Naturally,
A Port City Often Shrinks

Nature-based adaptation
for Wadden Sea Den Helder coast

Yi-Chuan Huang
TU Delft Urbanism Master Thesis

Naturally, a port city often shrinks.
- Nature-based adaptation for Wadden Sea coast.

Author: **Yi-Chuan Huang** (4622650)
Y.Huang-18@student.tudelft.nl

Delft University of Technology
Faculty of Architecture and the Built Environment
Department of Urbanism

MSc Thesis Report as part of,
Delta interventions Studio 2017-2018
North Sea – Landscapes of Coexistence

First mentor: Fransje Hooimeijer
Second mentor: Taneha Kuzniecow Bacchin

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Delft, the Netherlands

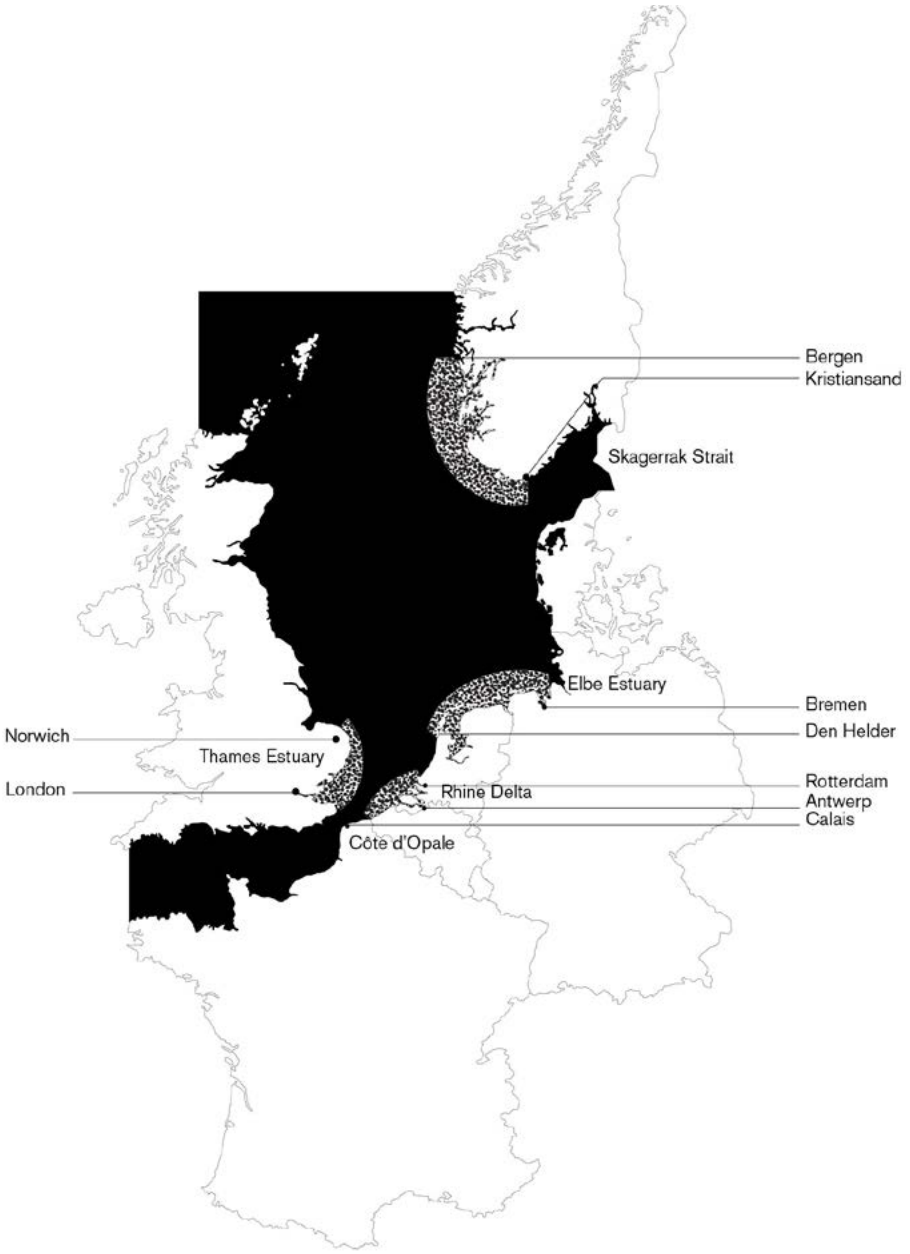


Fig. North Sea research field of
2017-2018 Delta Interventions studio.
(credit: D-i Studio 2017-2018)

Preface

Wadden Sea heritage, the world largest intertidal marshland, is the most valuable natural capital for coastal development. Nevertheless, for decades, many cities along Wadden coast have been shrinking, and been exposed to climate change.

The highest decline falls in Den Helder, The Dutch Northern tip small port city. Each day tourists transit through the port to Texel, but leave no impression on the grey city. People of Den Helder gradually lost faith in the dominated port industry, seeking for steadier forces to pilot their revitalization.

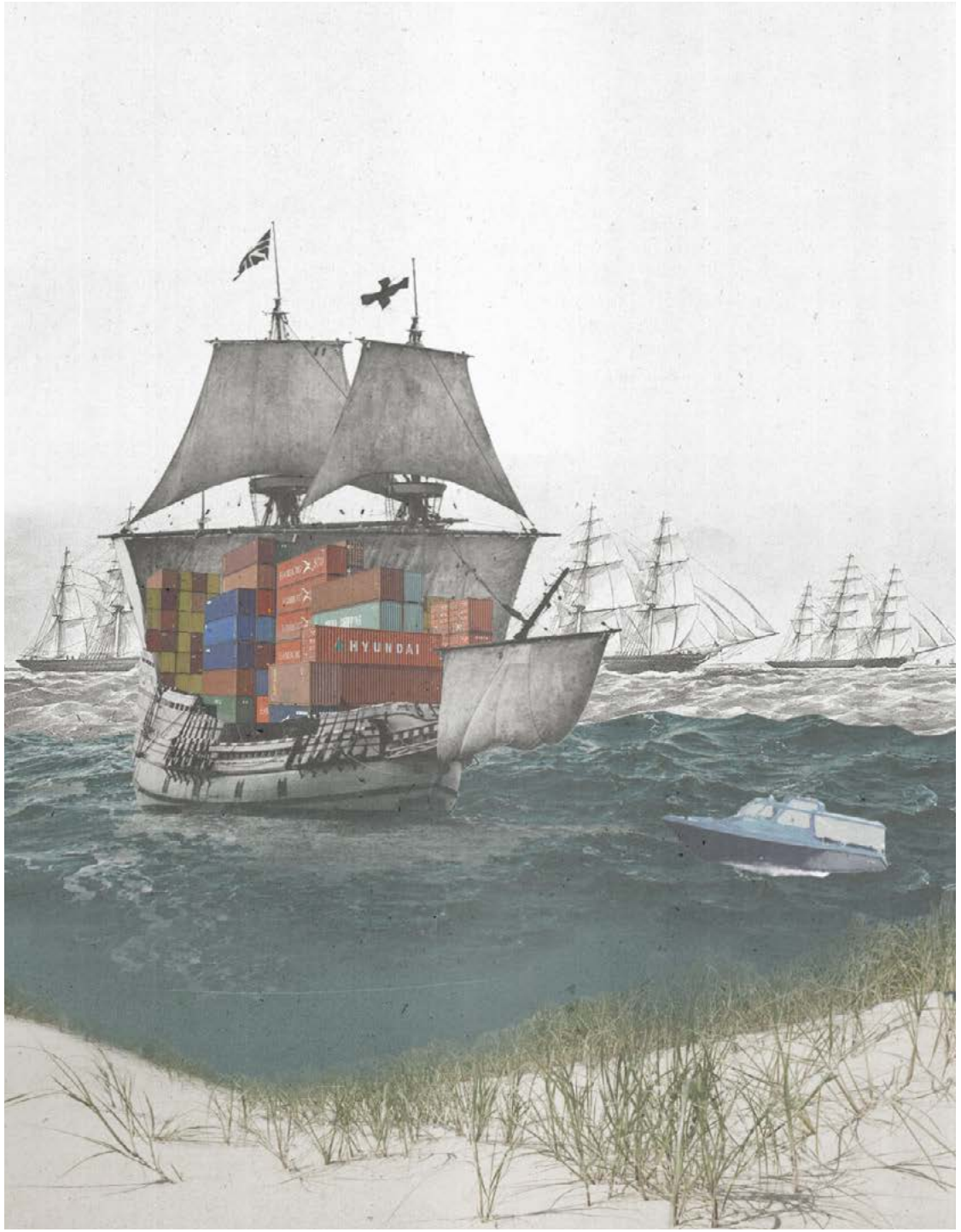
We climbed up the 9m tall rigid sea-dike, looked beyond the border, and there we realized that no force is as endless as the sea, "What if we cooperate with Wadden sea..."

This project documents the fall and rise of Den Helder. The story starts from the shrinking situation and soon proceeds to a catastrophic ending by flood. But after then we backcast a new pathway and start over again. By cooperating with natural system, this time we start strengthening risk adaptability earlier and invest a trade-off between economic development and ecosystem conservation.

Contents

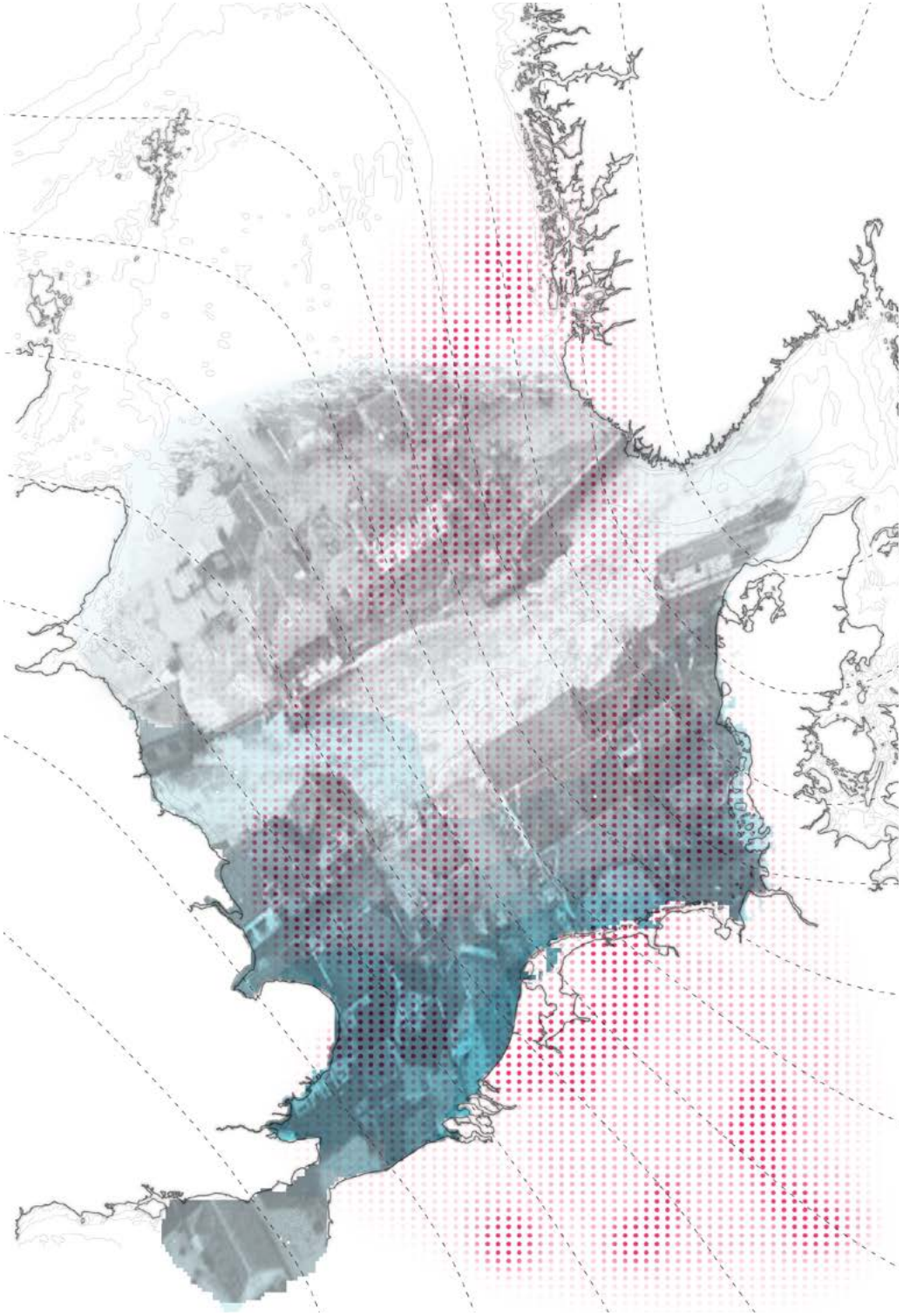
Chapter 1

Raised by North Sea,
Sunk by North Sea

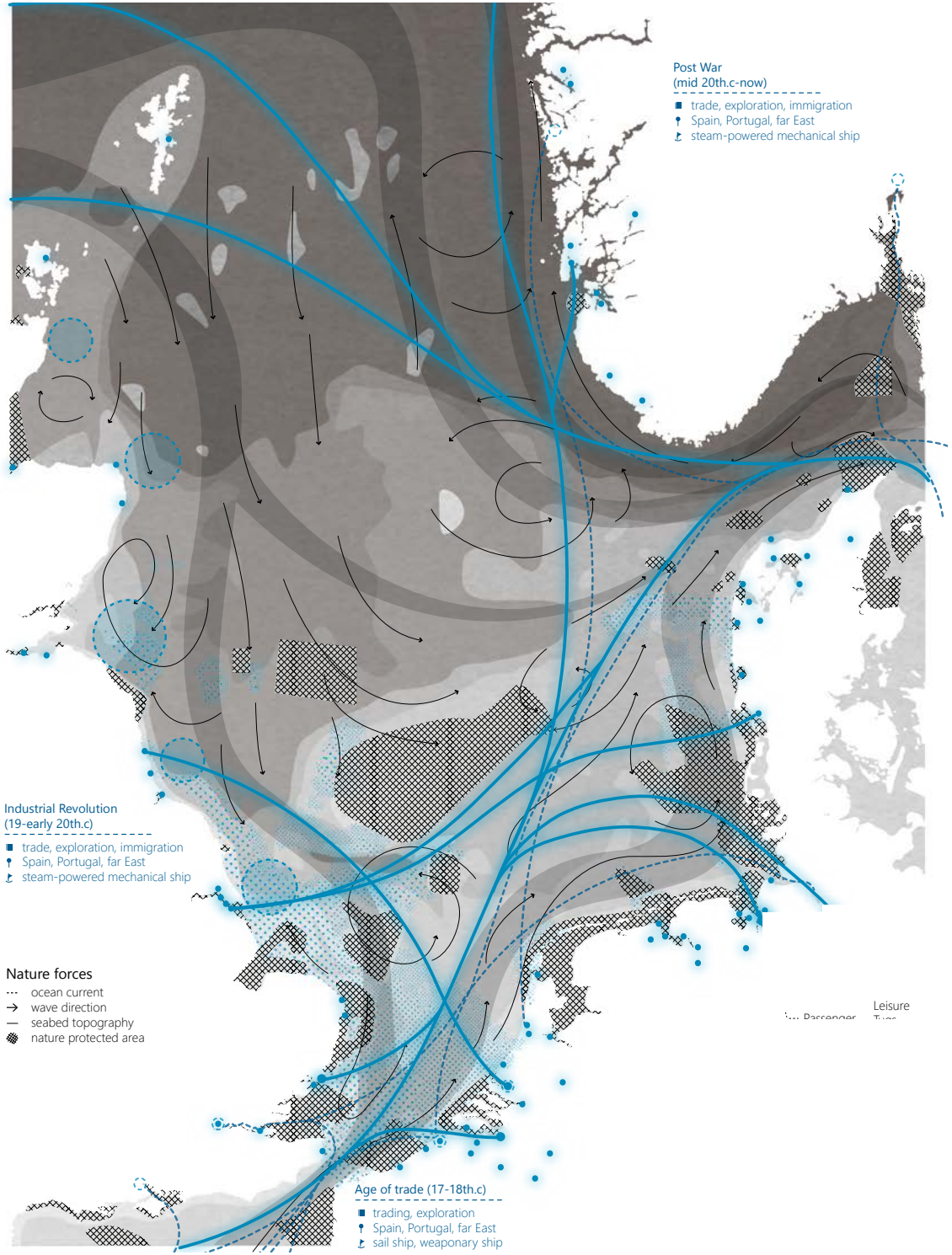


Surging force of North Sea

Representative occurence pattern of flood-producing storms in the North Sea



--- Isobaric topography
— Bathymetric
Probability of storm surge occurence
1953 storm surge influence



Carrying force of North Sea

Shipping network portrait economic
depandancy of coastal urbanization
on marine dynamics.

Shipping activity

- Post war shipping route
- Post war main harbor
- World War main battle field
- 17th.c trading route
- 17th.c main harbor

Nature system

- Ocean current
- Wave direction
- Nature protected zone
- Sediment

1916 Flood

1953 Flood

2007 Flood

2012 Flood

NORTH SEA STORM SURGE

A Recurring Natural Hazard

In 1953, a catastrophic North Sea storm surge ruined the Northwest Europe's coastal. Floods covered 9% of Dutch farmland, killed 2000 people and damaged 47300 properties. 60-years later, in 2012 December, a storm of similar magnitude hit the Netherlands, over 2800 properties were flooded. In terms of reduced damage, Dutch flood defense measures taken after 1953 can be considered a success.

However, it is certain that dramatic storm surge will happen again and again. According to bathymetry and funnel shape of the North Sea, storm surge flood is a natural reoccurring event. Isobaric tracks that push cyclones down to the Dutch coast occur approx. once every ten years (Rijkswaterstaat, KNMI 1961). Facing unexpected threats of climate change, no defensive construction can guarantee us a sustainable homeland.

NORTH SEA URBANIZATION

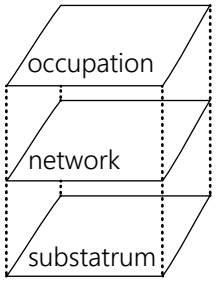
A Shifting Economy

Throughout history, the North Sea has played an important role in European urbanization. Coastal cities are gifted with marine resources and strategic location. Competitions of trading territory and exploiting logistic technology boost a rapidly shifting economy climate. The Netherlands is particularly a big player benefitted since the age of trade to current drilling and cargo industry. However, as fossil market recessing and on-land transport dominating urbanization, a structural change of North Sea economy is expected soon.

Urbanizing in Dynamics

The dominant power of sea has manifested itself in the rapid rise and fall of port cities. Through the lens of North Sea as joint base for natural and territorial dynamics, the Delta Interventions Studio explores innovative forms of coexistence.

3x3x3 model is an useful tool to unfold complex interactions between urbanization, landscape dynamics and time. The spatial configurations are organized into three layers: natural layer of ecology and environment (substratum), network layer of infrastructure, occupation layer of settlements and industry. The layering of changes at three chosen ages reveals their interrelations.



Age of trade (17-18th.c)

- Fishery, trading, exploration
- Spain, Portugal, far East
- Sail ship, weaponary ship

Age of Industry (19th.c-World War)

- Immigration. Battle
- US. British and German coastline
- Steam-powered ship,. War ship, submarine

Age of Energy (post war -)

- Cargo. Energy (oil, gas, wind farm). Leisure
- China, Russia. North Sea coastal
- Container ship. Drilling ship. Ferry

PORT CITIES
A HIGH RISK INVESTMENT

Homogeneous economy under multiple risks

Along the coastline hundreds of ports and cities have been raised to facilitate exploitation. But once the dominating port economy encounters recession, cities collapse significantly. Rapid shifts in trading economy and logistic technology challenge the adaptability of traditional port cities. Today, under the threat of climate change, port-dominated development becomes rather unsustainable.

SHRINKING Port Cities:
at the forefront of Flood Risk & Economic Shift

Common main causes of shrinking port city

- Maritime industry, logistic recessed
  (economy structure too homogeneous)
- Environmental restrictions
  (siltation, natural protection, climate risk)
- Marginalised in on-land transport network
  (low accessibility, distance to urban core)
- Technology advancement
  (limited infrastructure to cope with new, larger marine technology)

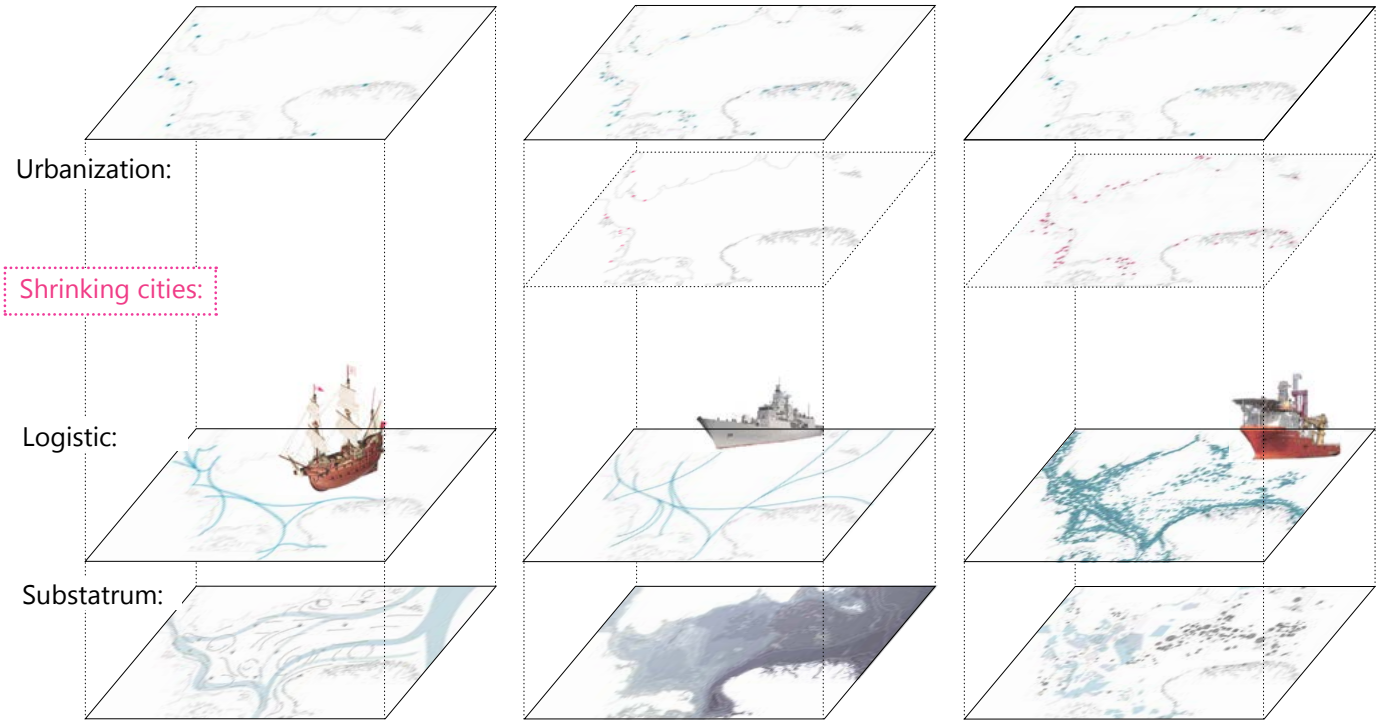


Fig. 3 Ages x 3 Layers

Three active shipping periods are chosen to explore major changes in economy (shipping destination, purpose), technology (ship types) and their relation with substatrum (current, wave, sediments). Strong correlations are revealed in **the way human leverage natural forces and shift of coastal development** (urbanizing or shrinking).

Paramor, O.A.L., Allen, K.A., AanesenC.L.J. (2009) MEFEPO North Sea Atlas. University of Liverpool. ISBN 0 906370 60 4 Wrecks. (n.d.). Retrieved October 03, 2017, from http://www.noordzeeloket.nl/en/policy/noordzee-2050/wrak-ken-noordzee

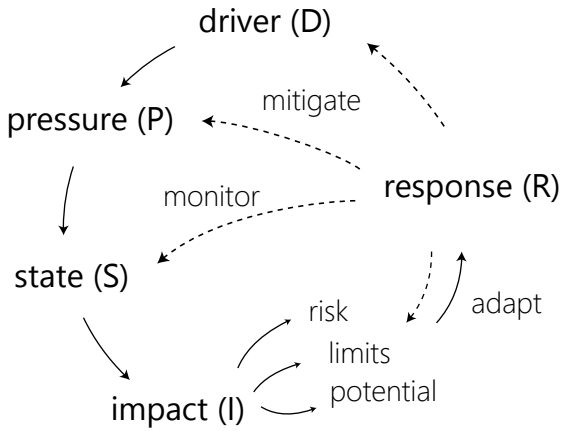
The need to cope with two faces of sea

Coastal zones are among the most vulnerable areas to climate change and natural hazards, but also provide the most productive ecosystem services to carry 200 million European citizens. To sustain well-being and economic viability, it is essential to integrate risk management and environmental protection in urban development "Coastal zone spatial planning should be established on the basis of ***integrated coastal zone management,*** and that coastal defence and sea level rise should be duly considered. The challenge is to provide good information on flood risk in the process." (CPSL, 2010)

Approach: DPSIR Framework

DPSIR is a ICZM decision-support framework proposed by European Environment Agency (EEA, 2007). It examines interactions between society and the environment through the cycle of driving forces (D), pressures (P), states (S), impacts (I) and responses (R).

The framework regards risks as pressure driving changes on current state to evaluate possible environmental and societal responses to these changes (Smeets and Weterings, 1999). It is often applied to **analyze human-environmental interactions and impacts under pressure from climate change.**



Integrated Coastal Zone Management

"ICZM seeks, over long-term, to balance environmental, economic, social, cultural and recreational objectives, all within the limits set by natural dynamics."

-- EU. (2013). Maritime Spatial Planning and Integrated Coastal Management.

CPSL (2010) CPSL Third Report. The role of spatial planning and sediment in coastal risk management. Wadden Sea Ecosystem No. 28. Common Wadden Sea Secretariat, Trilateral Working Group on Coastal Protection and Sea Level Rise, Wilhelmshaven, Germany.

Dijk, J. V., Broersma, L., & Mehnen, N. (2016). Options for socioeconomic developments in ICZM for the tri-national Wadden area. Ocean & Coastal Management, 119, 76-92. DOI: 10.1016/j.ocecoaman.2015.10.004

Chapter 2

Dilemma of port city development

Exploitation

Den Helder is the intersection of Dutch land and sea (Exclusive Economic Zone, wind farms)

Conservation

Den Helder is surrounded by Wadden Sea tidal zone - the downstream sediment basin of North Sea and River Rhine.

2.1 Problem field

WADDEN SEA DILEMMA

In the Netherlands, Wadden Sea coastal cities are particularly sensitive to economic shift and environmental change, regarding to the delicate **coexistence of protected tidal ecosystem and port-initiated urbaniazation.**

UNESCO World Heritage. The largest unbroken system of intertidal sand-mud ecosystem.

-- Declared by EU (2009) and protected by Trilateral Wadden Sea Plan 2010 (Danish, Germay, Netherlands).

— Dutch Wadden Sea conserved area

Ecosystem services:

Tidal biodiversity. Wave attenuation patches

dune

slufter

salt marsh

tidal flat

seagrass bed

oyster bed

World Heritage Nomination Group 2008; UNESCO2009
Trilateral Wadden Sea Plan (WSP). 2010

Exploitation & potential

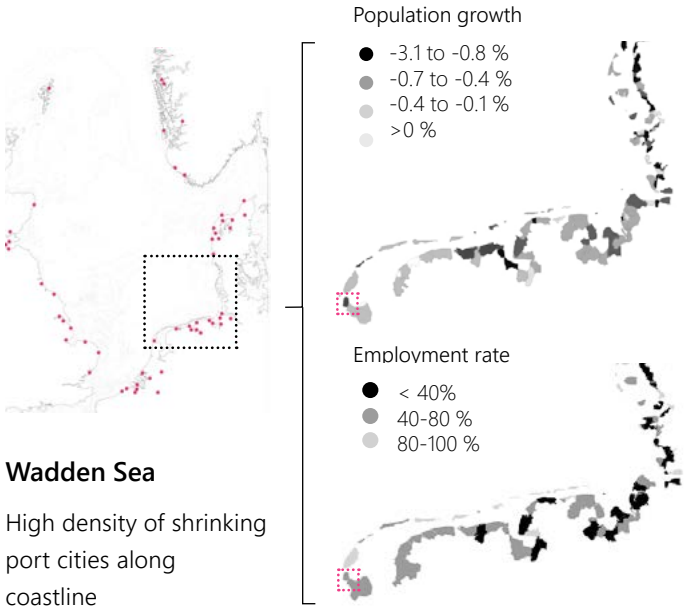
In Dutch Golden Age, shipping logistic flourished the Wadden Sea coastal region. A sequence of barrier islands absorbs the wave energy and draws a safe buffer for coastal settlements. The intertidal marshland preserves high biodiversity and heterogeneous habitats. It becomes valuable natural capital supporting coastal urbanization and various industries such as energy.

Conservation & limitation

Since 1978, coastal development at Wadden region has been limited by EU and Trilateral Wadden Sea Cooperation, in order to reduce disturbance on the precious habitat. Nations are obliged to protect the tidal ecosystem, ranging from complete transition zone of saltwater to sweet water.
Coastal activites, including fishery, industrial facilities, ports and maritime traffic, residential and tourism development and climate change, are all regarded as potential threats.

Shrinking Wadden cities

Today, Wadden Sea coastal development encounters severe recession. Port cities are compulsary to go through transformation within low environmental impact.



Wadden Sea

High density of shrinking port cities along coastline

SWOT analysis of Wadden port cities:

Port cities at Wadden Sea region in general | *Den Helder specific*

Strength

- Well developed infrastructure
- *Strong identity (historic town, royal navy)*
- ***Rich ecological asset (Wadden Sea)***

Weakness

- Industrial
- **Monotonous economic structure**
- *Shrinking city*
- *Robust sea dike blocks natural quality*
- *Outside Ranstad metropolitan area*

Opportunity

- **Offshore energy development**
- Rich marine ecosystem resources
- *Lower land use intensity*
- *Good connection with Texel tourism*

Threat

- **Global maritime industry recessing**
- **Climate change rises environmental risk**
- *Sedimented harbor*
- *Subsidence of land*

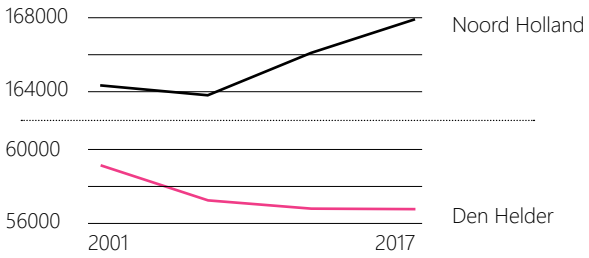
Prognose 2017-2040 bevolking,huishoudens en woning. (2017). Noord-Holland Provinvie

2.2 The worst case

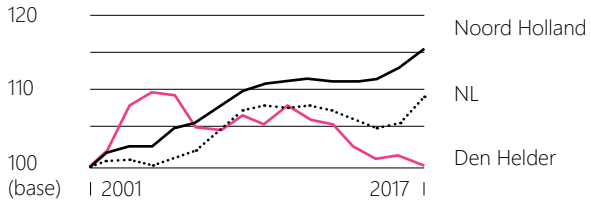
Den Helder and Balgzand bay

Den Helder is the city of the highest shrinking rate in the Netherlands for a decade already. It's also the Northern tip of the Dutch North Sea coast. Its strategic location for navy base and marine logistic once brought prosperity to the city, especially during post-war reconstruction phase.

Declining population growth



Declining employment rate



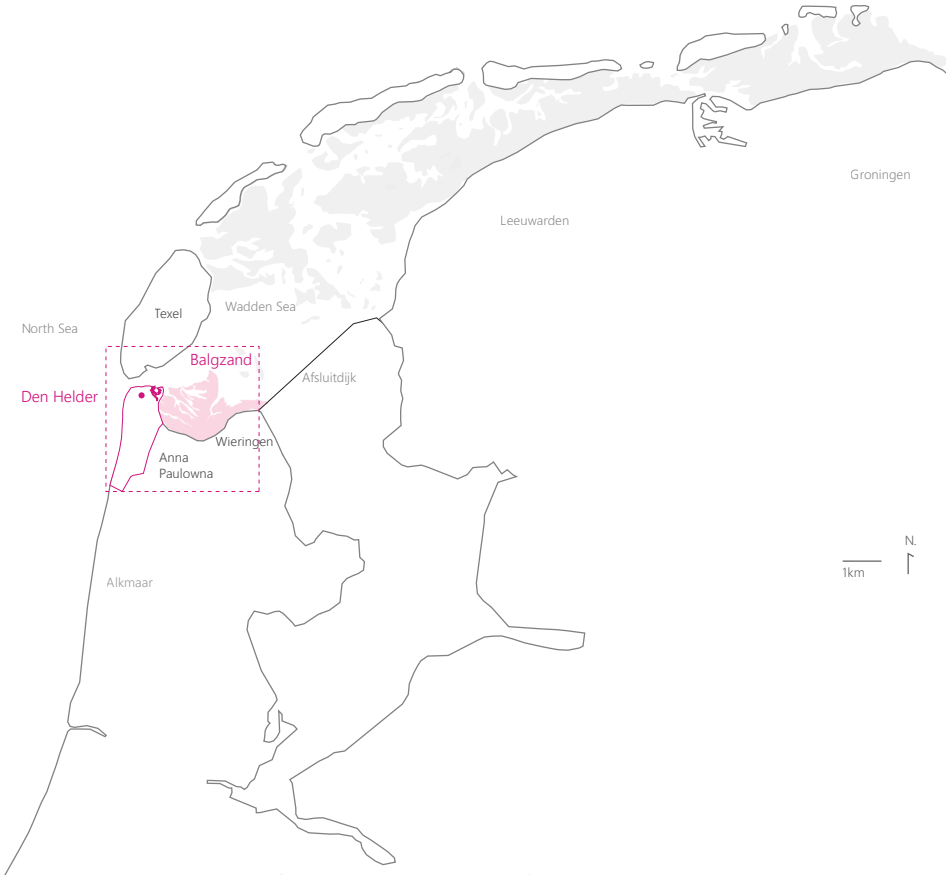


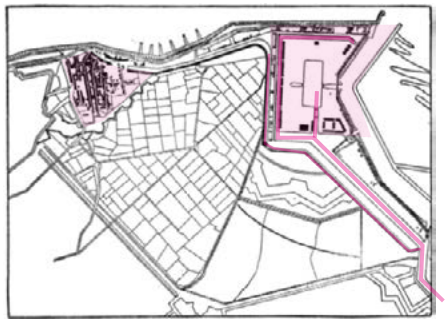
Fig. Den Helder and Balgzand bay is located at the Northern end of Dutch North Sea coastline and Southern tip of Wadden Sea.

Chart data from:
Prognose 2017-2040 bevolking,huishoudens en woning. (2017). Noord-Holland Provinvie

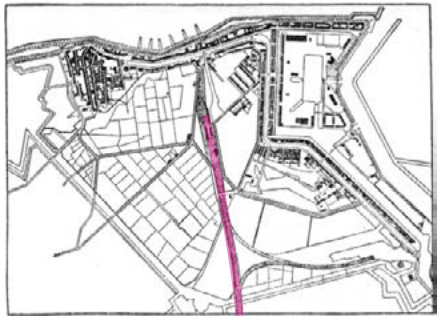
[1699] Fortification+seadikes, dunes piling.
Meadow polders' structure and water tower are still identical in current city.

current seadike - - former dike
current main road

[1830, 9k p.] Old Helder central at Northwest.
North Holland Canal and haven in construction.



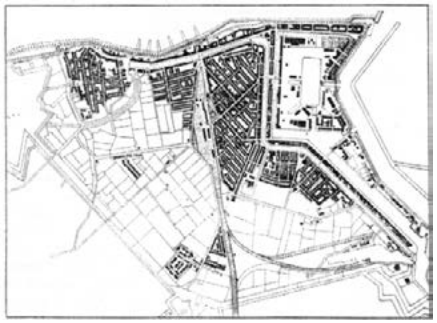
[1860] New railway extend to the city.
Canal connection to Amsterdam boost economy.



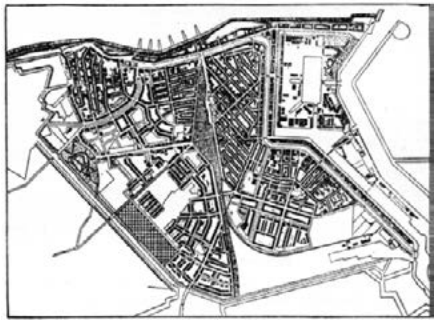
[1880] Densification between station and port.
Maritime industry dominated.
Urban form has been fixed since then.

Fig. Morphological evolution of Balgzand environment & Den Helder city central

The urban expansion pattern reveals a high dependancy on the port, canal and railway infrastructure.



[1900, 20k p.] Expansion on back side of station and outskirt. Residential area at harbor has reached full capacity.



[1940, 38k p.] Compacted inner fort area. Railway has become an obstacle between both side of city traffic.

[1960] post-war reconstruction. Navy base regnerated port economy.

+2.24 %/y

[1970] Outer fort neighborhood expanded due to maritime industry and navy port.

[1980] Population peak: 62k p.

-0.65 %/y

The rise and fall of Den Helder

Den Helder has a very strong maritime past that can be traced back to the fortification by Napoleon. After bombing attack during WWII, only 10.000 inhabitants were left. Thanks to the settlement of Dutch Navy base, the population increased with a 1.000 people/year during the 70s. Since then, marine and offshore industries has been dominated the city. However, as Dutch maritime economy and logistic declined, the drop of population has never stopped ever since the 80s. Outsiders often consider it a grey city, with a constant strong wind blowing through boring streets.

Recently, policy makers are focusing on Den Helder's 'DNA': branding the city as 'Den Helder at Sea', to profit from its unique location and its historic past for tourism, such as the renovation of harbor monuments and renovation of railway zone. On the other hand, investment in offshore service knowledge port and marine-related renewable energy is suggested by national reports.

Jan E. Jan S.(2016) Europese Chimer project. http://www.hansonline.eu/den_helder/
Helders Marinemuseum Archives
CBS population data (2017)

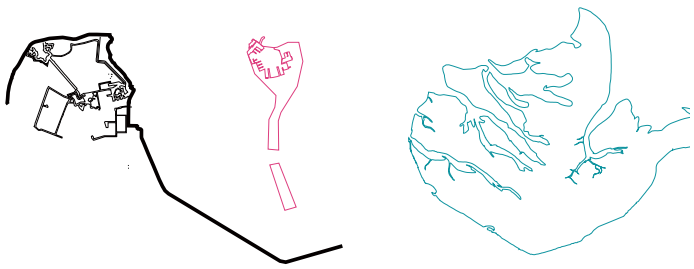
Jolien Groot.(2013). Shrinking Den Helder: The Dutch Detroit at Sea?. http://theprotocity.com/shrinking-cities-the-curious-case-of-den-helder/

2.2 The worst case

Dead End Coastline

Economic shift and environmental change are transcalar and interdependent challenges particular for shrinking port cities.
However, socio-economy and marine ecosystem are usually rigidly blocked off and addressed by segregate parties.

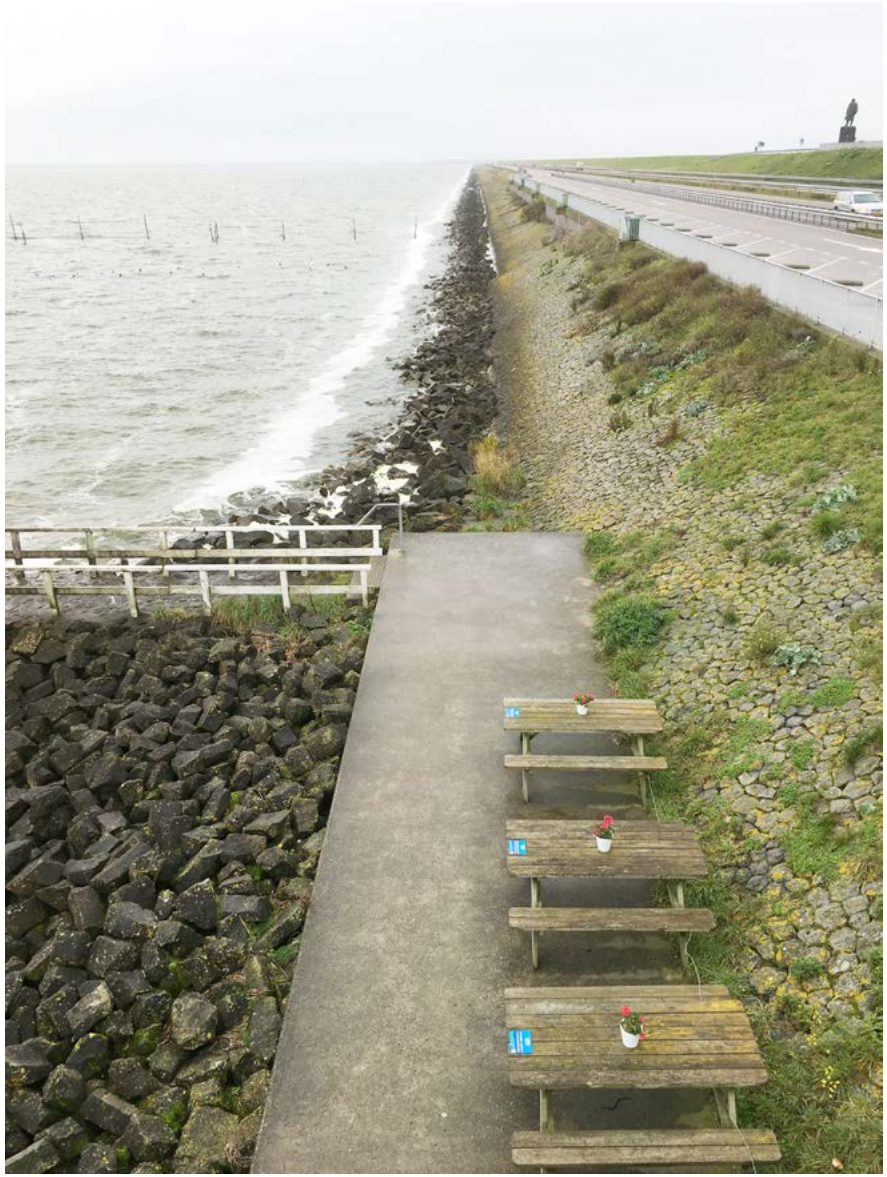
Fig. Wadden Sea development, Den Helder coastfront and Den Helder Port are three distinctly seperated agendas.



Wadden dike reinforce agenda

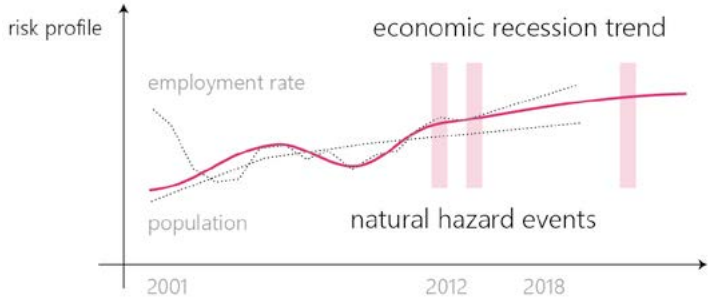
Port expansion agenda

UNESCO World Heritage PSSA fishing forbiden



Chapter 3

Den Helder in Risk



3.1 Scope of Risk

DPSIR +
TRANSCALAR APPROACH

The project integrate the DPSIR analytic framework to address risk impacts from dual driving forces - climate change and economic shift - across 3 scales- Dutch Wadden Sea, Balgzand coastal and Den Helder region.

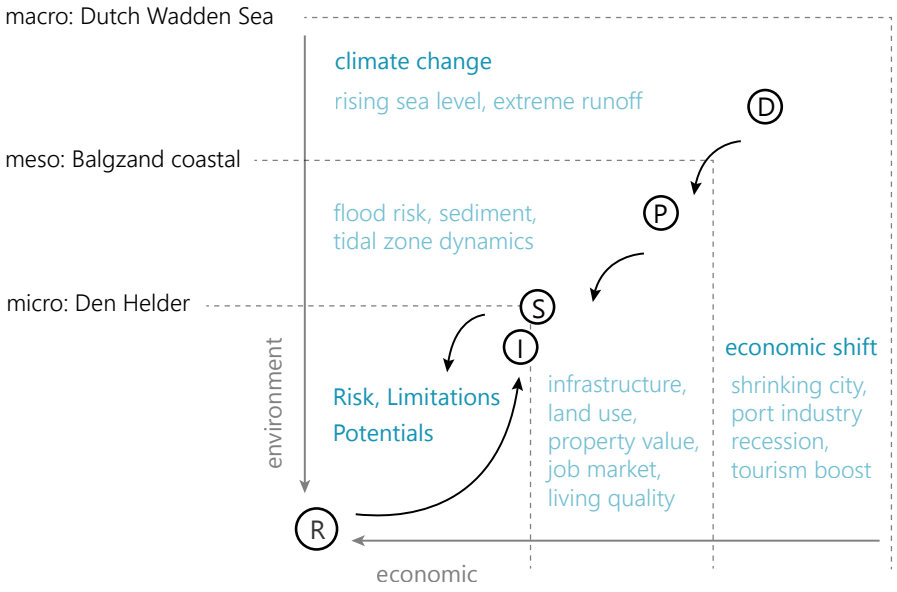
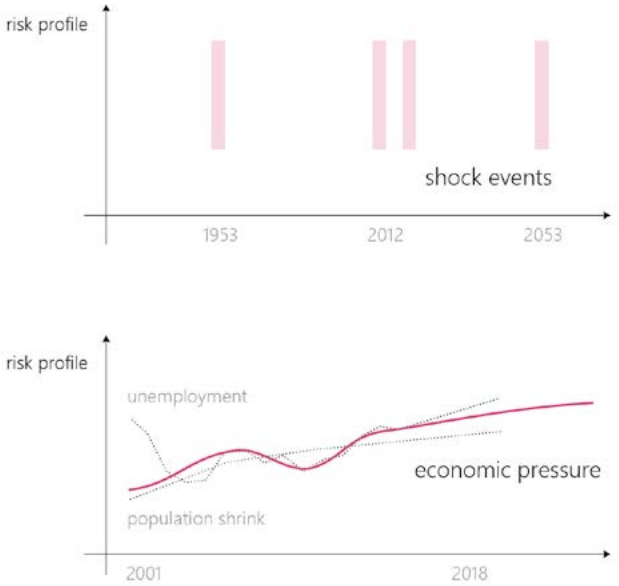


Fig. Scoping problem field with DPSIR framework (by author)

Coastal risk management:

Address short-term shocks + long-term pressure



3.2.1 Pressure: Environmental change

MAN-INTENSIFIED FLOOD RISK

Closure of Afsluitdike + Rising Sea Level

After the closure of the Zuiderzee in 1932,
tidal range in Marsdiep basin has enlarged and raised the flood volume significantly (30%). Increase of tidal velocity leads to higher sand import capacity, causing erosion of the outer delta and the adjacent coasts. Ebb volume increases due to fresh water from Ijsselmeer through the dam, especially when Wadden Sea is at a lower tide in the summer.

Dutch coast average sea level rose to +11 cm NAP, the highest record before 2017.
-- Deltares, Jan 2018

In long term,
with 5 -10 mm/year sea level increase,
the inner channels will become deeper which results in less flow resistance and larger flow velocities and thus a larger tidal prism. Also, draining of low lying hinterland will become more difficult, especially in combination with more extreme precipitation.

Sediments & Erosion

Nearly 300 million m3(mcm) of sediments were eroded from Texel Inlet's ebb-tidal delta and adjacent coasts following the closure of Zuiderzee in 1932. The morphological change intensified rotation and scouring in larger tidal channels and landward retreat. Today, erosion continues, and over 30 mcm of sand has been placed on the adjacent coastlines for compensation. The maintenance of these coastlines are the most intensive work of entire Dutch coast.

Quante & Colijn.(2016).North Sea Region Climate Change Assessment
Delta Programme Report.(2015)
Elias,E.PL.&van der Spek,A.J.F.(2017). Dynamic preservation of Texel Inlet, the Netherlands:understanding the interaction of an ebb-tidal delta with itsadjacent coast. Netherlands Journal of Geosciences

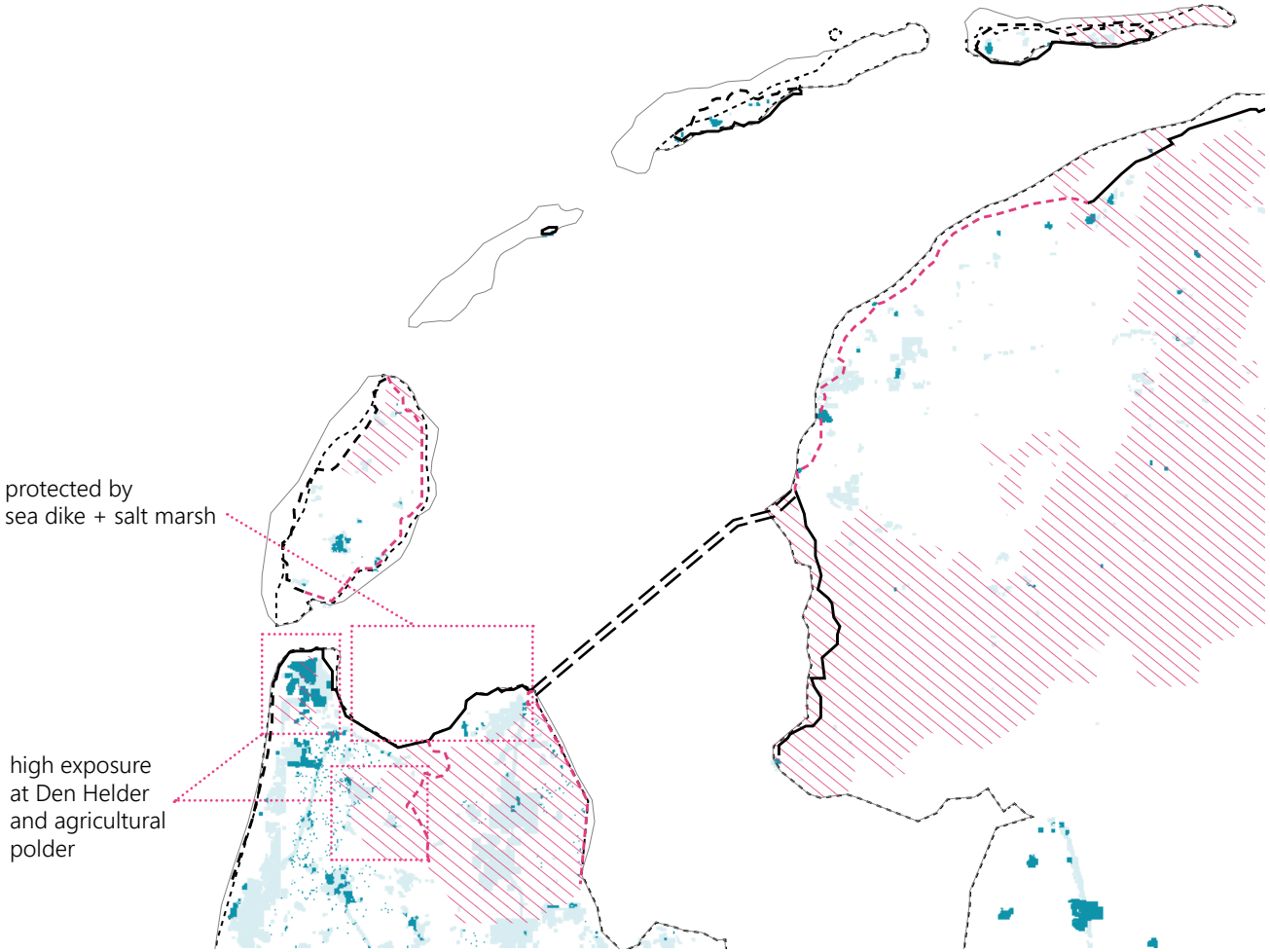
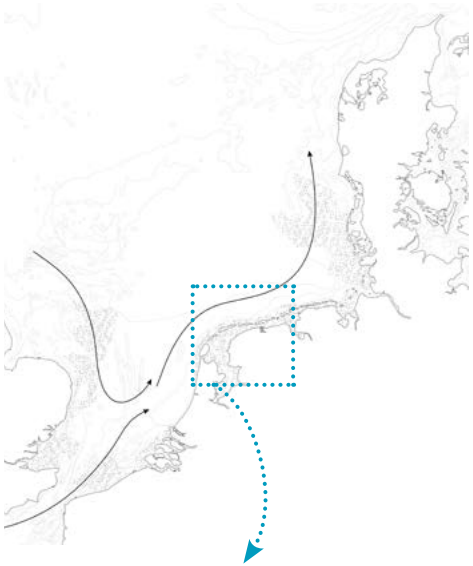


Fig. Increased flood risk due to rising sea level. Different types of sea defense structures are indicated.

- sea-defense dikes
- sea-defense dam
- sea-defense duins
- defense requires reinforcement

- areas expected to loss 2-3 mil euros if flooded
- areas expected to loss >3 mil euros if flooded
- flooded area if sea level rises 1m
- flood-prone (100 to 1000-year flood chance)



hydrodynamics + morphodynamics changes:

Higher wave height

Stronger **erosion at outer dunes**

Sediment & Erosion:

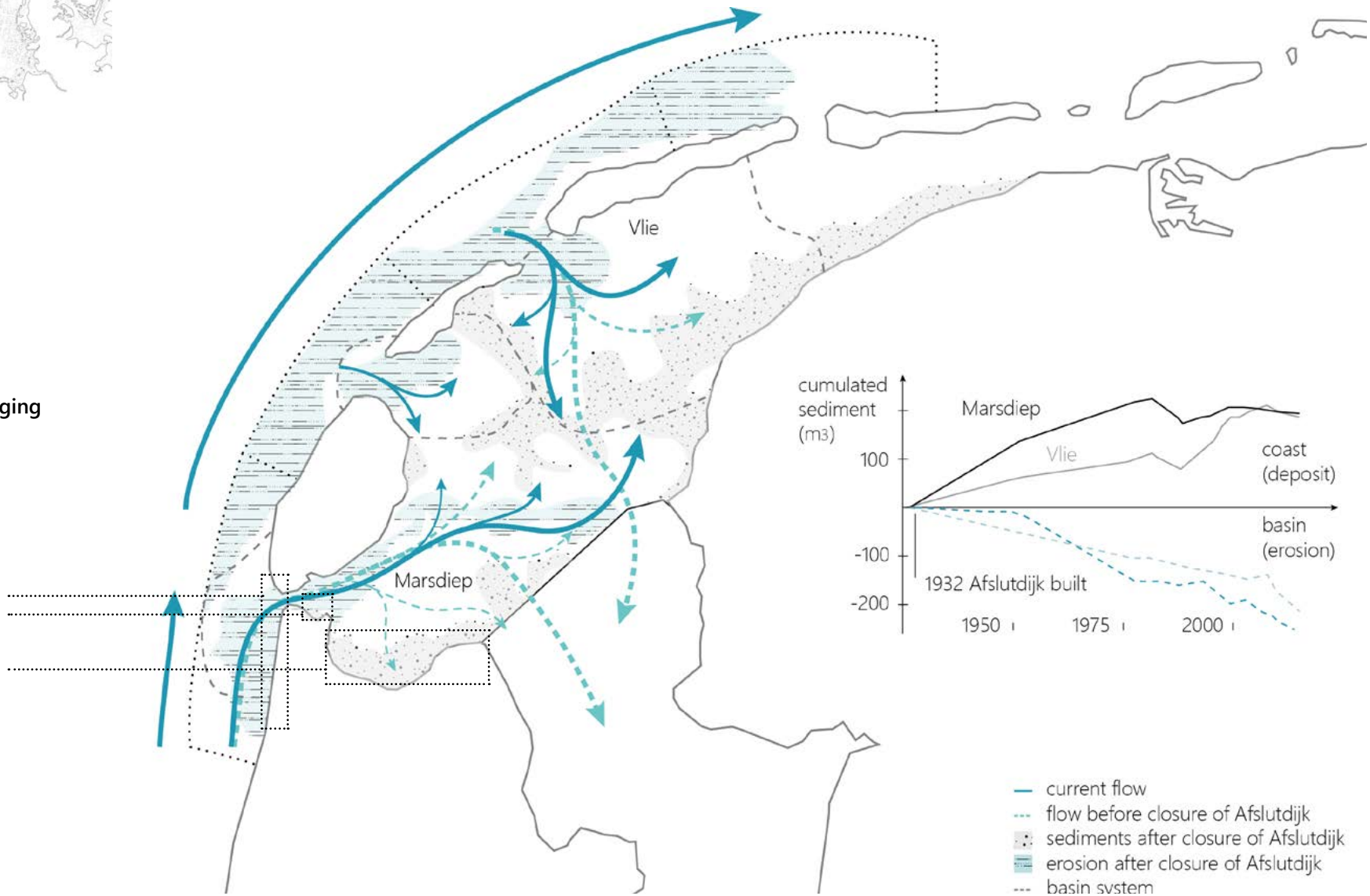
Wadden marsh erosion

Ports require frequent **dredging**

Dune: higher erosion

Port: High dredging cost

Reclaming salt marsh:
lack of new inflow



3.2.2 Pressure: Economic shift

FROM LOGISTIC HUB TO MARGINALIZATION

Den Helder is known as the main naval base of the Netherlands, an important offshore services port and the ferry pier connecting to Texel island.

Still, the port economy is significantly recessing, causing severe shrinkage of the city. Demands of maritime services for offshore renewables and Texel toursim are anticipated to regenerate the port. However, without pier expansion and sediment control and attractive impression, the contributions are very limited.

On the other hand, its environmental impact on the Wadden Sea is required to be minimized. Maritime activities and port expansion is hampered by environmental legislation. **Only if natural conservation is incorporated can Den Helder unfold its visions.**

Fig. Expansion vision of Den Helder Port. (image credit: Ontwerp Structuurvisie Den Helder 2025. (2012) Gemeente Den Helder)

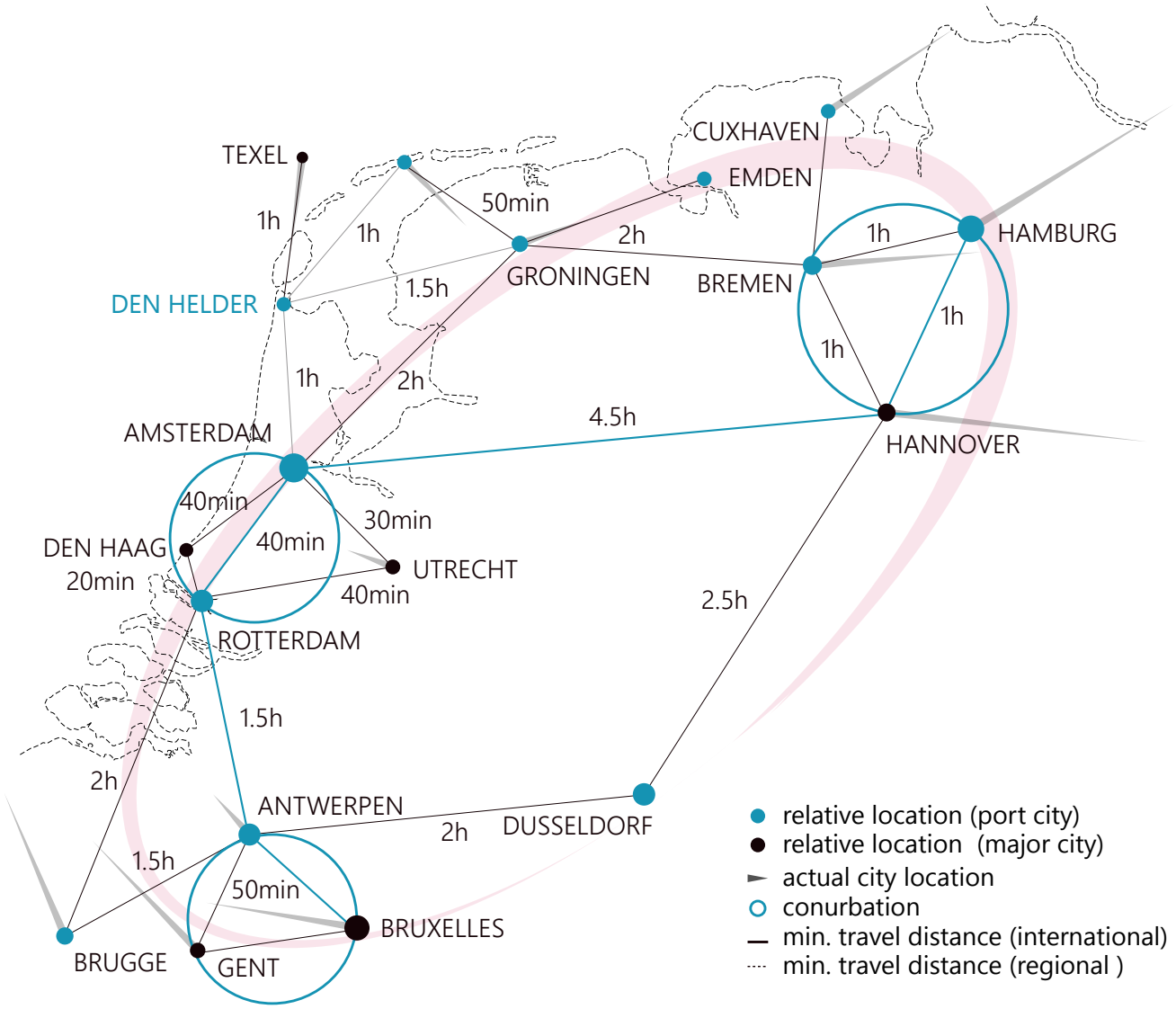
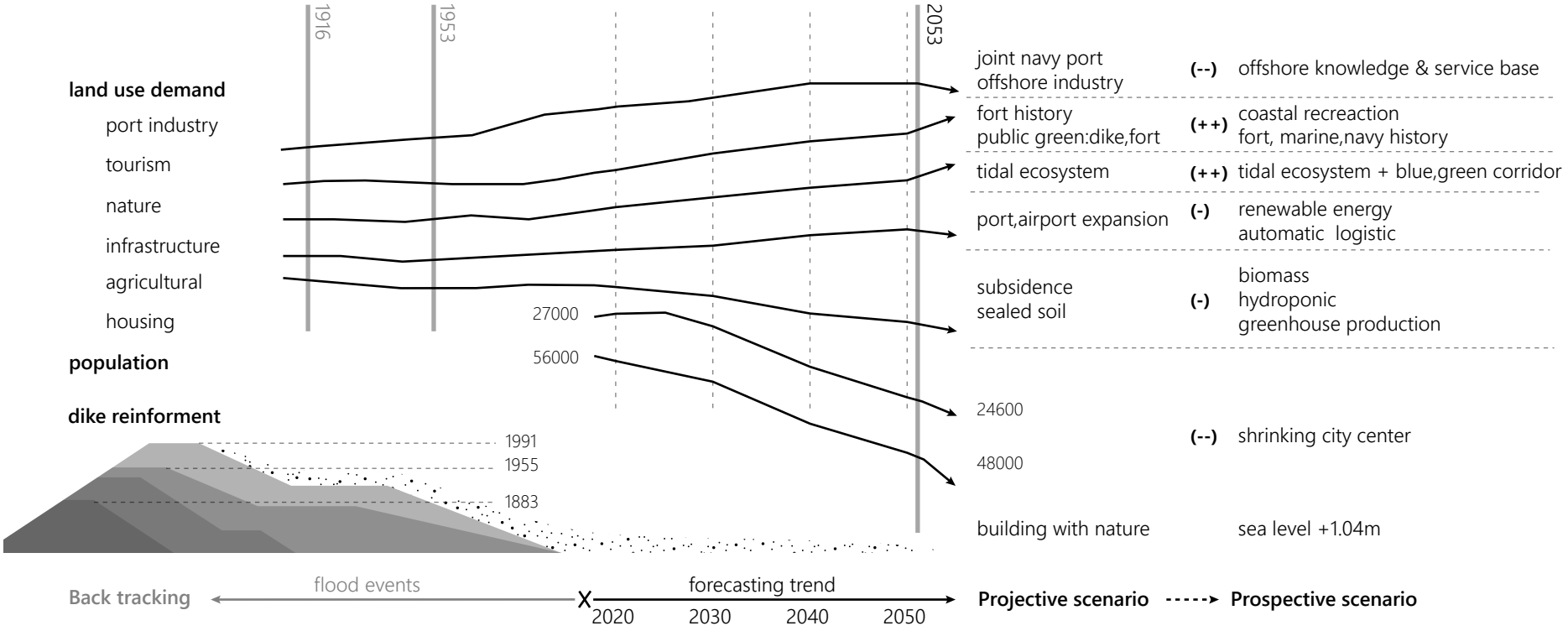


Fig. Distorted relative location of Den Helder to other cities, based on travel time.

Jolien Groot.(2013). Shrinking Den Helder: The Dutch Detroit at Sea?. http://theprotocity.com/shrinking-cities-the-curious-case-of-den-helder/

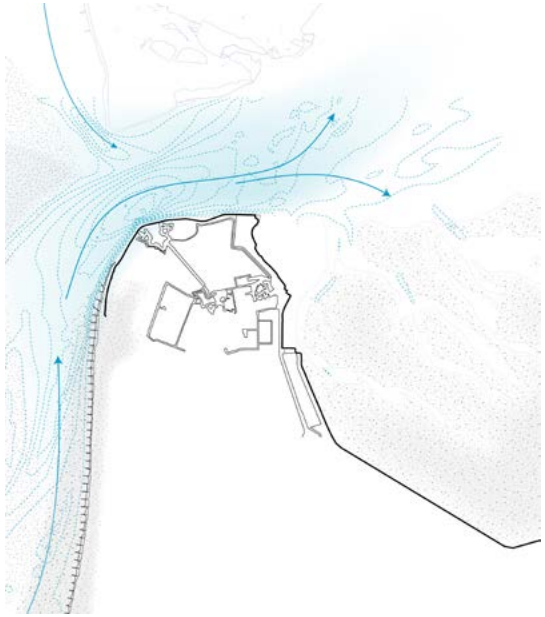
Economic recession trend:



gnose bevolking, huishoudens (2017). Sector Onderzoek en Informatie, Provincie Noord-Holland.

3.3 Status

Den Helder in 3 layers



Substatrum layer

- bathemetric
- marsh
- sea wave direction
- sea defense dike
- fort dike

Network layer

- motorway
- railway
- ferry way
- canal+port
- polder drainage+lake

Occupation layer

- commercial+residential
- commercial+port industry
- residential
- port industry
- airport
- cargo, manufacturing
- utility: waste, gas
- agricultural polder
- green: open space
- green: leisure
- green: conserve
- railway station

3.4.1 Impact: Limitations

Constrainted Infrastructural Capacity

Current infrastructures are mostly designed to facilitate marine industry and sea defense. As marine industry recessing, these rigid infrastructures have low capacity to support economic transformation.

The fact that Den Helder doesn't have highway and well connection to metropolitan region are main barrier to attract new business. For marine logistic, port expansion is required to accomodate growing size of offshore technologies.

The TESO ferry terminal in the northern tip causes a large traffic load on the shipping and unloading route. N250 is currently the only way to and from the TESO ferry port, offshore manufactories and civic port.

Limitations

- ■■ Joint touristic and port industrial traffic flow causes frequent congestion on A205.
- ■■ 8m high sea dike blocks accessibility to waterfront recreation.
- ■■■ Maritime port too shallow and small for offshore windfarm construction ships

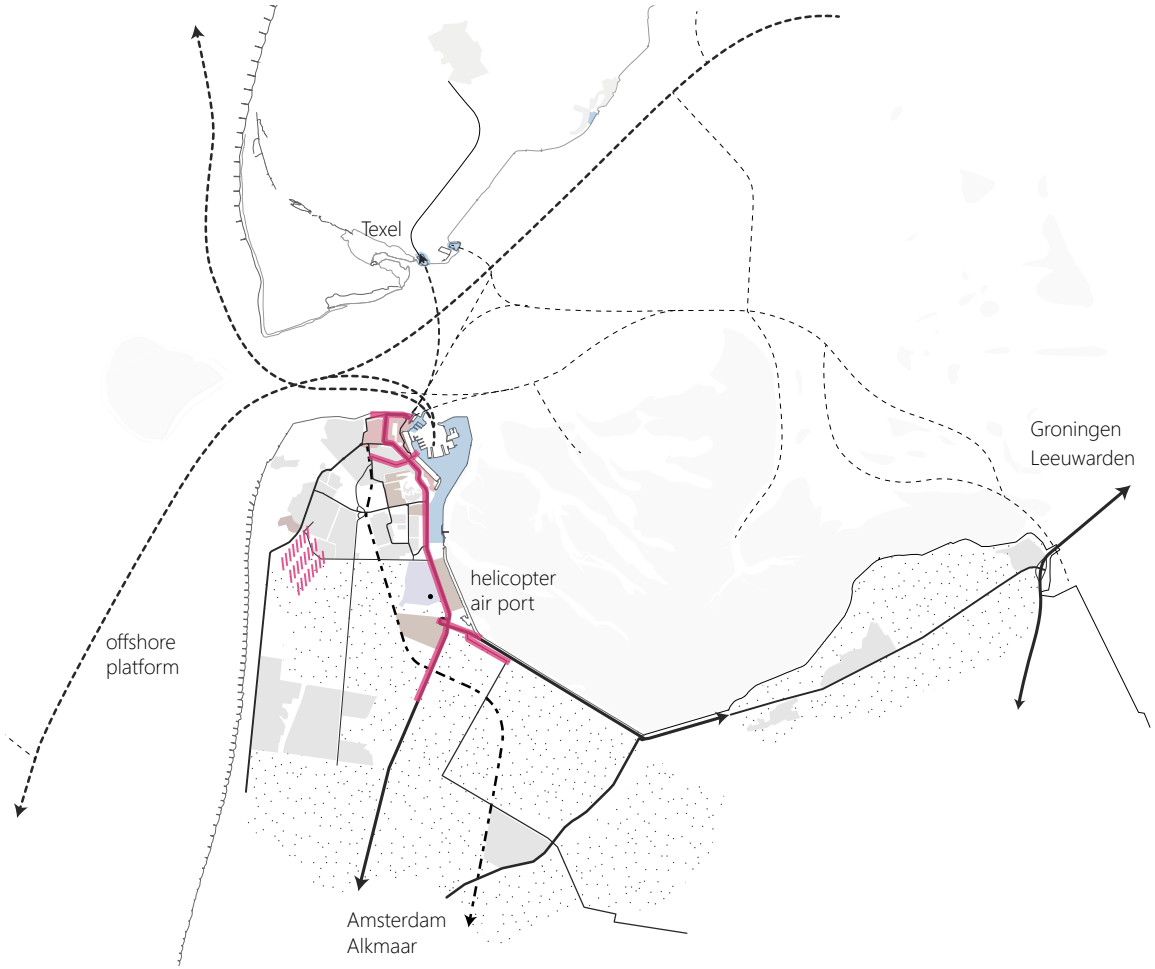
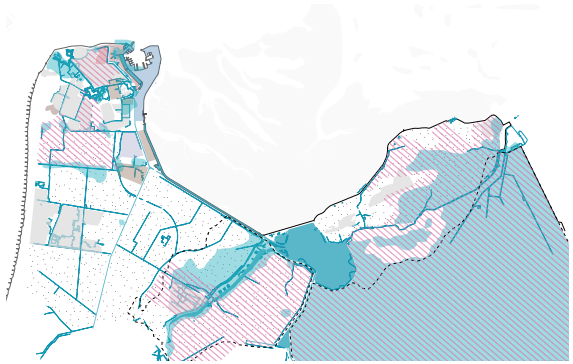


Fig. Infrastructural limitations to shifting economic activities.

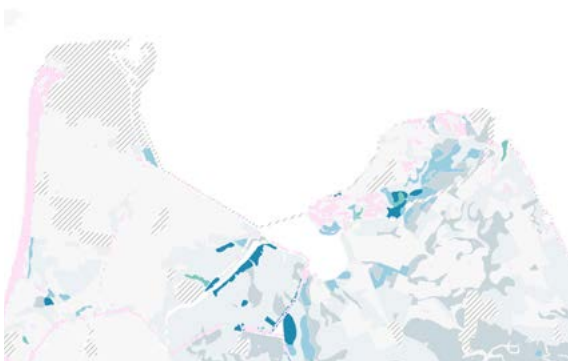
3.4.2 Impact: Threats

High exposure to rising flood chance



Flood risk on land use

- commercial+residential
- residential
- sea port, navy port
- airport
- marine industry
- agricultural polder
- higher flood potential
- higher flood depth
- higher flood duration



Sea level rise impact on soil

- peat
- sand
- light sand
- heavy sand
- light clay
- heavy clay
- urban area
- high erosion

Climate change impact on groundwater

- groundwater seepage
- high groundwater level (<0.2m)
- high infiltration (>2mm/day)
- polders with higher flood potential

Projective flood risk

Business as Usual+environmental change

A projection of where current policies coupled with market trends are likely to lead. The municipality of Den Helder has set several agendas focusing on port and urban revitalization.

2018-2050 major developments

Land use

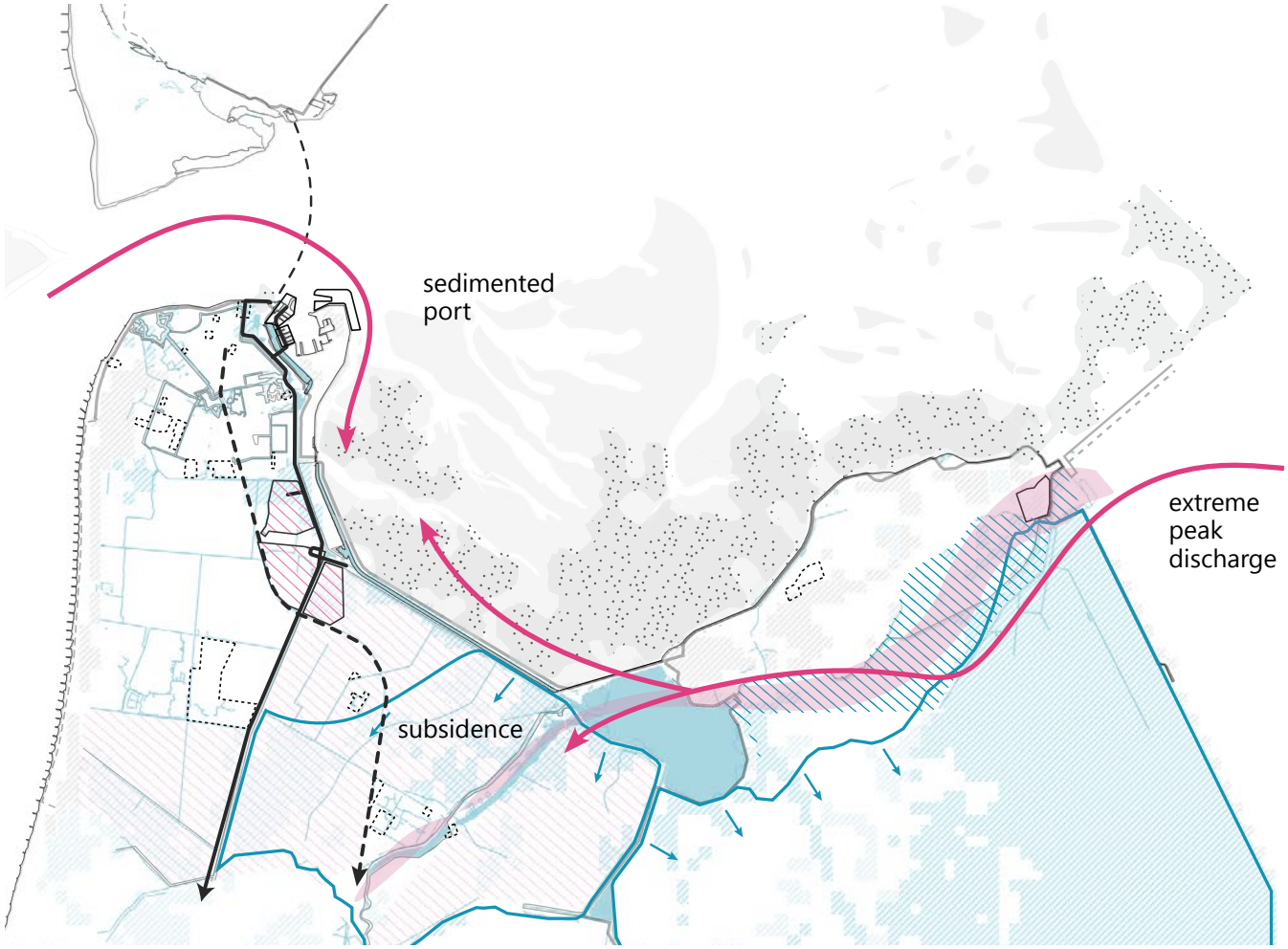
- expansion for offshore business
- densify for residential
- shrinking bulb-growing field due to seepage, soil compact
- room for river project

Transport

- loading on highway to Amsterdam port increase
- more frequent connection by rail
- more frequent connection to Texel

Risk

- higher vulnerabililty to flood
- high flood chance inflow
- sedimenation problem



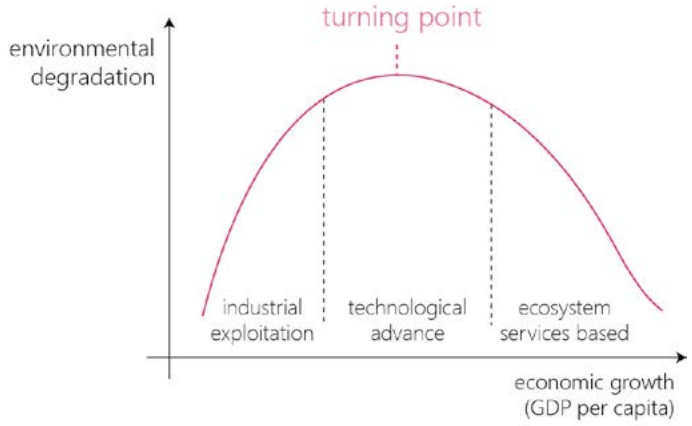
Chapter 4

Naturalism

' Get inspired and supported by nature, which are ***cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience.***'

-- Nature-based Solutions, European Committee 2015

HYPOTHESIS REFERENCE



economics reference:

Environmental Kuznets Curve (EKC)

According to EKC, although economic development initially often leads to environmental deterioration, but **after a certain point of economic growth, the environmental degradation tends to be reduced.** Environmental quality can benefit from economic growth that **renewable energy, green technology and de-industrialization** are often regarded promising.

EU policy reference:

Nature Based Solutions (NBS)

NBS is propagated and defined by EU as approaches **'inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits** and help build resilience'. Conservation of **ecosystem services** becomes a mean to address environmental and societal challenges simultaneously.

NATURE-BASED SOLUTIONS (NBS)

EU Research and Innovation policy agenda

The reference concept - 'Nature-Based Solutions' (NBS) is propagated in current European Union 'Horizon 2020' research and innovation policy agenda (EC 2015). The definition by IUCN is as following:

"actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits".

It goals to safeguard human well-being in ways that reflect *cultural and societal values and enhance the resilience of ecosystems,* their capacity for renewal, adapt and the provision of services.

Preliminary principles

1. Embrace nature **conservation** norms and ability of ecosystems to **evolve** over time
2. Determined by **site-specific** natural and cultural contexts
3. Produce societal benefits in manner that promotes broad **participation**
4. applied at a landscape scale
5. address trade-offs by producing few immediate economic benefits and long-term options
6. are an **integral part** of the overall design of policies, and measures or actions, to address a specific challenge

---

Kabisch, N., N. Frantzeskaki, S. Pauleit, S. Naumann, M. Davis, M. Artmann, D. Haase, S. Knapp, H. Korn, J. Stadler, K. Zaunberger, and A. Bonn (2016). Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecology and Society 21(2):39.

In the Horizon 2020 final report 'Nature-Based Solutions and Re-Naturing Cities', four primary ambitions have been set as: enhancing sustainable urbanization, restoring degraded ecosystems, developing climate change adaptation and mitigation, improving risk management and resilience (chart 1.)

Chart 1. The four goals of NBS set in Horizon 2020

Goal	Description
Sustainable urbanization	Stimulate co-benefits in economic growth, human well-being and environment
Ecosystems restoration	Strengthen ecosystems resiliency; secure vital ecosystem services
Climate change adaptation and mitigation	Provide more resilient responses and enhance storage of carbon
Risk and resiliency management	Offer interdisciplinary synergies in reducing multiple risks

Theoretical review

A review thesis of NBS and similar concepts is conducted to support a more holistic pathway towards environment-society coexistence. First, the principles of NBS are identified and related to the Ecosystem Services quantifying assessments. In second part a broader scope of social-environmental relation in urbanism is reviewed, to explore qualitative values that should be preserved in NBS. The final part examines the application of scenario making method as an agency to integrate both aspects of evaluation.

(see appendix for the report: *Evaluating Social Benefits of Nature-Based Solutions - A Review for Comprehensive Pathway).*

European Commission (2015) Horizon 2020: Towards an EU Research and Innovation policy agenda for Nature-Based Solutions and Re-Naturing Cities
European Commission (2017). HORIZON 2020 –Work Programme 2016–2017: 12. Climate action, environment, resource efficiency and raw materials.

EXPLORATORY HYPOTHESIS

NBS is propagated to facilitate transformation that turn environmental and social challenges into innovation opportunities (EC 2015), by managing natural capital as a source for sustainable societal development. It is set as a transdisciplinary umbrella encompasses existing concepts that promote the conservation of ecosystem as a mean to address multiple environmental and societal concerns simultaneously.

This project focuses on exploring the NBS performance in adaptative transformation for shrinking port cities. The adopted hypothesis of this project is that -

Adaptability of shrinking port cities to coastal risks depends reciprocal collaboration between economy and ecosystem.

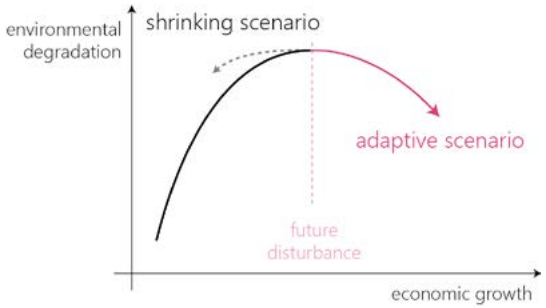


Fig. Concept diagram of project hypothesis modified from EKC. (by author)

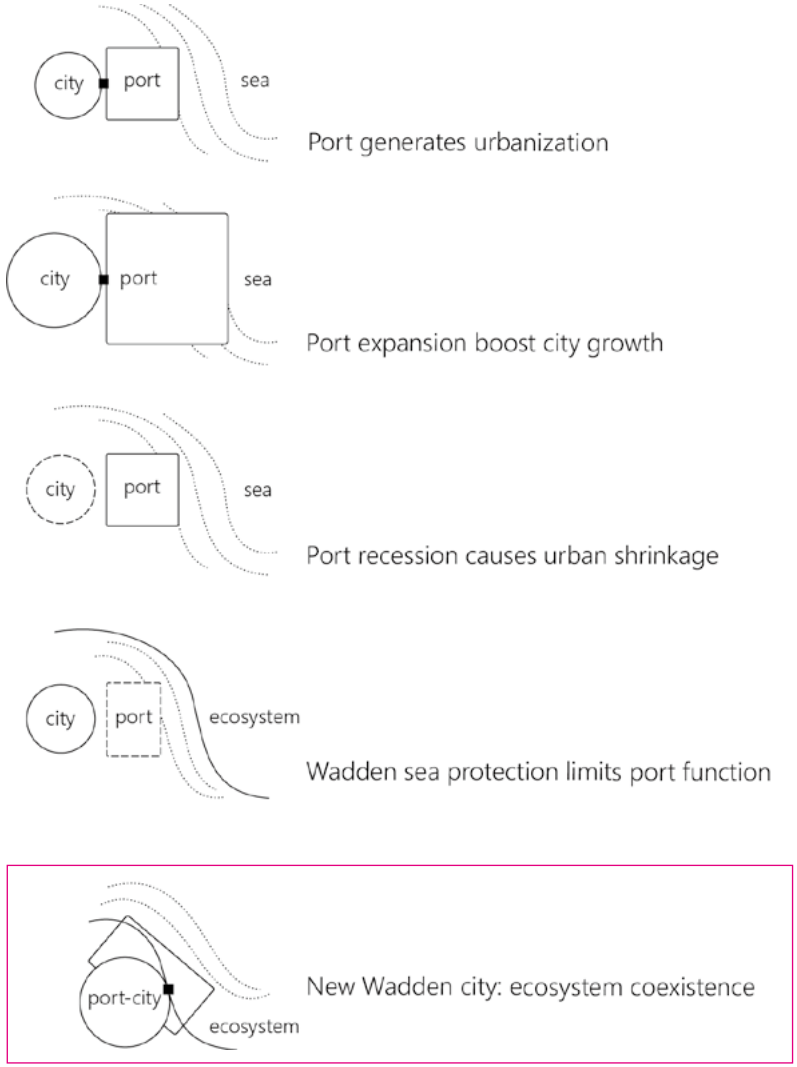


Fig. Concept drawing explaining explorative relationship between port, city and the sea. (by author)

European Commission (2015) Horizon 2020: Towards an EU Research and Innovation policy agenda for Nature-Based Solutions and Re-Naturing Cities

BUILDING WITH NATURE

BwN originally is derived from hydraulic engineering and becomes mainstreaming principle for Dutch water management, such as Room for the River and the 'Sand Engine' (Zandmotor). It attempts to harnesses the forces of nature to construct resilient and efficient measures. It requires thorough analysis and synthesis of the natural system of its dynamics, functions and services as well as interests of the stakeholders involved (Van Eekelen et al., 2017).

Incorporating Wadden potential

Wadden Sea salt marshes are of high regulating ecosystem service to reduce wave height and absorb energy, even under extreme conditions. Therefore, a salt-marsh zone in front of the Wadden Sea dikes that could keep pace with sea level rise may result in a reduced dike reinforcement task.

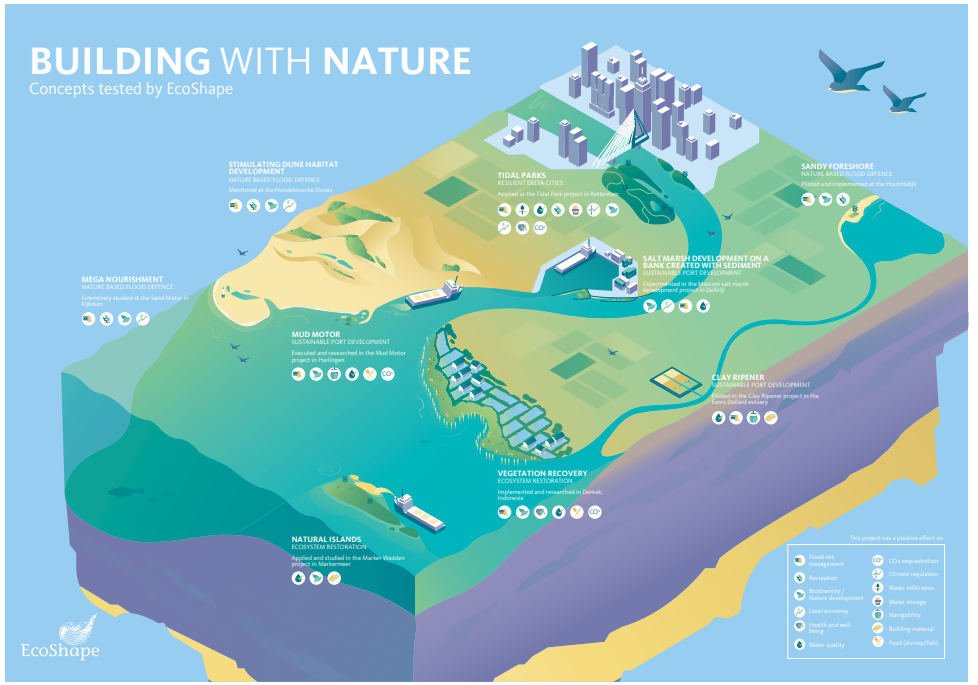
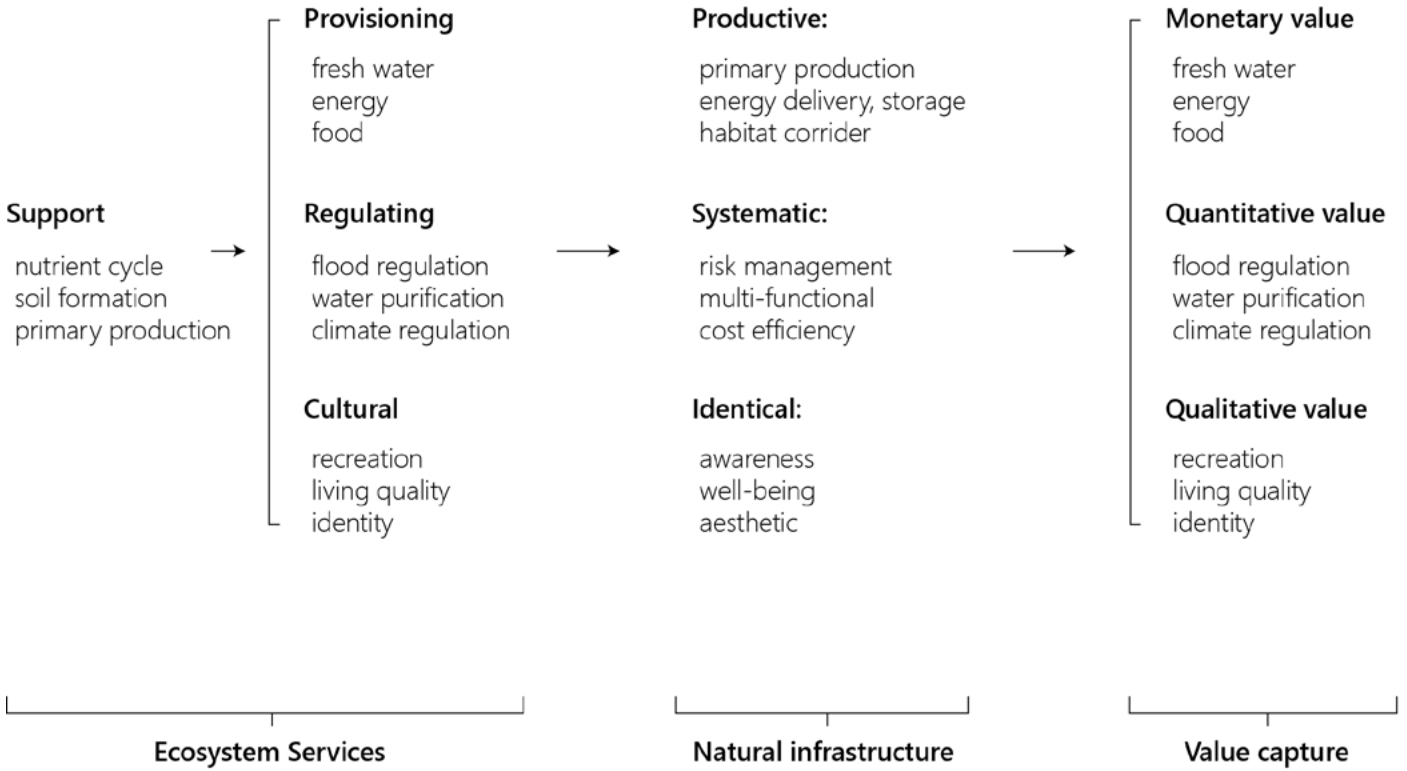


Fig. Infographic of Building with Nature projects conducted by Ecoshape. (Dutch public-private Building with Nature innovation programme)

Van Eekelen, Sittoni et al. (2017). Living Lab for Mud: Integrated sediment management based on Building with Nature concepts.

ECOSYSTEM SERVICES VALUING

ES generally implies "the functions and products of ecosystems that benefit humans, or yield welfare to society" (MEA,2005), and is often being categorized into four aspects: regulating services, provisioning services, supporting services and cultural services. In the project, regulating service to mitigate flood risk and cultural values generated from recreation and coastal identity are focused. What kind of landscape to be implied to different parts of the coastline can thus be suggested.



TEXEL DIKE MAINTENANCE

A Building with Nature method

"dike reinforcement typically involves having them raised and weighed, which was initially also the intention, until the local inhabitants of Texel came up with the idea for the sand-based alternative."

– Jan Fordeyn, Technical Manager

Prins Hendrik dike in Texel is reinforced with a soft, natural barrier of 30 million cubic metres of sand on the seaside of the dike. This 'natural' method ensures that the flood defense can keep up to rising flood threat, and preserve agricultural property and Wadden tidal habitat.

Advantage:
1. Reduce sediments at port.
   Less dredging work is needed.
2. Conserve Wadden Sea tidal ecosystem
3. Stabilize dike foreshore.
   Reduce frequency, costly dike maintenance.

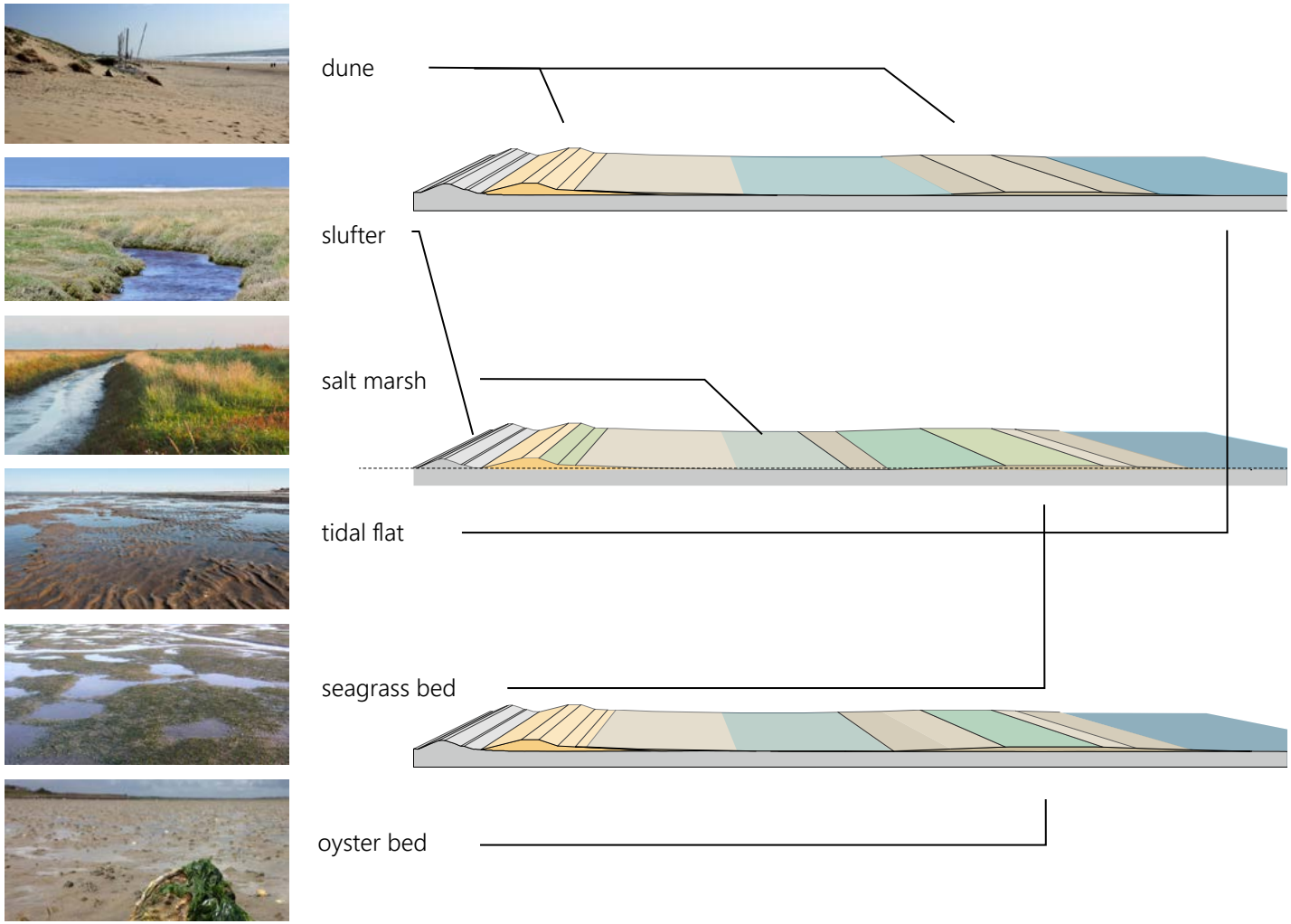


Fig. Transect of functional habitats.

Ecosystem services evaluation

Ecosystem services (coastal)	Provision		Regulation				Supporting		Culture			
	biodiversity nourishment	**raw material**	**wave attenuation**	**sediment trapping**	**erosion control**	**water qualification**	**nutrient recovery**	**primary productivity**	**recreation**	**accessibility**	**cost-benefit (maintenance)**
Sandy dune, beach	■	■	■■■	■■	■■		■	■	■■■	■■■	■■
Tidal flats	■■■	■■■	■	■	■	■	■■■	■■	■	■	■■
Vegetated salt marsh	■■	■■	■■	■■■	■■■	■■■	■■■	■■■	■■	■■	■■
Seagrass	■■■	■■■	■	■■	■■	■■■	■■■	■■■	■	■	■ ■
Oyster bed	■■	■■■	■■	■■■	■■■	■■	■■	■■■	■	■	■

Fig. Quantified ecosystem services of different tidal habitats. Flood regulation and support for coastal light industries are highlighted.

Potential for Den Helder

Presence of a 1000m minimum wide salt-marsh zone would result in stable water depth in front of the dike. If it could keep pace with the rising sea level(0.15 m by 2050), only modest dike reinforcements would be needed in 2050 (heightening approx. 50 km of dikes by <0.25 m). If without, all dikes along the Wadden Sea need to be heightened by up to 0.5 m.

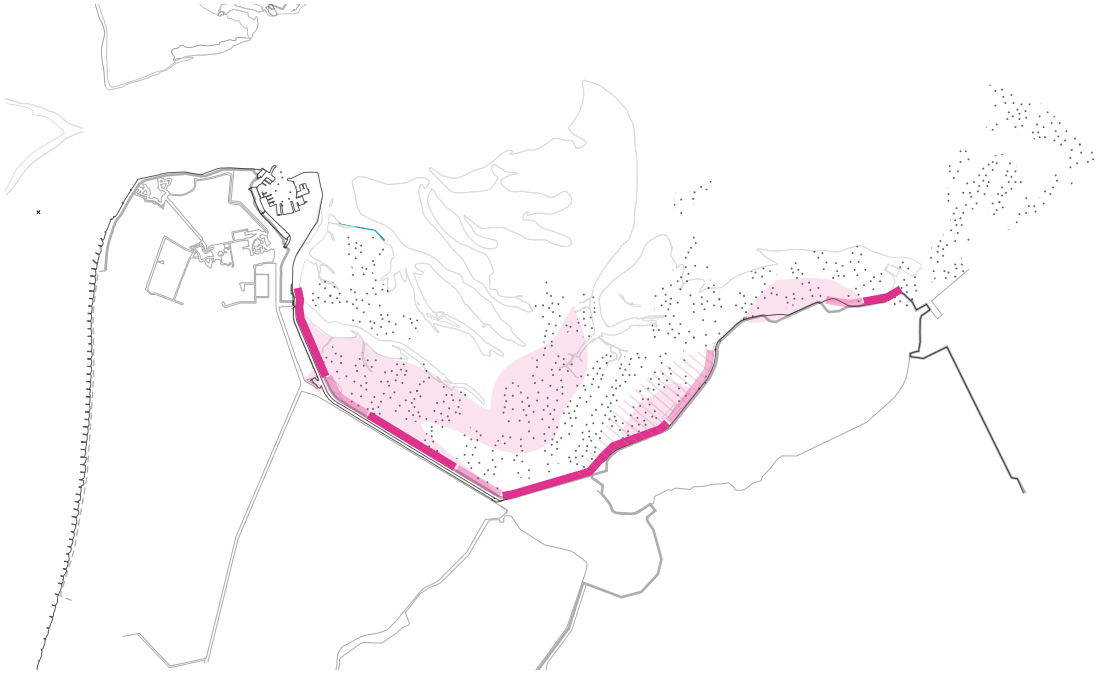


Fig. potential area for marsh nourish

- potential habitat for salt marsh
- existing salt marsh
- potential habitat for seagrass
- previous oyster bed location
- sedimentation issue

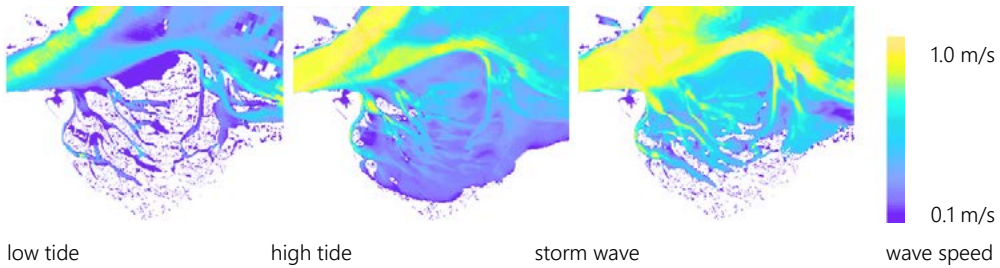


Fig. simulation of wave speed reduction by salt marsh.
(credit: RHDHV hydrologic report)

Chapter 5

Research Methodology

5.1 Methodology Framework

INTERDISCIPLINARY APPROACH

The general theoretical background is based on ***Landscape Urbanism*** that regards cities as urbanizing landscape where ***transcalar, process-oriented and imageability*** should be emphasized in design process. To reinforce transferability in coastal planning, the theory is comprised into ***Driver-Pressure-State-Impact-Response (DPSIR)*** framework, which is often applied in ***Integrated Coastal Zone Management (ICZM)*** to adapt both environmental and socio-economic changes. Thorough methodology report is included in Appendix 2.

5.2 Research objective

RESEARCH QUESTIONS

The thesis adopts a "research by design" method, attempting to respond the question:

" How to adapt shrinking port cities to economic and environmental uncertainties with nature-based solutions? "

Sub-questions

The objective to explore adaptive pathway with nature inclusive design is unfolded with following three main sub-questions:

◦ How to facilitate reciprocal collaboration between ecosystem and economy through urban design?

◦ How to employ integrated coastal zone management in coastal urban design?

◦ How to employ Nature-Based Solutions to strengthen adaptability of shrinking Den Helder to flood risks?

Respondence

1. Assess **risk impacts** on port city from both environmental change and economic shift.

- DPSIR:
  an analysis framework to integrate coastal zone management with urban design.

2. Explore extreme scenario to collect local imaginations and BwN **references**.

- Design Fiction:
  transcript computer-aid projective stimulation to proactive narrative

- Semi-structured interviews and workshops:
  collect local qualitative narratives for prospective scenario

3. **Backcasting design** and reflection

- Nature-based urban development strategy

- Transcalar spatial design:
  regional development (infrastructure, landuse) and local transformation

- Risk management:
  propose scheme to share risk, responsibility and benefits

Sub-questions

How to employ integrated coastal zone management in coastal urban design?

- How to integrate risk management in transcalar spatial design?

How to employ integrated coastal zone management in coastal urban design?

- How to comprise local spatial quality with coastal engineering?

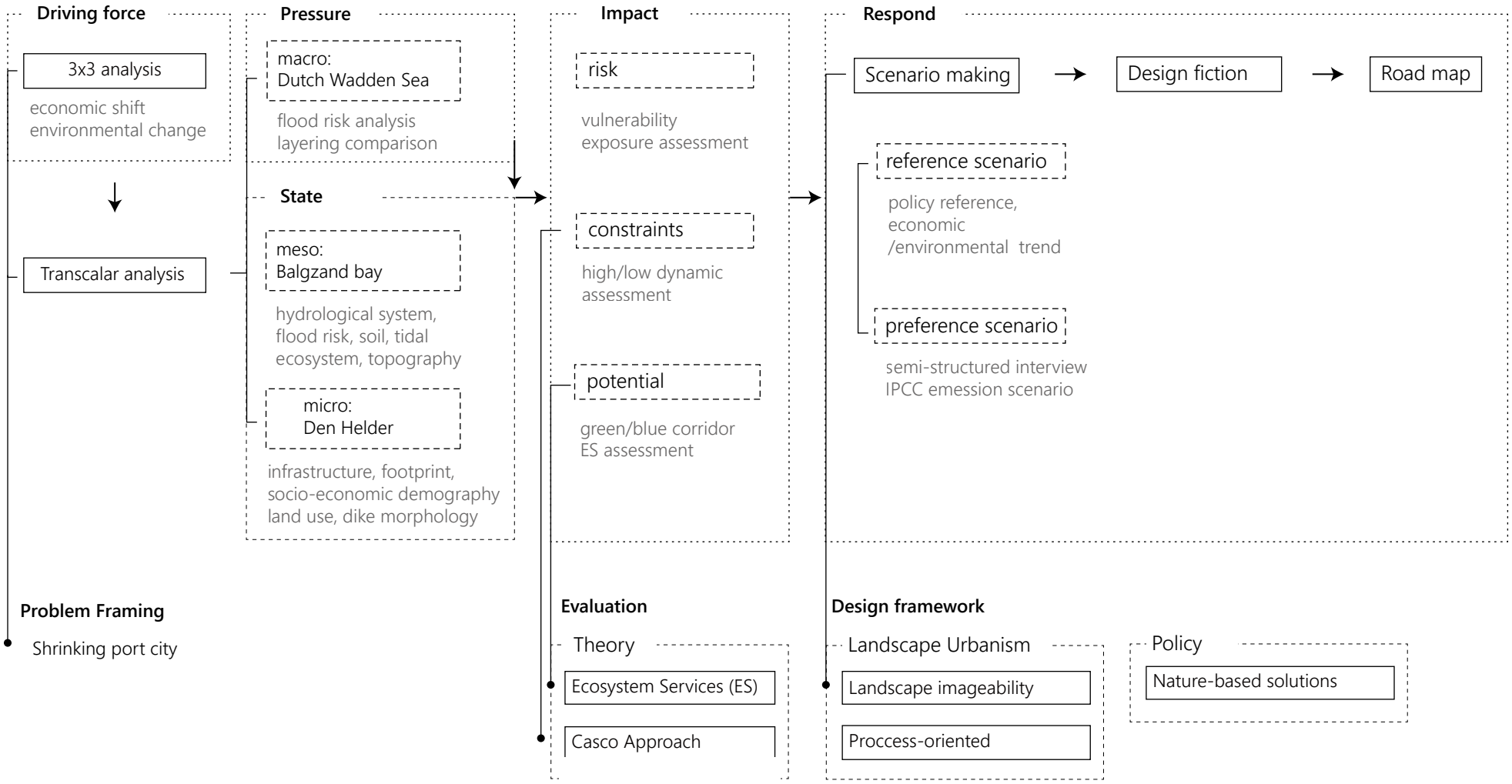
How to employ Nature-Based Solutions to strengthen adaptability of shrinking Den Helder to flood risks?

- What are the values of Nature-Based Solutions that can strengthen local adaptability to flood risk?

How to employ Nature-Based Solutions to strengthen adaptability of shrinking Den Helder to flood risks?

- How to conserve ecosystem services and natural evolution in a shrinking economy?
- How to support Den Helder's long-term development with Wadden Sea ecosystem services?

Methodology framework



But, what if ...

A catastrophic flood hits again one day ...

DESIGN FOR FLOODING

Perhaps the *shrinking* trend of a city is a push to the crossroad between breakdown and breakthrough. And a flood chaos could be an opportunity to "leap to a new civilization"

Since climate change is such unpredictable and coastal substratum is of high dynamics, perhaps what nature-based design should explore is how to leverage on upcoming floods, instead of seeking for the most robust defense. Based on the history that storm surge is a recurring natural event, flooding can also be designed as transforming point to regions if it is anticipated.

Local imaginations

By immersing readers, stakeholders in a fictional narrative, local imaginations of possible future development are encouraged. The objective is to raise awareness that provokes participation in urban transformation. Thus, visions collected from on-site interviews are important qualitative principles of this project.

Design Fiction Approach

To explore a site specific nature-based development vision, this project is driven by Design Fiction and Scenario approaches. The narratology expresses coastal uncertainty with provocative fictional setting.

A projective storyline based on trajectory of climate change risk is first showcased to interviewees. Then through semi-structured interview, local perceptions and imaginations on coexisted development of environment and socio-economy are provoked, collected, and further collaged into prospective scenarios. How to proceed from reality to this vision draws the design objectives. Possible spatial interventions toward this desirable future are portrayed in reference to state-of-the-art Building with Nature projects in Netherlands. This strengthen the linkage between design output, social content and cultural ecosystem services.

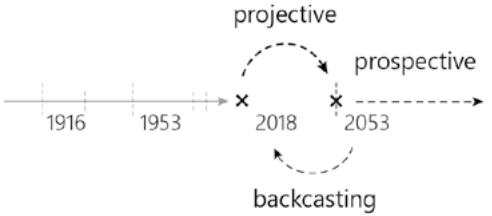


Fig. The research-by-design framework is structured through design fiction approach as a loop.

Bleecker, J. (2009). Design Fiction: A Short Essay on Design, Science, Fact and Fiction, 49. Retrieved from http://drbfw5wfjlxon.cloudfront.net/writing/Design-Fiction_WebEdition.pdf

Experimental setting

A catastrophic flood event is fabricated at 2053 (in memory of 1953 flood). The story setting is distinctly designed according to GIS stimulation. Yet, it is portrayed with provocative image to stimulate local imagination of living with flood, and to challenge the status quo with innovative interventions.

2053 Flood event setting

Simulation: 0.1% recurrence rate flood event
- North Sea storm surge
- Amstelmeer extreme discharge
- low atmospheric pressure

Relevant trends:
- rising sea level
- canal silt
- urban low infiltration
- land subsidence

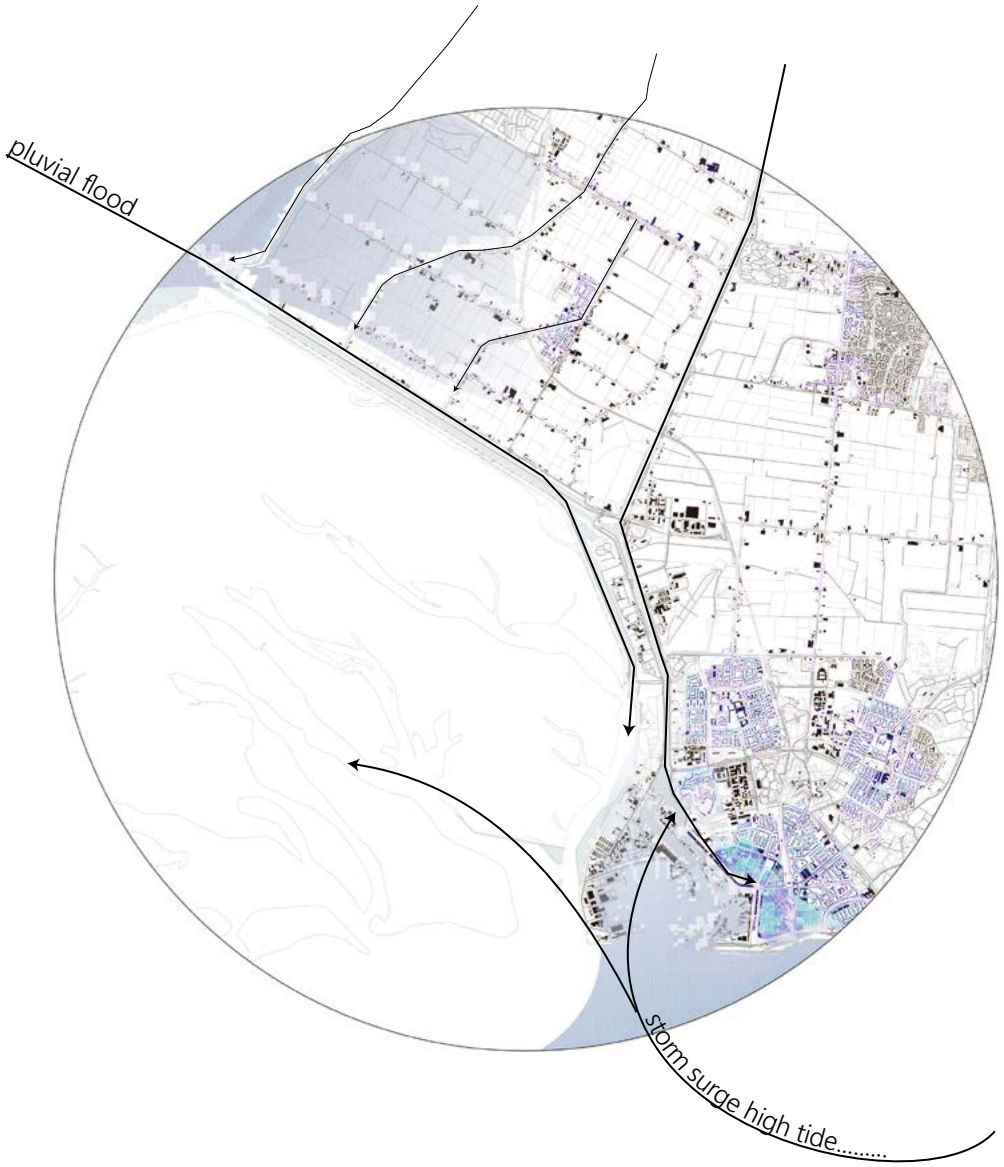


Fig. Illustrated 2053 flood scene based on GIS simulation. Data retrieve:
Klimaateffectatlas. http://www.klimaateffectatlas.nl/nl/
PDOK. https://boerenbunder.nl/page/welcome?next=%2F

CO-DESIGN WORKSHOP

Facilitate local imaginations on
"prospective qualities of living with nature"

in order to
"identify critical natural services and values that can promote nature-based solutions to strengthen Den Helder's adaptability to risk"

Semi-Structured Interview

The interview emphasizes that residents, as key stakeholders, are able to provide first-hand descriptions on environmental impacts and trends through "stories" (Kok et al., 2011). On the next page shows the key guiding questions. Urban designers are experts of the innovation process and to leverage scientific information, whereas locals are experts of their own experiences. This project adopts the qualitative research and GIS simulation to bridge local imagination and scientific data into urban planning.

Geodesign and scenarios

Geodesign aims to tightly couple the creation of design proposals with impact simulations informed by geographic contexts." (Steinitz. C 2012). Current GIS application in adaptation design often built up through two process: the layering observations of integrated geodatabase (ecology, geology, social demography...); and the visualized simulation or scenario upon analyzed outcomes.

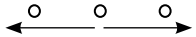
Geodesign is effective in communicating the possible environmental changes, design performance, functions and social impacts. This value aligns with the goal of NBS to encourage citizen involvement..is a co-design process that facilitates users to inspire ideation through own experiences. As a result, GIS is considered notably adequate to promote the transferability and integrated performance of NBS.

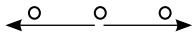
Regarding to the purpose of simulation - stakeholder communication, awareness rising and efficient impact evaluation - Esri CityEngine is chosen to build up flood scenarios for the workshop. The 3D GIS modeling provides high flexibility discussing alternatives against uncertain future.

Fig. Photos of on-site workshop and discussions for port redevelopment.

Questionnaire:

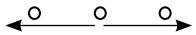
' To revive Den Helder from shrinking, how do you measure the effectiveness of following development objectives? And are you willing to invest or be involved in the process? '

promising  not promising

interested  not interested

' To recover Den Helder from flood damage, how do you measure the effectiveness of following development objectives? And are you willing to invest or be involved in the process? '

promising  not promising

interested  not interested

Interview:

' After 2053 storm, floods frequently happen in Den Helder.
What are the incentives that make you willing to stay?
And what would you like to change about while rebuilding Den Helder? '

Indicators

Pressure: trends of environmental and socio-economic changes
State: results from spatial analysis
Impact: risk; limitations; potentials

Bussiness as usual: policy, official plans

Prospective scenario:

The preferred options and first-hand stories shared by locals are documented and transcripted into the fiction.

Projective scenario:

A projection of where current policies coupled with market trends are likely to lead. The municipality of Den Helder has set several agendas for port and urban revitalization.
(see 3.4.2 Impact: threats)

Design Fiction: (chapter 6)

A narrative scenario of future is designed, immersing readers, stakeholders in a possible future to raise awareness and provoke participation. The story is distinctly designed according to problem field, environmental and socio-economic analysis, policy and collective local visions; and yet, the provocative image challenges the status quo to facilitate innovative interventions.

Voting cards:

The 14 objectives are retrieved from official agendas of three major public parties. Each objective card is illustrated with relevant image of Wadden Sea region, and is annotated with its dependency on economic support and ecosystem services.

Referenced official agendas:

Gemeente Den Helder
*Strategische visie 2020
*Ontwerp Structuurvisie 2025

Port of Den Helder, Koninklijke Marine
*Structuurvisie Den Helder 2025

Waddenzee
*Programma Naar een Rijke Waddenzee
*Projectteam Gebiedsagenda Wadden 2050

Port expansion

Offshore industry

Maritime logistic

Marine industry

Mobility

Maritime R&D

Agricultural upgrade

Port publicization

Urban renewal

Renewable energy

Flood defense

Climate mitigation

Tourism

Wadden Sea conservation

Chapter 6

Fiction: 2053 The End of Netherlands

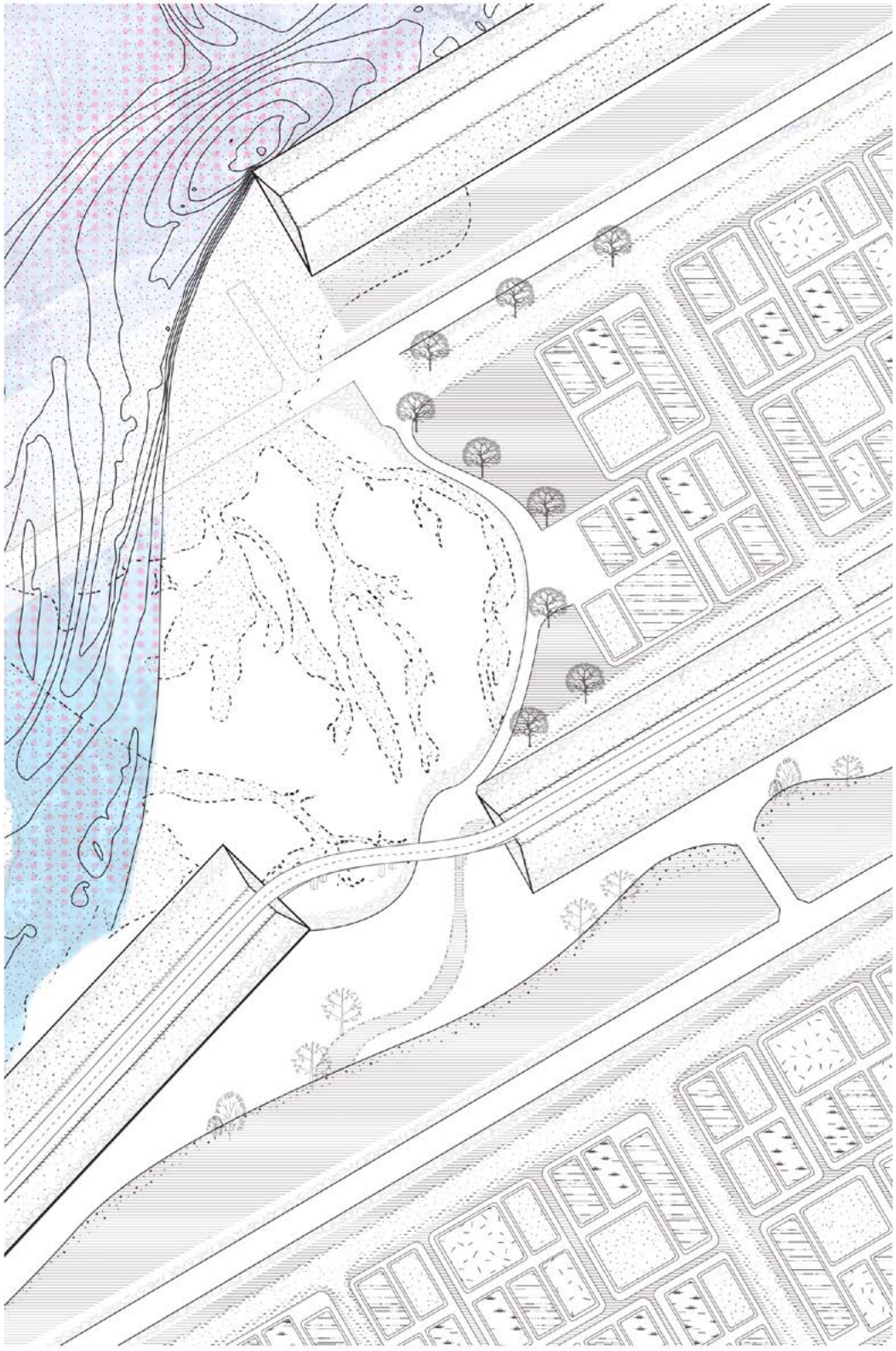
Transcripting local imaginations to qualitative scenarios

2053 Storm Surge

the End of Netherlands

In 2053 winter, a North Sea storm surge breached the invincible Dutch dike and swallowed the Wadden Sea. What being left is neither sea nor land, but a floodplain of marshes. At the Northern endpoint of Netherlands, it used to be Den Helder, the small maritime city that only being recalled when the Navy port and the ferry terminal to Texel island is mentioned.

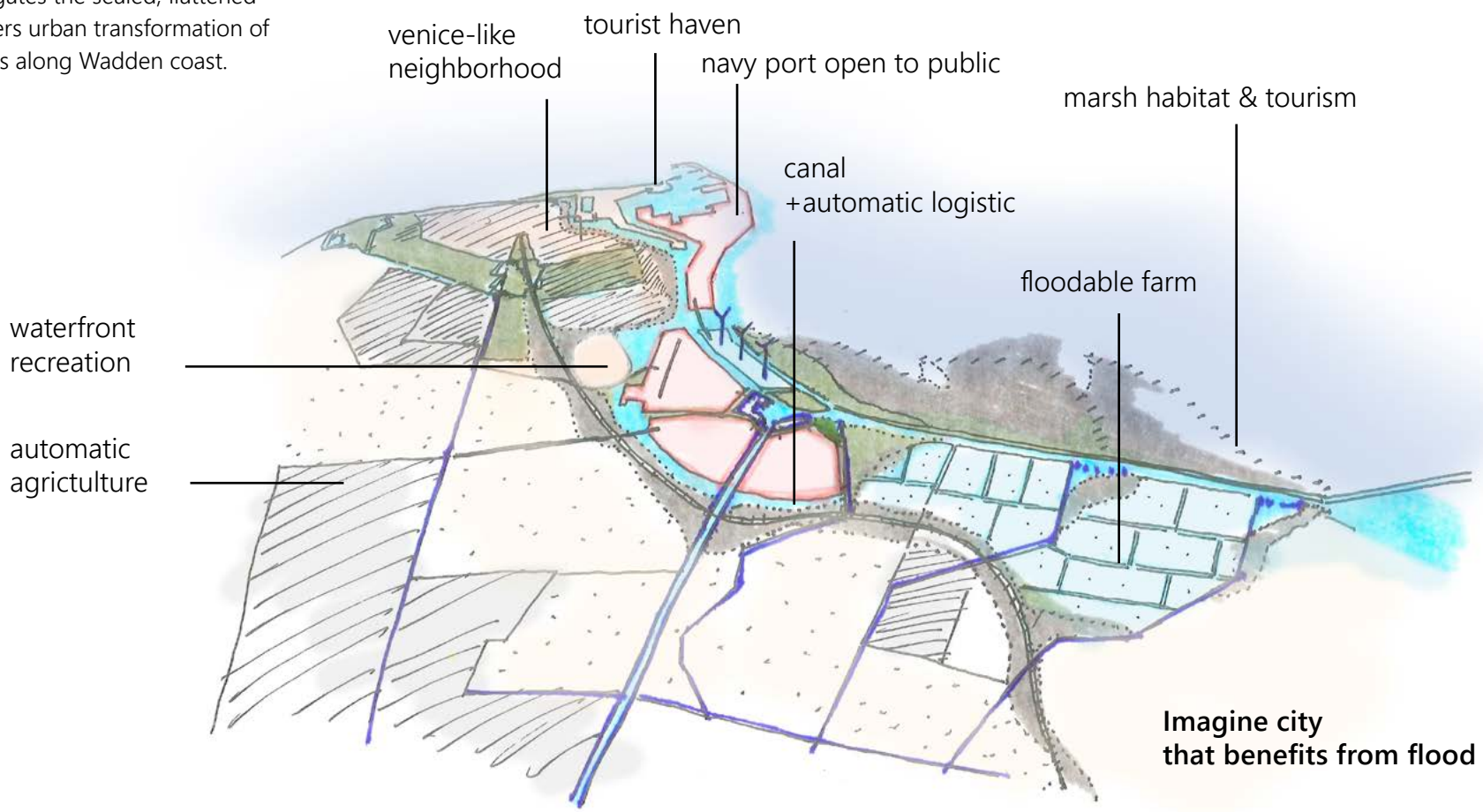
However, during the storm, a flood on the marine base and surrounding polders was raised while high tide meet Amstelmeer Lake discharge. The following year is a trend of relocations and some frequent small floods. People of Den Helder lost faith in the dike protection and port economy, seeking for steadier forces to pilot their revitalization. They looked beyond the edge, and realized that no force is as sustainable as the sea. "What if we cooperate with the sea..."



after 2053 Flood

the New Edge

Decades after, Den Helder becomes the well-known city reborned by 2053 Flood.
Some even says the dike breach is manufactured by Dutch 'Building with Nature' techiques. The new flows re-irrigates the sealed, flattened ground and triggers urban transformation of shrinking cities along Wadden coast.



" After 2053 storm, floods frequently happen in Den Helder. What are the incentives that make you willing to stay? And what would you like to make a change while rebuilding Den Helder? "

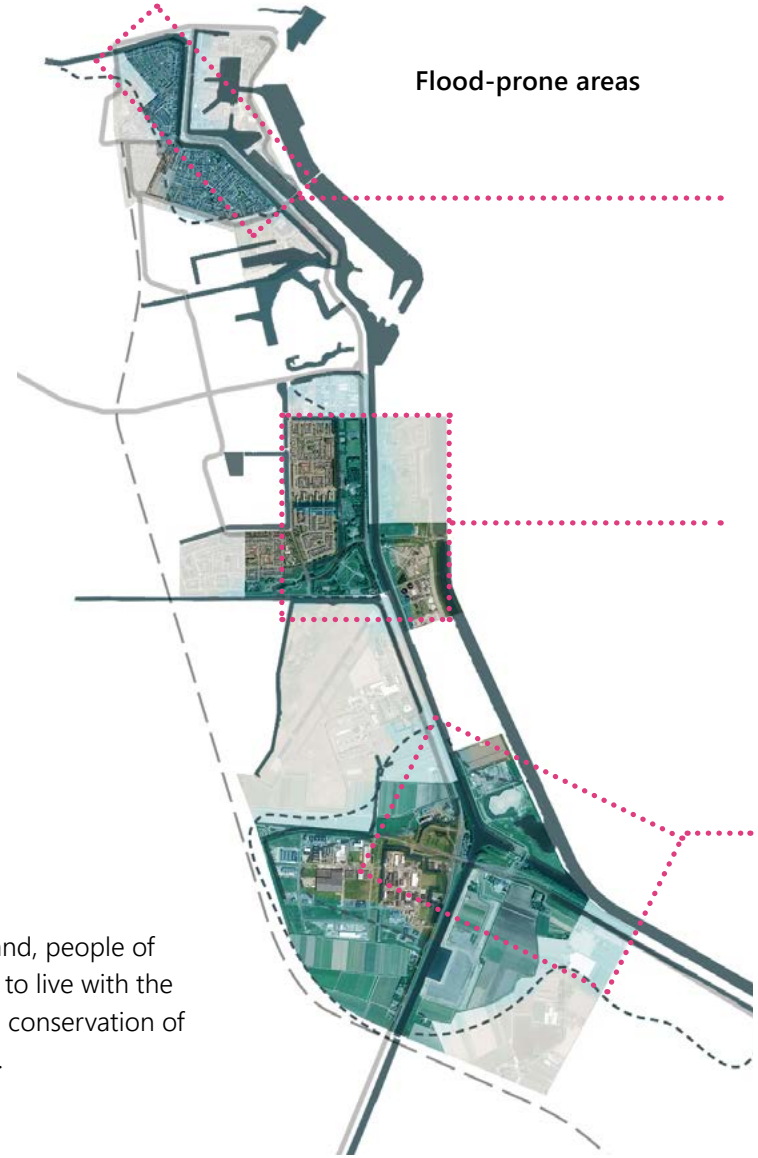
After having children, we moved from city central to the neighborhood at South station, where has more parks, new houses and shopping center. We won't move away soon because the children love this place. We often take them to the beach or the mud to find some mussel. If the area will be flooded in the future, I guess they will be happy to replace my car with a boat and play with more water. Den Helder can be the Dutch Venice with many canals.

My whole life has been living here with the sea so I'm not leaving even if it is flooded. The shipyard we work for is a bit outdated anyway. Maybe with the compensation, we can transform it into a bar and the boats can be rented to tourists. We have a very beautiful coast with many animals. With the sea and our boats, we can always make a living even being flooded.

We are colleague at a logistic company delivering goods between Den Helder and Texel. We have network on both land and sea, so as long as the flood doesn't interrupt both connections, the company can survive. Flood will cause much bigger trouble to our warehouse. But I guess the low-laying farmlands surrounding Kooypunt will be flooded first. Or let the airport flooded, so we can have some quiet moments.

People of Den Helder

On the new edge of sea and land, people of Den Helder find their own way to live with the dynamic sea and benefits from conservation of Wadden Sea natural resources.



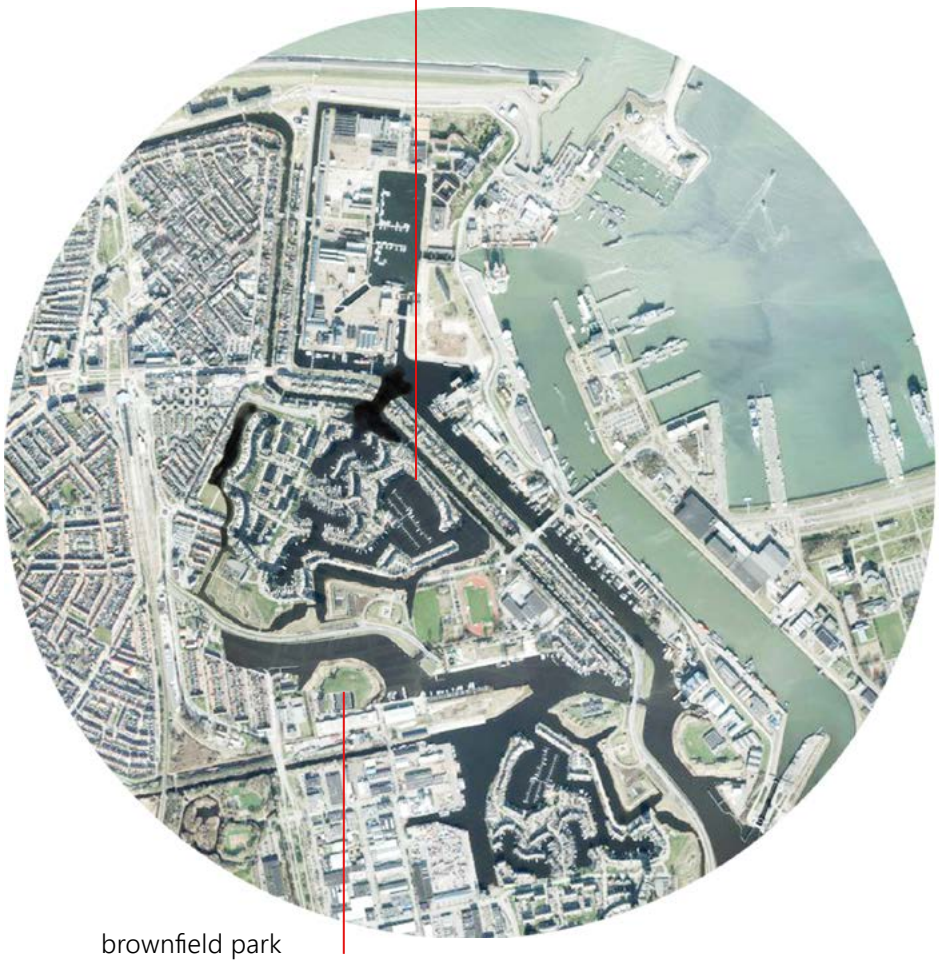
Flood-prone areas

Proposal

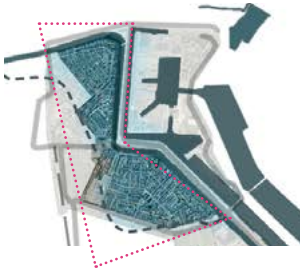
- Attract tourists by transforming port and preserving marshland
- More waterfront neighborhood
- Develop waterways as Venice
- Coastal recreation
- Alternative transport
- Airport noise control

Interpretations

Port-front residential area before flood



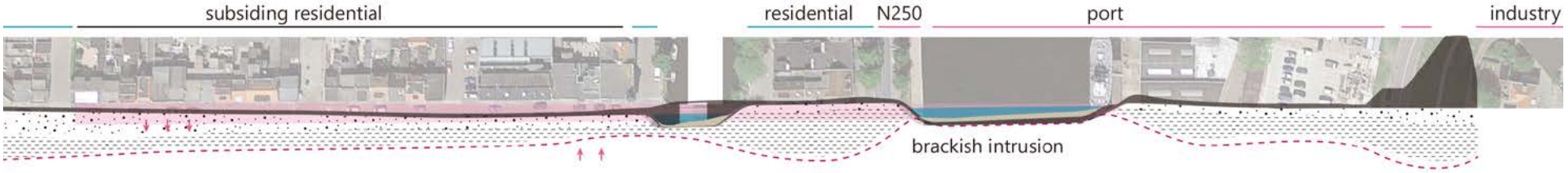
Lagoon city after 2053



- Risk:
  subsidence
  oldest housing district with low quality houses

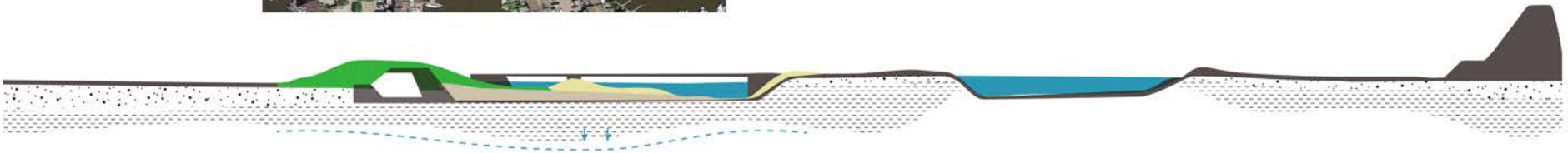
- Land-use:
  city central mix-used, residential
  adjoins to port

Situation before flood



Proposed section for reconstruction

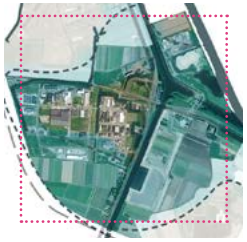
Reference: lagoon neighborhood in Den Helder



Interpretations

Maritime manufacture and logistic hubs before flood

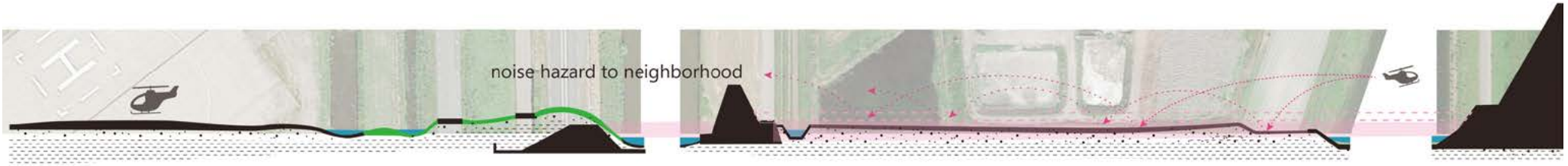
Lagoon business park after 2053 flood



- Risk:
  Outlet joint of sea current, lake and polder drainage

- Land-use:
  residential district
  maritime industry, vacant industrial land
  airport, A9 motorway

Situation before flood



reference: Buitenschot Land Art Park beside Schipol Airport

Proposed section for reconstruction

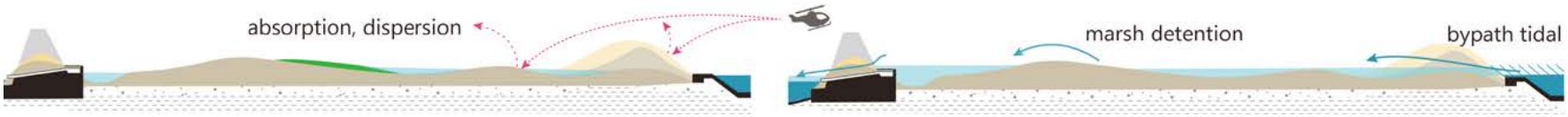
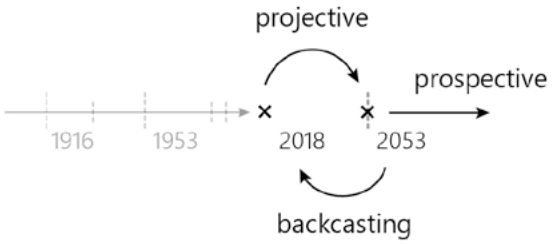


Fig. Buitenschot Land Art Park situated beside Amsterdam Schipol Airport. A wide range of ground ridges are designed to serve a dual function: reduce ground noise and recreation. The shape of mounds visualizes sound waves and deftly turns it into an experience.

Chapter 7

Back to reality:

Den Helder Shrinks



7.1 Observations

Observations from questionnaire

Several environmental oriented agendas appear to be more favorable, when the target issue is shifted from economic recession to environmental hazard. In the meanwhile, higher willingness among citizens to participate are noted. In their explanations, lower cost, better living environment and wider opportunities to be involved are three main incentives.

Observations from fictional exploration

The fiction provides a glimpse of pausible future under exaggerated awareness. An interesting finding from residents' stories is their ability, confidence and skills to live with water. It is built up through their intimate relations with water either in living environment or daily works. On the other hand, however, rather low risk awareness is observed. Most people neglected flood and climate threats on Den Helder, especially comparing to stressful economic recession. Over-trust upon national flood defense is a major reason for awareness gap.

Perhaps the social affiliation to water can be regarded as a gifted strength of port cities to face climate change. But the "awareness gap" may become the biggest barrier. Thus, a critical question is how to increase the awareness of environmental risks, to engage more property owners and businesses in adaptive transformation?

' To revive Den Helder from shrinking, how do you measure the effectiveness of following development objectives? And are you willing to invest or be involved in the process? '

promising — not promising

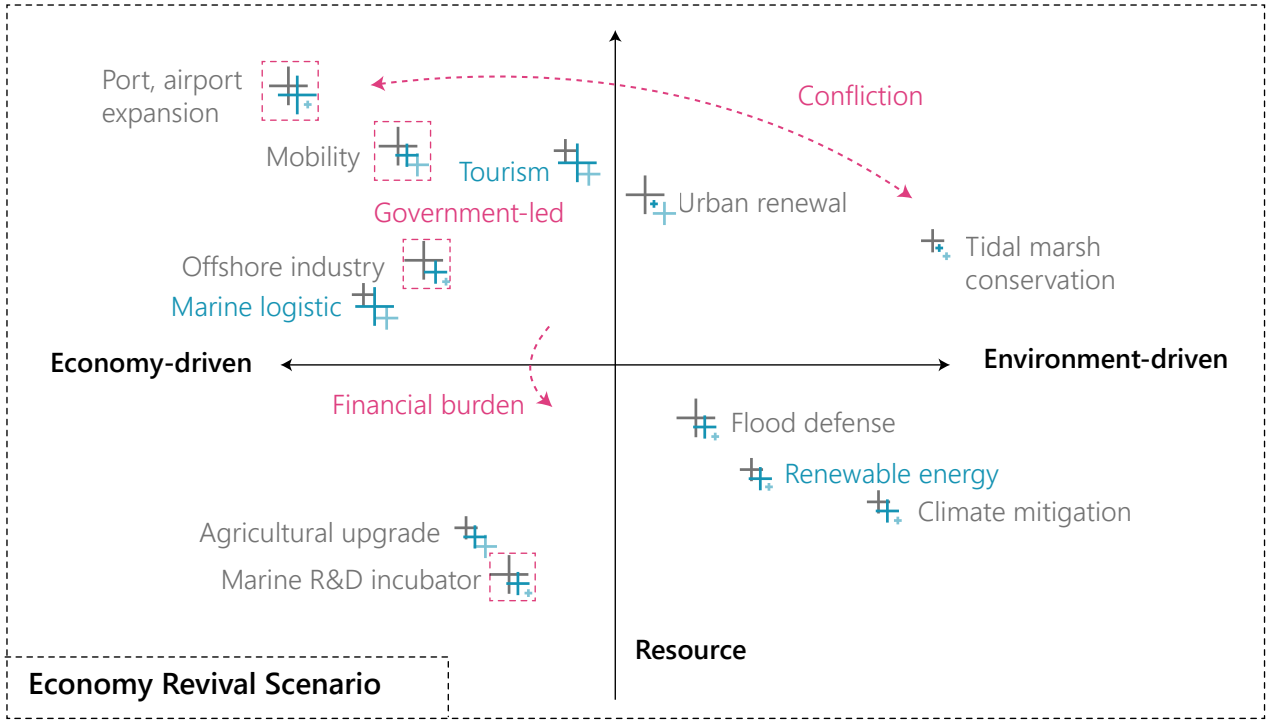
interested — not interested

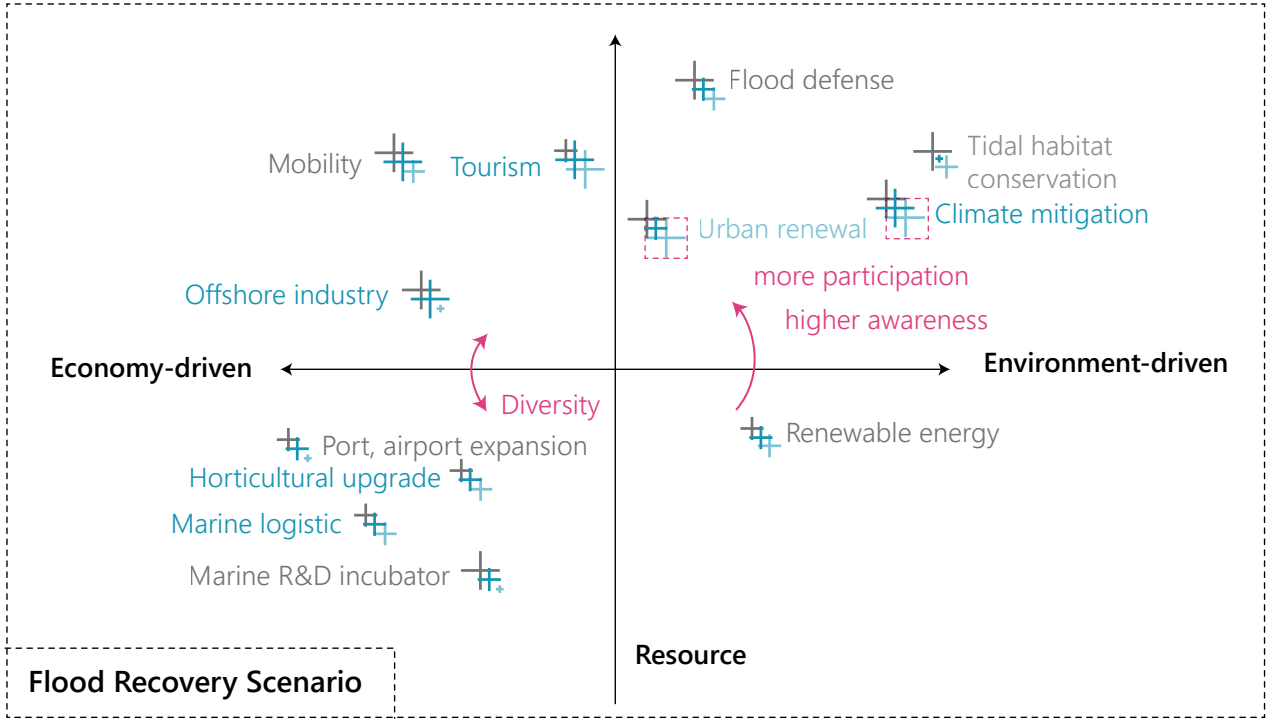
Economic revival objective:

- Government-led economic development
- Port development dominated

Natural hazard recovery objective:

- Incline to environmental-driven options
- More balanced, diversed development
- Higher willingness to participate





LESSONS TAKEN FROM FLOOD

Local perception of natural values

Cost-efficiency:
- multi-functions
- supported by natural resources

Inclusiveness:
- more parties can be invloved
- lower barrier for bottom-up participation

Sustainability:
- risk awareness
- support diverse economic activities
- preferable living quality

Opportunities to apply NBS

Through local narratives collected in design fiction workshop, three critical qualities of nature-based solutioins to improve resiliency of Den Helder to flood risk are identified as above. Theses qualities further adopted as principles to apply NBS in risk adaptive design.

Common visions against shrinking:

- Attract population...
- Increase job opportunities...
- Long-term development...

Proposed NBS principles for coastal cities to adapt shrinkage

- by optimizing coexistence with nature in living quality
- by promoting diverse trade-off with multi ES productions
- by rising awareness, involving more parties and optimizing cost-efficiency in risk management

Shrinking cities

Definition

" A densely populated urban area with a minimum population of 10.000 residents that has faced population losses in large parts for more than two years and is undergoing economic transformations with some symptoms of a structural drop in shrinkage became a structural " (Hospers, 2010).

"Shrinkage" describes declines of population size, amount of households and the composition of pop-ulation. In general, the most crucial factor results in rapid changes in population is migration. Main pushing forces including low employment rate, low accessibility, poor public facilities, unpleasant quality of the housing stocks and living environment.

Dutch shrinking cities

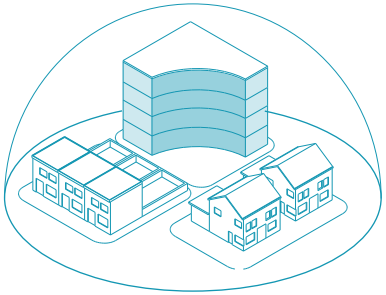
Shrinkage of historic maritime bases is a common issue not only in the Netherlands, but particularly along the North Sea coastal regions. According to literature reviews, common strategies adopted by Dutch cities to manage shrinkage can be categorized into four strategies: ignoring shrinkage, opposing shrinkage, guiding shrinkage and utilizing shrinkage. It responds to the scale, duration and speed of shrinkage. Although it is usually being unfolded with economic angle, what the *hypothesis of this project propagates is to address this structural phenomenon through both socio and environmental perspectives.*

Fig. Conceptual drawing of three common strategis tackling urban shrinkage in the Netherlands. (by author)

Hoekstra I., Mulkens J.(2014). City shrinkage: Renewing the casco approach for shrinking cities in the Netherlands. Wageningen University.

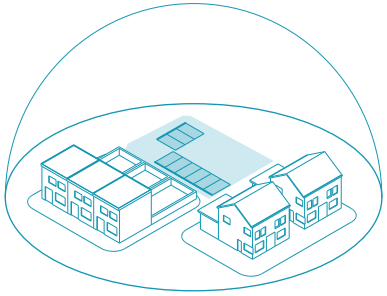
OPPOSING

Ignore shrinking trend. **Upscale existing sectors** with new development to create attractions and jobs.
ex. Construct social housing, new business park.



GUIDING

Adjust to shrinking trend. **Transit, re-scale landuse programs** to better resource efficiency.
ex. Reuse vacant warehouses for smaller business units.



UTILIZING

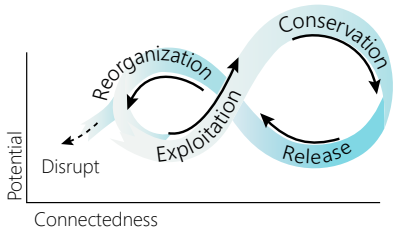
Follow shrinking trend. **Transform** current landuse programs to **relieve pressure on** environment.
ex. Transform brownfield to tourist spot.

ADAPTIVE CYCLE OF NATURE

The model of the adaptive cycle was derived from the ecological evolution. Whereas urban declay and shrinking are often neglected in favor of economic growth, ***release*** and ***reorganization*** are two critical phases of natural evolution:

- growth or exploitation
- conservation
- collapse or release
- reorganization

To align with such natural adaptive cycle, perhaps the *shrinking* of a city should also be addressed as nature-based succession. That is, the strategies for shrinking cities shall **follow a systematic process of conserve - release - reorganization before the next exploitation.**

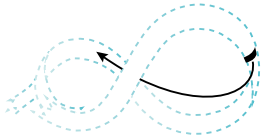


Status of shrinking
Den Helder

Common strategies for shrinking cities in Netherlands

OPPOSING

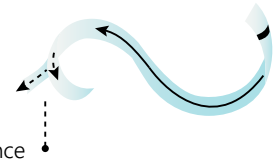
GUIDING



UTILIZING

NATURE-BASED SOLUTION

Take advantage of shrinking trend.
Conserve natural capital to align with **RELEASE, REORGANIZE** and to prepare for disturbance.

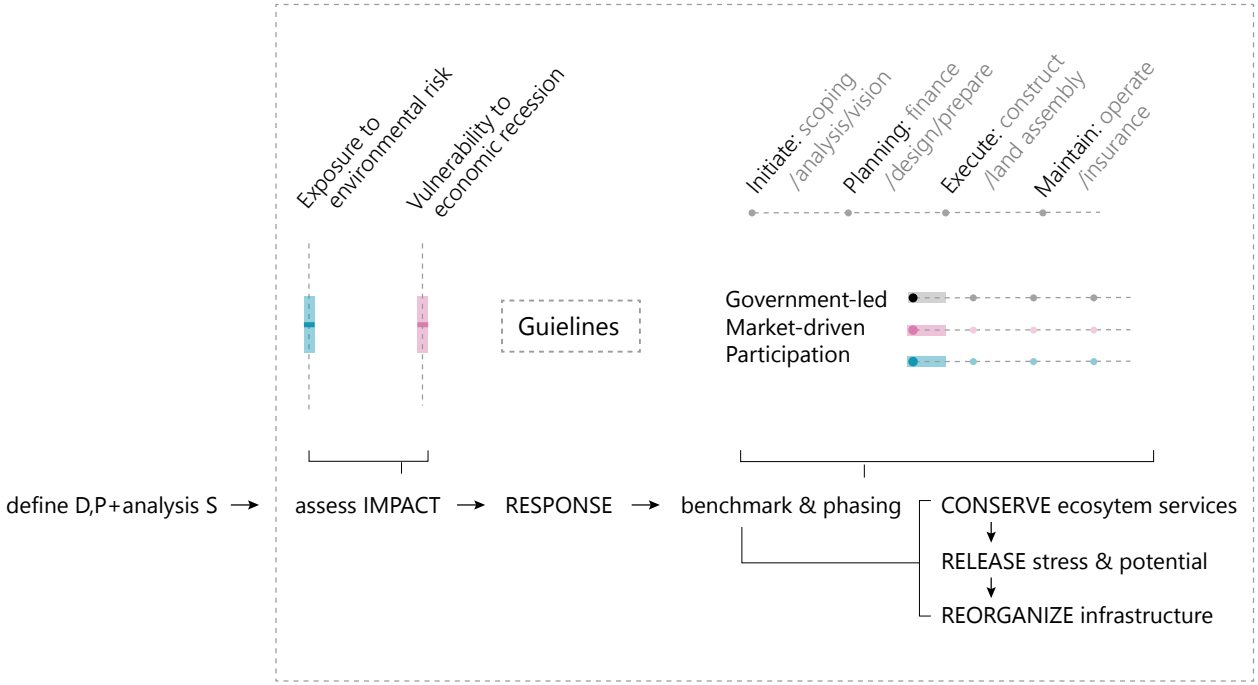


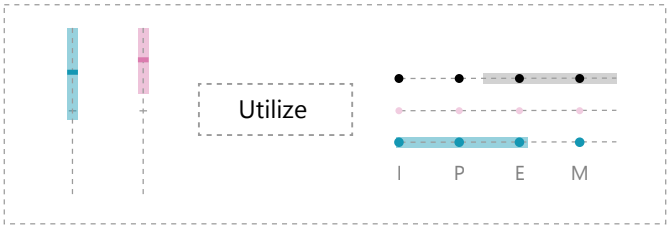
natural disturbance

Holling, C. S. 1986. Resilience of ecosystems; local surprise and global change. pp. 292-317 in Sustainable Development of the Biosphere, W. C. Clark and R. E. Munn, editors. Cambridge University Press, Cambridge.

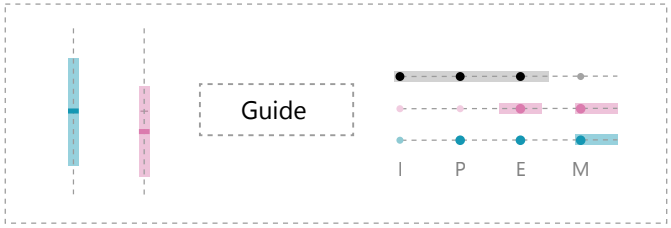
Nature-based adaptive strategy for shrinking city:

The proposed process to revitalize a shrinking city integrate natural process with urban development strategy. The phasing is evaluated by the impact of risk on current exposure and vulnerability state.

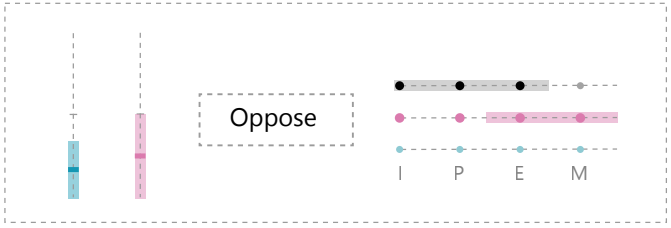




UTILIZE:
Focus on *Conserving* ecosystem services to *Release* stress on exploited land or resources.
Apply to areas with high risk exposure and high vulnerability.



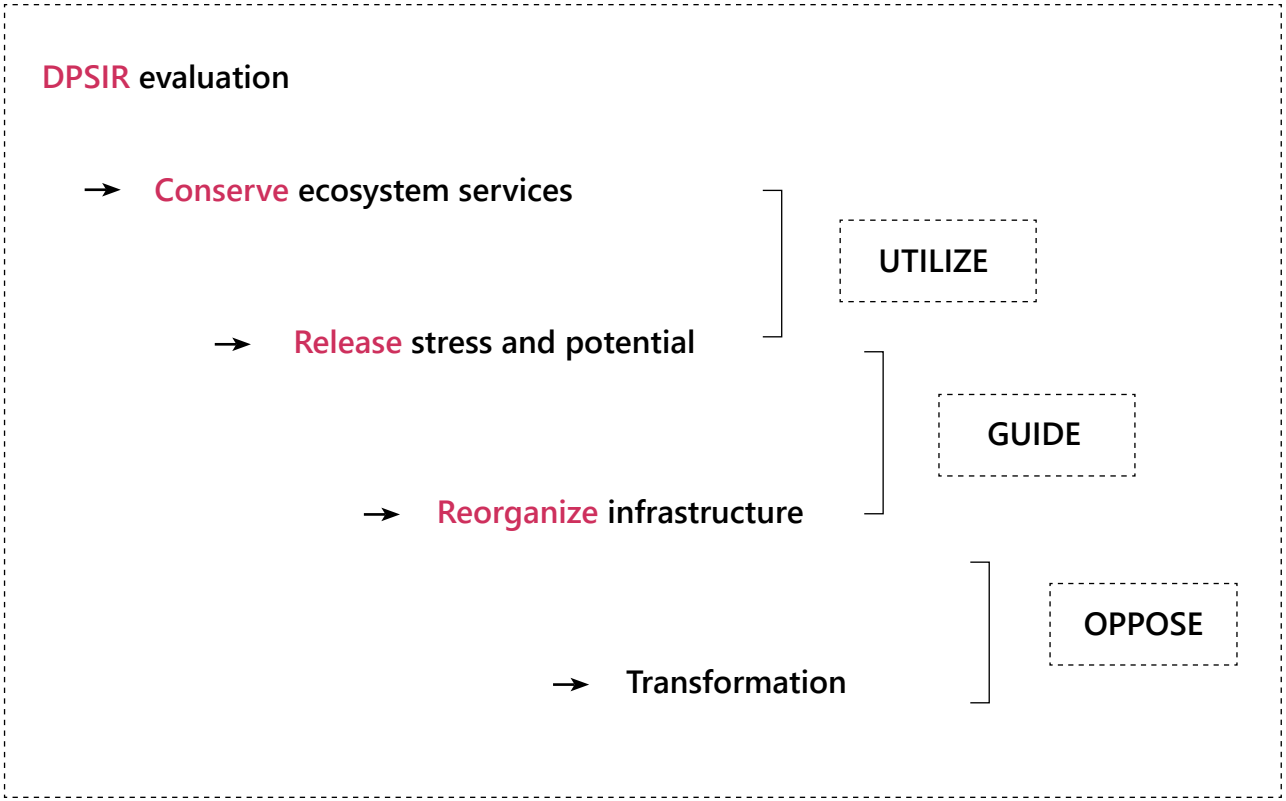
GUIDE:
Reorganize the delivery of ecosystem services to prepare for future development.
Applied when risk exposure and vulnerability are mitigated in a reducing trend.



OPPOSE:
Leverage on natural capital and economic opportunities to launch interventions for intensive urban growth.
Applied only after impacts of risk are well decreased or adapted.

Chapter 8

Spatial Intervention



BLUE VITALIZING INFRASTRUCTURE

From blue print to organic growth

Blue infrastructural network is usually the backbone of port cities, supporting sprawling development from logistic, maritime industry to settlement and outskirt business. To refuel the city as a whole, it is efficiency and system wise to pilot a revival move with existing blue infrastructure. However, regarding to environmental changes, new adaptive structures are also required.

The strategy proposed is to

1. reuse existing canal system to deliver tidal ecosystem services
2. embed ecosystem services in recessing economic plots align the flows

in order to

reinforce flood resiliency, catalyze urban transformation and to create values.

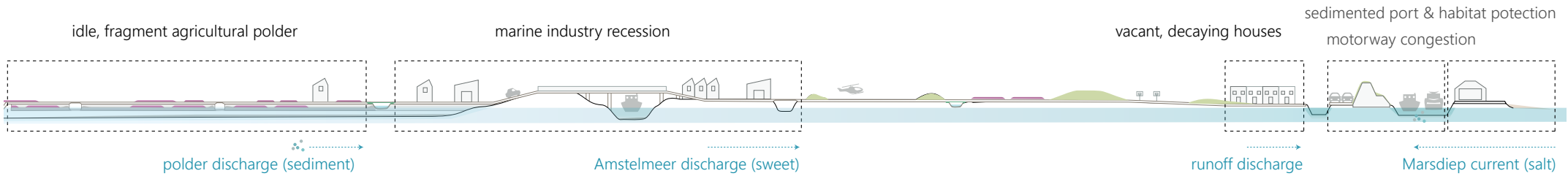
Balgzand synergy corridor

Balgzand canal is where tidal current meets discharge of urban runoff, Amstelmeer and polders. Meanwhile, it is also the critical infrastructure connecting tidal habitat, port industry, airport, neighborhoods, agricultural polders and Amstelmeer.
The canal motored the birth of Den Helder port-city, but is currently low-functioning (mainly for drainage purpose). Leveraging on its well connection to both economic and environmental assets, the transformation proposes a synergy scheme of two corridors to vitalize tidal ecosystem, industries and urban renewal following conserve-release-reorganize cycle.

Fig. As a result of canal logistic recession and agriculture, many canals in the region are low in function.

- low functiong canals
- sediments flow dirction
- main sedimentation area

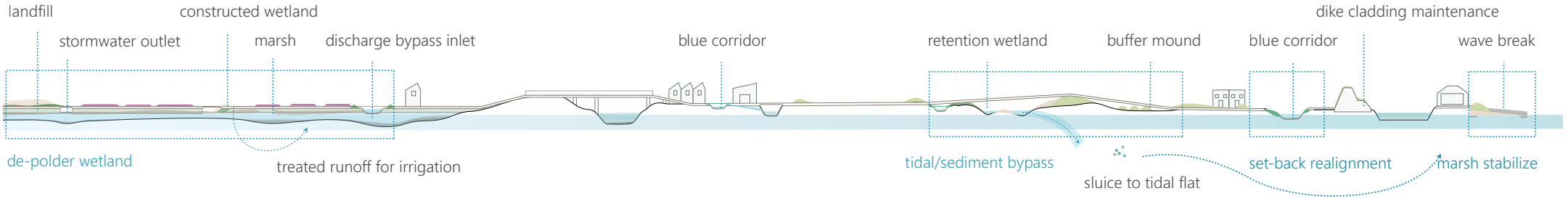
Fig. Section showing conflicting flows (discharge,tidal, sediments) in Balgzand canal with current economic recession issues:



Corridor of Natural Infrastructure:

Target:

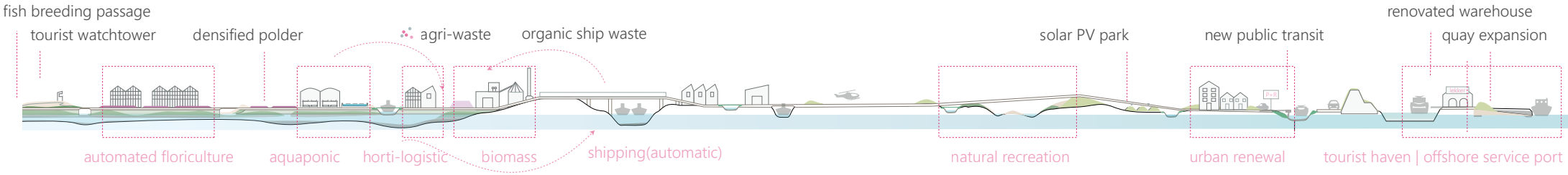
- Conserve estuarine dynamic, tidal ecosystem
- Release confliction between freshwater discharge, tidal current and sediment
- Release idle polders and spaces to nourish natural capital.



Corridor of Economic :

Target:

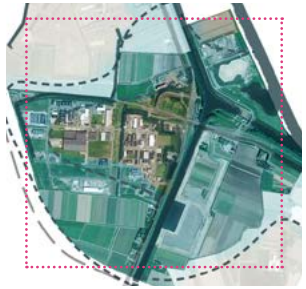
- Release domination of maritime industry
- Reorganize landuse to cope with tourism, automation and flood risk
- Facilitate port expansion and urban renewal



1 corridor x 2 scopes x 3 schemes:

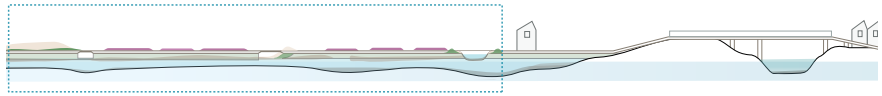
zoom-in: suburban productive landscape

Polder Realignment

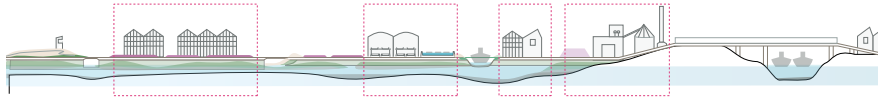


Suburban area has a homogenous agricultural polder landscape scattered with a manufacter hub (maritime, logistic business). However, both industries are not promising in near future due to polder subsidence, marginization and outdated facilities.

Balgzand corridor will first innovate more adaptive uses of polders, then explore a more local-based and collaborative business model between both sectors.



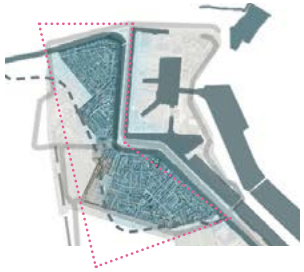
de-polder wetland



automated floriculture aquaponic horti-logistic biomass

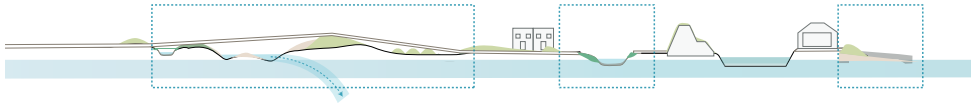
zoom-in: urban core residential

Risk Incented Urban Renewal

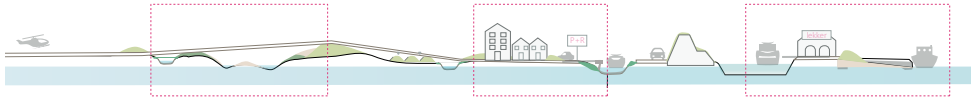


To regenerate shrinking cities, responsive urban transformation is necessary. However, due to recessing socio-economy, the process often be obstructed by high financial burden and low participation.

To facilitate transformation, the proposal is to *raise awareness and financial incentives in the name of risk management.*



tidal/sediment bypass set-back realignment marsh stabilize



natural recreation urban renewal tourist haven | offshore service port

Risk Incentive Urban Renewal

Between canal and port is the earliest residential clusters formed along the canal logistic industry in late 19th. Ironically, today it is the corner with lowest accessibility by public transport.

The blocks of terraced houses are structured with thin, monotonous streets. All blocks are closed and filled with private backyards or semi-private parking squares. Several runoff floods on streets were reported in record. Overall, it is not a surprise that a majority of properties are suffered with dull sales and high vacancy rate. Such condition frustrates the motivation for urban renewal.

Risk assessment index applied

Risk= Exposure x Vulnerability

- Exposure
  - flood probability
  - flood depth
  - flood damage
- Vulnerability
  - accessibility
  - building age
  - building typology
  - average age

Exposure:

- flood reported in record
- lowland

Vulnerability:

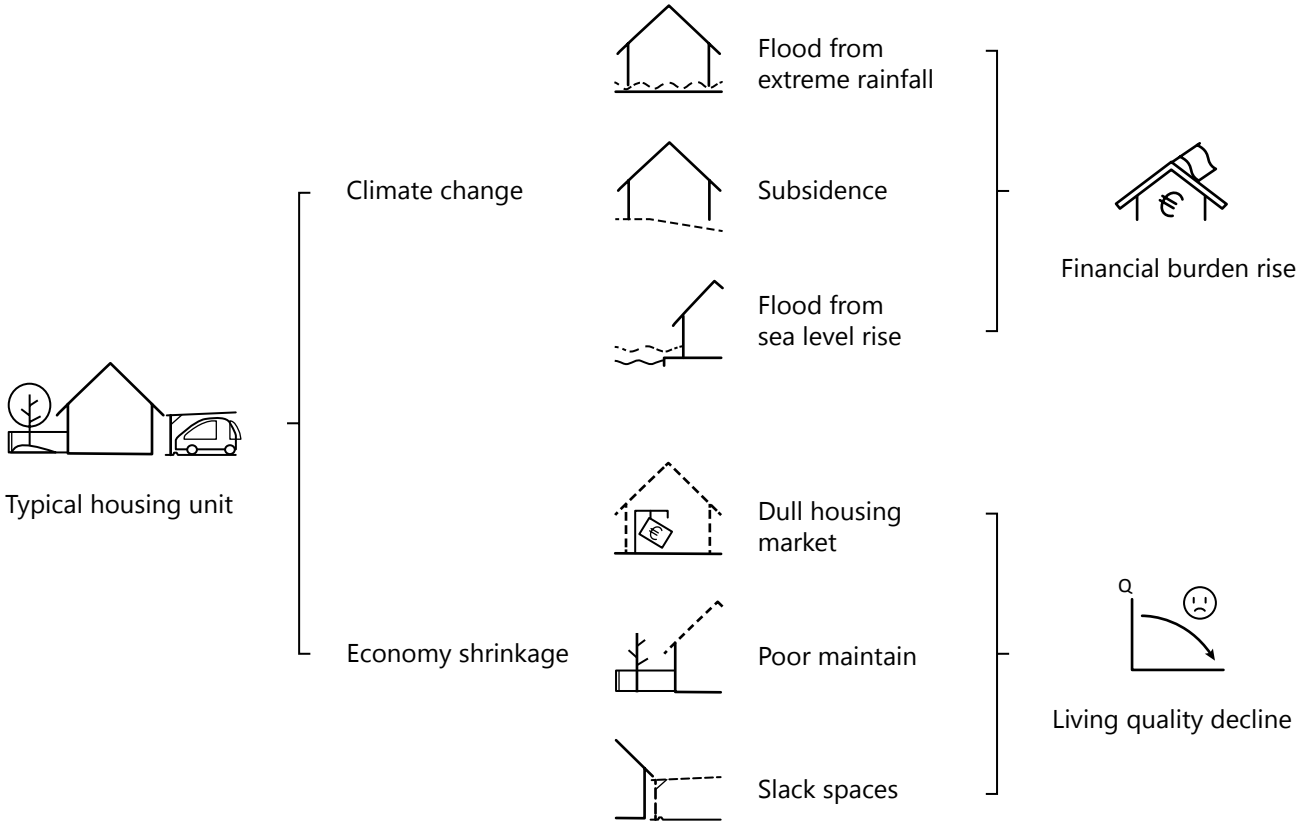
- major transit routes
- Low accessibility with public transport
- houses built before 20th century

Risk Management

Private participation and local rehabilitation is a determining factor to regenerate underutilized urban plots. For port-city regeneration projects, one of the main risks affecting economic viability is the uncertainty of environmental hazards. To incentivizing private funding, it is crucial for public sector to raise confidence for investment and reduce the level of risk. (The World Bank,2016)

Cumulative flood risk

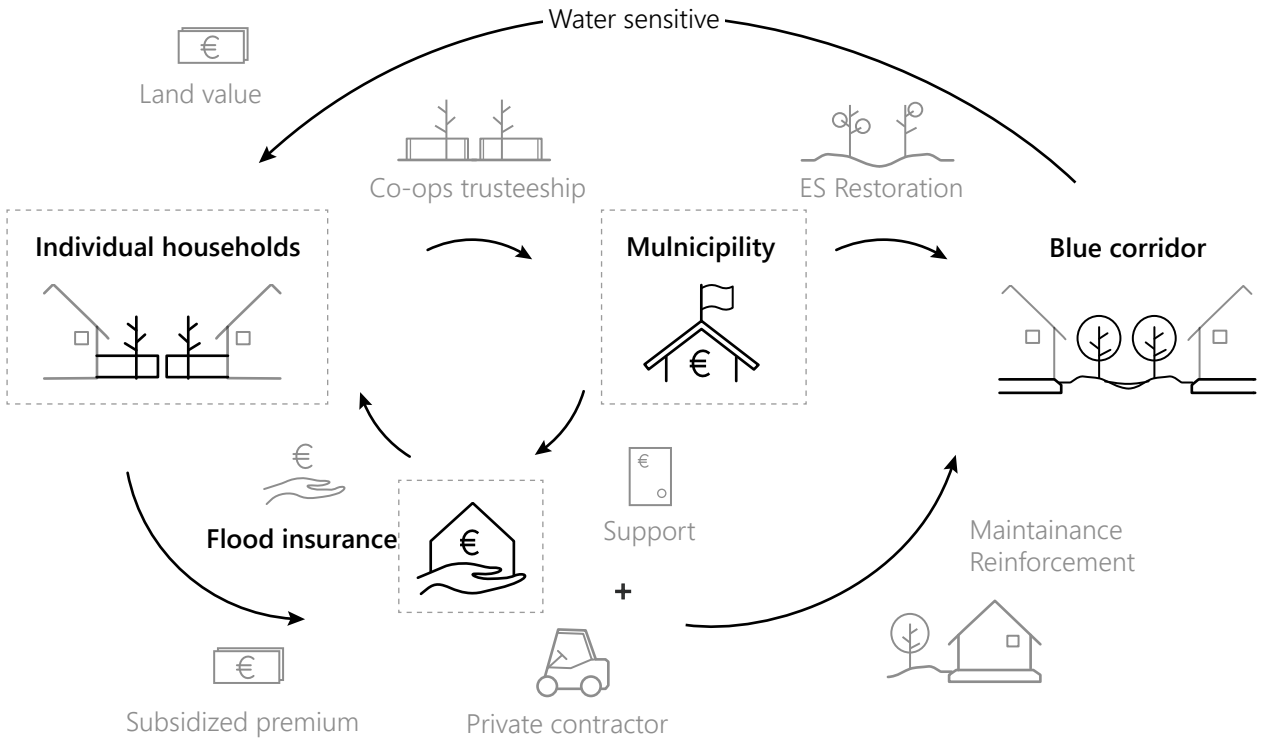
Current flood protection is completely provided by central government and water boards in the Netherlands. Unclear measurements of expected damage is the main reason crowding out private insurance market.



Incentive

Risk and Benefits Sharing

An integrated management package is proposed to facilitate renewal, combining technical renovation of houses and a PPP insurance model to incentivize participation and to share the risk.



Value capture:

Household

- Property price rise
- Better environmental quality
- Subsidized flood insurance
- Lower flood damage

Government

- Spreading risk
- Lower land acquistion barrier
- Urban transformation

Insurance foundation

- Estimable flood risk
- Official finance support
- Community-based maintanance

8.2.2 Prototype

Backyard Intervention

According to shrinking trend, more idle yards and houses will be released in near future. To align such status with the adaptive cycle, the UTILIZE phase will delve into collection of idle yards and undervalued properties to invest in natural capital, in the name of flood risk mitigation.

step 1.

Release spare space & sealed soil

- Unseal yards, parkings to enhance infiltration
- Soil remediation and organics nourishment

step 2.

Reorganize underground

- Excavate detention ponds / fill mounds
- Fill mounds
- Geothermal district heating infrastructure

step 3

Nourish livings

- Encourage passive greenhouse units
- Rain harvest

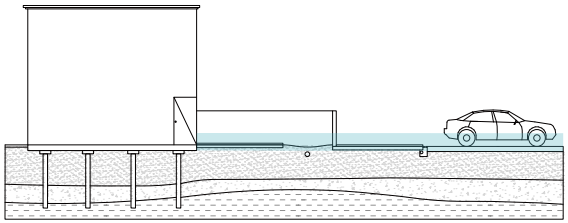
Value creation:

- Lower reconstruction cost
- Lower land acquisition prerequisite

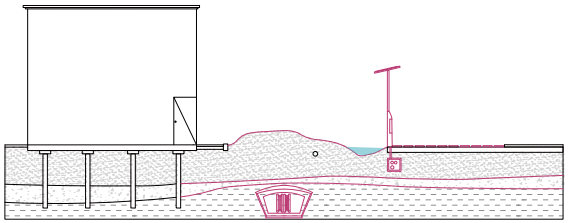
- Multi-functional infrastructure
  (flood-storage & renewable district heating)

- Lower energy consumption
- Aesthetic landscape

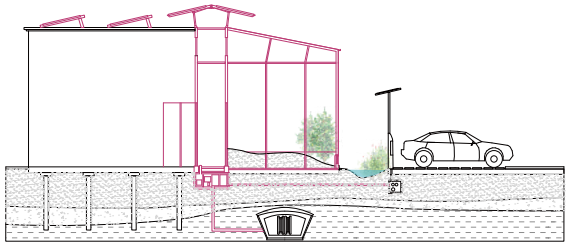
config. S: end-of-terrace/detached house + backyard



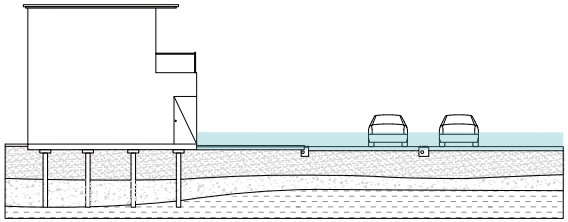
upgrade indoor environment



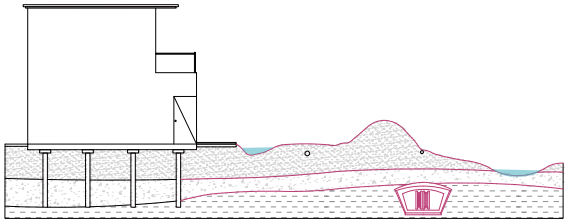
attached private passive house + rain garden



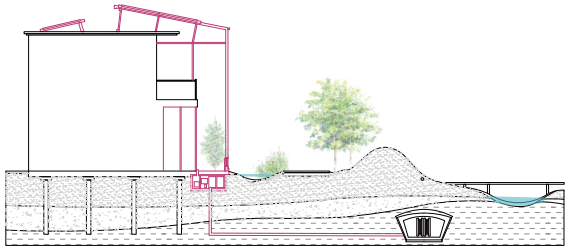
config. M: terraced houses + parking lots



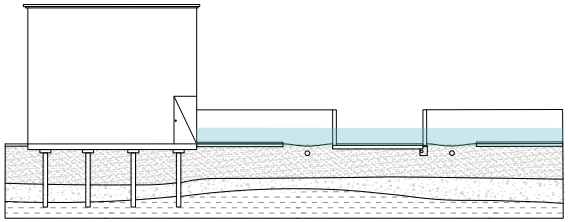
upgrade semi-public space



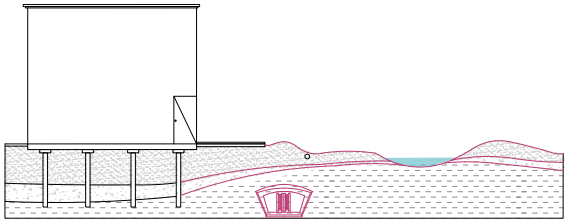
attached shared passive house + flood buffer



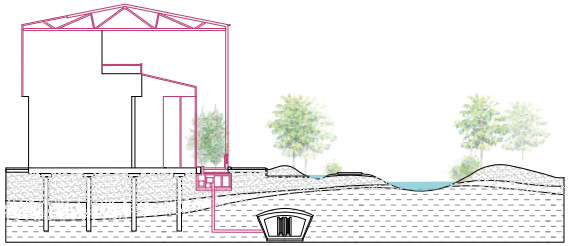
config. L: terraced houses + adjoining backyards



upgrade building typology



house renewal + green corridor



cfg.M

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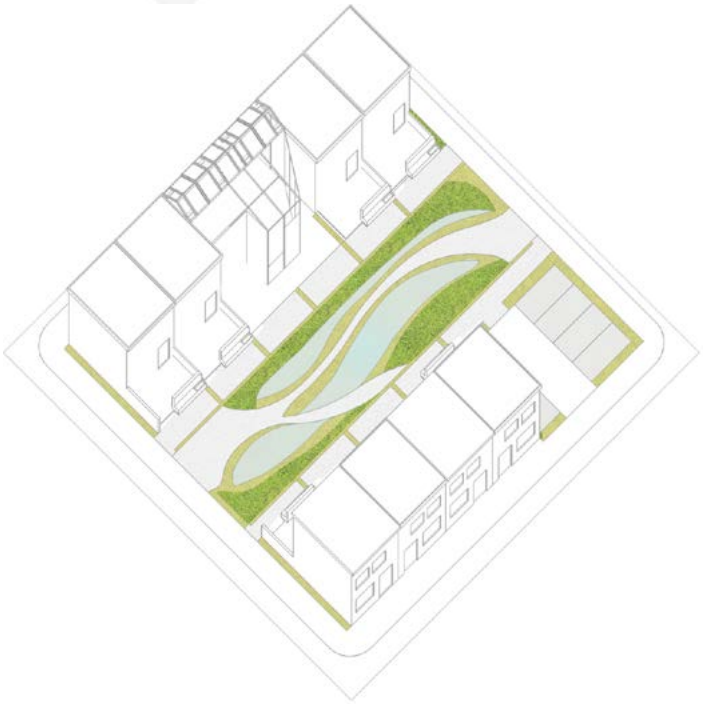

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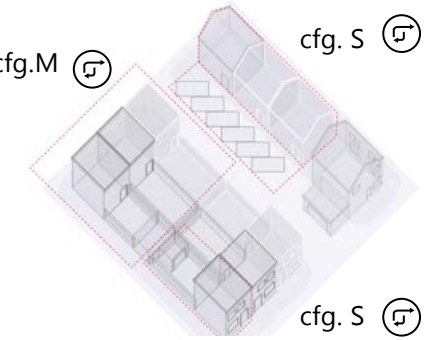

cfg. S

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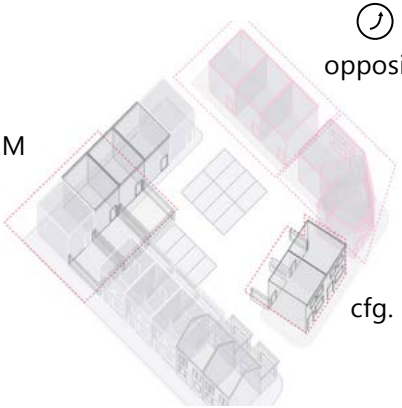
opposing



cfg. S

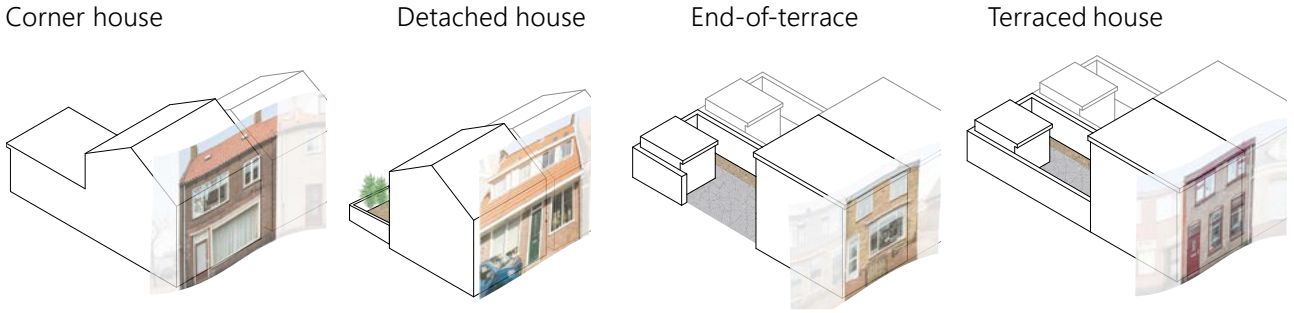
8.2.3 Transect of transformation

Utilizing Economic Recession

Spatial Impact from Economic Dynamism

Building typology is an important index to estimate the imapct of economic recession on property value and living condition. This also suggests residents' willingness to participate in urban renewal. Regarding high or low dynamics, a phasing transformation towards water and shrinkage resilient neighborhood is proposed.

In the area, there are four common building typologies, each with different vulnerability to economic climate:



	Corner house	Detached house	End-of-terrace	Terraced house
Renewal intention	■	■	■■	■■
Maintenance	■■■	■■■	■■	■ ■
Vacancy rate	■■■	■	■■■	■■
Property value	■■■	■■■	■■	■
Market fluctuation	■■■	■	■■	■

Quantitative Incentives

Quantifying ecosystem services and land usages (FSI and GSI) can provide a casco to launch transformation in process. Plus, the index indicates not only the amount of spaces that is used for dwelling, but also the amount of public spaces that can be used for natural infrastructure.

- Reduce cost of flood damage
- Reduce cost of subsidence damage
- Reduce cost on grey infrastructure
- Reduce water, energy costs of property
- Increase property value
- Economic impact, job creation

- Insurance reduction
- Volume reward
- Subsidy

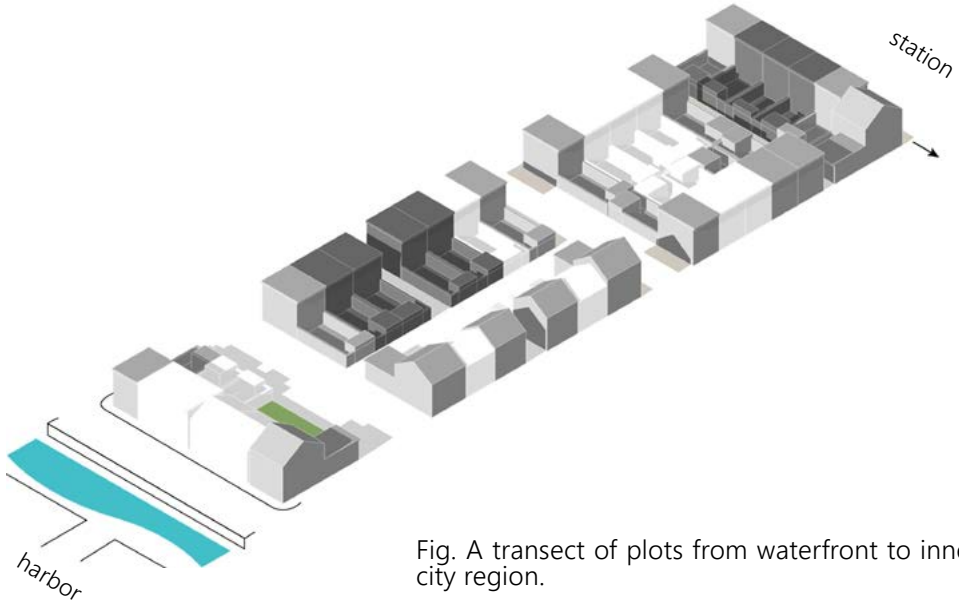
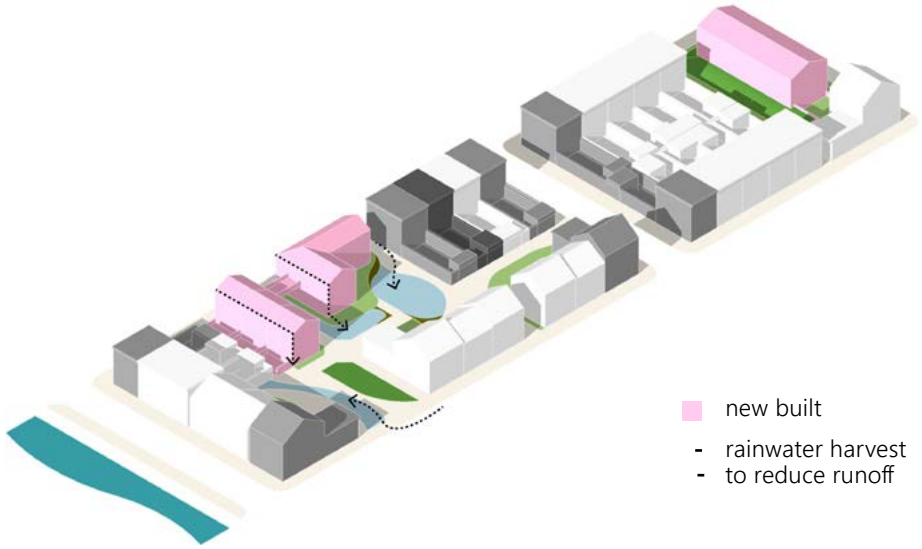
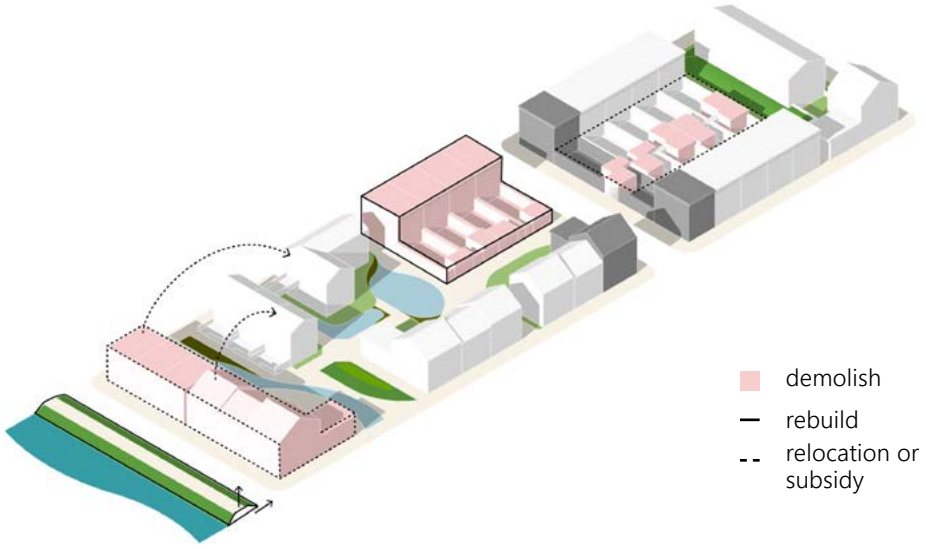


Fig. A transect of plots from waterfront to inner city region.

- house value highly subject to economy status
- devalued houses





phase 1.

Land acquisition for affordable housing

Provide subsidy to acquiste spaces for risk management.

Guidline:
- rise FSI
- build for relocation, public rental
- flood-buffering building

site:
- public areas,
- devalued / dull sale vacant houses

landscape:
- excavate retention pond
- filling grass slope

Executive:
- government-led rebuilt; BOT

Stakeholders:
- mulnicipality; residence;
- infrastructure department

phase 2.

Set-back relocation

Flood-prone land acquisition

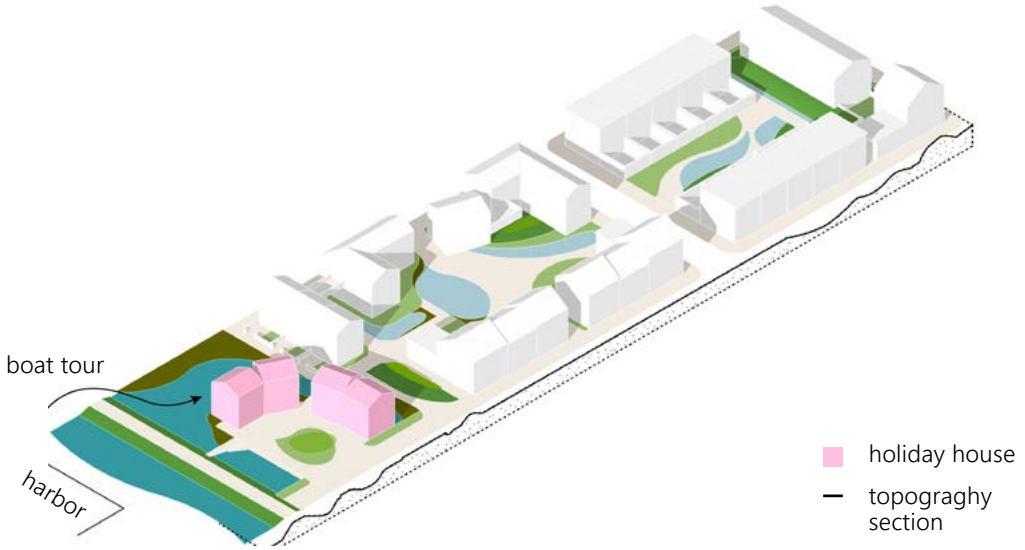
Guidline:
- lower GSI, rise OSR
- volume transfer and reward

site:
- high flood risk housings,
- private unbuilt areas

landscape:
- filling excavated material at waterfront

Executive:
- government-led acquisition

Stakeholders:
- mulnicipality; residence;
- insurance company



phase 3.

Integrate with green/blue corridor
Backyard transformation

Guidline:
- rise OSR
- mix-used community

site:
- acquisited building units, open spaces

landscape:
- create community public space
- integrated rain harvest system

Executive:
- BOT

Stakeholders:
- mulnicipality; residence; infrastructure department

phase 4.

Multifunctional program
Increase landuse diversity and temporal uses

Guidline:
- flood detention zone
- recreation program

site:
- waterfront

landscape:
- marsh nurishment
- waterfront recreation

Executive:
- comminity assembly

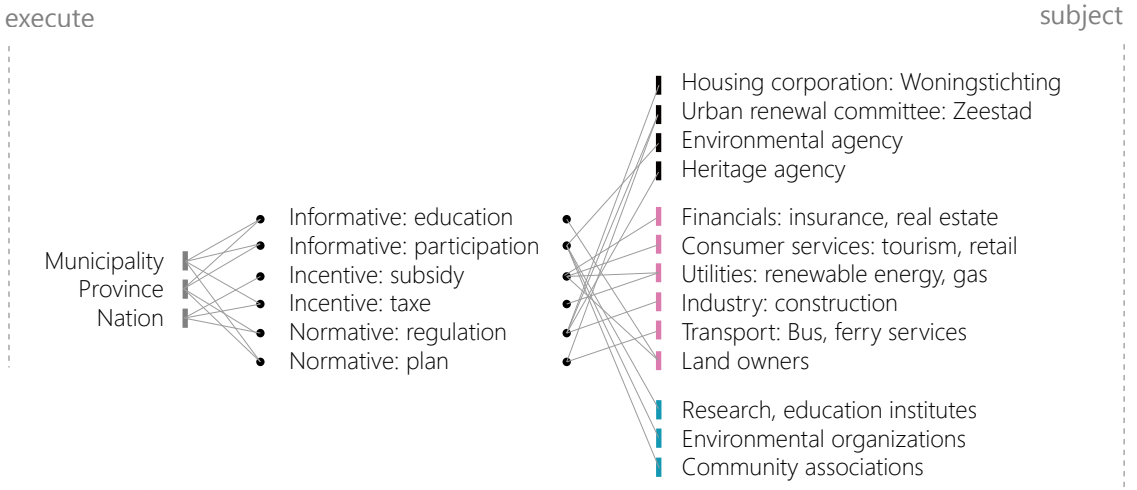
Stakeholders:
- mulnicipality; residence; local company

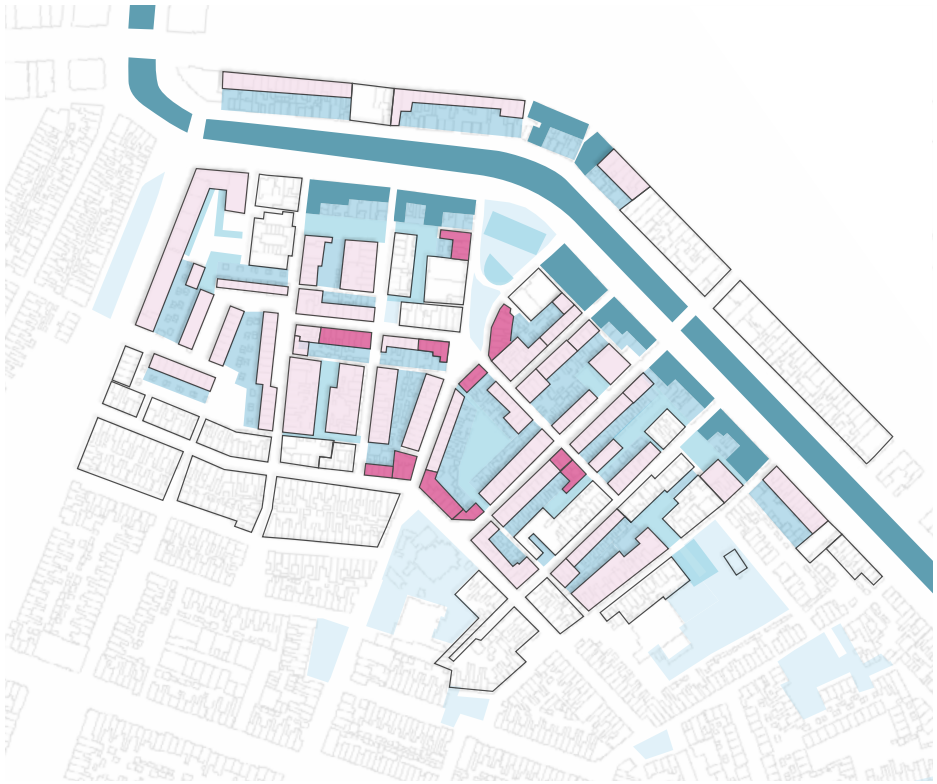
8.2.4 Masterplan

Neighborhood Renewal

Strategic location for transformation

Strategic transforming locations are identified through risk assessment GIS analysis. Here the exposure of each house to flood damage and vulnerability of housing value to economic degradation are highlighted. For neighborhoods with higher risk, proper incentives can trigger renewal process more effectively.





Apply prototypes and transects to embed natural quality in living environment and reduce flood risk.

Utilizing:

- Brakish retention: relocate flood-prone houses
- Runoff collection: backyards of terraced houses
- Runoff detention: private parking spaces and laneshouses

Guiding:

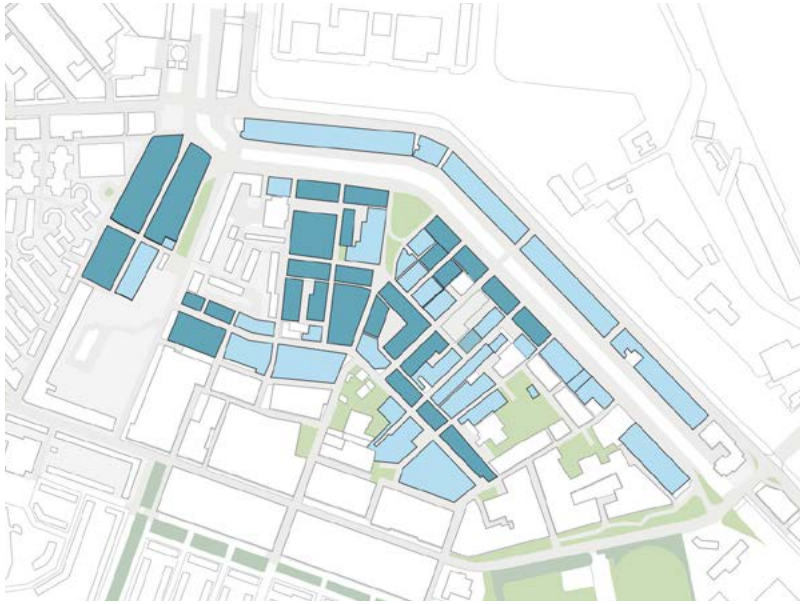
- Renewable district heating: backyards of terraced houses
- Renovation: houses involved with flood insurance

Opposing:

- Renovation: location-wise houses

Utilize: release flood risk

Based on flood risk simulation, partial realignment and set-back is suggested.



Realignment

- Relocation/ realignment blocks: Reconstruction required.
- Retrofit blocks: Added value required.

Guide: reorganize network

Leverage on exsting blue infrastructure and potential mobility.

Blue infrastructure

Reconstructed functions of damaged blocks

- brackish retention
- runoff detention
- embankment

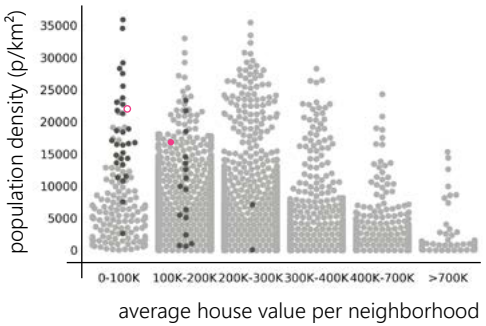
- proposed major transit axis

Oppose:

In response to a scenario with reduced risk and high participation, a transformative masterplan is designed.

Adapted size for value investment

Regarding to shrinking trend, the density of this neighborhood is suggested to downsize. Statistic relation of density and property value reveals that a loosen density may be an opportunity to re-capture values.



- ○ current
- • designed proposal
- • neighnorhoods of Den Helder
- • neighnorhoods of the Netherlands

Chart. Designed lower housing density is reflected on potential to gain value.

Fig. Water sensitive masterplan

- new built
- brackish retention
- runoff detention
- embankment

AlleCijfers.nl (2018). Dutch neighborhoods housing value & population density

Gravel filtration

Detention pond

Phytoremediation

Bioremediation

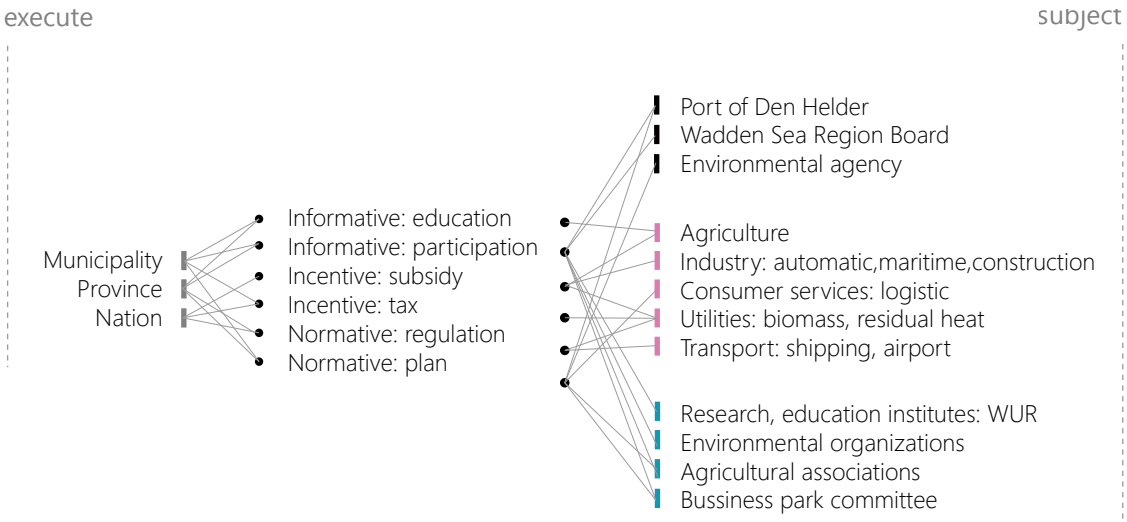
Polder Realignment

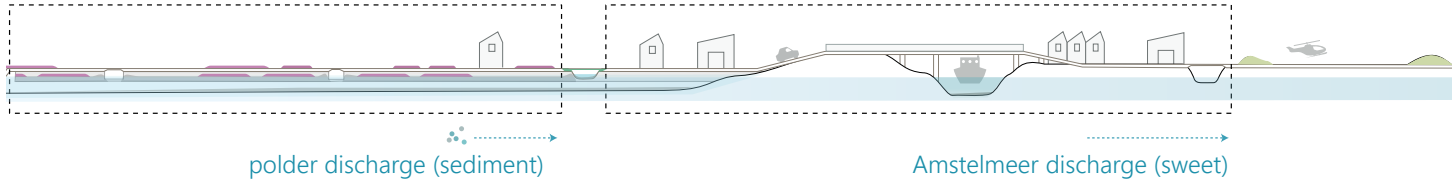
According to province's estimation, the area demanded for horticultural polders in Den Helder will drop 12 % in 2050. This is due to economic recession but also concentration by automated technology. The polder landscape will be more fragmented with transformed landuses, especially along logistic routes.

Meanwhile, extreme discharge volumn and subsidence will be more common. Thus, polders are expected to bear higher flood chances.

From natural infrastructure to regional economy

In response to *higher water storage demand and shrinking horticulture trend, a more efficient use of polder system* (arable lands+controlled water circulation) is proposed.

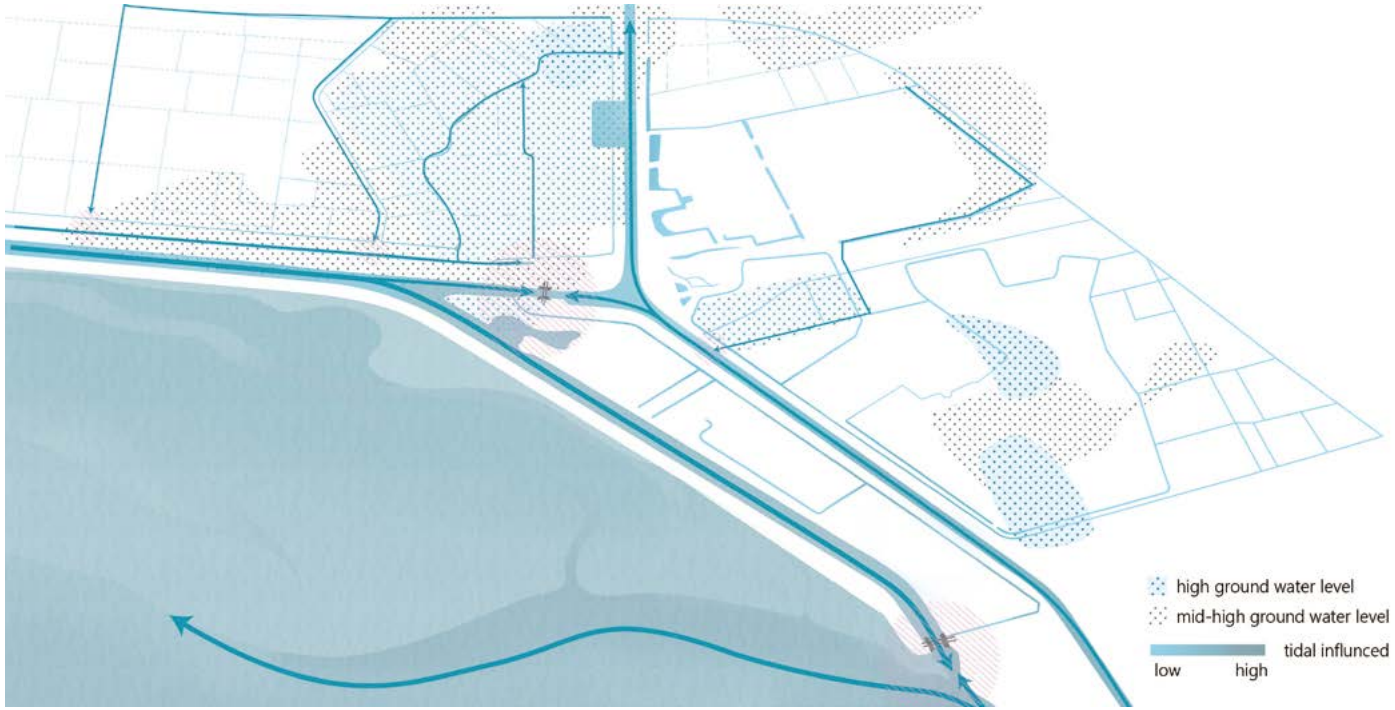




8.3.1 Phasing

Adaptive Polder Realignment Scheme

A flexible transformation process leveraging on dynamics of landuse demand and tidal forces.



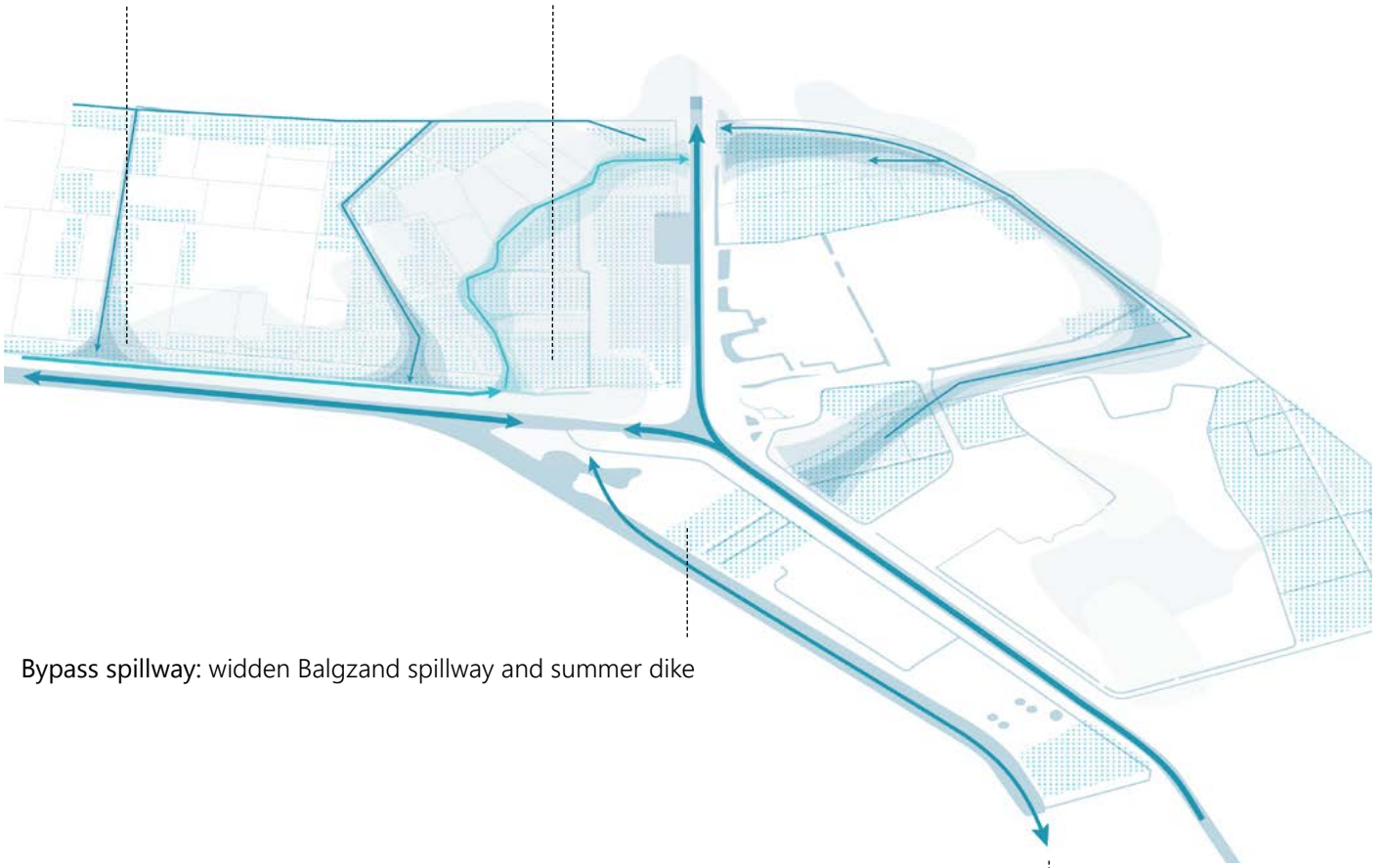
Environmental trend: higher flood potential

++ tidal force
+ groundwater level
++ Amstelmeer extreme discharge volumn
+ sediment
+ sea level

Economic trend: shrinking landuse demand

-- arable polder areas
+ maritime industry
- households
+ airport logistic
- cargo logistic

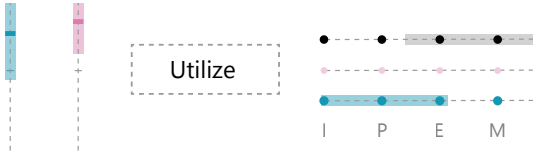
Discharge retention: de-polder areas that are under-valued and of high groundwater level



Bypass spillway: widden Balgzand spillway and summer dike

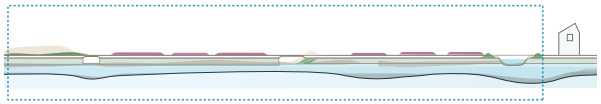
Sediments control:
leverage tidal force to pull
sediments from Balgzand sluice to marshland.

Phase 1: 2018-2023

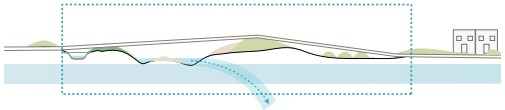


New flood management system

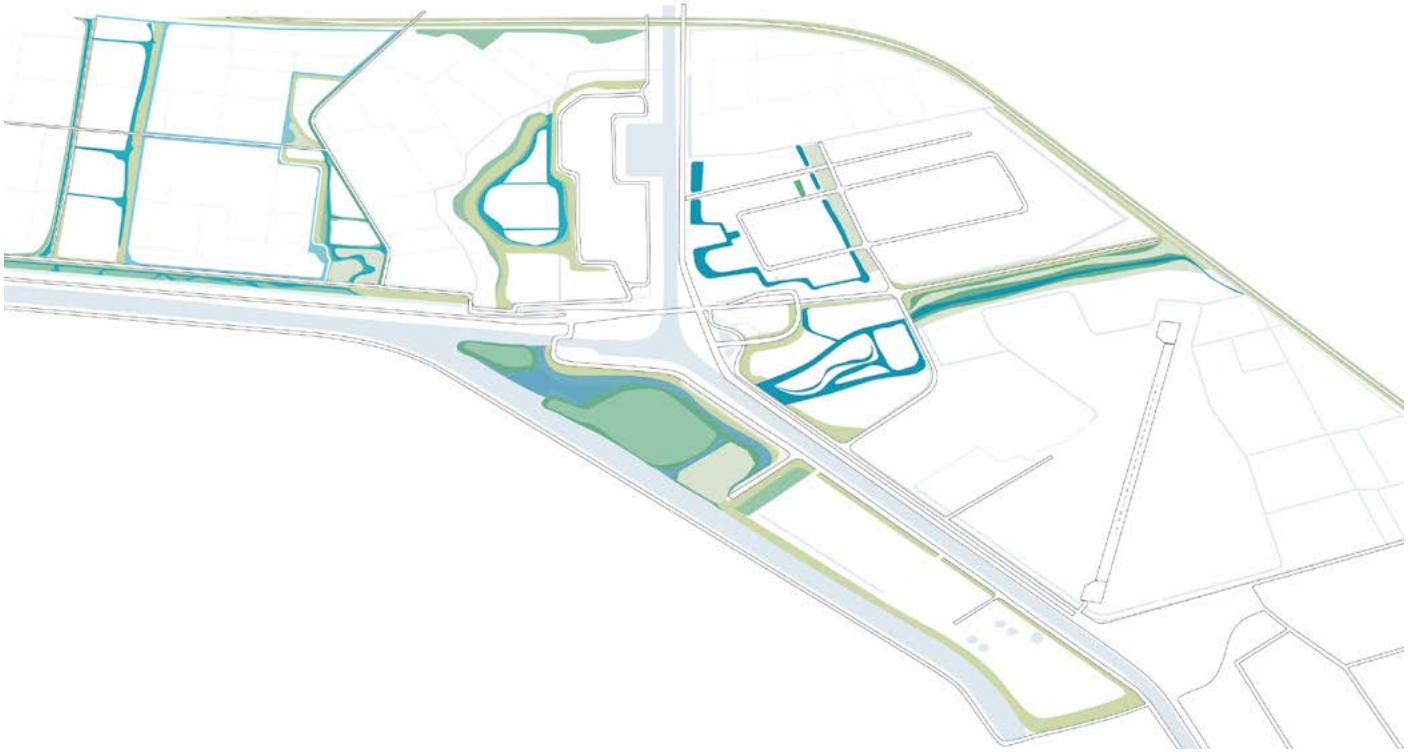
Pilot phase employs nature-based engineering to increase runoff detention, relocate bypass for discharge, nourish saltmarsh/seagrass and manage flood-prone areas.



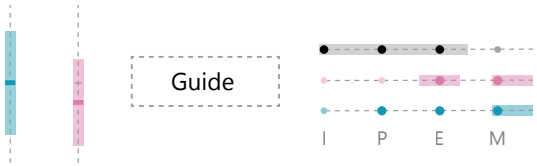
de-polder wetland



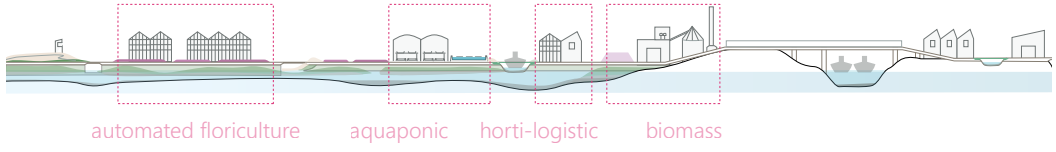
tidal/sediment bypass

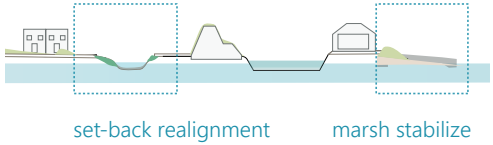


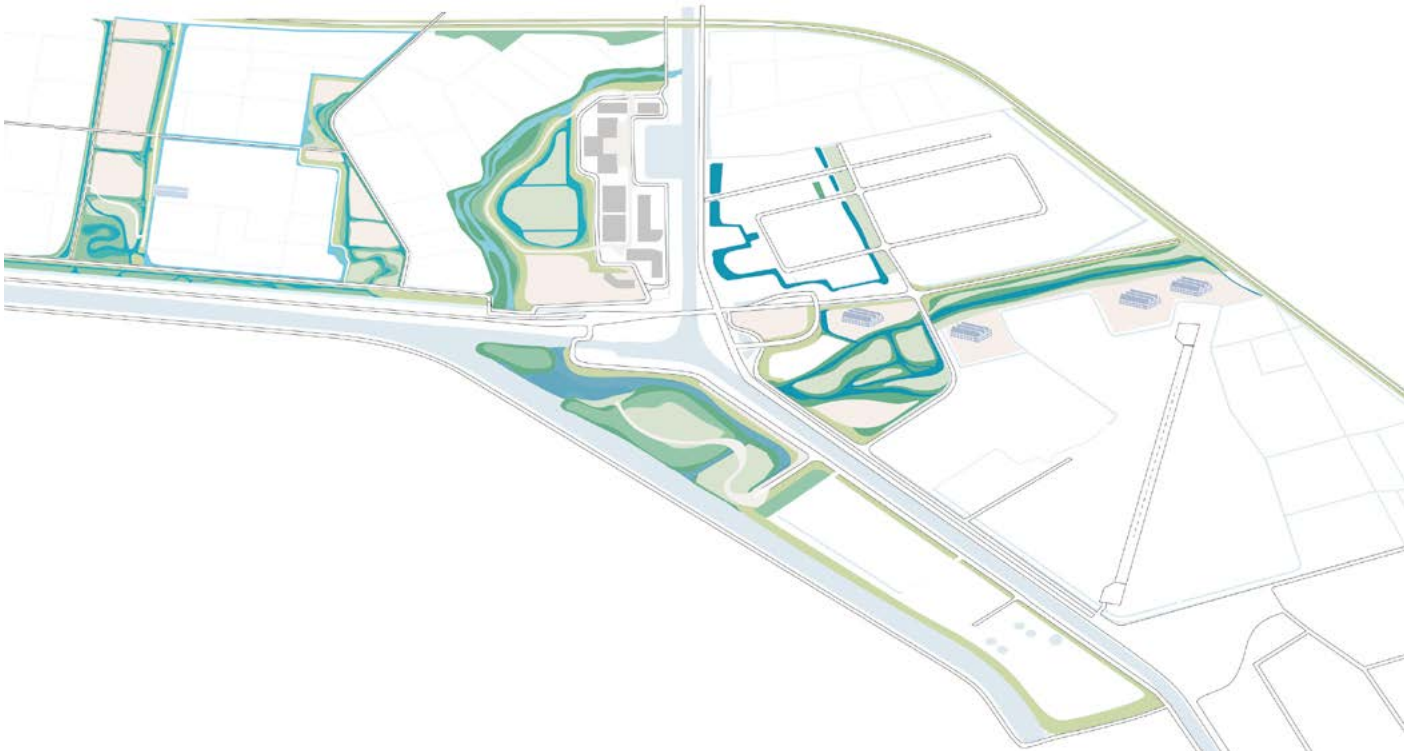
Phase 2: 2020-2030



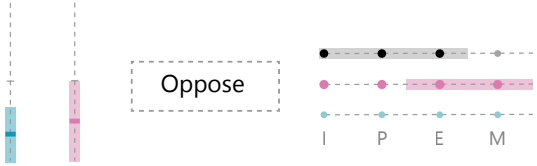
Modified landscape and inflow guide growth of related industries and cooperation among agriculture and maritime logistic. This diverse coexistence sets market for future automated technology that can upgrade current industries.







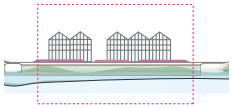
Phase 3: 2025-2050



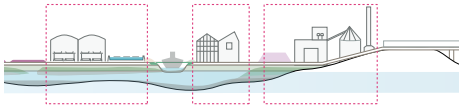
Modified landscape and inflow guide growth of related industries and cooperation among agriculture and maritime logistic. This diverse coexistence sets market for future automated technology that can upgrade current industries.

Waterfront set-back and backyard nursery can improve residential quality and lower flood risk. The optimal goal is to reinforce a stabler, attractive living environment confronting economic flunctuation.

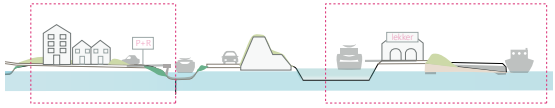
By coping with wave and minimize dredging construction, the disturbance of quay expansion can be compensated by breaking wave and stabalizing Balgzand bay sediments.



automated floriculture



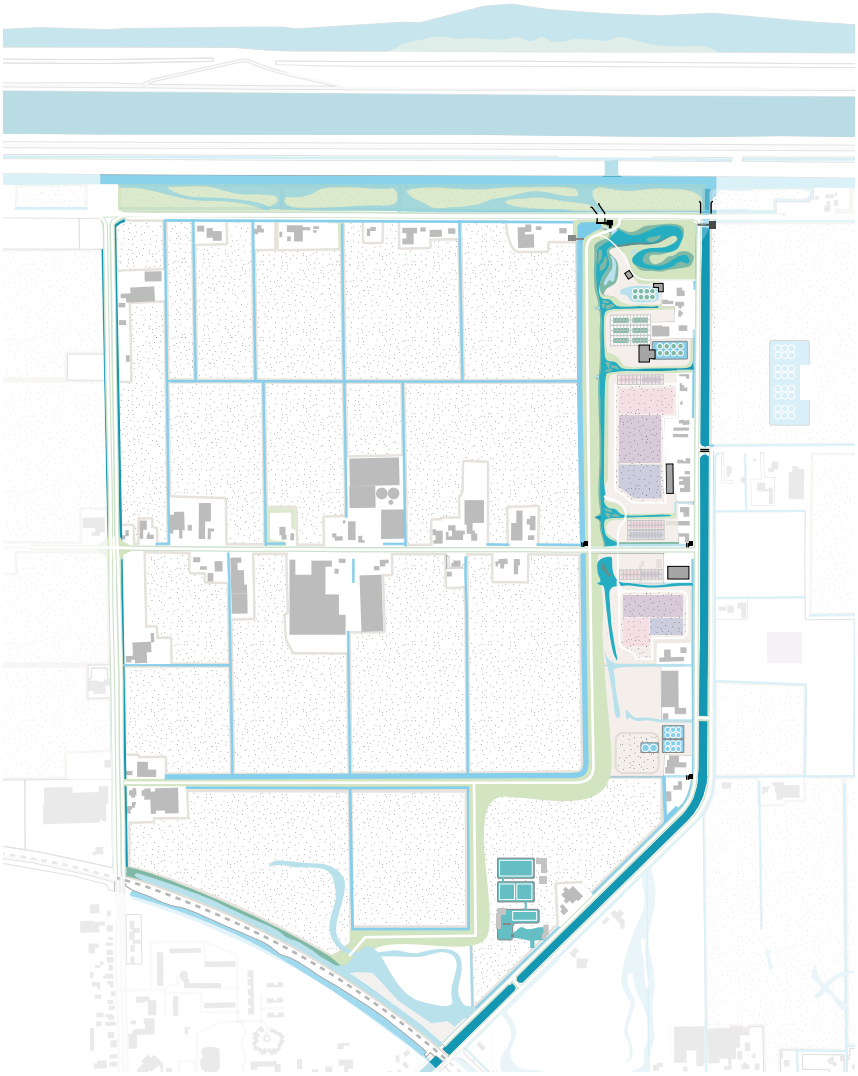
aquaponic horti-logistic biomass



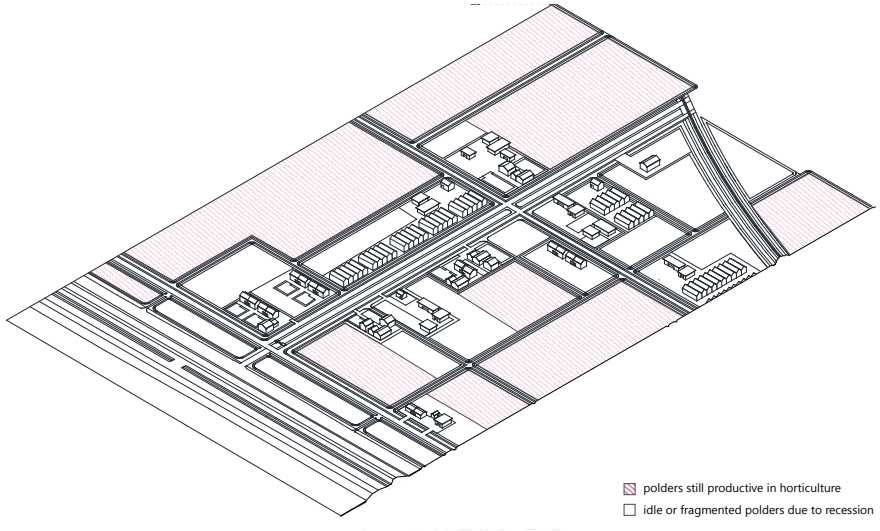
urban renewal tourist haven | offshore service port

8.3.2 Prototype

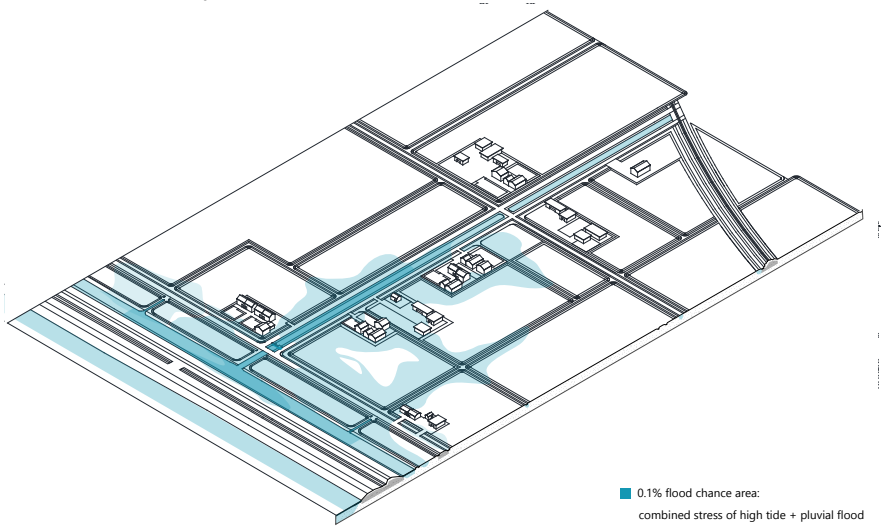
Adaptive new polder unit

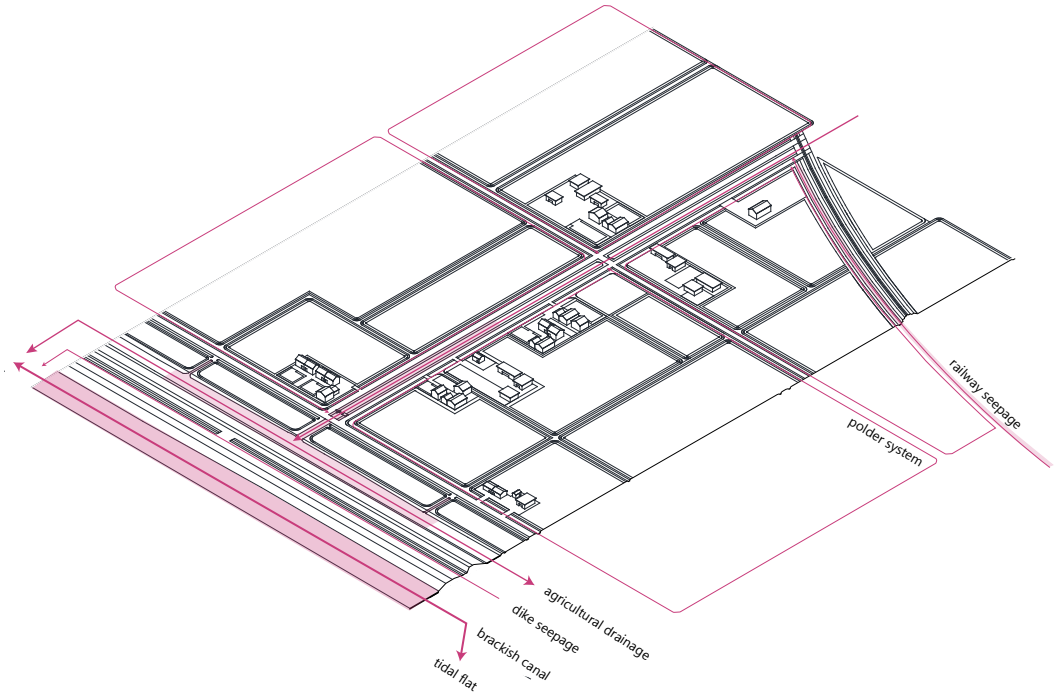


Shrinking trend impact

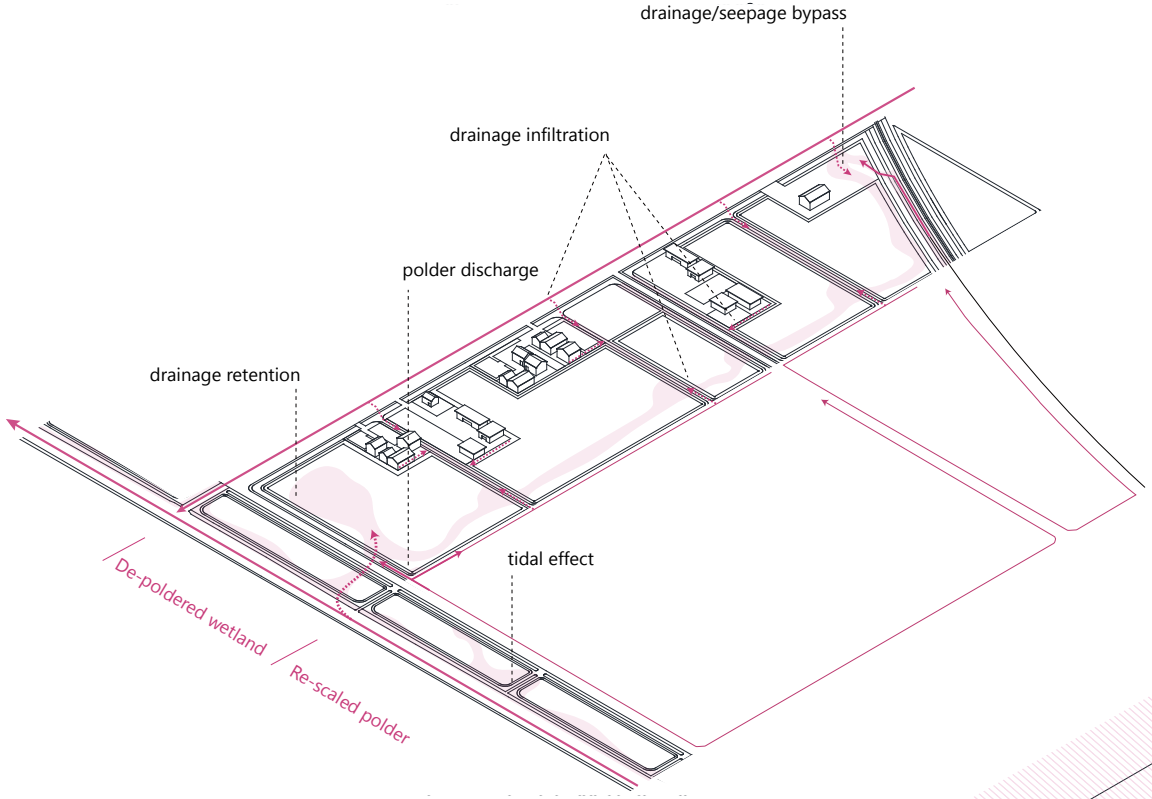


Flood hazard potential



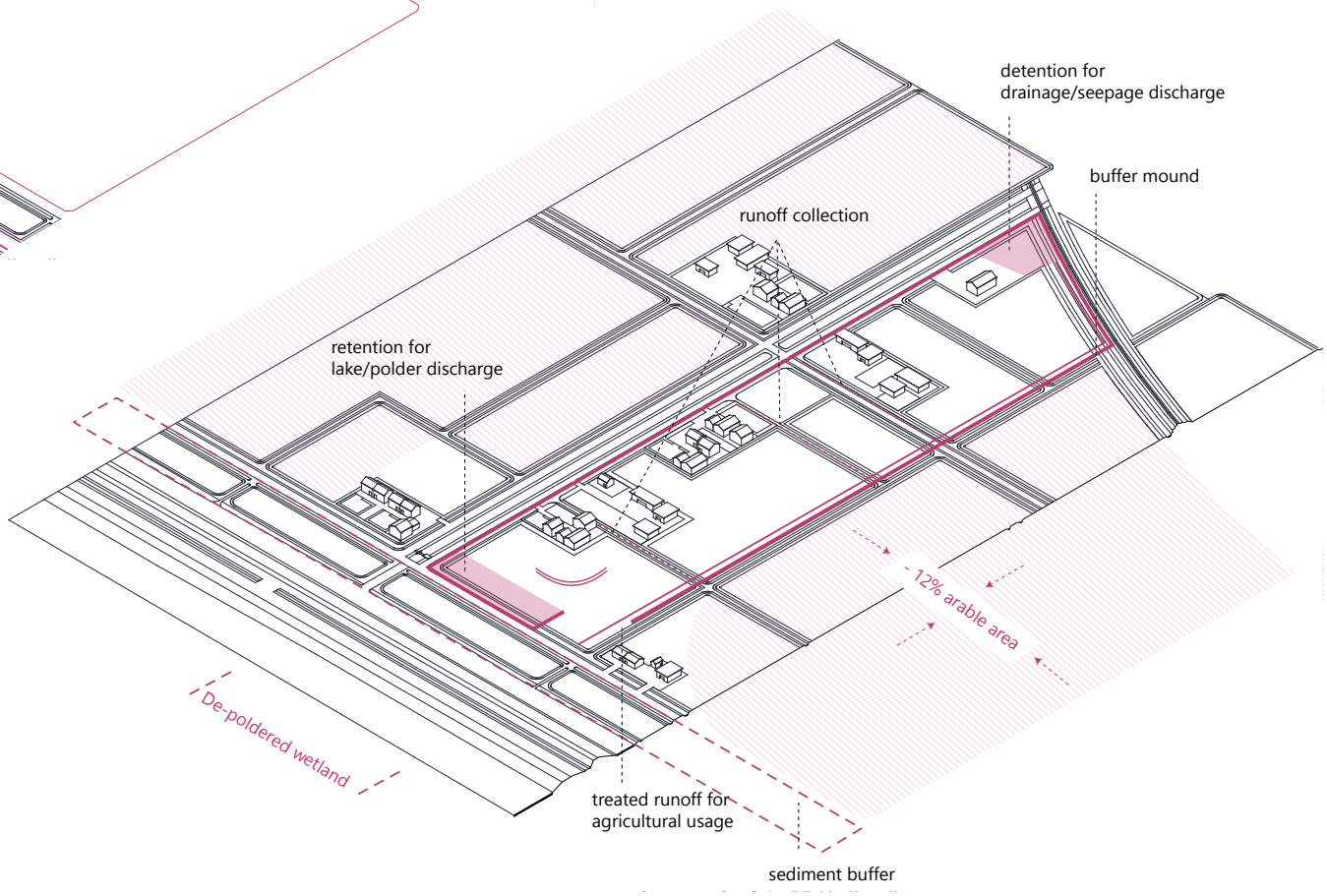


Original combined system of runoff discharge, polder discharge Amstelmeer discharge and irrigation.



surface flow

subsurface flow

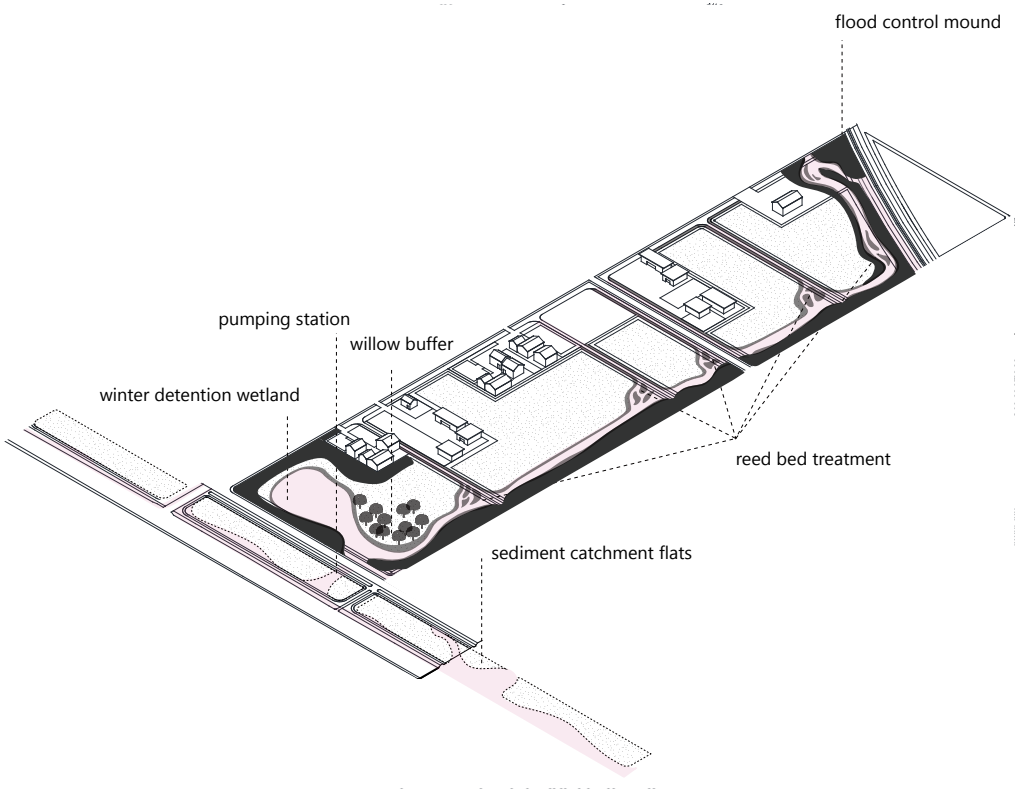


Utilize

- Depolder roadside (gutter side) fragmented polders. Released plots are conserved for discharge storage.

Guide

- Reorganize smaller polder circulation unit. Concentrate arablle spaces.
- Reorganize discharge bypass and sluice to detention ponds.

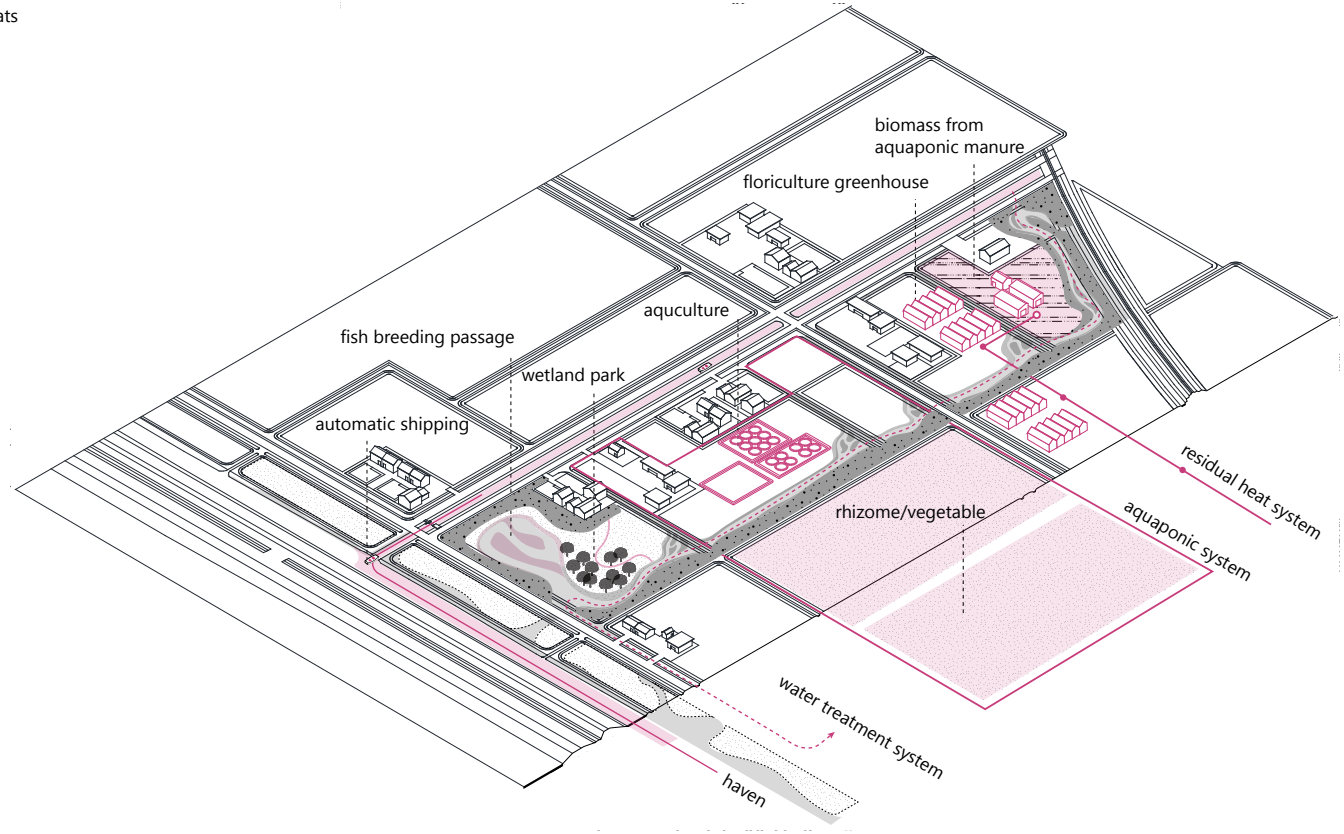


Guide

◦ Use marsh, wetland and clay mound ecosystem to construct flood control and runoff treatment corridor.

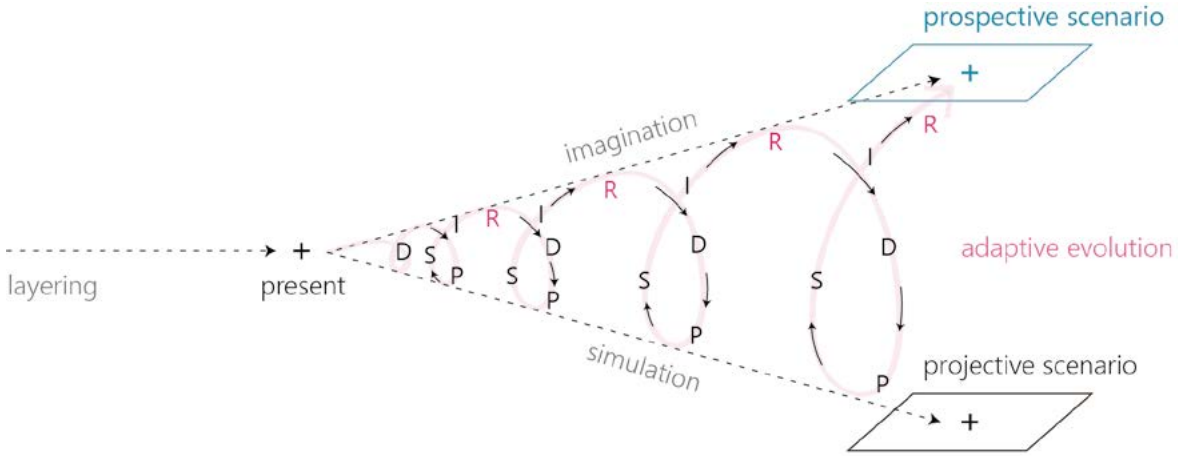
Oppose

◦New landscape types and future automations can nourish more diverse landuses. Light industries (ex. tourism, aquaculture, greenhouse) and circular biomass industry are encouraged.



Chapter 9

Open-ended Evolution

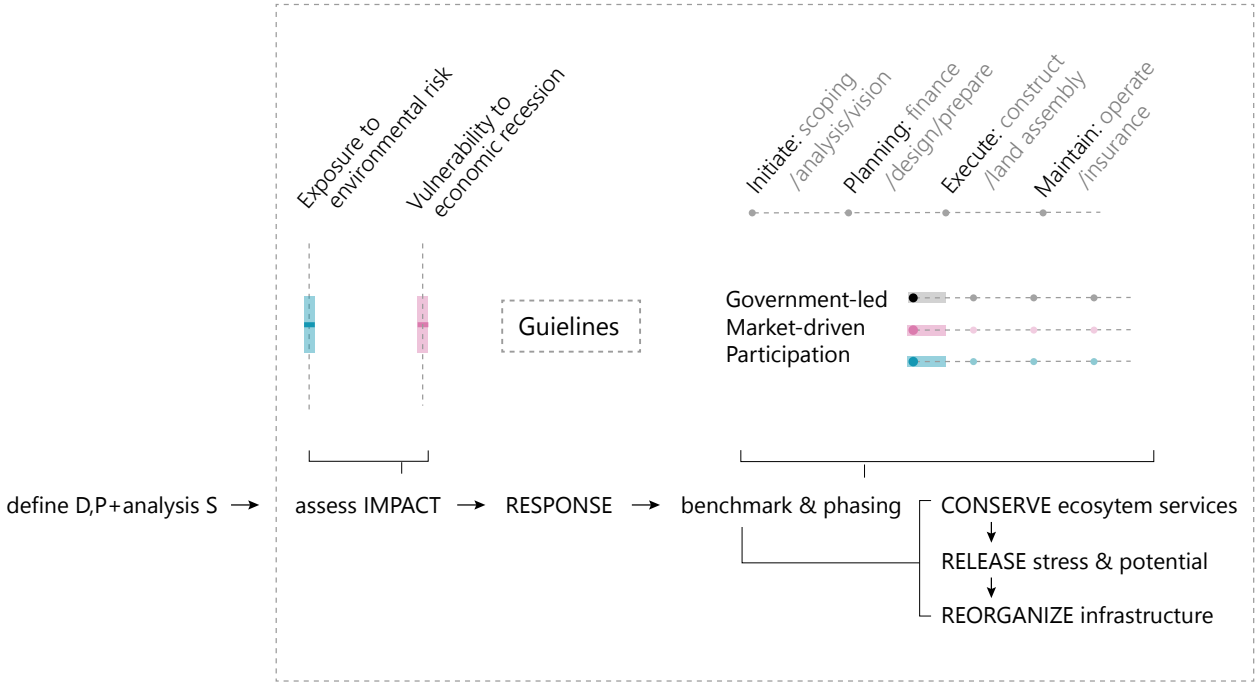


SHRINK NATURALLY

Shrinking is an inevitable fate for many port cities. Aiming to oppose shrinkage may deteriorate the lose of resources, resulting in vulnerable urban decline and higher exposure to coastal risks.

Thus, the proposed adaptive strategy is to reframe shrinkage as a phase of natural evolution, or even as an opportunity to conserve resources, release pressure and reorganize structures. The goal shall be to let such a city 'sustainably shrinks', and to make it a smaller but more attractive living environment, instead of ' poorly sinks'.

Principle:
Natural system as sustainable fuel



3 STRATEGIC SCHEMES+1 EXPERIMENT

scheme: UTILIZE

High risk exposure+ Recessing economic

Along Balgzand canal, three flood-prone low-laying areas are rezoned temporary detention basin in extreme situation. Idle spaces in these pockets are collected to construct gree/blue infrastructure for water management.

Mud motor

- Manage sediment in port and from de-polder
- Bypass surface runoff from port
- Transform idle canals to tidal park
- Reuse subsiding polders for flood storage

Flow management (water, sediment)

- new outlet of sweet water
- new main drainage direction (existing canals)
- new sediments sources
- sediments transport

Flood management

- mounds
- marsh nurishment

Ecosystem services management

- green patches
- corridor carrying biodiveristy and recreation

scheme: GUIDING LINES

High risk exposure+ Flat economic growth

Diversify industry sectors and facilitate flood-adaptive urban renewal by revitalizing existing canal-drainage-fortage network system.

Blue synergy infrastructure

Den Helder has a high percentage of open field and green/blue areas. By improving the connections between these spaces, a green infrastructure can be designed to enhance ecosystem services.

Connectivity of green/blue area

- Fort heritage
- Sand dunes landscape
- Arable polders
- Wetland and marsh
- Canals

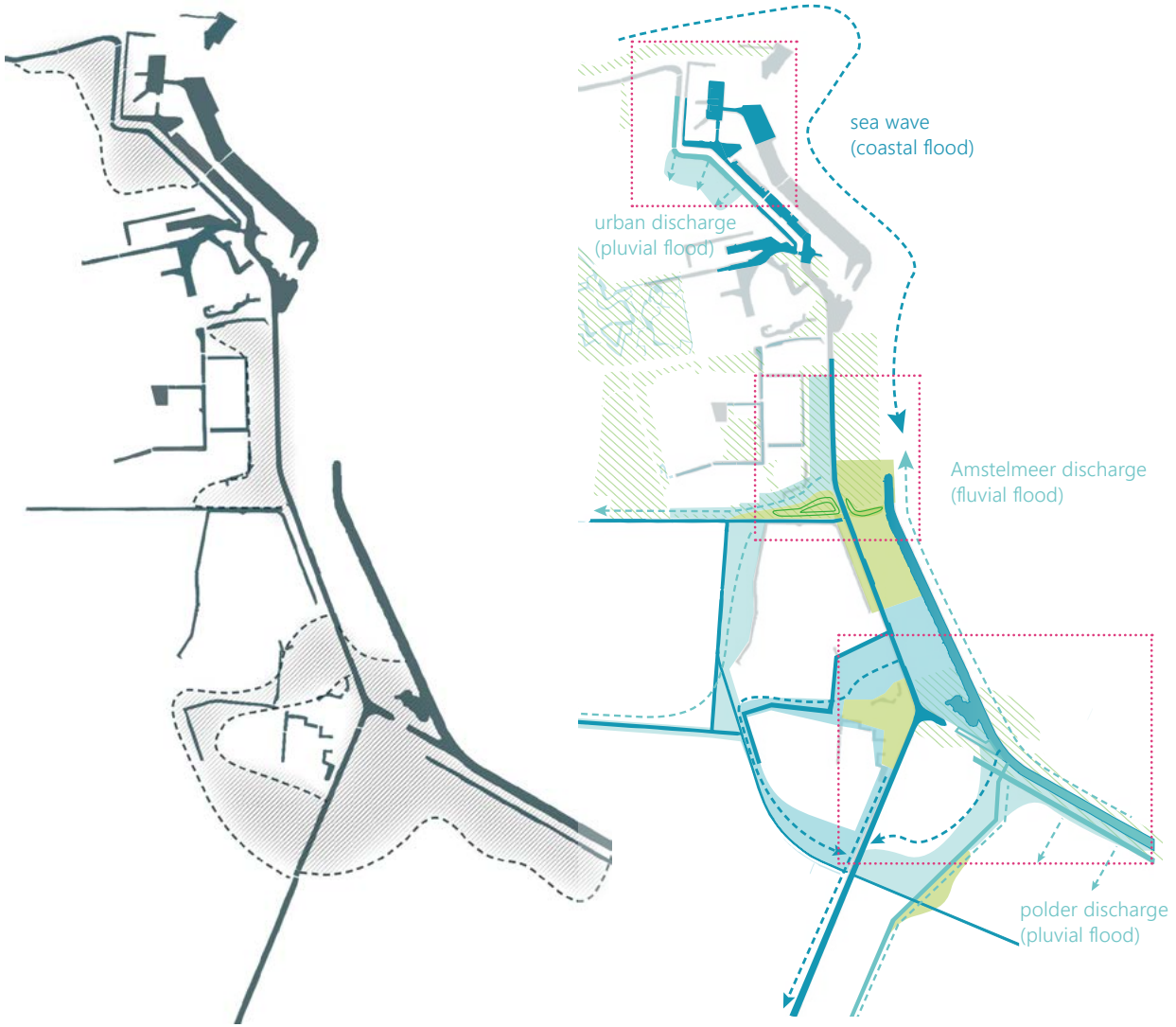


fig. Three detention basins are grid to existing green blue patches to mitigate combinated flood risks.

- green buffer mound
- temporary blue corridor

scheme: OPPOSING

Low risk exposure+ economic growth

Enlarge traffic capacity to support scale-up of offshore and tourism industry by cost-efficiently reusing blue infrastructure. Port expansion can be designed to cope with wave and nourish Balgzand marsh.

Building with nature

- Port expansion adapt to current as wavebreak to nourish marsh
- Integrate sea dike with wave attenuation marsh and artificial oyster reef

Current traffic capacity and bus service area

Proposed renew service plan

Fig. New development cope with high/ low dynamic character of places.

(left) Low dynamic structure:
Areas with low economic vitality.
More incentives required.
Conserve natural capital.

(right) High dynamic pockets:
Areas sensitive to economic climate
Leverage on market

Fig. Reuse existing canal and bus lanes to provideTouristic transit service

- areas sensitive to economic growth
- P+R hubs
- canal tour hubs
- bike path
- P+R route
- canal tour

Experiment:

Managed Flood Festival

Objective:

- rise risk awareness
- adjustment
- collect new sediments from sweet flux

Period:

- early Spring: (around King's day)
  medium tidal level+ regular precipitation
  + less traffic load (off-peak touristic season)

Procedure:

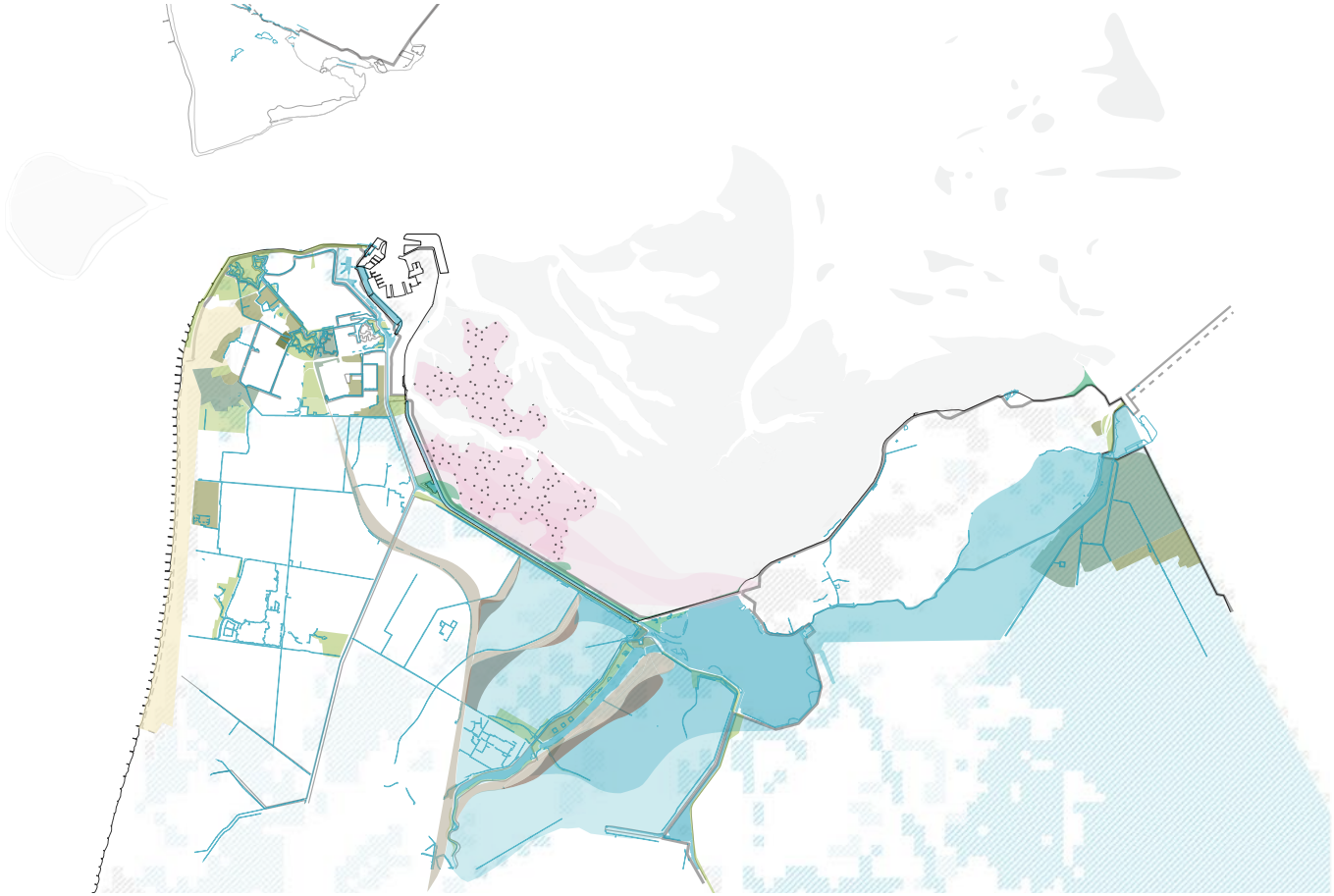
- temporarily open sluice of Amstelmeer to let sweet discharge run through flood detention plains

Evaluation:

- ecosystem services valuing framework
- cost-benefit: nourished marsh area, flood control preformance, dike maintenance
- insurance coverage, participations
- property value; de-polder trade-off
- detention capacity in transformed plots

Adjustment

- flood defense measurements
- land use realignment
- flood simulation accuracy
- insurance package
- policy incentives

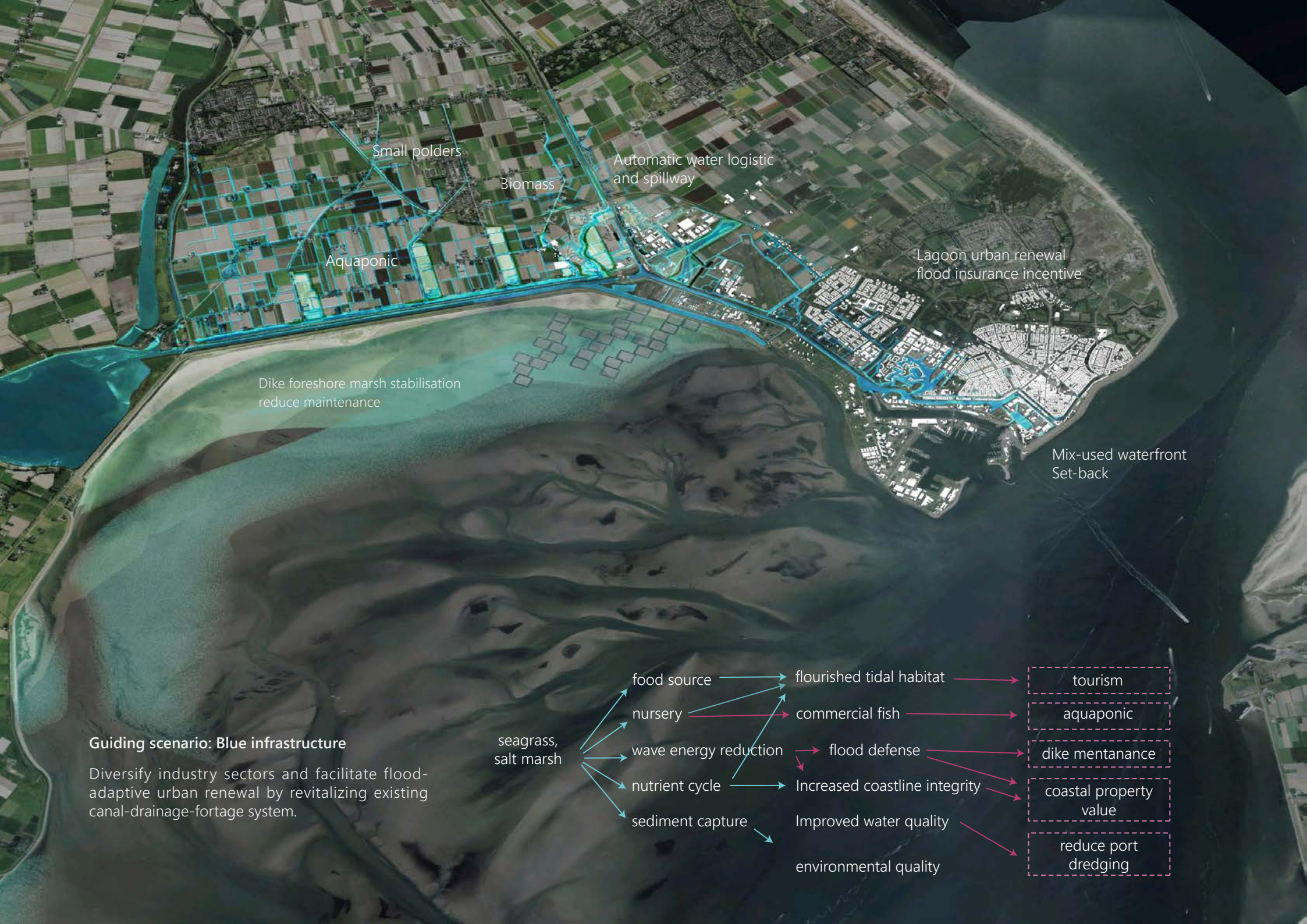


Natural Base: hydraulic forces + tidal ecosystem

Den Helder is an experimental habitat at the edge of Netherlands and Wadden Sea. Its urban development leverages on ecosystem services and flexibly adapts to hydro dynamics – sometimes shrinking and sometimes extensive.

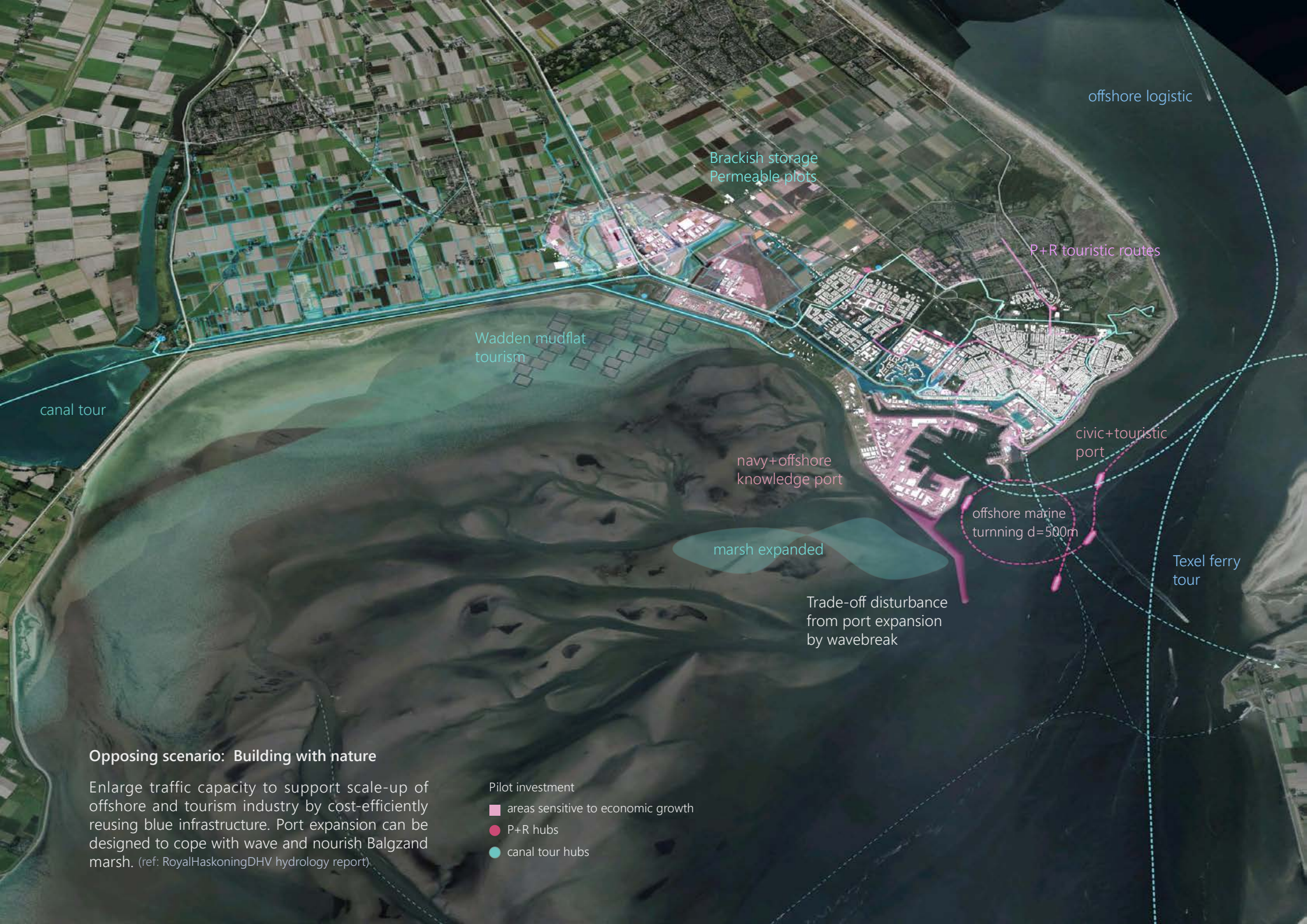
Utilizing scenario: Mud motor

Generated by dredging and drainage, the mud motor operates as systematic management over sediments, flood, ecosystem conservation and productivity, by a sequence of marsh, de-poldered detention basins and idle perneable plots.



Guiding scenario: Blue infrastructure

Diversify industry sectors and facilitate flood-adaptive urban renewal by revitalizing existing canal-drainage-fortage system.

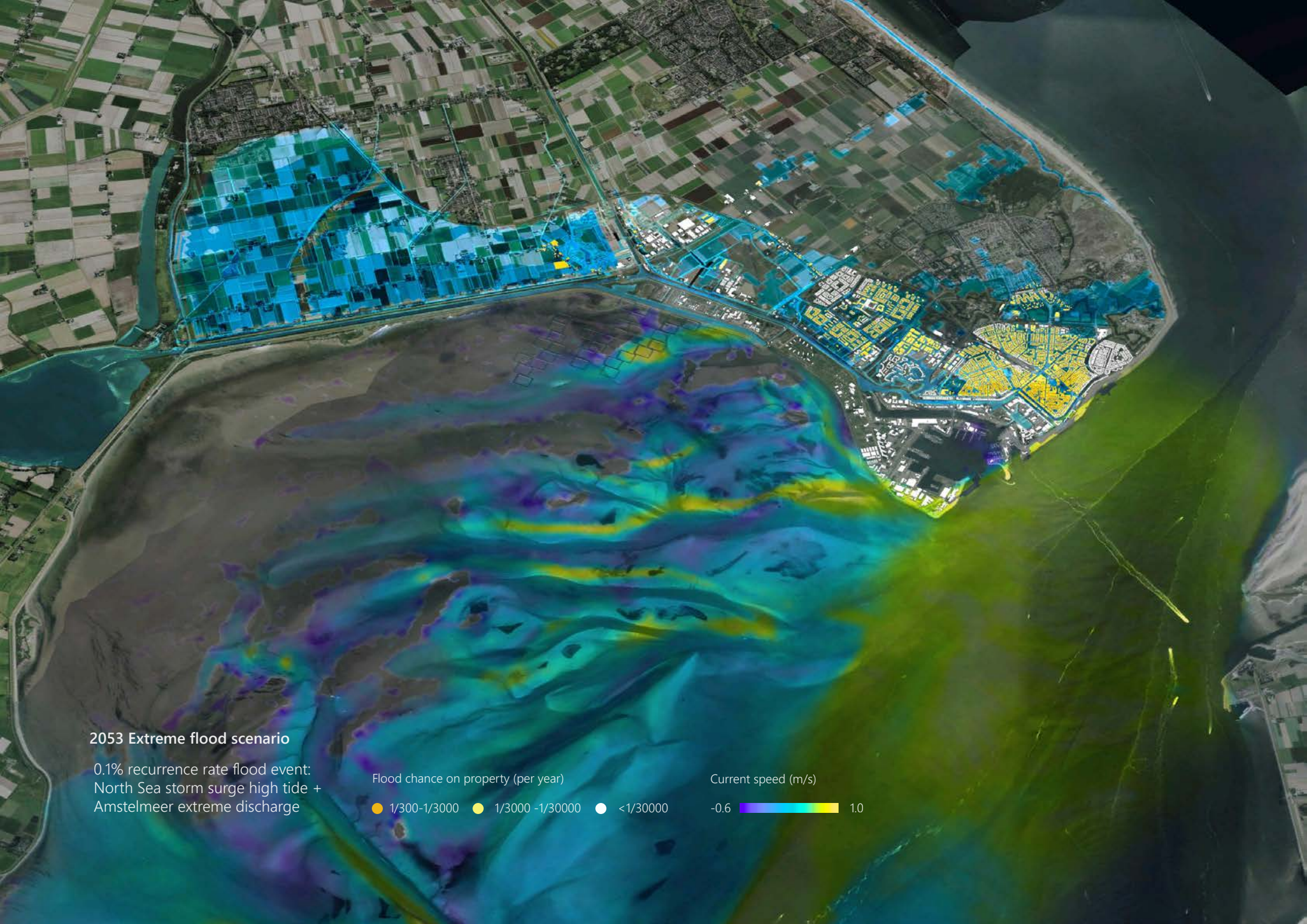


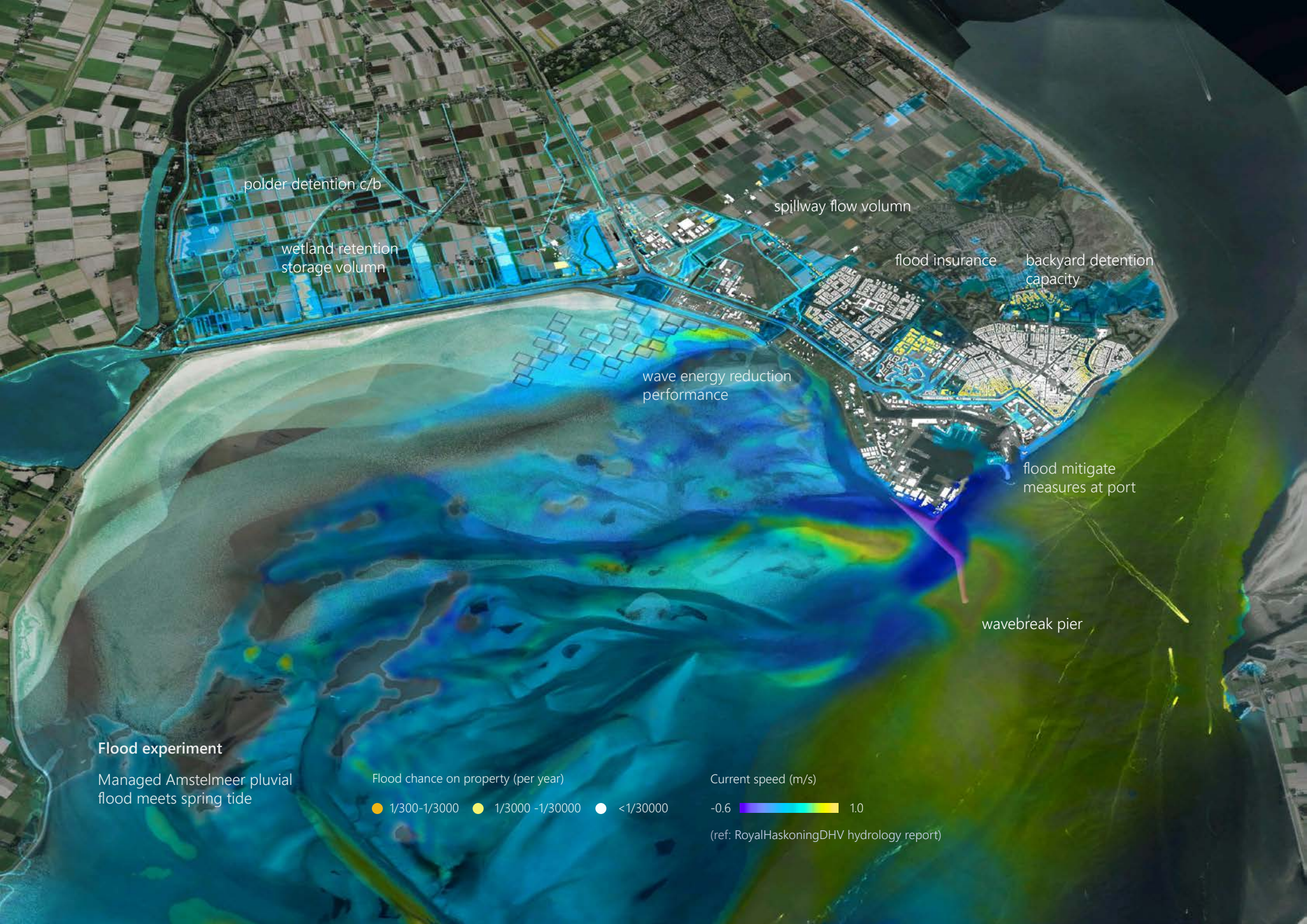
Opposing scenario: Building with nature

Enlarge traffic capacity to support scale-up of offshore and tourism industry by cost-efficiently reusing blue infrastructure. Port expansion can be designed to cope with wave and nourish Balgzand marsh. (ref: RoyalHaskoningDHV hydrology report)

Pilot investment

- areas sensitive to economic growth
- P+R hubs
- canal tour hubs


2053 Extreme flood scenario
0.1% recurrence rate flood event:
North Sea storm surge high tide +
Amstelmeer extreme discharge
Flood chance on property (per year)
1/300-1/3000
1/3000 -1/30000
<1/30000
Current speed (m/s)
-0.6
1.0


polder detention c/b
wetland retention
storage volumn
spillway flow volumn
flood insurance
backyard detention
capacity
wave energy reduction
performance
flood mitigate
measures at port
wavebreak pier
Flood experiment
Managed Amstelmeer pluvial
flood meets spring tide
Flood chance on property (per year)
1/300-1/3000
1/3000 -1/30000
<1/30000
Current speed (m/s)
-0.6
1.0
(ref: RoyalHaskoningDHV hydrology report)

Chapter 10

Reflection

10.1 Discussion

How to employ Nature-Based Solutions to strengthen adaptability of shrinking Den Helder to flood risks?

- What are the values of Nature-Based Solutions that can strengthen local adaptability to flood risk?

◦ For Den Helder locals, *cost-efficiency, inclusiveness, sustainability and better living quality* are highlighted values of nature-based solutions.

How to employ Nature-Based Solutions to strengthen adaptability of shrinking Den Helder to flood risks?

- How to conserve ecosystem services and natural evolution in a shrinking city?
- How to support Den Helder's long-term development with Wadden Sea ecosystem services?

◦ Accept urban shrinkage as part of *natural evolution phase*. What should be avioded is further exploitation and exposure to risk.

◦ Revise common strategies against shrinkage (utilize, guide, oppose) with *adapative cycle (release, reorganize, conserve).*

◦ Highlight *dynamic balance* between economy and ecology development

◦ *Risk sharing insurance* as an incentive to trigger urban renewal process and long-term investment

How to employ integrated coastal zone management in coastal urban design?

- How to integrate risk management in transcalar spatial design?

◦ Address risk from both environmental change and economic shift. *Transcalar DPSIR framework* ensures a holistic scope.

◦ Transcalar, process-oriented: 3x3x3 analysis

◦ *Multi-functional* spatial intervention: natural + logistic+ flood management *landscape infrastructure*

◦ Risk management: combine *spatial intervention with incentive* (insurance scheme) to rise awareness, share risk and facilitate adaptation

How to employ integrated coastal zone management in coastal urban design?

- How to comprise local spatial quality with coastal engineering?

◦ *Design Fiction* as an explorative method to comprise local imaginations and site-based desirable living quality with in spatial design

◦ *BwN* coastal interventions are proved to effectivity leverage on nature-based potential and thus to conserve its quality

Relation between research, design and practice

This project is an exploratory research by design. There are three aspects in the process. The first is to analysis the risk impacts on shrinking port-cities from both environmental change and economic recession. The DPSIR framework offers an integrated pathway to support coastal zone management and urban design as a whole.

The second is to explore extreme scenario and collect local imagination. In Design Fiction method, a provocative story is designed, challenging the status quo to provoke readers, stakeholders' awareness and imagination. In the storyline, a catastrophic flood event is fabricated at 2053 (in memory of 1953 flood). The story setting is distinctly projected following plausible trends according to policy, environmental and socio-economic analysis. Yet, it is portrayed with provocative image to challenge the status quo with innovative interventions. By immersing readers, stakeholders in a fictional future, the objective is to raise awareness that provokes participation, as well as to incorporate local visions in future development. As a result, narrative collected from on-site interview also plays an important role in the following design objective. An imaginary future scenario is prospected as ultimate goal. How to proceed from reality to this vision draws the structure of the research. Possible spatial interventions toward this desirable future are illustrated through the state-of-the-art Dutch coastal defense technique - Building with Nature projects.

Lastly, a systematic design across both regional structure and local design is proposed to respond multiple risks and local visions. On regional scale, reorganized natural infrastructure aims to reduce flood damage through nature-based engineering. The approach to nourish local economy and preferable living qualities with the new system is further visualized in landscape and neighborhood scale.

In sum, the research, design and practice consistently correlated. Research provides nature-based hypothesis and local participating approach to address socioeconomic vulnerability. Building with Nature engineering practices with Royal Haskoning DHV provide solid support for the visions. Design, in this journey, is a persuasive and shared narrative to bridge these different aspects into an inspiring project.

Relation between Studio and the subject, method and approach chosen in the project

The project adopts the 'environmental and economic co-benefits' principle of NBS to frame research questions, which aligns to the objective of Delta Urbanism in managing a balanced coexistence between economy, urbanization, environmental quality and safety in coastal areas. The hypothesis is that economic growth and environmental quality can be reciprocal and should be sustained simultaneously.

In the Delta Interventions (D-i) studio, complex social-environmental interactions, particularly the tension between environmental uncertainty and coastal squeeze, are addressed through transcalar and temporal aspect. 3x3x3 method of studio provides a framework to align interventions with environmental systems and processes. In research, dynamic systems can be organized into three layers (Meyer and Nijhuis, 2016): natural layer of ecology and environment (substratum), network layer of infrastructure, occupation layer of settlements and industry.

For Den Helder, flood risk and shrinking economy are the targeted issues. The project compiles interventions among 3 scales (setting objective in response to macro issue, further strategized in meso and implemented at micro scale), 3 periods (current, 2053 projective scenario, prospective scenario) and 3 layers (substratum, infrastructure, occupation) into a storyline. For the project, the model provides insights on interactions between changes in each layer through time. In design process, the Casco model further highlights their different dynamics, speed of evolution. Accordingly, a phasing roadmap with projects of different timespan can be drawn.

The general theoretical background of the project and the studio have a common root in Landscape Urbanism, that regards cities as urbanizing landscape where transcalar, process-oriented and imageability should be emphasized in design process. Yet, to reinforce transferability to coastal development, the theory is comprised into Driver-Pressure-State-Impact-Response (DPSIR) framework, which is often applied in Integrated Coastal Zone Management (ICZM) to adapt both environmental and socio-economic changes.

Integrated environmental performance	The DPSIR methodology framework ensure an integrated aspect for this project (natural hazard and economic recession) as two driving forces). The performances are described by ecosystem services, namely regulation in flood risk, provision in new nature-based industries and cultural value for urban renewal.
Human health and well-being	The benefits for human well-being are evaluated by four aspects of ecosystem services using the framework proposed by Millennium Ecosystem Assessment
Citizen involvement	Design fiction is a storytelling way of sharing research and stimulation results to the public. Semi-structured interview in the workshop further collected local visions and feedback.
Transferability	The design offers an interdisciplinary synergy pathway (urban and landscape design, coastal management, coastal engineering) in reducing multiple risks

Chart 2. Reflection on relation between methodology and the four principle of NBS. Quoted from the EU NBS agenda on climate change mitigation and adaptation in urban areas.

Elaboration on relationship of graduation project and wider social, professional and scientific framework, touching upon the transferability of the project results, ethical issues, dilemmas and potential applications of the results in practice

Adaptive transformation through Nature-based intervention is set as the hypothesis of this project. This is referred to current European Union 'Horizon 2020' research and innovation policy agenda (EC 2015), in which the concept 'Nature-Based Solutions' (NBS) is propagated and defined as approaches 'inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience'.
Conservation of natural capital becomes a mean to address environmental and societal challenges simultaneously. In one of the identified goals: climate change mitigation and adaptation in urban areas, four principles are considered crucial. This project refers the design outcome to these indicators in order to enhance the relevance with current policy. In below framework, each indicator is interpreted by with the methods taken in this project

A unique part of the research is combined with internship in Royal Haskoning DHV, the construction and design consultancy company in charge of renewal work at Den Helder port. While working with water management experts, coastal engineers and locals, I found risk reduction as a common objective to facilitate cooperation. However, how risk is perceived and addressed is very different. The notion of flood risk as a mathematical function of the probability and consequences of an event is favored by engineers, as the probability can be reduced by strengthening the flood defense. On the other hand, from a more social perspective flood risk is often explained as a geographic overlay of (flood) hazard and vulnerability of the society. As an urban designer, I try to combine both environmental engineering and societal inputs in design. The principles of NBS and DPSIR are useful guidelines through the process.

However, since climate change is such unpredictable and coastal substratum is of high dynamics, perhaps what nature-based design should respond to is to prepare for hazards, instead of the most robust defense. Based on the history that storm surge is a recurring natural event, flooding can also be designed as transforming point to regions if it is anticipated. Thus, I fabricate a catastrophic flood event to facilitate imagination of a desirable nature-based future, challenging the business-as-usual agenda and engineering solutions. I also try to empower local visions in this adaptation process. Indubitably, the disaster cycle remains incomplete without manifested enquiry into local environmental concerns and subsequent incorporation while ushering in the goal of urban risk reduction and societal resiliency.

Successful BwN cases build up supportive practical knowledge in my project to address risks with ecosystem services (ES)-flood regulation service of marsh and blue infrastructure in particular. However, what I aim to research through the design process isn't only the performance of ES as a solution to environmental threat, but also the values that can be created to strengthen socio-economic resiliency. This focus is a shift from BwN, ES, to Nature-based solutions. Design is experimented as a method to co-illustrate the qualities with multi-parties that can be supported by ecosystem services.

To achieve this, the multidisciplinary objective significantly deeper the complexity of the project. It is hard to define to what extent should a good design response to each aspect involving spatial quality, engineering, ecology, socio-economy, management and so on. I reflect on the role of an urbanist and identify the ability to strike 'balance' among interdisciplinary collaboration as the critical task I want to explore. Despite a solid spatial design, the project contributes more on exploring an interdisciplinary transformation pathway towards desirable future scenarios.

Chapter 10

Appendix

Appendix 1: Theoretical background

Landscape Urbanism

The idea that city as an urbanizing landscape features open spaces as a medium linking cities with nature system, offering a synthetic, coherent and stable surface for urban environment (Waldheim, 2006). Multiple impacts of landscape characters on urbanization are highlighted, which can be summarized as multi-scales (openness and transection), functions (ecologies and economies), formal and spatial attributes (both natural and cultural organizations, systems, and formations), and processes (temporal qualities) (Cezerrniak, 2006). In James Corner's publication -Terra Fluxus – the theory is conceptualized in four operational principles - processes over time, staging of surfaces, operational method and the imaginary.

Processes over time and staging of surfaces

Urbanizing landscape highlights the **process-oriented approach, which represents the temporal, systematic characters of landscape.** City composition is interpreted as process of interactions between different sub-systems at multi-scales and different speeds (Holling, 2001).

These dynamic systems can be organized into three layers (Meyer and Nijhuis, 2016): natural layer of ecology and environment (substratum), network layer of infrastructure, occupation layer of settlements and industry). Accordingly, the 3x3x3 analysis further provides an insight of driving forces and speeds for changes in each system.

3x3x3 layering approach

3x3x3 analysis first provides a multi-scalar model to understand the dynamic interactions between three layers, three critical periods and three scales; thereby limitations, opportunities and trends can be mapped, layered and interpreted.

Operational method

The ground of landscape is prominent as a "field of action". The design of infrastructure matrix of urban surfaces is featured with uncertainty and is described as "irrigation of territories with potential (Koohaas, 1995) ". The theory further contributes to Landscape Infrastructure concept (and similar concepts such as green infrastructure, ecological-based infrastructure) which focuses on operating **landscape as infrastructure that conserves and delivers ecosystem services into urban environment. In Den Helder and Balgzand region, three infrastructural systems – flood defense, transport and water** are identified critical for operation.

Imageability

In The Image of City, Kevin Lynch reinforced the linkage of 'imageability' and 'quality' of spatial elements that evokes perception. The quality of public space is credited to activate individual imagination and further collected as urban identity. According to James Corner, the 'imageability' is the key factor for rooting values from environment to social content, such as cultural image, but also to raise environmental awareness.

To facilitate the imagination of a social-environmental collaborating future, this project is elaborated through a **Design Fiction** approach. The buildup of fictional future **involves semi-structured interview to collect local perception on environment and urban development and is represented as the scenario.** This strengthen the linkage between design output, social content and cultural ecosystem services.

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Appendix 2: Theoretical Report

Evaluating Social Benefits of Nature-Based Solutions - A Review for Comprehensive Pathway

Yi-Chuan Huang

Y.Huang-18@student.tudelft.nl

Student number: 4622650

Delft University of Technology, Department of Urbanism

Delta Intervention Graduation Studio 2017-2018

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ABSTRACT --

The concept of 'Nature-Based Solutions' (NBS) is propagated in current European Union 'Horizon 2020' research and innovation policy agenda (EC 2015). It is set as a transdisciplinary umbrella encompasses existing concepts that promote the conservation of ecosystem as a mean to address multiple environmental and societal concerns simultaneously (Pauleit S. et al. 2016). However, this general position also blurs the principles and evaluation criteria of NBS, which is a threat for practical application. As a result, this paper focuses on exploring comprehensive evaluation framework to optimum the co-benefits on ecology and society of NBS.

The research is conducted in three parts of review. First, the principles of NBS are identified and related to the Ecosystem Services quantifying assessments. The second part of review searches a broader scope of social-environmental relation in urbanism to explore the qualitative values that should be preserved in NBS. The research questions include: what values and drawbacks are brought to the society from each concept? How the concept reinforces and qualifies these values in social domain? How to comprise these concepts and values in the development of NBS?

In the final part of the review examines the application of scenario making method as an agency to integrate both aspects of evaluation. For the conclusion of this paper, a collaborative approach through GIS technique is suggested to promote the participatory and transferability goal of NBS.

Key Words: Nature-Based Solutions, Landscape Ecology Landscape Urbanism, Ecosystem Services, social impact evaluation

INTRODUCTION

'Nature-Based Solutions' (NBS), a concept introduced to promote nature as an effective approach to mitigate climate and social challenges (MacKinnon et al. 2008; IUCN, 2012), is a high-lightened goal for recent European Union. The European Commission has launched the research and innovation policy agenda 'Horizon 2020' to explore NBS across research, policy-making, non-governmental organizations and business (Nature 541, 133–134; 2017). According to European Commission, NBS is defined as approaches

> *'inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.' (EC 2015)*

In the Horizon 2020 final report *'Nature-Based Solutions and Re-Naturing Cities'*, four primary ambitions have been set as: enhancing sustainable urbanization, restoring degraded ecosystems, developing climate change adaptation and mitigation, improving risk management and resilience (chart 1.).

Chart 1. The four goals of NBS set in Horizon 2020

Goal	Description
Sustainable urbanization	Stimulate co-benefits in economic growth, human well-being and environment
Ecosystems restoration	Strengthen ecosystems resiliency; secure vital ecosystem services
Climate change adaptation and mitigation	Provide more resilient responses and enhance storage of carbon
Risk and resiliency management	Offer interdisciplinary synergies in reducing multiple risks

The notion to enhance nature and its benefits in urban areas isn't new considering a number of existing nature-based principles (Pauleit S. et al. 2016). In fact, according to Horizon2020, NBS is positioned as a transdisciplinary umbrella encompasses existing concepts such as 'blue–green infrastructure' in engineering, 'natural capital' and 'ecosystem services' in economics, and 'landscape functions' in environmental planning. In general, these concepts are partially

overlapped or complementary (Potschin et al., 2016), and yet each with specific target issue and approaches. Therefore, it is fundamental to reflect on existing concepts and experiences to reorganize a holistic pathway toward environment-society coexistence.

Moreover, the general definition of NBS has raised critics on its ambiguous methodology background and evaluation criteria. A deeper theoretical insight in social-environmental relationship is suggested (Pauleit S. et al. 2016). Referring to existing urbanism concepts, the environmental-inspired operations are often explored in the term of *Landscape,* which by the definition of European Landscape Convention is "an area perceived by people, whose character is the result of the action and interaction of natural and/or human factors (ELC2000)" This holistic insight is considered adequate to set a solid ground for exploring NBS (Ramos, 2010), especially under the goals of sustainable urbanization and climate adaptation.

As a result, after an understanding of current principles for NBS, two well-developed landscape-based urban theories – *Landscape Urbanism and Landscape Ecology* - are reviewed with the focus on relation between spatial quality and socio-impact. Building upon these existing concepts, an integrated framework is proposed to foster more comprehensive values in NBS application.

METHODOLOGY

This research consists of three parts of reviews. First, a review on current quantifying evaluation principles of Nature-based Solutions is carried out. The outcome then suggests the problem field for second part of review, where a broader range of 'landscape', 'ecology' initiative concepts in urbanism is searched to explore more comprehensive qualitative values that should be preserved in NBS. According to European Commission, NBS should be distinguished from traditional approaches by more efficient and direct innovations in socio-economy domain (EC 2015). Thus, the comparison of different existing concepts focuses on their social impact, trying to answer the questions including: What values and drawbacks are brought to the society from each concept? How the concept reinforces and qualifies these values in social domain? How to comprise these concepts and values in the development of NBS?

Based on these findings, the final part of review explores a landscape theoretical-based method to integrate these concepts and values into the development and operation of NBS. A conclusion is then drawn in response to the goals of NBS.

RESULTS AND DISCUSSION

Part 1: Review of current valuation criteria for Nature-Based Solutions

NBS is credited to facilitate new transformational pathways that turn environmental and social challenges into innovation opportunities (EC 2015), by managing natural capital as a source for sustainable societal development. (Maes and Jacobs, 2015) Recently, regarding to the topic of *climate change mitigation and adaptation in urban areas*, indicators to assess the effectiveness of NBS had been discussed (Kabisch, N. et al. 2016). Four criteria are considered crucial for setting the implementation goal and each should be evaluated by the value created through natural capital (chart 2.). This is often validated by Ecosystem Services (ES) framework which is introduced in next paragraph:

Chart 2. The four assessment criteria for NBS identified for the goal of *climate change mitigation and adaptation in urban areas*

Criteria	Description
Integrated environmental performance	The performance is usually evaluated by regulating ecosystem services, such as regulation and mitigation benefits in climate change, flood control.
Human health and well-being	The benefits for human well-being are often calculated by four aspects of ecosystem services using the framework proposed by Millennium Ecosystem Assessment (MA 2005)
Citizen involvement	In ES framework, the ultimate benefit in human well-being is the freedom of choice and action, which indicates the inclusiveness of citizens in application process
Transferability	Offer interdisciplinary synergies in reducing multiple risks

These criteria highlight the distinctive focus of NBS on ecology-society co-benefits. Not only the supply-side (environmental performance) but also the demand-side (health and well-being, citizen's involvement and transferability) are taken into evaluation.

Ecosystem services assessment

Ecosystem Services (ES) imply "the functions and products of ecosystems that benefit humans, or yield welfare to society". The concept derived from the rising concern in the 70s that benefits human obtains from nature are not adequately reflected in traditional economic structure (Goméz-Baggethun et al. 2010). Therefore, a monetary assessment on demands for and supply of natural services is promoted to raise environmental awareness. In past two decades, the

concept becomes a critical role in reconnecting socio-economy to biosphere in terms of environmental quality and human well-being (Gómez-Baggethun and Barton 2014).

According to the classification by Millennium Ecosystem Assessment (MA 2005), ES are most often being categorized into four aspects: regulating services, provisioning services, supporting services and cultural services. Depending on different site and goal, monetary values are assigned to these services, and together determine the benefits to human well-being.

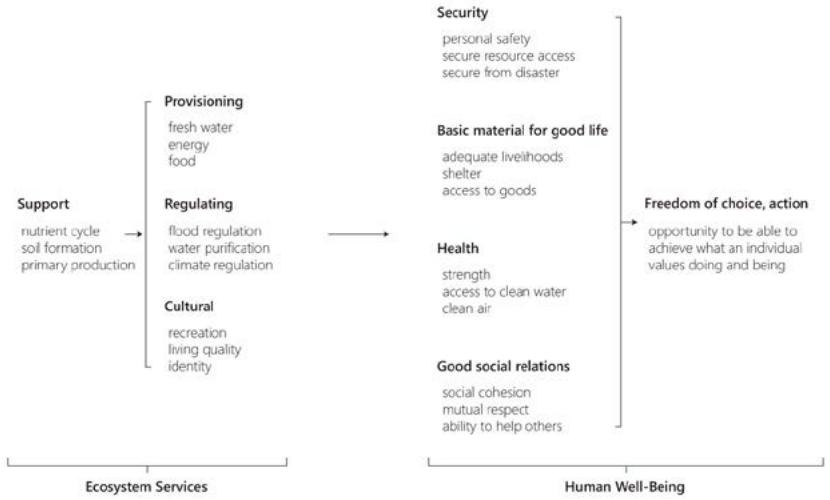

Figure 1. Millennium Ecosystem Assessment framework for ecosystem services (modified from MEA 2005)

The monetization aligns with NBS's concept that ecological-based interventions are not only to conserve natural resources, but also to generate additional environmental and social benefits, and to foster the functioning of ecosystems as new economic opportunity (European Commission 2015). Furthermore, the large amount of cross-disciplinary applications of ES shown in the database builds NBS a transdisciplinary common ground, enabling comprehensive cooperation to develop NBS.

However, the monetary approach is often being criticized for excluding other qualitative and nonmaterial values which are crucial to human well-being (Schröter, M et al. 2014). For example, the cultural services particularly contribute to intangible values that maintain environmental quality and social equity but hard to identified through monetary method. Besides, as an integrated approach, many actions of NBS could bring multiple values which are hard to be categorized into one aspect. More comprehensive values of ecosystem services are thus being suggested (Figure 2.). In the meantime, tension also being raised between the pursue of anthropocentric advantages and the conservation of ecological existence (McCauley 2006). Several researches are critical to ES's economic metaphor which tends to foster the exploitative human–nature relationship (Schröter, M et al. 2014). As a result, besides ES assessment, approaches to promote qualitative values are as well essential to maximize the benefits from NBS (Pauleit S. et al. 2017).

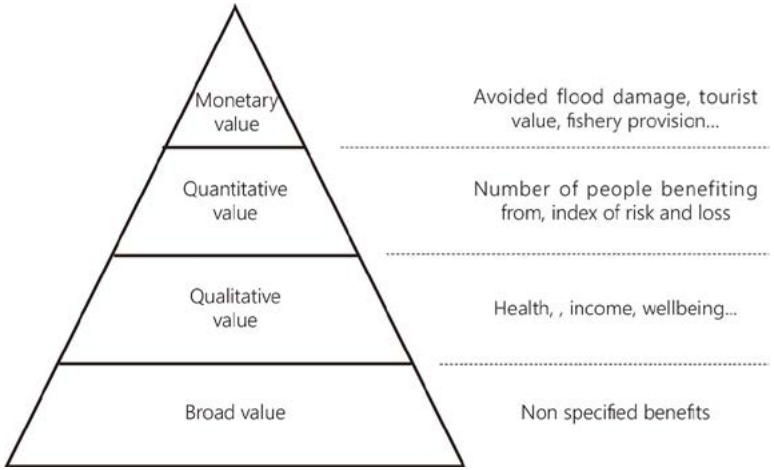

Figure 2. The comprehensive pyramid of values benefit from environment. (Modified from Patrick ten Brink, 2008)

Part 2: Review of qualitative value in Landscape Ecology

In post-industrial era, modernism was criticized for its inability to create a "meaningful" or "livable" built environment (Waldheim, 2006). Urban designers claimed massive, homogeneous building complexes as comprehensive approach toward social demand; and yet still failed to react to decentralized urbanization and degrading livability. In response to this circumstance, the awareness of environmental quality gradually revived.

In 1969, Ian McHarg's publication '*Design With Nature'* particularly revealed the ecological value in urban environment. It raised the exploration of a more sustainable future under the guidance of ecological process and mechanism. This catalyzed the conceptualization of *Landscape Ecologyy.* In scientific point of view, *Landscape Ecology* provides a deep linkage between ecological observation with spatial patterns interweaved by people and nature. The theory adopts ecological principles in managing stability of landscape heterogeneity, assessing dynamic interaction between scales, configurations and functions (Forman 1995). It contributes to a scientific description on spatial pattern which is categorized as patch, corridor and matrix.

In Richard Forman's publication *"Land Mosaics: The Ecology of Landscapes and Regions (*1995)", landscape was defined as "the template on which spatial patterns influence ecological processes". What distinguished it from the social value discussed in Landscape Urbanism is the emphasis on human disturbance in environment (Naveh 1984), which often referred to pattern's connectivity and fragmentation. This focus on performance of different landscape elements shares a common insight with the layering approach in Landscape Urbanism, and is further broadly applied in developing systematic urban resistance to disturbances. Catalyzed by rising pressure of climate change, the ecological-based theory has been developed into various principles to tackle different challenges in recent years.

Chart 3. Value derives from Landscape Ecology (Modified from Forman R., 1995)

Principle	Value Description	Possible Approach
Heterogeneity (functions)	Resiliency: redistribution ability under disturbance; Diversity: stability toward disturbance Dynamic: flows stimulated by corridors	Corridor analysis; Multi-functional landuse; Sink/source analysis
patch-corridor-matrix (structure)	Porosity (connectivity or isolation defined by number, size, location of patches); Network (defined by links or barriers of corridor. Ex. stepping stones, edge/border);	Space syntax analysis Green infrastructure

Review of qualitative value in Landscape Urbanism

In the 90s, series of avocations propagated landscape as fundamental ground to relink cities with environment, prevailing traditional domination of architecture-based development. The arguments further conceptualized into the theory 'Landscape Urbanism'. Inspired from natural system, it interprets composition of cities as layers of different forces among time and scales, offering a systematic and process-based approach to root the values derived from landscape in urban redevelopment (chart 4.) (Waldheim, 2006).

In the meanwhile, proponents ascribed the failure of postwar urban planning to "optimized rationalization and capital accumulation". In landscape theory, social-environmental interaction should be responded by promoting performance of public spaces that could activate individual imagination and further collected as public identity. According to James Corner, the 'imageability' is instead the key factor in rooting environmental values in social content, such as culture image and sense of belonging. Rather, the relation of environment and socio-economy is explored through spatial perception and experience (Palmboom, 2010). In *The Image of City*, Kevin Lynch further reinforced the linkage of 'imageability' and 'quality' of spatial elements that evokes perception.

The concept "urbanizing landscape" broadens the prominent value of nature from ecology to "an agent producing and enriching culture" (Corner, 1999). Evocative focuses on landscape performances (ecologies and economies), forms (both natural and cultural organizations, systems), and processes (temporal qualities) generate great influence over city formation in both spatial and social domains (Cezerrniak, 2006). In the past decades, landscape urbanism has emerged as the paradigm for urban development (Shane, 2004). However, its ambiguity in practical terms has long been criticized as a main drawback.

Chart 4. Value derives from Landscape Urbanism (Modified from Waldheim, 2006)

Principle	Value Description	Possible Approach
Process-based	Systematical interventions with different timeframe. Responsive to multiple driving forces.	Temporal design Open-ended design
Staging of Surfaces	Open space network: shared space for continuity across private/public, human/nature Infrastructure network: irrigate territories with potential (Koohaas, 1995)	Layering analysis Landscape infrastructure Transcalar deisng
Imageability	Collective images stimulated by perception of spatial quality. Enable rooting of urban identity, affinity, coherence	Kevin Lynch model Scenario making

Part 3: Review of integrated approach to develop NBS

Landscape Scenarios

Scenario-making has been developed as a tool to "order one's perceptions about alternative futures" (P. Schwartz 1996) through constructions of "internally consistent set of assumptions

about key relationships and driving forces" (International Panel on Climate Change 2012). Landscape scenarios are useful in assessing preferable landscape configuration alternatives of patterns and functions, based on assumed future conditions to deal with the uncertainty (Peterson et al. 2003). In practice, a wide spectrum of communication techniques have been developed, varied from narrative storylines, 3D visual simulations, GIS or maps and qualitative or quantitative models (Plieninger, T. 2013; Peterson et al. 2003). Consequently, a valuable feature of scenarios is the intention to engage experts, stakeholders and decision makers in the collaborating process of scenarios development and evaluation (Ramos, 2010).

GIS scenarios

This value aligns with the goal of NBS to encourage citizen involvement. The GIS simulation technique is particularly being found broadly adopted among projects of both ecological quantification (ecosystem services) and qualification (landscape patterns and functions) evaluation (Hoeven F., Nijhuis S. et al. 2016). Current application in adaptation design often built up through two process: the first is the creation of integrated database by GIS software, such as QGIS, ArcMAP. The collected data ranges from ecology, geology (soils, hydrology, roads, land use etc.), social demography… The synthesis workflow used in the software to merge such cross-disciplinary information for analyzation purpose is actually derived from the theoretical framework of landscape layering concept and ecological patterns, namely the patch-corridor-matrix model. The second part involves visualized simulation, which is built upon the analyzed outcomes from GIS database for scenario development. Depending on the purpose of simulation, such as stakeholder communication, awareness rising or impact evaluation, different tools, software are chosen, such as 3D GIS modeling (Chiang Y.2016), but overall provide high flexibility to support responsive design alternatives against uncertain future (Lee D. et al. 2014).

Recently, the term *Geodesign* has been propagated to promote this collaboratively design method "which tightly couples the creation of design proposals with impact simulations informed by geographic contexts." (Steinitz.C 2012). It is effective in communicating the possible environmental changes, design performance, functions and social impacts (Hoeven F., Nijhuis S. et al. 2016). As a result, GIS is considered notably adequate to evaluate the transferability and integrated performance of NBS.

CONCLUSION

Nature Based Solutions is set as an umbrella concept to integrate existing nature-based theories that promote the conservation of ecosystem as a mean to address multiple environmental and societal concerns simultaneously. Such development of systemic solutions pursues the optimized generation of multiple ecosystem services. However, this general definition also blurs the theoretical principles and evaluation criteria, which is a threat to promote the practice of NBS. Although the criteria based on Ecosystem Services assessment has been explored, multiple qualitative values are neglected in the monetary approach.

On the contrary, the review of well-developed urban theories – Landscape Ecology and Landscape Urbanism – reveals significant values in social domain retrieved from designs or planning inspired by natural pattern, process and functioning. The theories are useful in identifying and qualifying these social impacts; and yet lacking platform to bring into practical application.

The two parts of reviews present adequate quantifying and qualifying evaluation of NBS relatively. However, to align with the integrated performance goal of NBS, it is necessary to comprise two aspects in the developing process. As a result, the review on Landscape Scenarios is conducted. Among multiple scenario making method, the application of GIS technology is found particularly powerful to adopt the landscape theoretical framework into cross-disciplinary application, including the comprehensive evaluation from both quantity and quality. What's more, the visualized simulation also bears a high potential to support the participatory and transferable goal of NBS.

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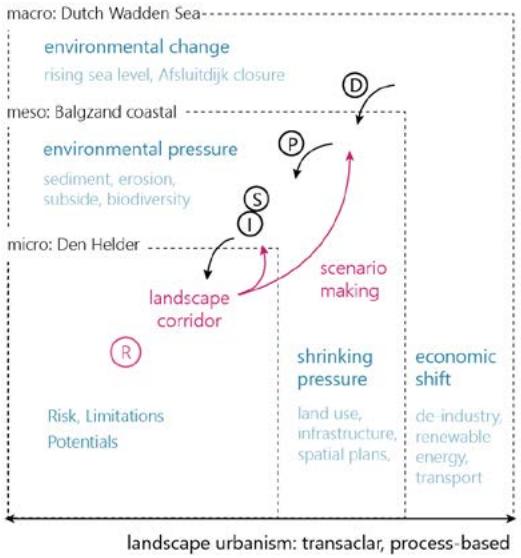
Appendix 3: Methodology Report

This project aims to balance environmental quality and economic growth in coastal development to strengthen adaptability to future uncertainty. Based on the premise that risk is adaptable, flood can be set as a trigger to raise awareness and to facilitate urban transformation.

I. Theoretical framework

The general theoretical background is based on *Landscape Urbanism* that regards cities as urbanizing landscape where transcalar, process-oriented and imageability should be emphasized in design process. To reinforce transferability to coastal development, the theory is comprised into *Driver-Pressure-State-Impact-Response (DPSIR) framework*, which is often applied in *Integrated Coastal Zone Management (ICZM)* to adapt both environmental and socio-economic changes.

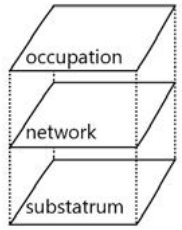
Chart 1. Environmental and economic integrated framework of DPSIR through different scales.



Landscape Urbanism

Temporal scale

Dynamic urbanizing landscape requires infrastructure with multi-functional, flexible features, and is described as "irrigation of territories with potential" (Koohaas, 1995). This project operates on landscape as infrastructure to conserve and deliver ecosystem services into urban environment. In Den Helder and Balgzand region, three infrastructural systems – flood defense, transport and water are identified critical for operation.



In theory, dynamic systems can be organized into three layers (Meyer and Nijhuis, 2016): natural layer of ecology and environment (substratum), network layer of infrastructure, occupation layer of settlements and industry. The 3x3x3 model provides insights on interactions between changes in each layer through time. In design process, the Casco model further highlights their different dynamics, speed of evolution. Accordingly, a phasing roadmap with projects of different timespan can be drawn.

Imageability

In *The Image of City*, Kevin Lynch reinforced the linkage of 'imageability' and 'quality' of spatial elements that evokes perception. The quality of landscape is credited to activate individual imagination and further collected as urban identity. According to James Corner, the 'imageability' is the key factor for rooting values from environment to social content, such as cultural image, but also to raise environmental awareness.

To facilitate the imagination of a social-environmental collaborating future, this project is elaborated through a Design Fiction approach. The buildup of fictional future involves semi-structured interview to collect local perception on environment and urban development, which is organized into scenarios in the reference of IPCC Emission Scenarios. This strengthen the linkage between design output, social content and cultural ecosystem services.

This project explores future uncertainty with design fiction and scenarios. An imaginary future scenario is projected as ultimate goal. How to proceed from reality to this vision draws the structure of research.

The story setting is distinctly designed following plausible trends according to policy, environmental and socio-economic analysis. Yet, it is portrayed with provocative image to challenge the status quo with innovative interventions. By immersing readers, stakeholders in a fictional future, the objective is to raise awareness that provokes participation, as well as to incorporate local visions in future development. As a result, narrative collected from on-site interview also plays an important role in the setting.

Semi-structured interview

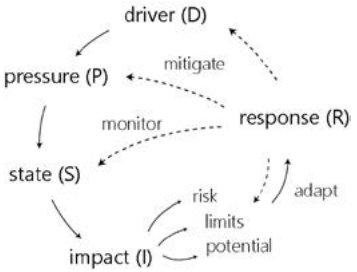
The interview emphasizes that residents, as key stakeholders, are able to tell the "story" of plausible future, referring to their perception on environmental and economic impacts (Kok et al., 2011). As such, scenarios and 'What if…' question can encourage locals to re-image the future and guide the interview process. This approach values more in first-hand qualitative narrative than quantitative investigation. As a result, stories told by 10 random locals on-site are collected and encompassed into the setting of visionary future.

Scenario making

To organize inputs from both official plans and local visions, the *IPCC Emission Scenario* can provide a basic framework. Originally, UN constructed the framework to explore future trends of greenhouse gas emission and urban development (land use) referring to technology and socio-economic development. Four future scenarios are descripted along two axes: globalization vs regionalization and economic orientated vs. environmental sustainability. In this research, the same structure is adopted with more emphasizes on urban development.

Coastal Zone Management: DPSIR Framework

DPSIR is a decision-support framework describes interactions between society and the environment proposed by European Environment Agency (EEA, 2007). It is composed as a cycle by driving forces (D), pressures (P), states (S), impacts (I) and responses (R).



The framework understands risks as pressure driving changes on current state to evaluate possible environmental and societal responses to these changes. It is applied in the project to analyze human-environment interactions under risk from climate change and shrinking economy. The responses contain two parts: design leveraging on potentials to adapt risks and constraints in micro scale; and spatial strategy in meso scale to mitigate pressure.

II. PROBLEM FRAMING

Transcalar analysis: 3x3x3 Layering Approach

This systematic model provides a framework to explore interactions between three spatial layers (substratum-network-occupation), three critical periods and three scales (macro-meso-micro). It helps to frame the problem field and research questions that reflect to trans-scalar and process-based intention.

Three active marine times are chosen based on major changes in economic (shipping destination, purpose) and technicle background (ship types). This results in disdinctive shifts in shipping routes. By overlapping the traced network with substatrum and occupation layer, strong correlation is found between natural dynamics (current, wave, sediments) and coastal development (harbors, port cities).

III. DESIGN FRAMEWORK

Imageability: Design Fiction

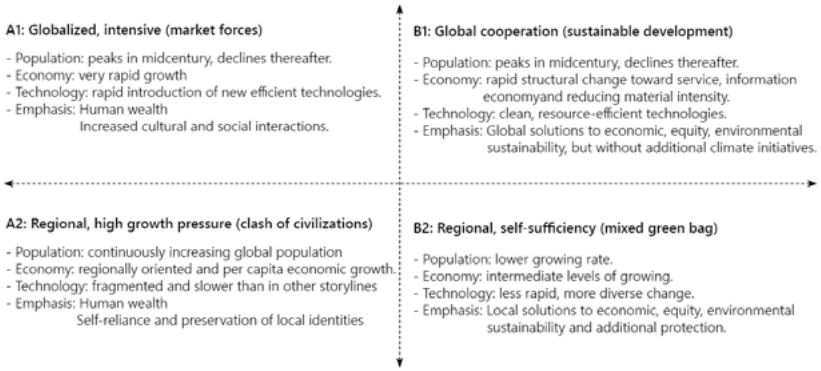
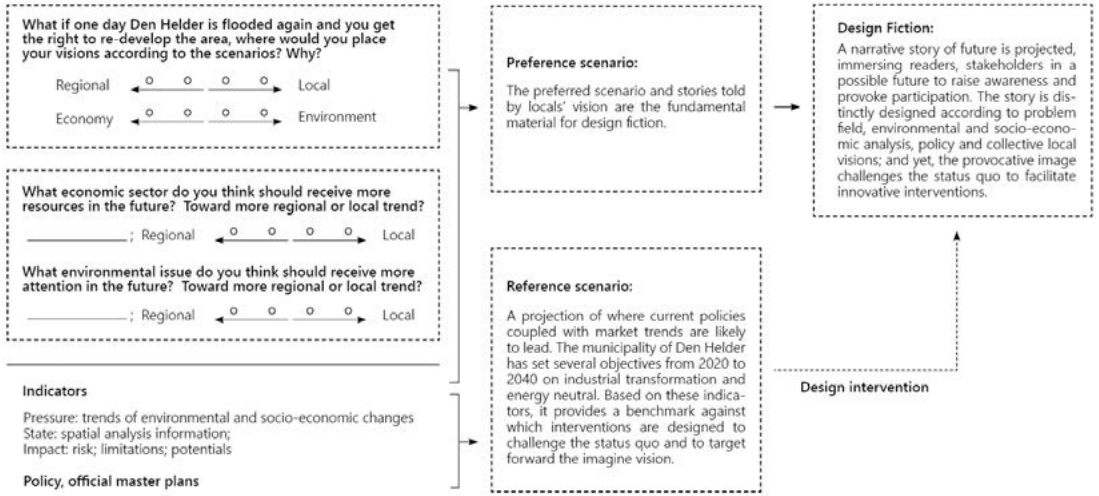


Chart 2. Narrative of four scenarios modified from IPCC Emission Scenario.

Among four scenarios, the preferred one is set as the background for the fiction. It challenges the reference scenario which projects where current policies coupled with market trends are likely to lead. Together with the indicators according to policies and interviews, a visionary image of 2116 and a referenced one for 2053 are portrayed. What the comparison revealed creates the field for design intervention.

Chart 3. Flow chart to design fiction. Scenario and semi-structured interview are involved.



IV. Impact Assessment

As an integrated assessment of transcalar analysis, the impacts are classified into: risks from flood threat according to socio, environmental vulnerability and exposure; spatial constraints to support economic development and conserve ecosystem services; and potentials to be leveraged on for further design intervention.

Potential: Ecosystem services (ES)

ES is introduced here as an agency to create co-benefits in environment and economy. It generally implies "the functions and products of ecosystems that benefit humans, or yield welfare to society" (MEA,2005), and is often being categorized into four aspects: regulating services, provisioning services, supporting services and cultural services. In the project, regulating service to mitigate flood risk and cultural values generated from recreation and urban identity are focused. What kind of landscape to be implied to different parts of the coastline can thus be suggested.

Constraints: Casco Concept

The Casco concept provides a guiding model for urban landscape planning by distinguishing spaces with low or high dynamic functions. Low dynamisms are those embedded in stable environment such as the ecological process; whereas high dynamisms are often related to economic and technological development which require high coping flexibility (Kerkstra & Vrijlandt,1988). Such spatial segregation is set to prevent stable substratum from being crushed by rapid-turning wheel of urbanization; but also to identify carrying structure that supports adaptability to future uncertainty in a synergism way.

One representative practical project is the Dutch river project at 1986 - *Plan Ooievaar,* through which a floodplain ecology is restored in substitute for agricultural exploitation (Sijmons,1990). Recent researches also applied the model to reprogram land-use in shrinking cities (Hoekstra,Mulkens,2014). In reference to the cases, this project revitalizes hydrological network as main carrying framework to proceed coast-front redevelopment from 2053 reference scenario to 2116 visionary scenario. Through layering approach, low dynamic landscape structures are identified to be maintained or gradually multi-functionalize. Pockets in-between the frame are operational field to accelerate economic, logistic and energy transition. Thus, the transformation strategy is a phasing process with programs of different timeframe.

' ... bring more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions....'

-- *Nature-Based Soultions. European Committee 2015*