoord Cummulative Damage:
Current

Feyenoord Cummulative Damage:
G+ 2100

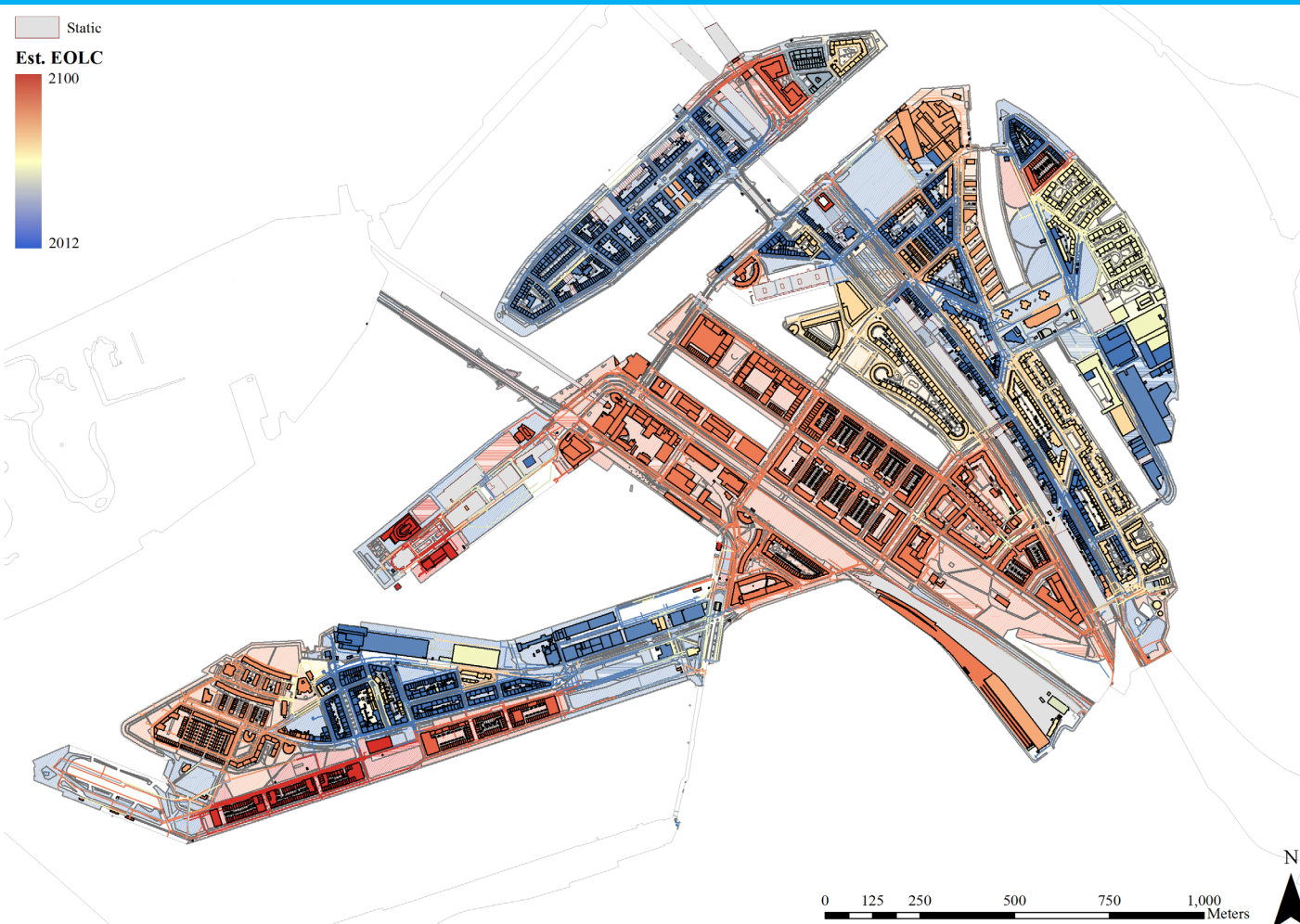
What if the damage distribution shifts?

Maybe damages are suffered in assets that are old and need to be replaced anyway!



Rotterdam South: An urban case study

Estimated EOLC: Significant portion seems up for replacement



Rotterdam South: An urban case study

Estimating EOLC

- **Asset based:** Based on EOLC of individual assets
- **Asset Clustering:** Group adjacent assets that reach EOLC at approximately the same time

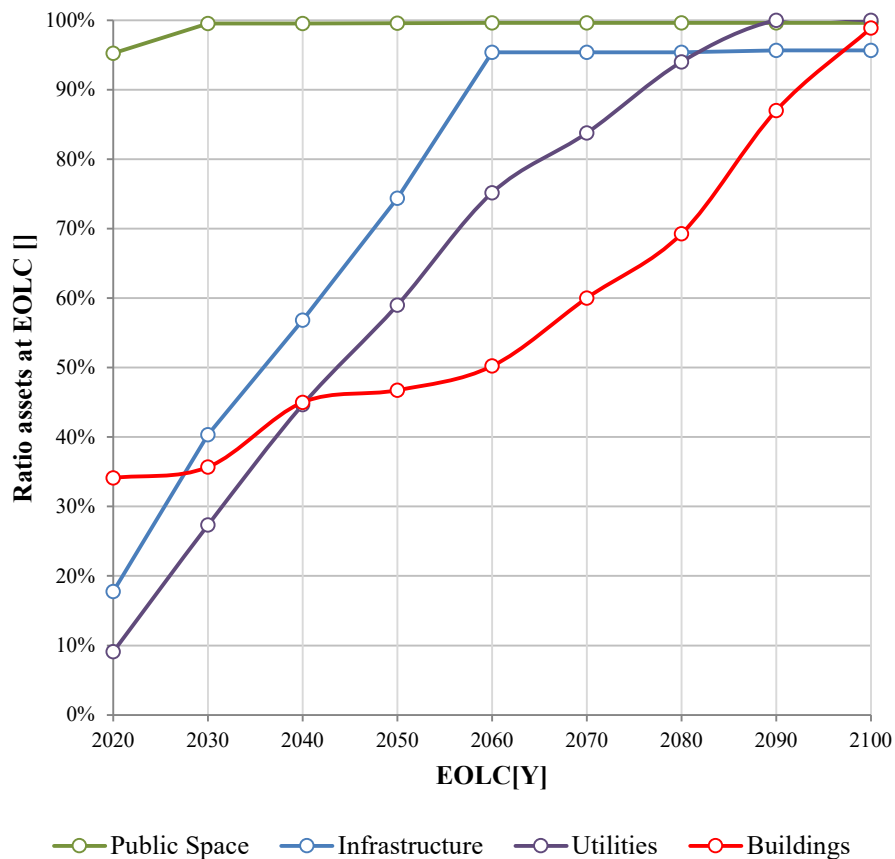
How fast can we adapt/retrofit the area?

Rotterdam South: An urban case study

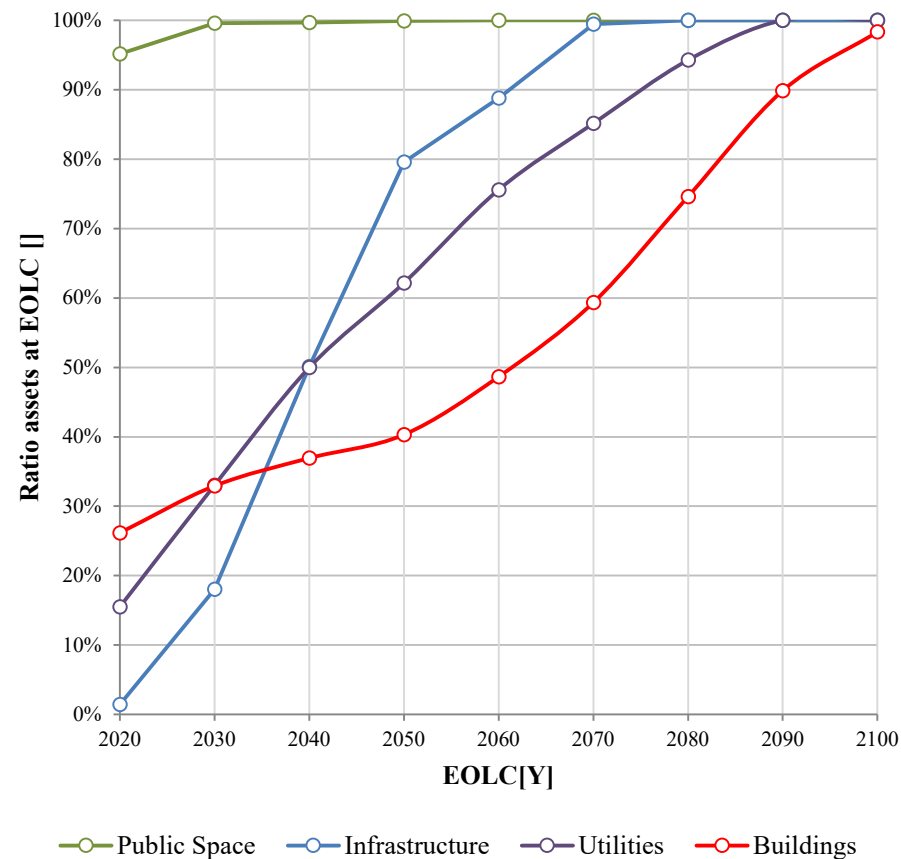
Adaptation rate: individual

Estimated EOLC for the case study area (left) and the Rotterdam urban area (right)

Case Study Area



Rotterdam Urban Area

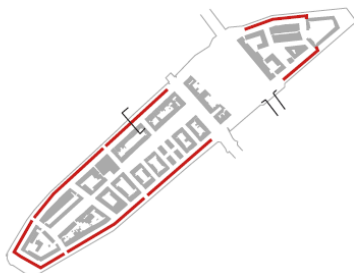


Rotterdam: An urban case study

Retrofitting options

SUPERDIKE Maaskade
RESPONSIBILITY: AUTHORITIES

- water safety for RP 1/10.000 (+3,59 m NAP)
liferisk, social disruption
 - water safety for RP 1/1.000 (+3,30 m NAP)
damage to new buildings
 - water safety for RP 1/100 (+3,11 m NAP)
damage to existing building
 - existing situation
 - new interventions
- relevant waterlevels
 Av. R'Dam waterlevel -0,50/+1,50 m NAP
 Current 1:10.000 +3,59 m NAP
 Current 1:1.000 +3,30 m NAP
 Current 1:100 +3,11 m NAP

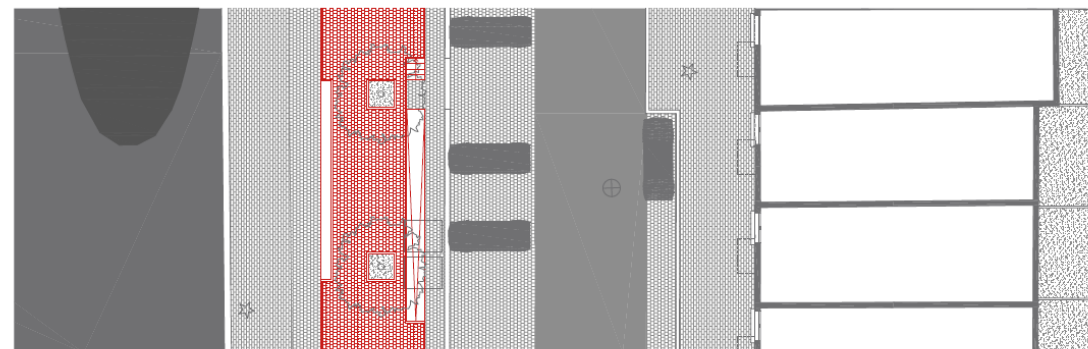
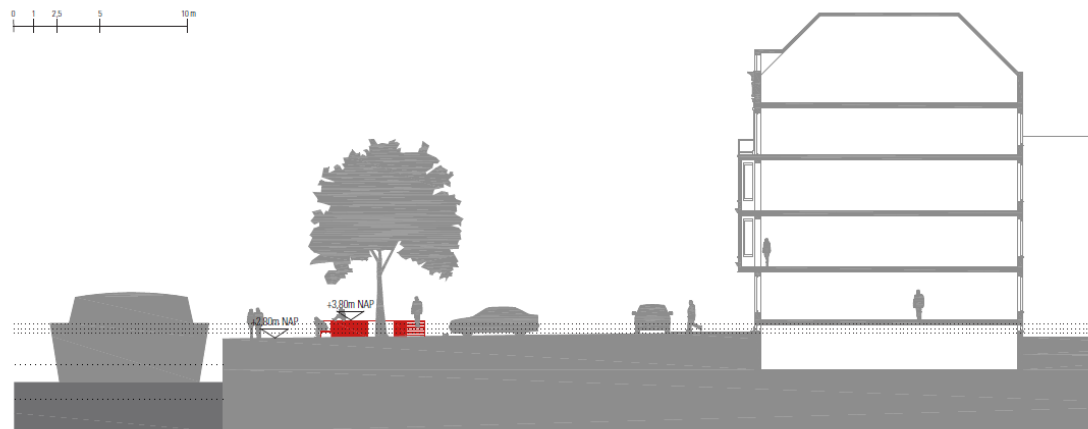
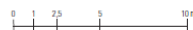


OPEN ISSUES

ACCESSIBILITY OF THE QUAY TO VEHICLES
(according to its use)

NUMBER AND POSITIONING OF OPENINGS

HOW TO CLOSE OPENINGS

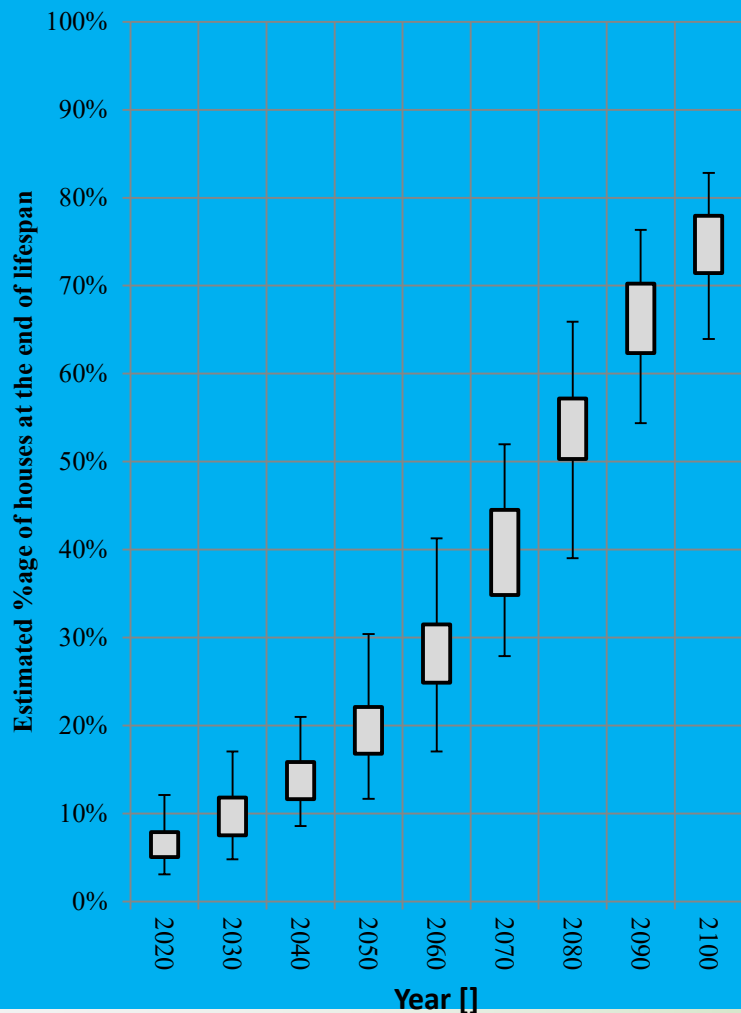


WATER - OUT (1) POM NOORDEREILAND 1

Rotterdam South: An urban case study

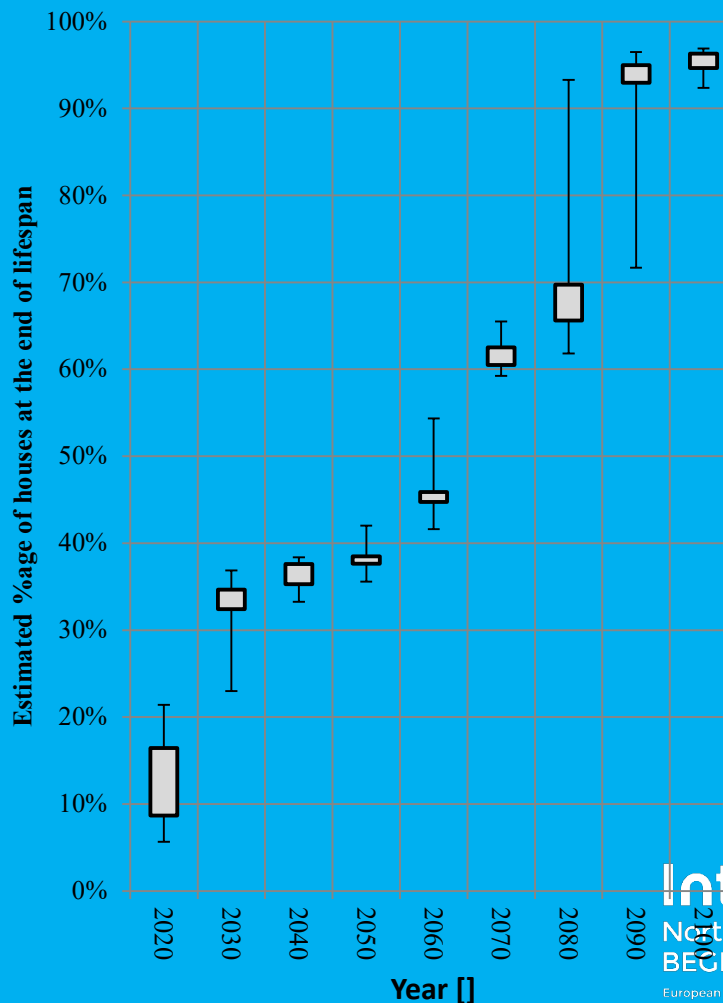
Almost linear

Stand-alone with deviation



S-shaped

Clustering with deviation



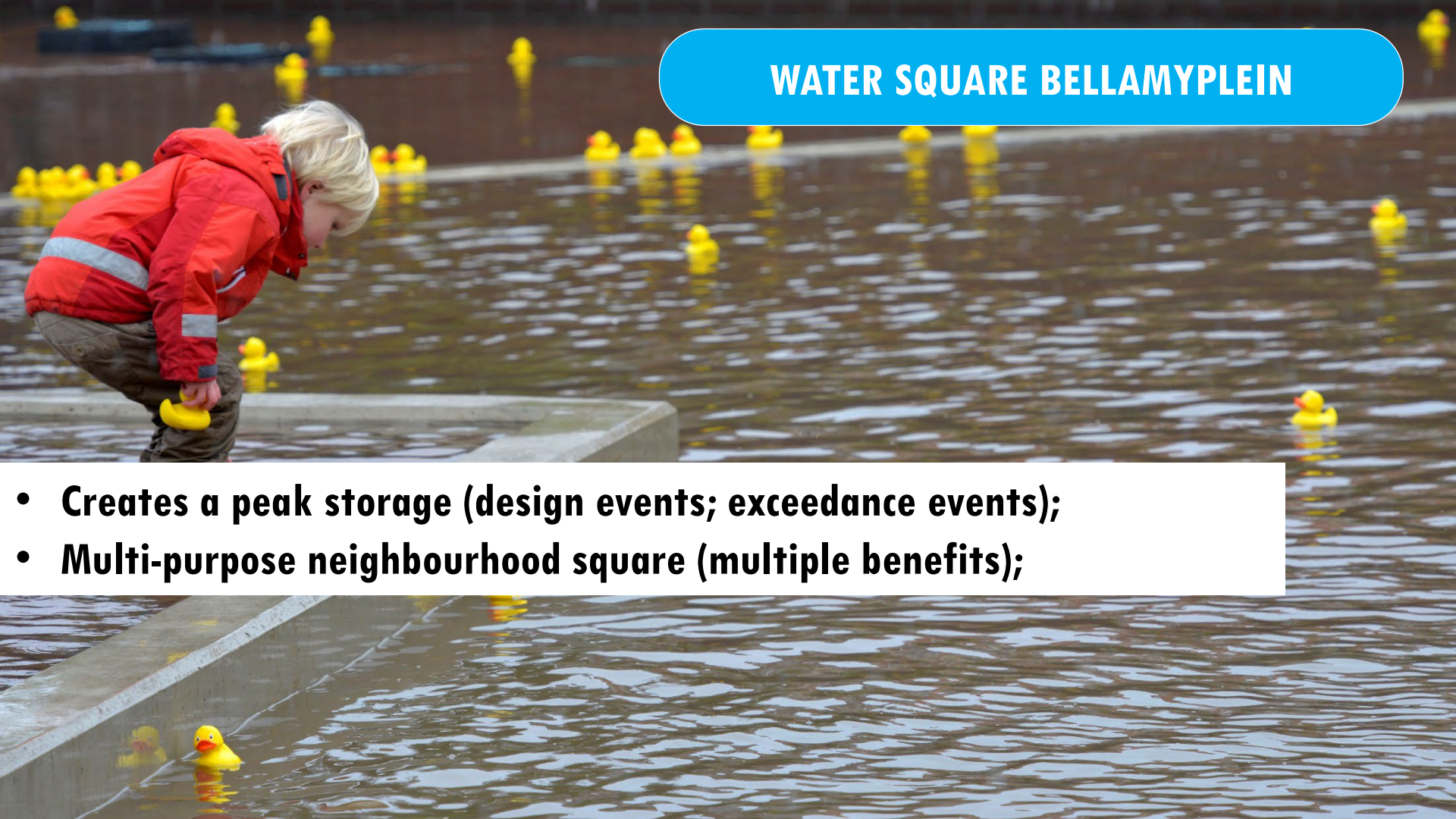
Rotterdam: An urban case study

Retrofitting options: Asset based

Design: Gemeente Rotterdam

WATER SQUARE BELLAMYPLEIN

- **Creates a peak storage (design events; exceedance events);**
- **Multi-purpose neighbourhood square (multiple benefits);**



Rotterdam: An urban case study

Retrofitting options: Asset based

Design: Gemeente Rotterdam

WATER SQUARE FREDERIKSPLEIN

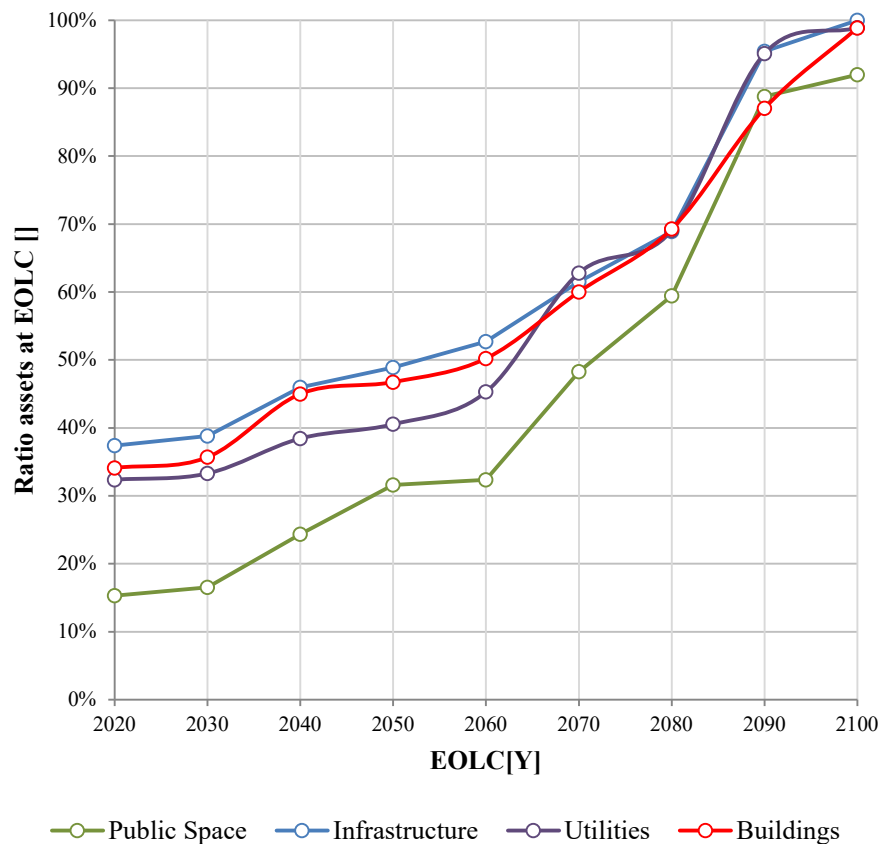
- **Creates a peak storage (design events; exceedance events);**
- **Playfield (multiple benefits);**

Rotterdam South: An urban case study

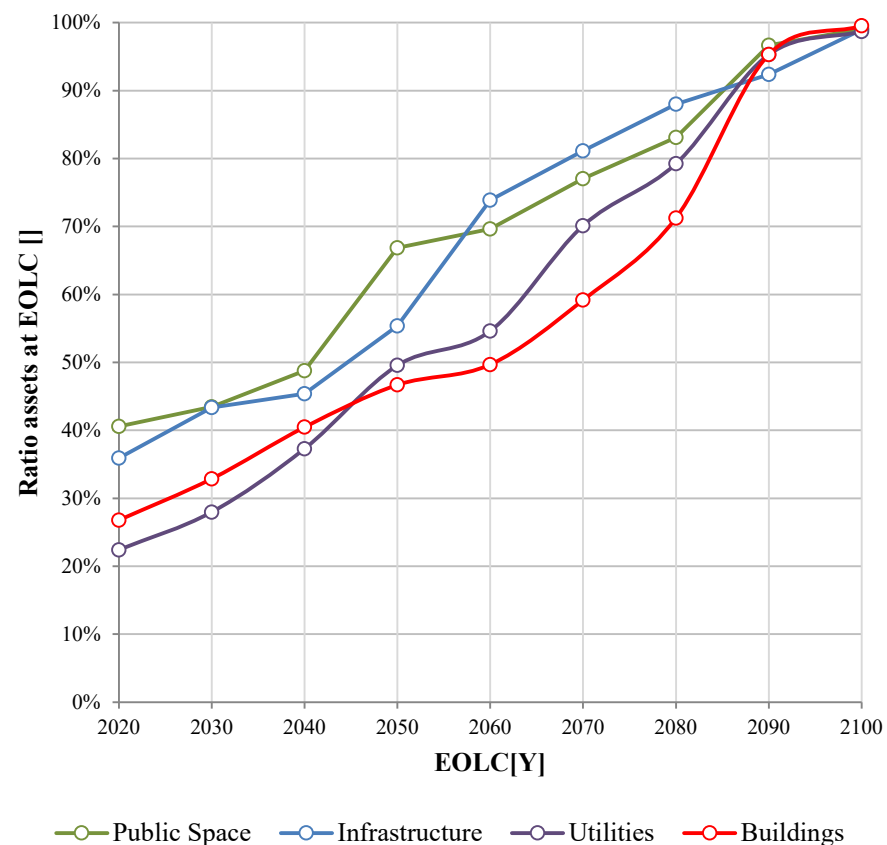
Adaptation rate: clustering

Estimated EOLC for the case study area (left) and the Rotterdam urban area (right) using inheritance.

Case Study Area



Rotterdam Urban Area



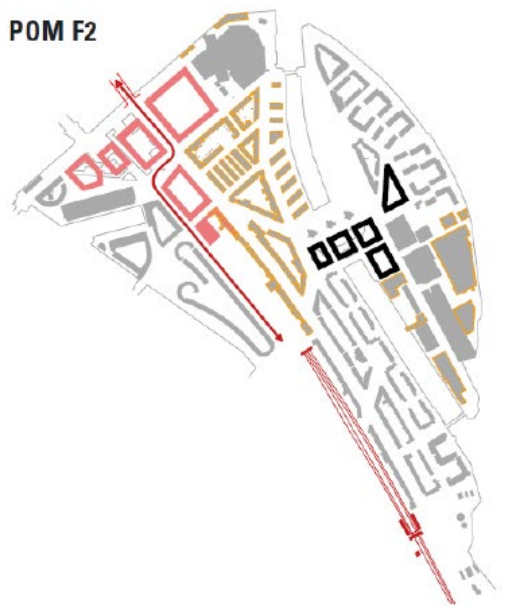
Rotterdam South: An urban case study

Retrofitting options: clustering per block

POM N2



POM F2



P0



Rotterdam: An urban case study

Retrofitting options: Clustering

Design: Buro Sant & Co, The Hague

ROOFPARK VIERHAVENSTRAAT

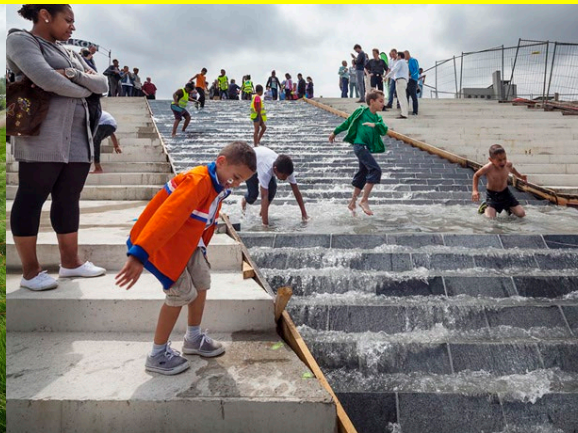
- Part of primary flood defence system (1:10,000 standard)
- Integration of flood defence, park and retail area;



Rotterdam: An urban case study

Retrofitting options: Clustering

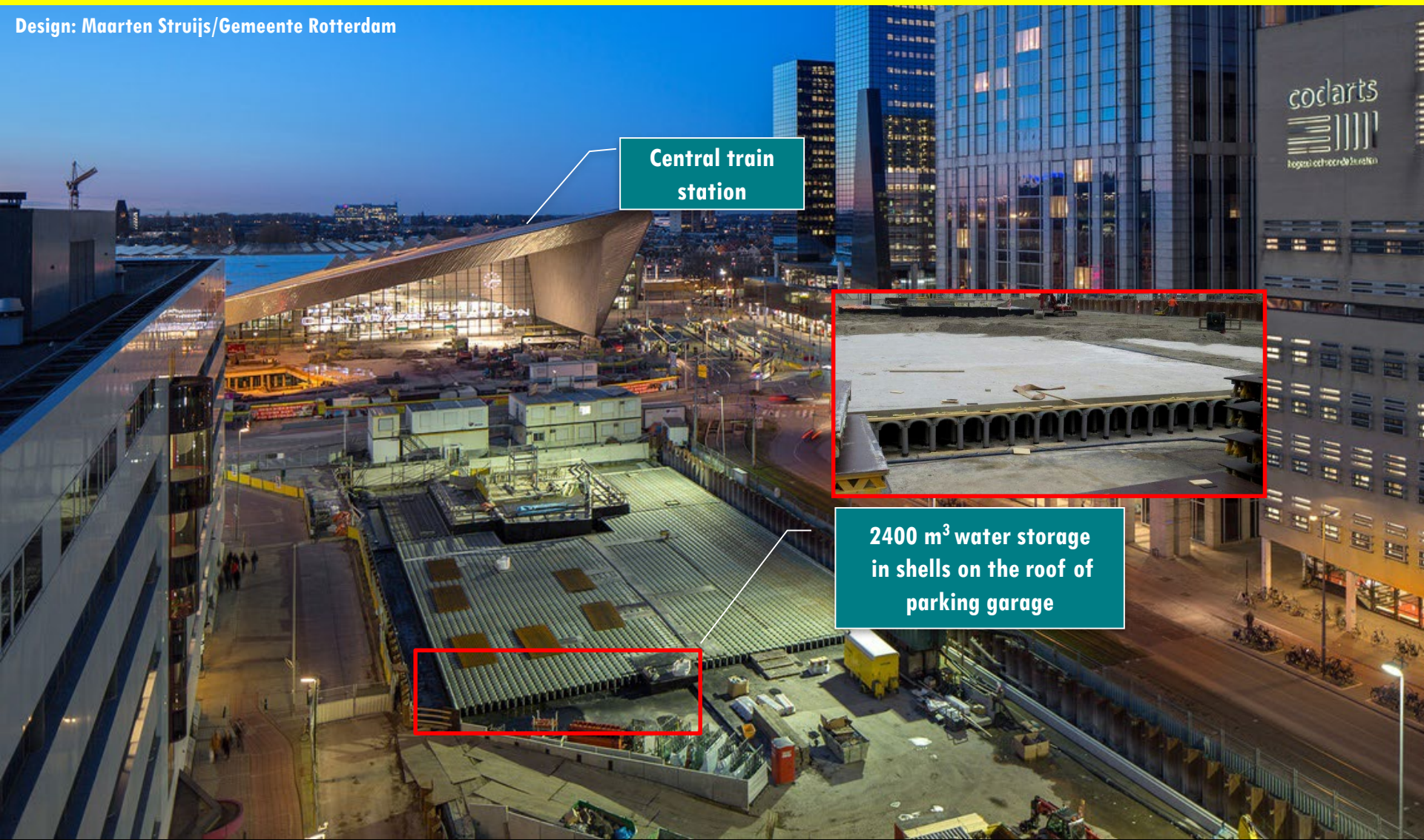
Design: Buro Sant & Co, The Hague



Rotterdam: An urban case study

Retrofitting options: Clustering

Design: Maarten Struijs/Gemeente Rotterdam

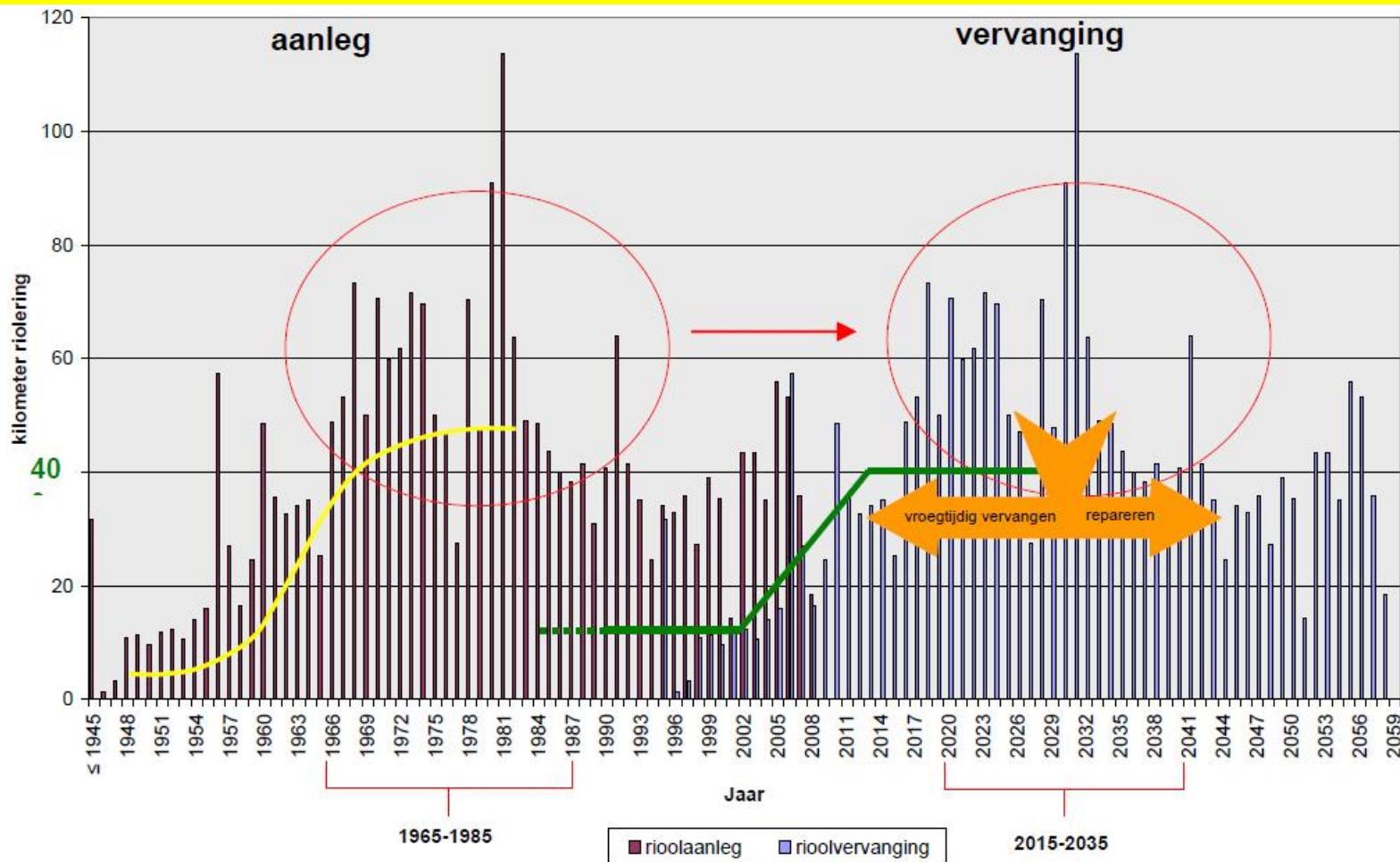


Central train station

2400 m³ water storage in shells on the roof of parking garage

Rotterdam South: An urban case study

Adaptation rate: individual



Figuur 0-1 Riolaanleg en vervanging per jaar

re
a Regi
Development

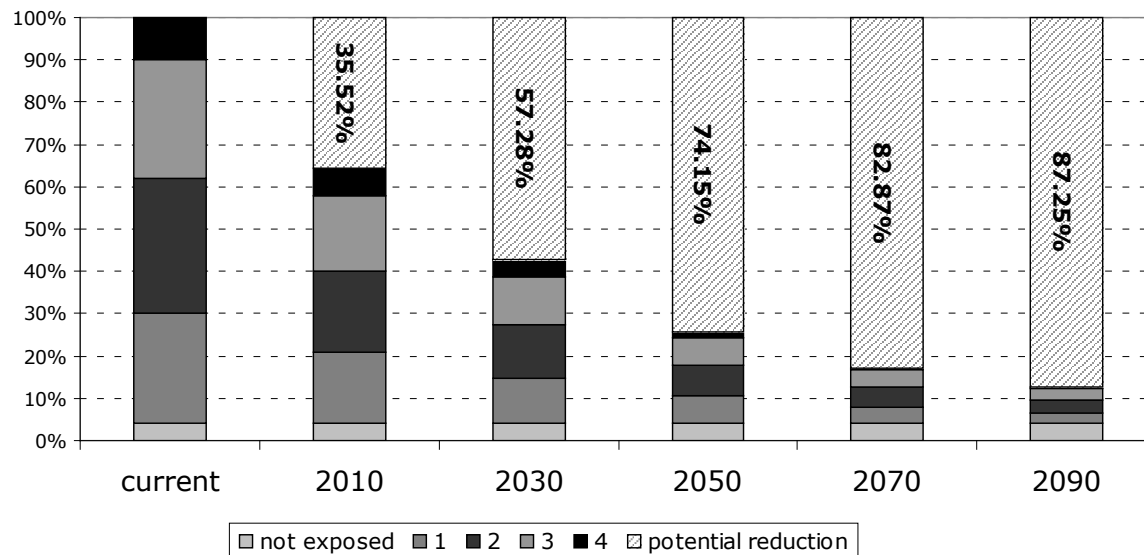
Opportunistic adaptation: NL

Opportunistic adaptation:

- What's the proportion of areas we can upgrade when waiting for the end of lifecycle?

Exposure to climate related hazards:

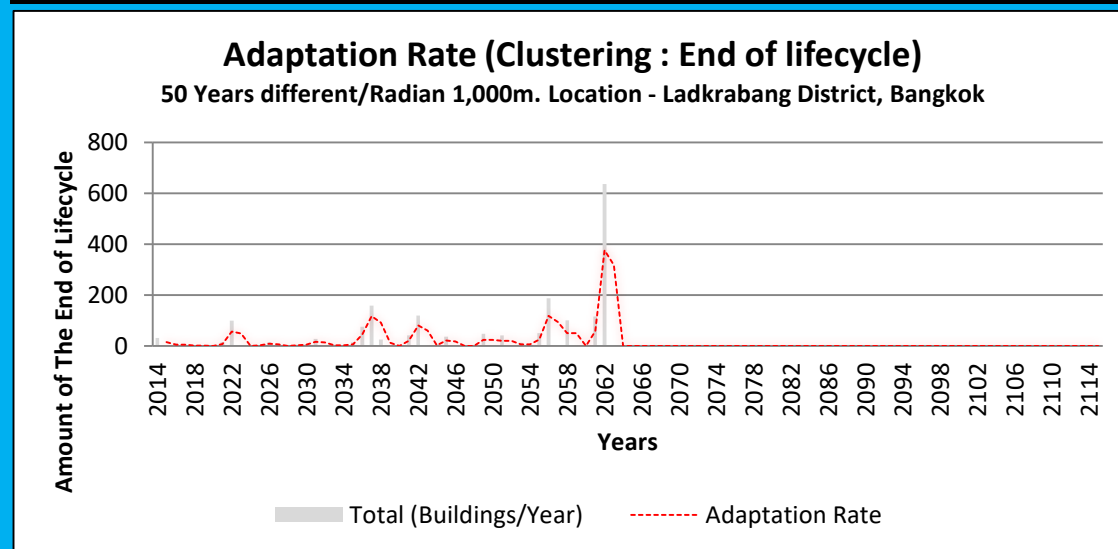
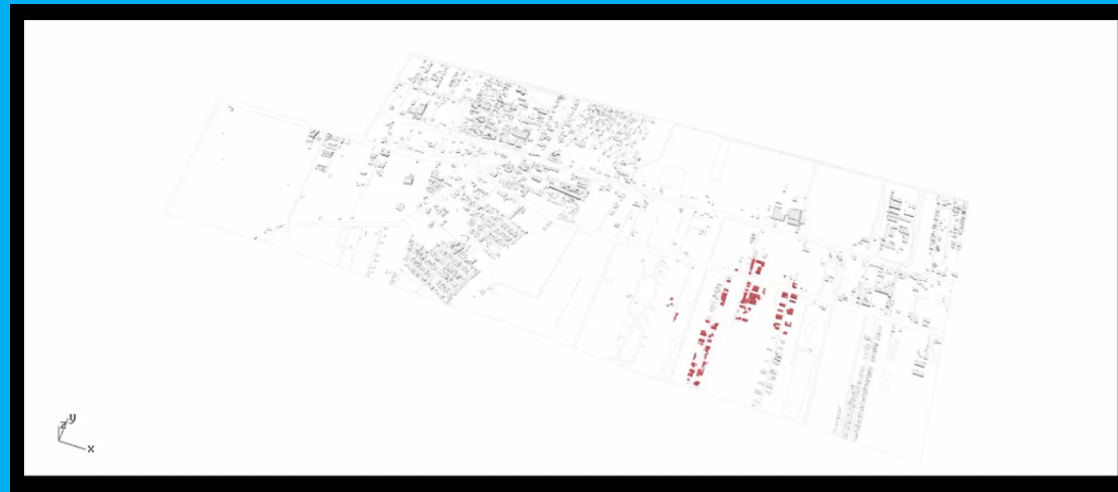
- Types: coastal & river flooding; pluvial flooding; drought; heat stress
- Cumulative exposure



Opportunistic adaptation: Bangkok

Clusters reaching the EOLC

- Large scale adaptation measures are feasible;



Nilubon, 2016

Challenges

Assets:

- Something you **own** that has value;

What's often the problem for any city?

Challenges

Assets:

- Something you **own** that has value;

So, it's difficult to rely only on opportunistic adaptation

- Offices, retail, etc: companies, institutional investors;
- Factories, storages, etc.: companies
-

Infrastructure

- Local roads, regional roads: Municipality
- Highways, trunk roads: State

Flood protection

- River dikes: state;
- Secondary dikes: waterboard

Utilities

- Power grid: Electricity utility companies;
- Water supply: Water company
- Drainage network: Municipality
-

Challenges

Integration of components, functions

Creating multi-functional urban areas by integrating blue-green infrastructure as both environmental functions (e.g. parks) as well as stormwater management



Challenges

Opportunistic Adaptation: Challenges because of Integration

Manageability

- What are the components?
- Multi-benefits;
- Multi-stakeholder;

Monitoring and evaluation

- Performance is not always easily measurable;
- Multi-hazard approach (e.g. flood & drought management): multiple standards

Technical issues

- What is the construction age, i.e. knowing your assets;
- Lifespan: technical, functional, economic, etc.;
- Maintenance and redevelopment strategy: often piecemeal;
- Rational approach to redevelopment;

Conclusions

Opportunistic Adaptation: Challenges because of Integration

- Opportunistic adaptation is inevitable;
- Yet, more systematic approach is highly desirable;
- Benefits can only be assessed at large scale over longer periods;
- Still in its infancy;

Part 2: Field Trip

Water square, Multi-functional peak storage, Rotterdam, Netherlands



Part 2: Field Trip

Multi-functional water detention

URBAN FLOODPLAIN

