

Planning and implementation of floating buildings as an adaptation measure in the Netherlands

Karina Czapiewska & Vicky Lin, MSc



IHS Rotterdam, Urban Management Tools for Climate Change – 28th June 2017

Topics | Outline

1. Background
2. BlueRevolution
3. Floating development: climate change adaptation & mitigation measure
4. Case Study I: **Floating pavilion, Rotterdam**
5. Case Study II: **Floating houses in Harnaschpolder, Delft**
6. Other examples of floating development around the world
7. Take-home message
8. Q & A

Floating development | Characteristics

- Buoyant foundation
- Adapts to the changes of water level
- Anchored to the bottom of water bodies
- Moveable/ re-arrangeable



Introduction | DeltaSync and Blue21

DeltaSync:

- Dutch company established in 2007
- Floating development specialist
- Research, design and consultancy
- Multidisciplinary and international team
- Perform location analysis and feasibility studies
- Mission: realizing floating cities with positive impact -> **Blue21**

DeltaSync | Floating city IJmeer



Source: DeltaSync, 2006

DeltaSync | Projects



Source: DeltaSync and Public Domain Architecten

DeltaSync | Projects

- Autarkisch floating buildings
- Flexible, modular
- Cradle to cradle



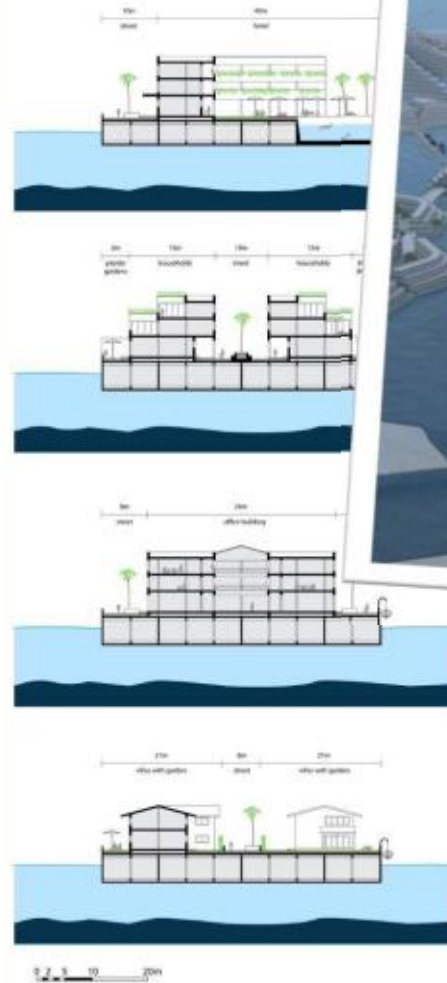
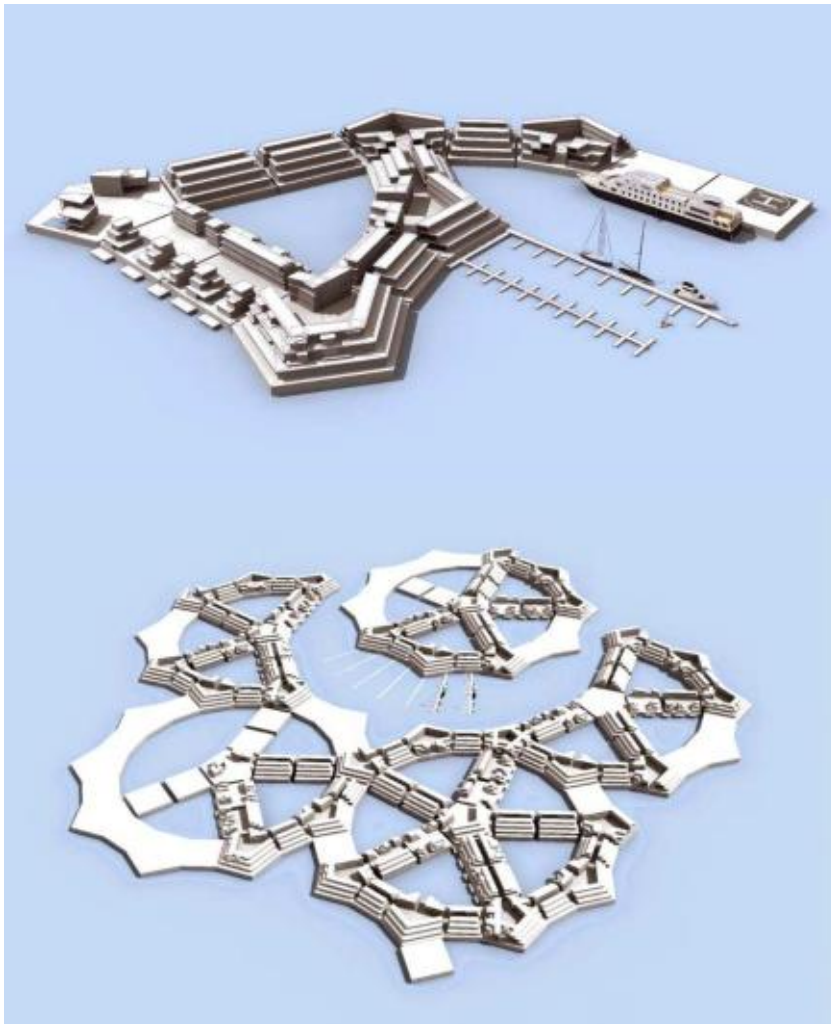
DeltaSync | Projects



Stichting Rijnhavenpark, Stad op het Water & DeltaSync

DeltaSync | Projects

The Seasteading Institute, U.S.A.



Source: DeltaSync, 2013

DeltaSync | Projects



[About](#) [Floating Island Project](#) [Architectural Design Contest](#) [Blog](#) [Participate](#) [Donate](#) [Contact Us](#)

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Government of French Polynesia Signs Agreement with Seasteaders for Floating Island Project



Source: DeltaSync and BlueFrontiers, 2017



Rutger de Graaf
Blue21

WATER INNOVATION
ENTREPRENEUR



Bart Roeffen
Blue21

WATER PIONEER AND ARCHITECT



Karina Czapiewska
Blue21

WATER PIONEER AND REAL ESTATE
EXPERT



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URBAN DEVELOPMENT EXPERT



Harry den Hartog
Urban Language

NEW TOWN EXPERT



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Rui de Lima
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Floris Boogaard
Tauw

WATER MANAGEMENT
PROFESSIONAL



Michael Captain
Welwynd Marine

NAVAL ARCHITECT



Jelle Vedder
Bartels&Vedder

FLOATING STRUCTURES &
ENGINEERING EXPERT



Ronald Vuijk
Member of Dutch Parliament

GOVERNANCE EXPERT



Peter Mooij
Delft University of Technology

BIOTECHNOLOGY & ALGAE EXPERT



Pernille van der Plank
Utrecht University

LEGAL EXPERT



Mission: realizing floating cities with positive impact

BLUE REVOLUTION



Source: DeltaSync

WHY IS IT TIME FOR A BLUE REVOLUTION?

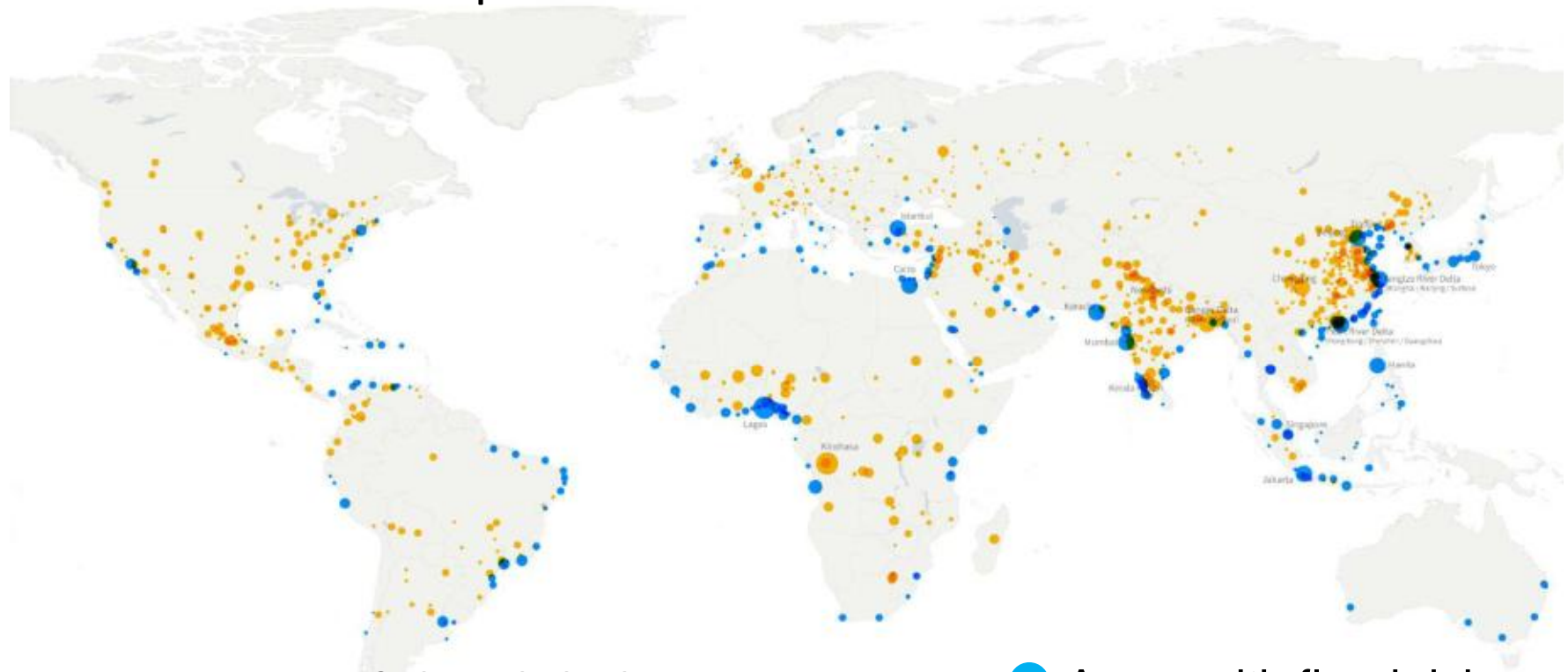
Global city light image

at present there are about **3.5 billion city dwellers**
living on **2 million square km of land**

NASA

Coastal areas | Cities

Many of the world largest metropolitan areas are located in coastal areas and river floodplains



In 2030, 50% of the global population will live within 100 km from the coast

- Areas with flood risk
- Rapidly growing areas

Source: DeltaSync, 2017

Coastal areas | Ecosystems

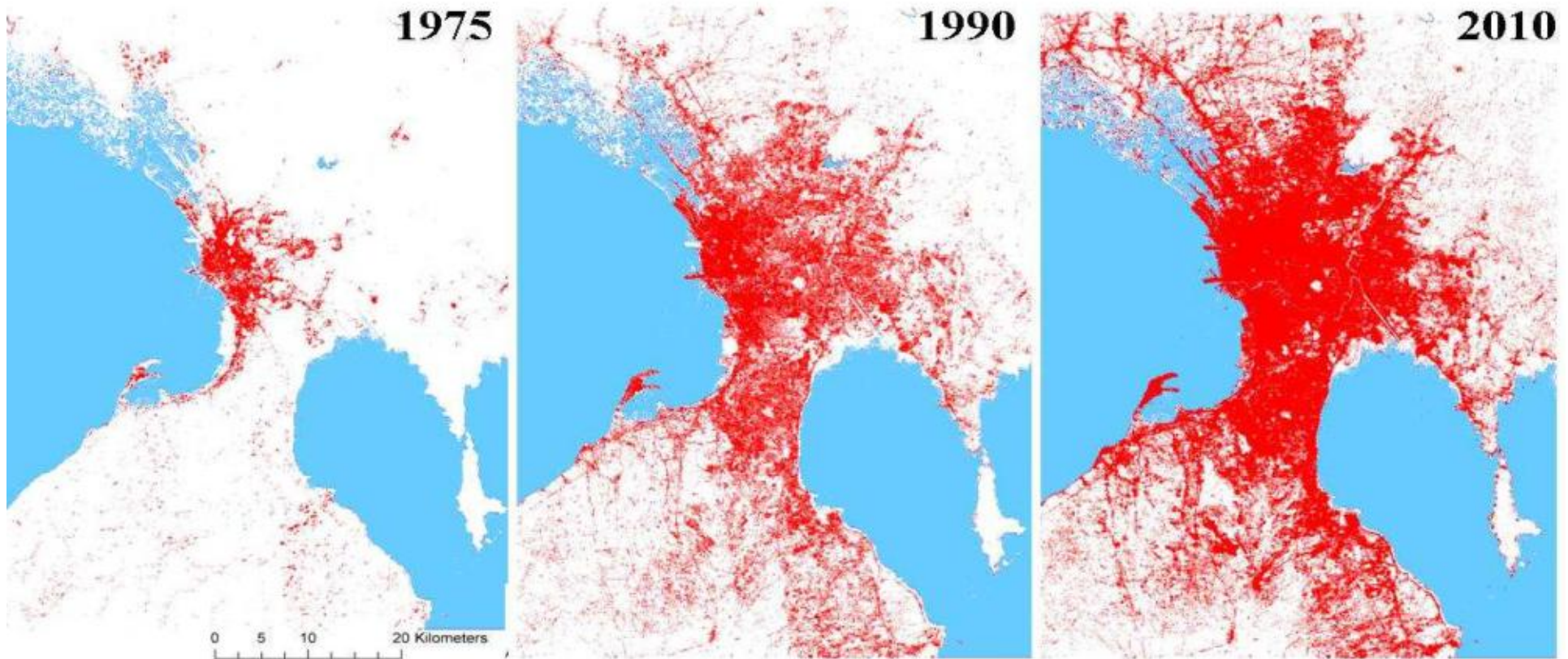


- 42% animal species
- 50% plant species

Biodiversity.sg

Coastal areas | Rapidly growing cities

Manila, Philippines



Earthzine, 2010

Coastal areas | Land subsidence

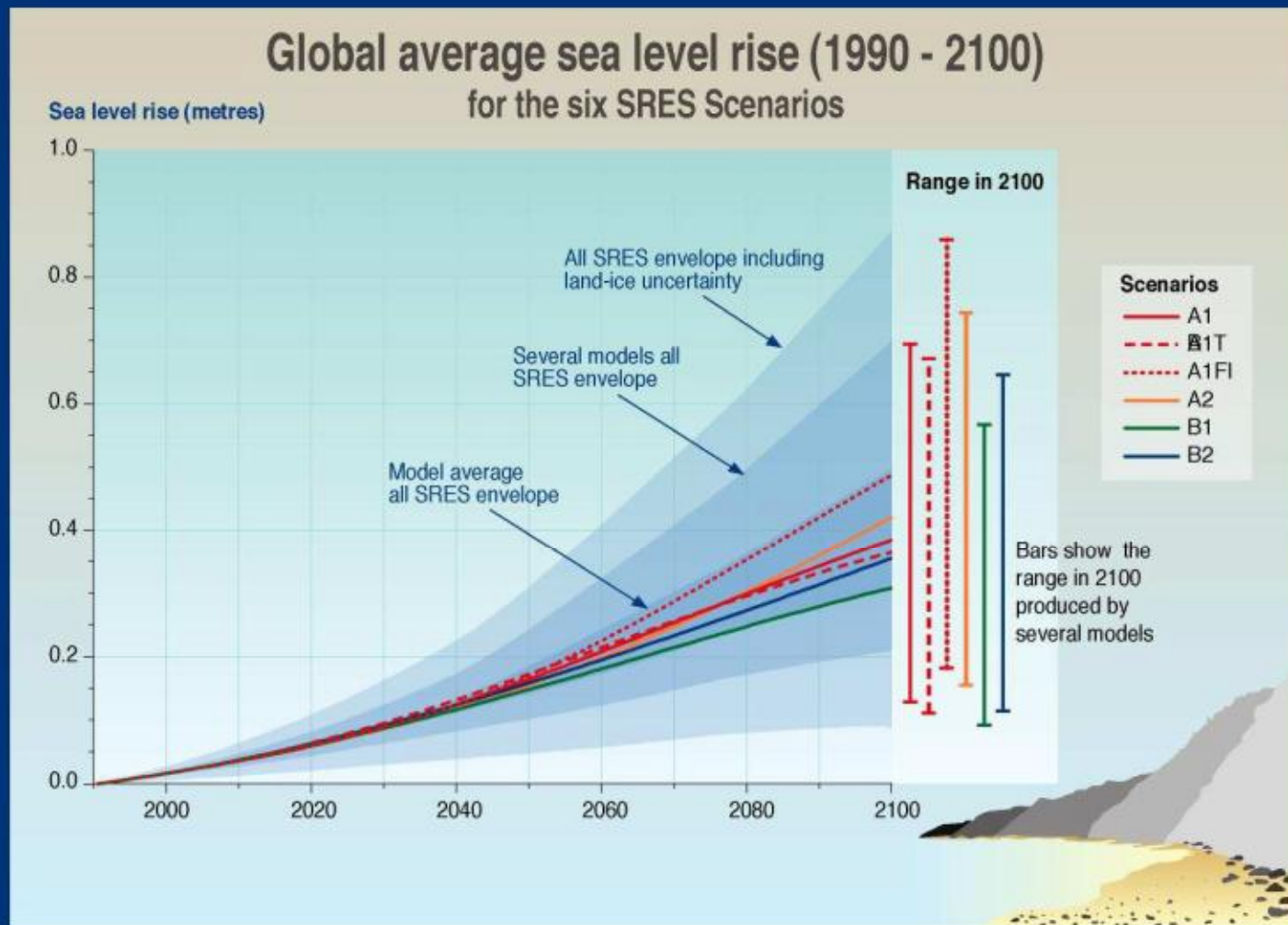


Jakarta, Indonesia

Land subsidence rate: 10-20 cm/yr, 4m in 35 years

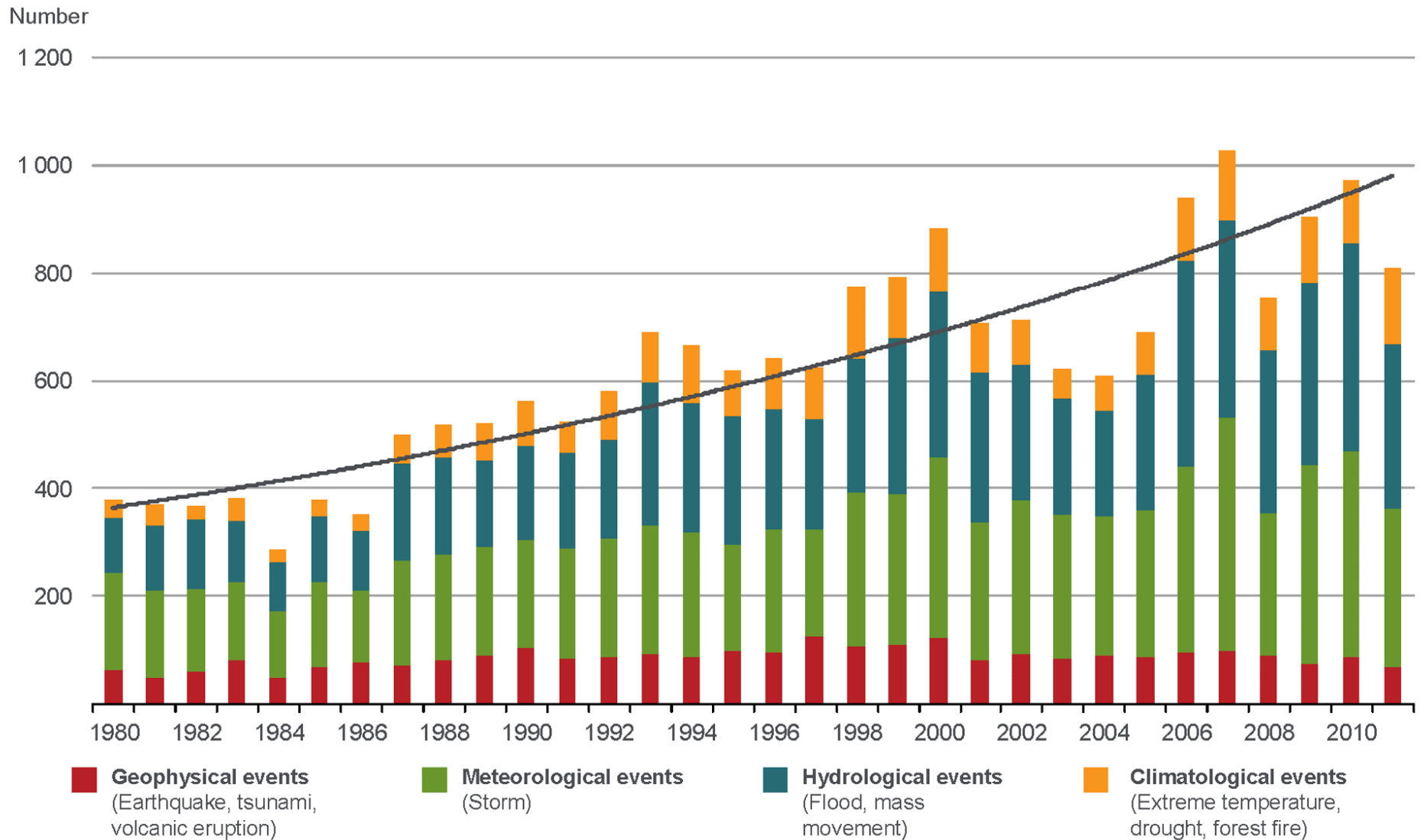
Source: Piet Dircke, 2012

Climate change | Sea level rise



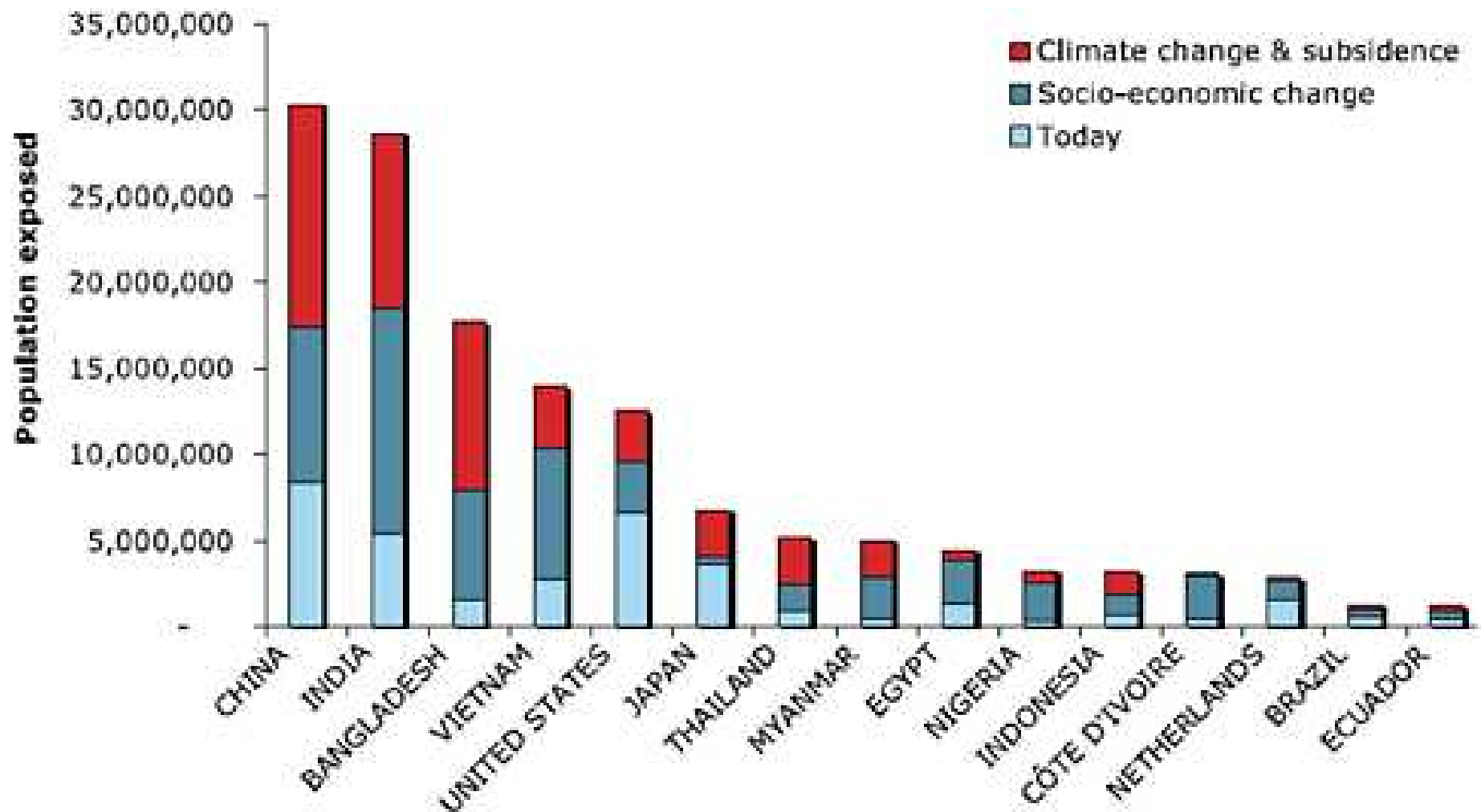
WG1 TS FIGURE 24

Climate change | Risk of weather catastrophes



Source: Munich Re

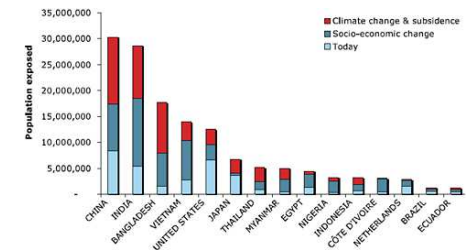
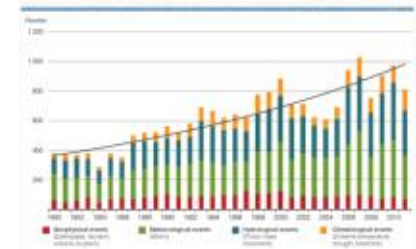
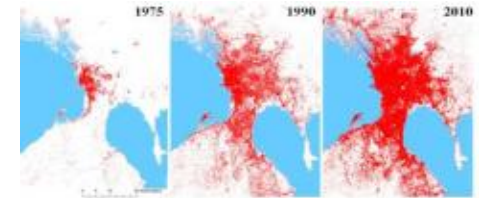
Climate change | Population exposed to flooding (2070)



Source: OECD, 2007

21st century urban challenges

- Rapid urbanization in vulnerable coastal areas
- Land subsidence
- Extreme weather events and climate change
- Pressure on coastal ecosystems



FUTURE LAND SHORTAGE

A growing world population consuming more food and resources, will require additional space to expand cities and produce food. Land shortage seems inevitable, mainly due to agriculture and biofuel demand.

TRENDS AND FACTORS

more people

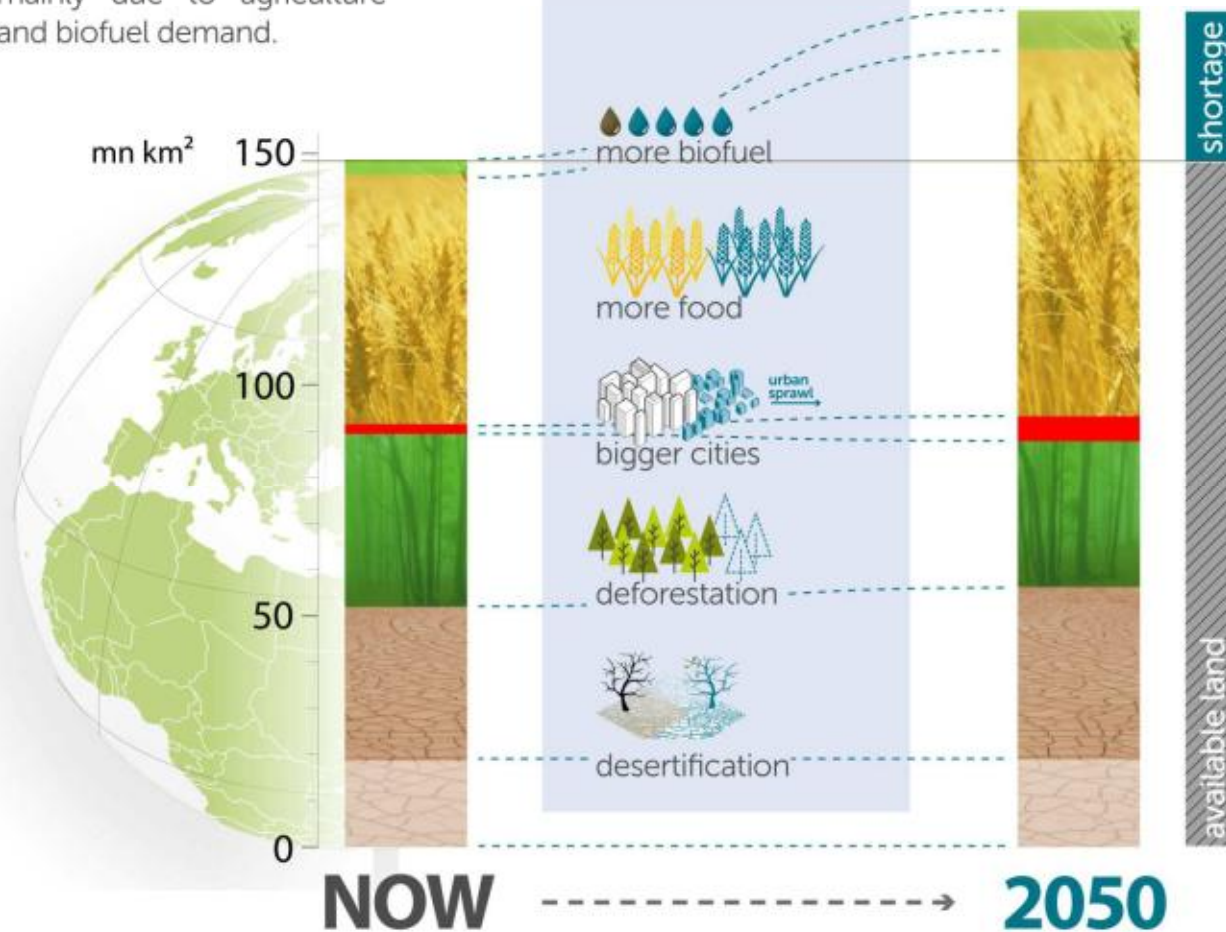


more consumption



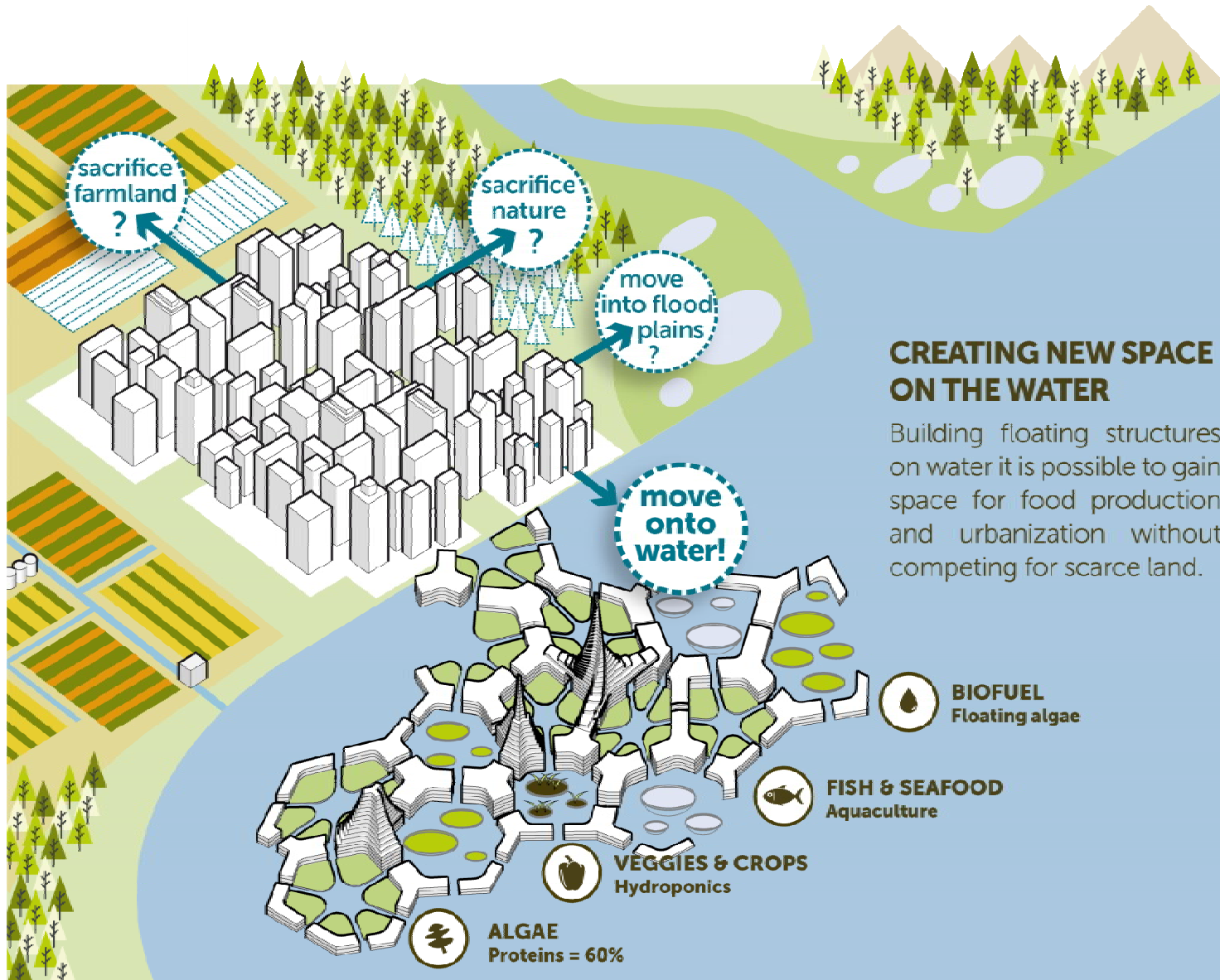
WE WILL BE
22 MILLION
sq km
SHORT

equal to the
area of
North
America!



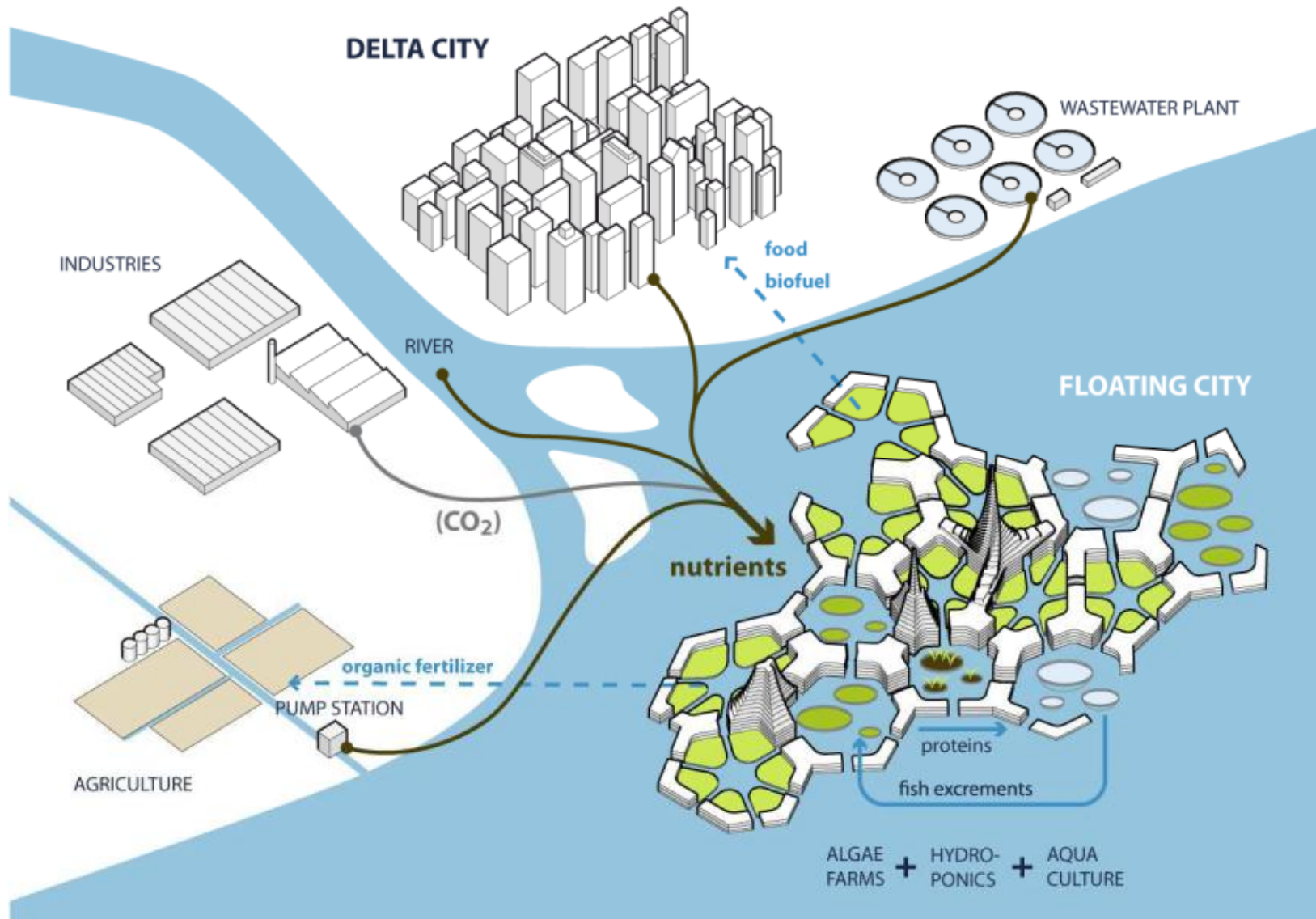
Source: DeltaSync, 2013

HOW ARE WE GOING TO GET THIS SPACE?



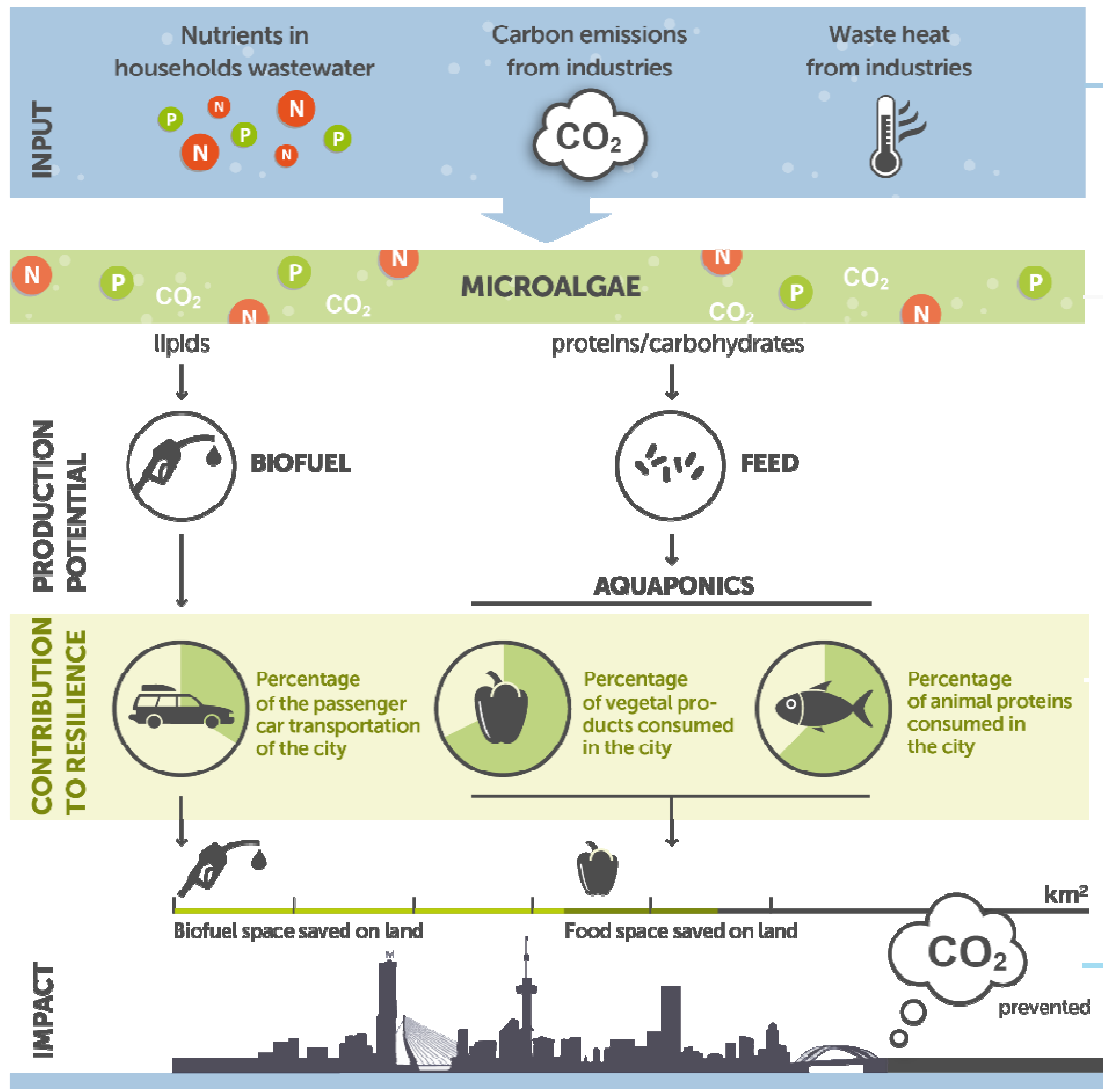
Source: DeltaSync, 2013

Concept | Closing CO₂ and nutrients cycles



Source: Deltasync, 2012

METHOD



MAIN SOURCES:

- FAOSTAT data on food supply
- Jönsson et al. (2004). *Guidelines on the Use of Urine and Faeces in Crop Production*. EcoSanRes
- Data on CO_2 emissions
- Borowitzka et al. (2013). *Algae for Biofuels and Energy*. Springer.
- Sudhakar et al. (2012). *Theoretical Assessment of Algal Biomass Potential for Carbon Mitigation and Biofuel Production*. Iranica Journal of Energy & Environment
- Tidwell (2012), *Aquaculture Production Systems*. Wiley Blackwell
- FAO reports on aquaponics
- Gerber et al. (2013). *Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities*.
- FAOSTAT data on land use

Source: DeltaSync 2015

CASE STUDIES

- pollution issues
- high CO₂ emissions
- high population density and growth rate

Rotterdam



Manila

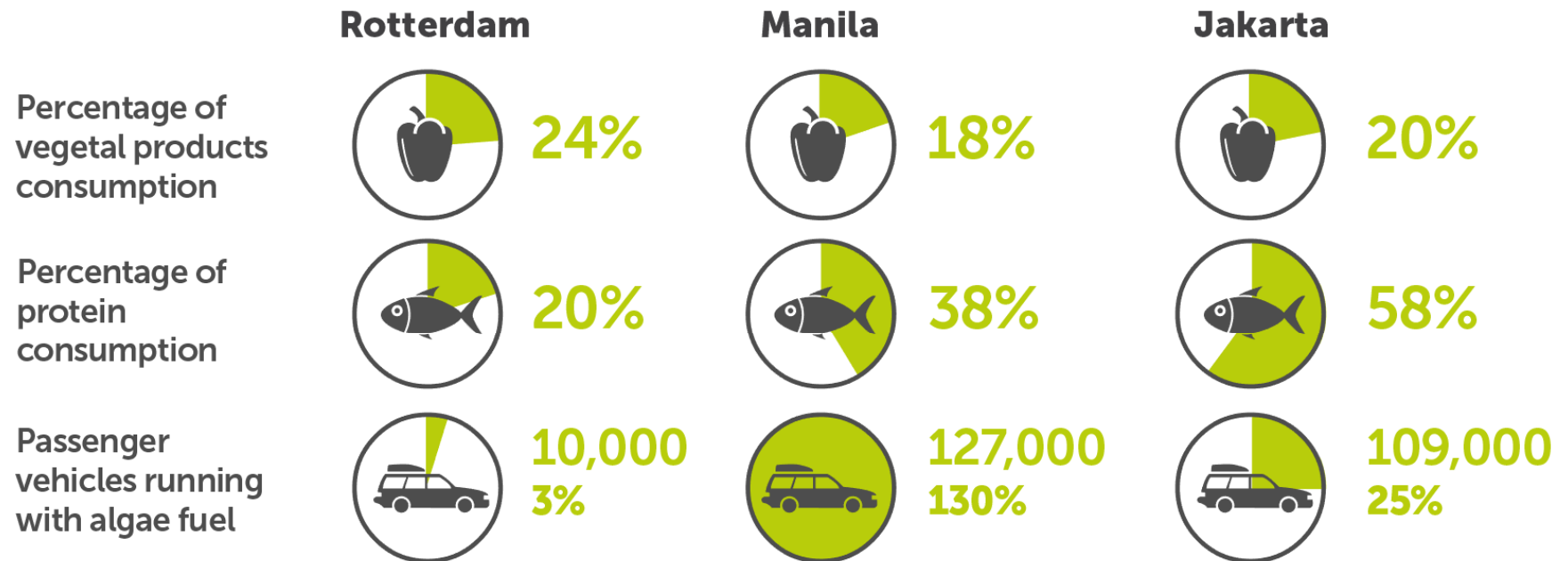


Jakarta



Sources: rezon.org, dutchwatersector.com, hdtravelpics.com,
affordablehousinginstitute.org, indosurflife.com, qz.com

CONTRIBUTION TO RESILIENCE



Values estimated from data for the Netherlands, Philippines and Indonesia, proportioned to each city population
(Sources: FAOSTAT, EPA, The World Bank)

PUBLISHED STUDY

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Potential of floating production for delta and coastal cities



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ABSTRACT

The disruption of nutrient cycles caused by human activities such as agriculture and burning fossil fuels is impacting ecosystem services on global and local scales. The increasing concentration of carbon dioxide in the atmosphere contributes to rising global temperatures and ocean acidification, whereas the accumulation of nutrients in water systems is leading to degradation of water quality and biodiversity. City populations play a major role in carbon dioxide and nutrient emissions as 'end consumers' of resources. The current challenge towards more resource-efficient cities is to transform urban metabolism from linear to cyclical. Discharged nutrients and carbon dioxide can be used as input for algae, which fixate carbon very efficiently into energetic storage compounds as starch or lipids. However, cities often lack the space to implement large-scale algae production. This article evaluates the potential of reusing nutrients and carbon dioxide to produce algae, food and biofuel on water nearby coastal and delta cities. First, nutrients and carbon dioxide discharge is estimated and two scenarios are developed. From the cities nutrient production, the potential algal yield is evaluated and translated into feed, food and oil yields. Two delta cities are chosen as case studies: Rotterdam and Metro Manila. The conclusion of this article is that Floating Production can help cities increasing their resilience in the field of food and energy. Floating Production can also contribute to a solution for global land shortage. The combination of food and energy production with floating urban development provides a climate-proof urban expansion in delta and coastal areas.

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Comparison with land reclamation

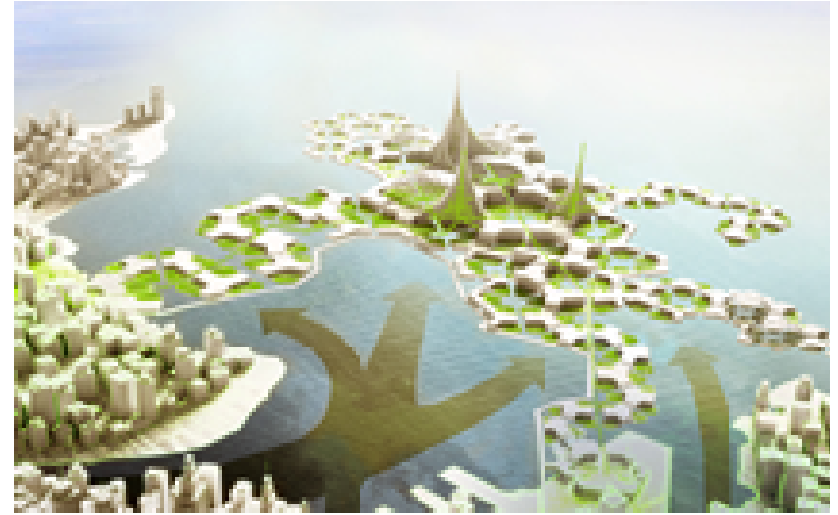
Land reclamation



Characteristics:

- Large investment needed to start
- Sea level rise protection with additional dikes
- Destroys local aquatic ecology

Floating urban development

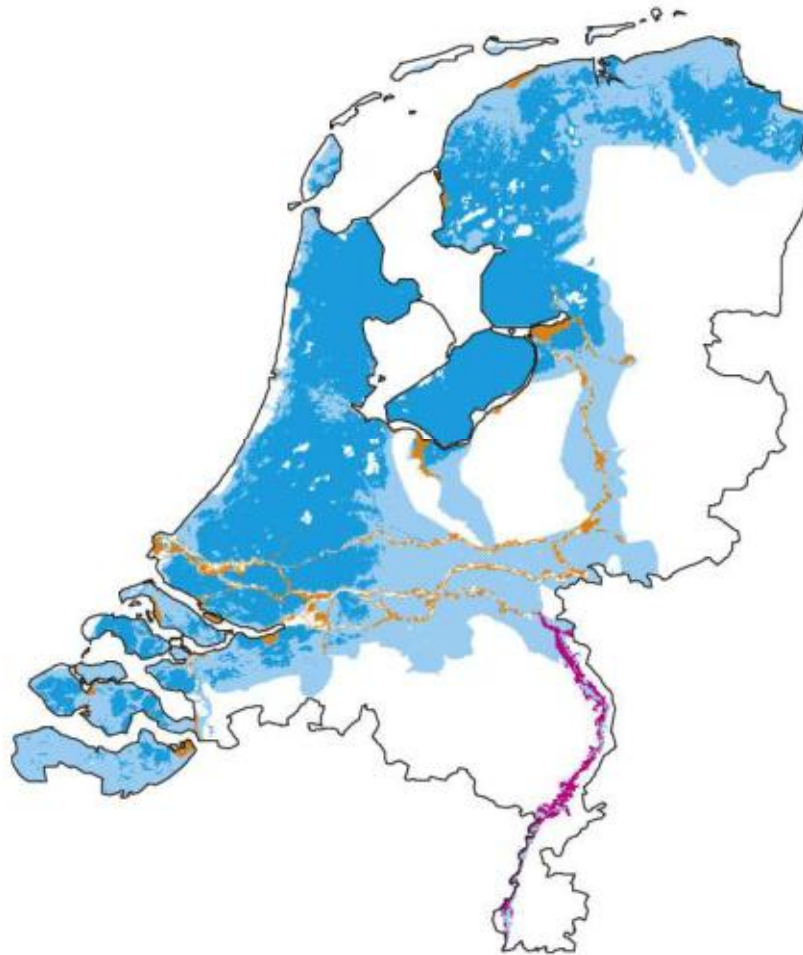


Characteristics:

- Large scale and small scale possible
- Adapts to sea level rise
- Water quality and ecology benefits

The Netherlands | Flood prone areas

Overstromingsgevoelig gebied, 2005



Binnen dijkringen

■ Beneden NAP: 26%

■ Boven NAP: 29%

■ Buitendijks gebied: 3%

■ Onbedijkte Maas: 1% *)

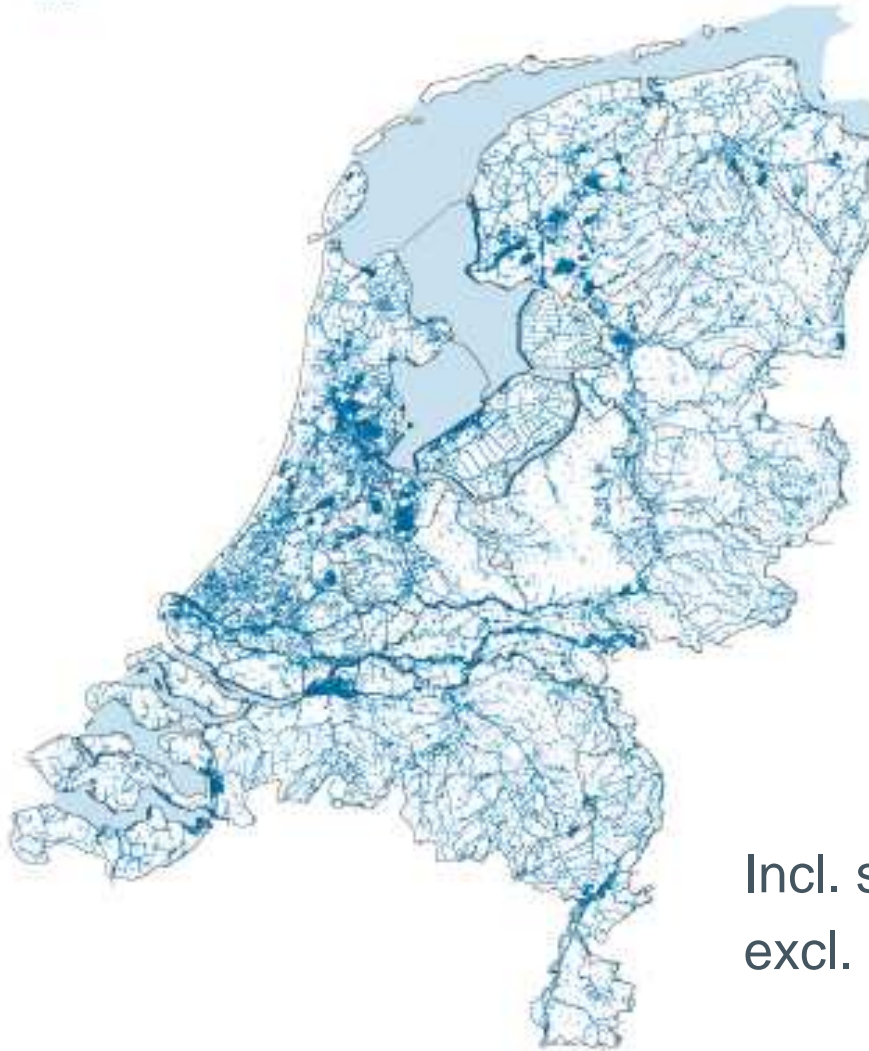
*) Overstroombare deel
van de onbedijkte Maas
binnen de 1/250-contour.

Bron: PBL (2009)

www.pbl.nl

The Netherlands | Surface water areas

Oppervlaktewateren



Incl. salt water: 65,630 km²

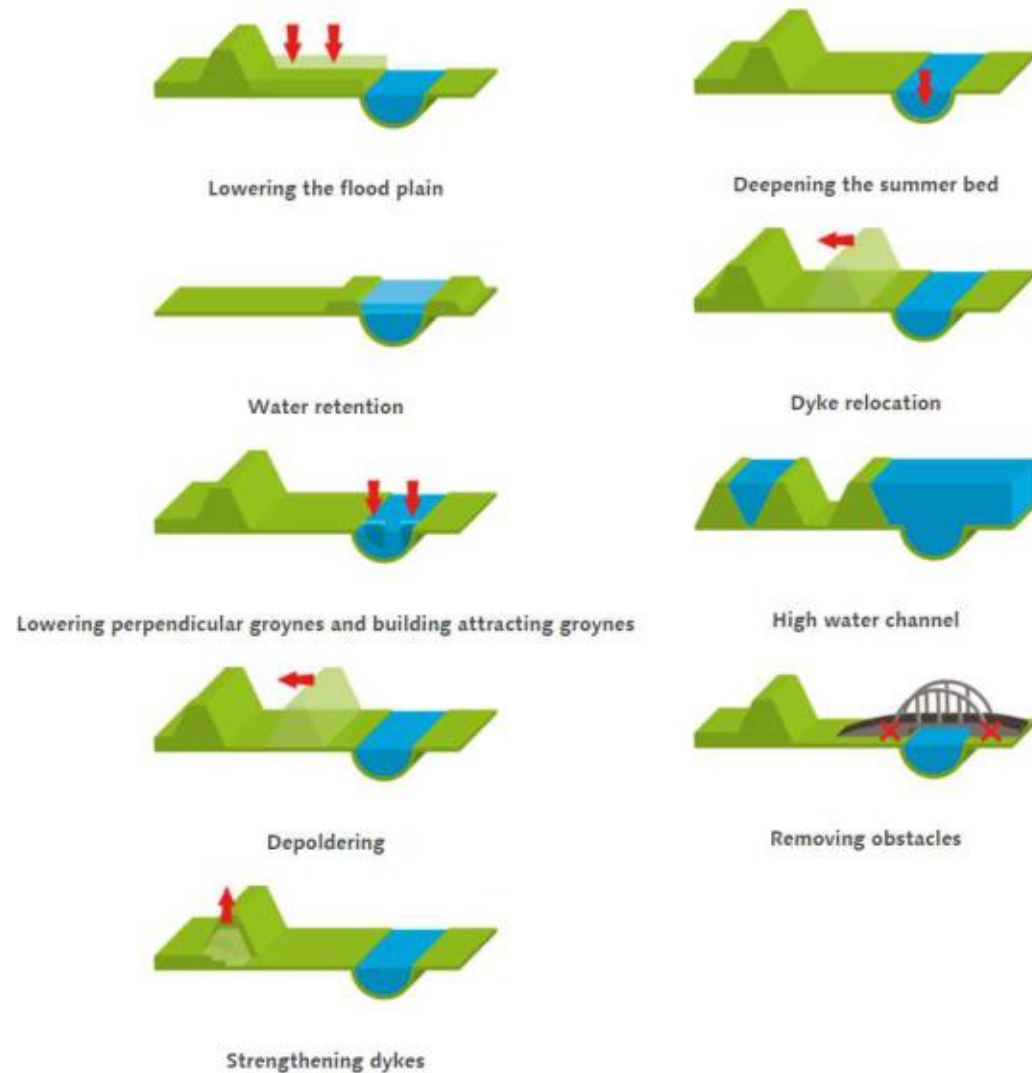
excl. salt water: 3,630 km²

Bron: Topografische Dienst Kadaster.

PBL/deco8/1401
www.compendiumvoordeleefomgeving.nl

The Netherlands | 'Room for the River' Programme

- The goal is to give the river more room to be able to manage higher water levels
- More than 30 suitable locations were identified and several measures applied, improving safety and the quality of the surroundings



Source: ruimtevoorderivier.nl

The Netherlands | 'Room for the River': opportunities



- New opportunities for recreation, nature, agriculture and (floating) buildings



Sources: beeldbank.rws.nl, ruimtemeesters.nl, siebeswart.photoshelter.com

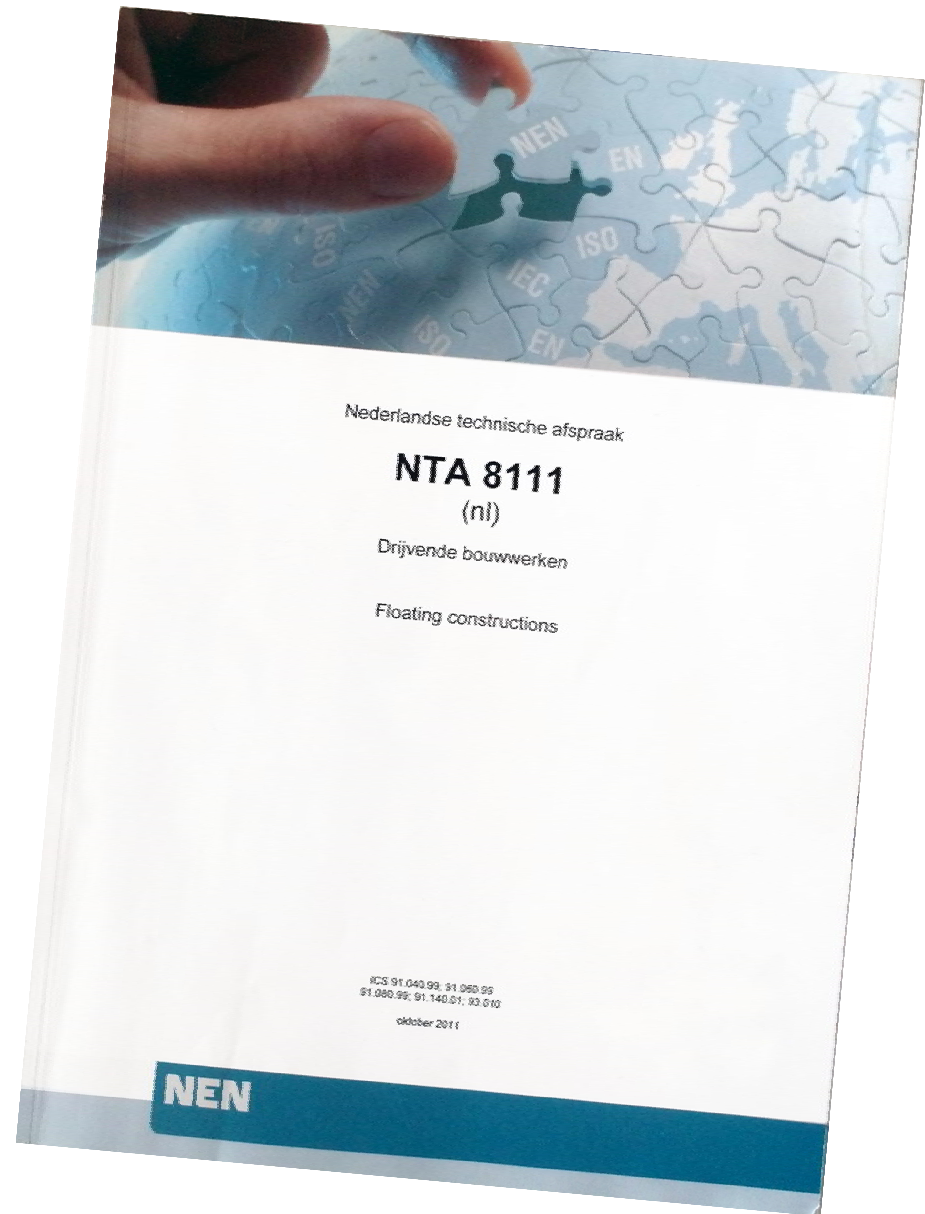
The Netherlands | Regulations for floating constructions

- 2008 document from the Dutch Ministry of Housing, Spatial Planning and the Environment
- Aims at supporting developers, builders and municipalities in **understanding and applying** regulations to floating buildings



The Netherlands | Guidelines for floating construction

- 2011
- Important step: floating construction as fully-fledged and accepted standard construction form
- Municipalities can check if floating constructions are built properly and compile with the building code
- Contribution from DeltaSync



Implementation | Case studies

Floating Pavilion, Rotterdam



Houses in the Harnaspolder,
Delft

Implementation – Case study I



Floating Pavilion, Rotterdam

Source: Google maps, 2017

Rotterdam | Climate Adaptation and Mitigation Strategies



FLOOD RISK



WATER SQUARE
source: fastcoexist.com



GREEN ROOFS
source: Erasmus MC

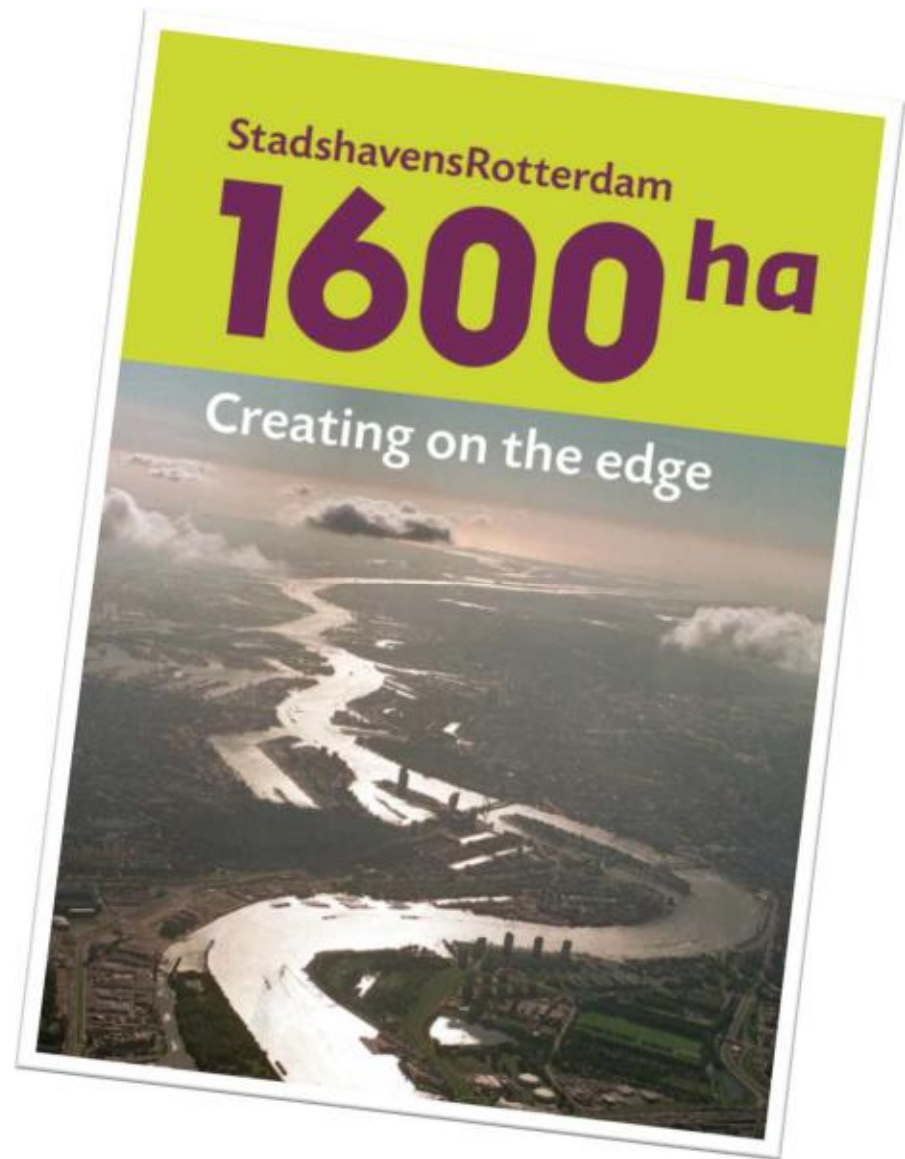


FLOATING EXPANSION
source: René de Wit

Rotterdam | Stadshavens plans for city harbours

2008 report '**Creating on the edge**':

- New entity: Stadshavens
- 1600 ha of harbors in the city center



Rotterdam | Stadshavens plans for city harbours



Source: williefikken.nl

Rotterdam | Suitable locations for floating development

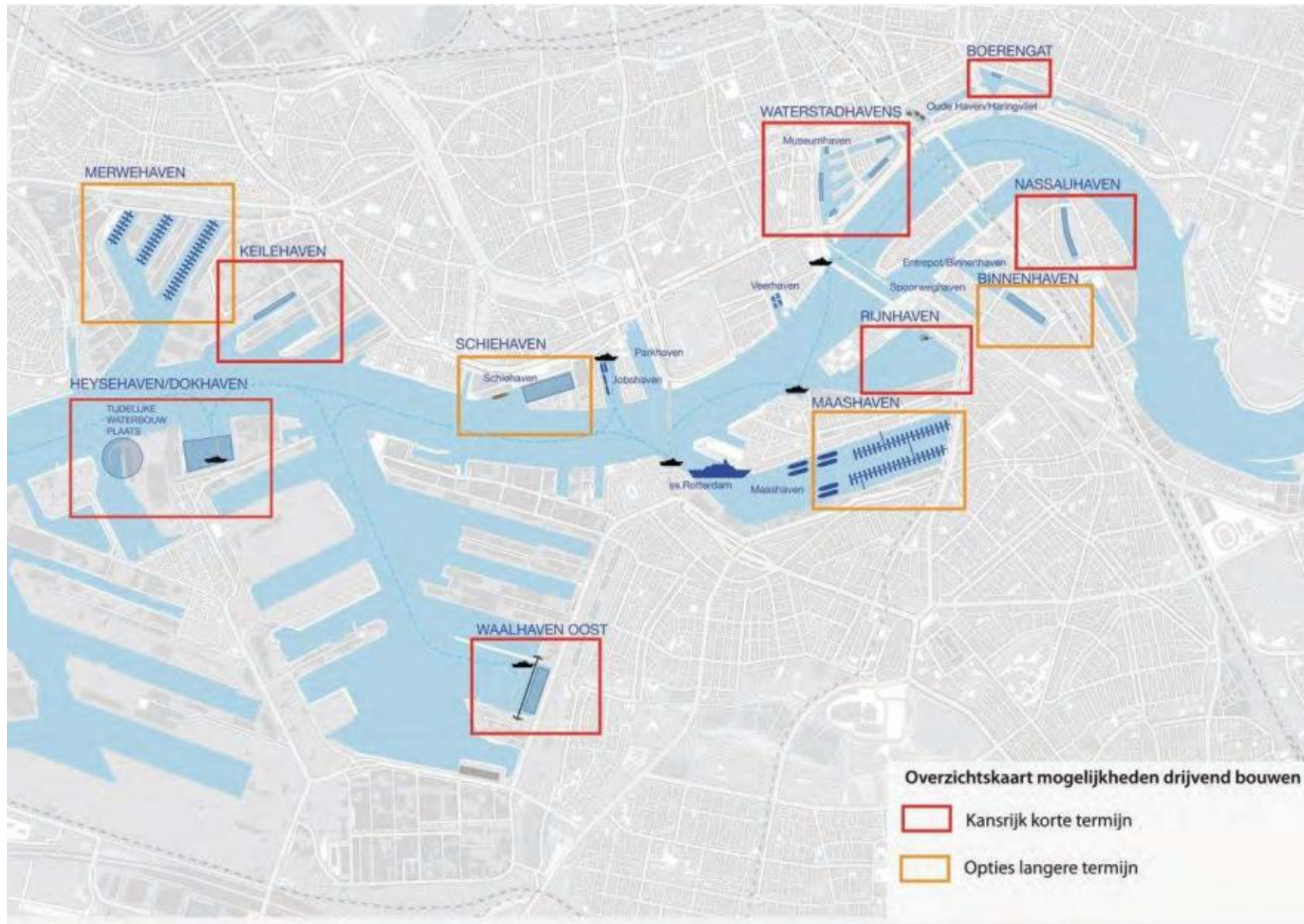
DeltaSync giving advice the municipality on the most promising locations for floating development

Veto criteria:

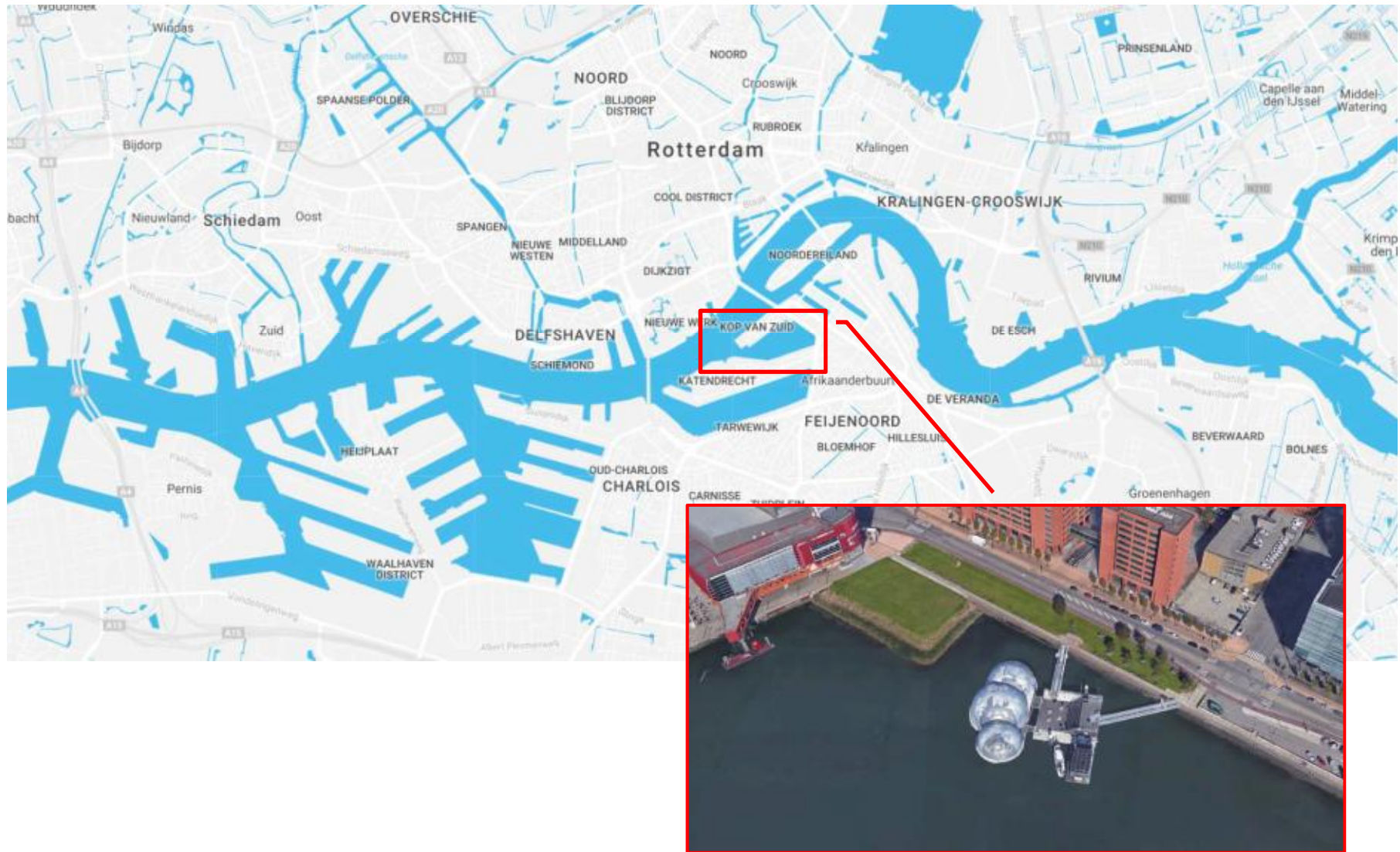
- Space availability (ownership, shipping routes, future plans, etc.)
- Depth (low tide, storm, etc.)
- Ecology (exclude protected areas)



Rotterdam | Suitable locations for floating development



Floating Pavilion, Rotterdam | Location



Source: Google maps

Floating Pavilion, Rotterdam | Design strategy

starting principles



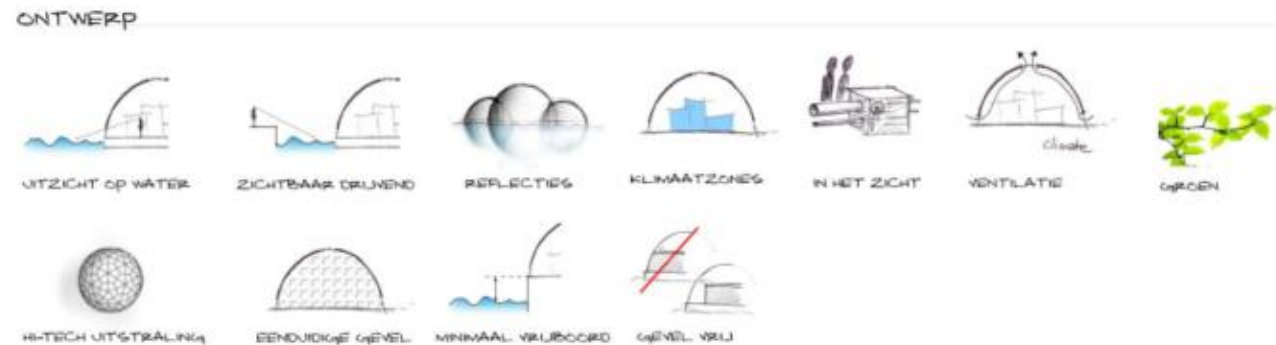
boundary conditions



technical demands



design wishes

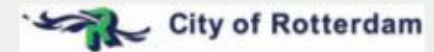


Floating Pavilion, Rotterdam | Process & Stakeholders

- DeltaSync made a first sketch (concept) design + program of requirements, wrote a tender
- 5 consortia applied
- Multidisciplinary consortium

Development Team

Client:



Main Contractor:



Architect:



Installation Consultant:



Floating Foundation:



Dome Construction:



Structural Engineer



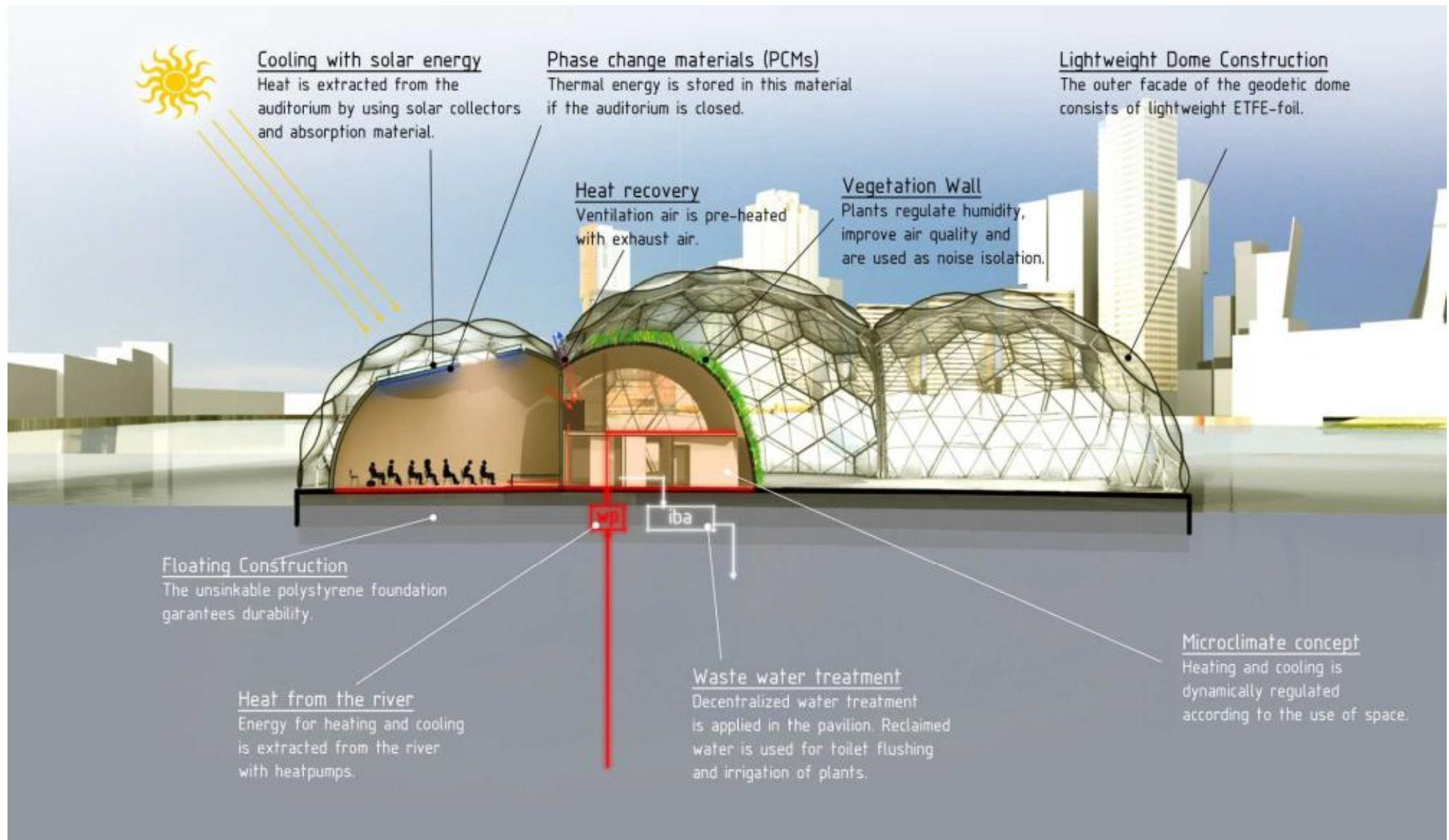
Installations:



Floating Pavilion, Rotterdam | Construction

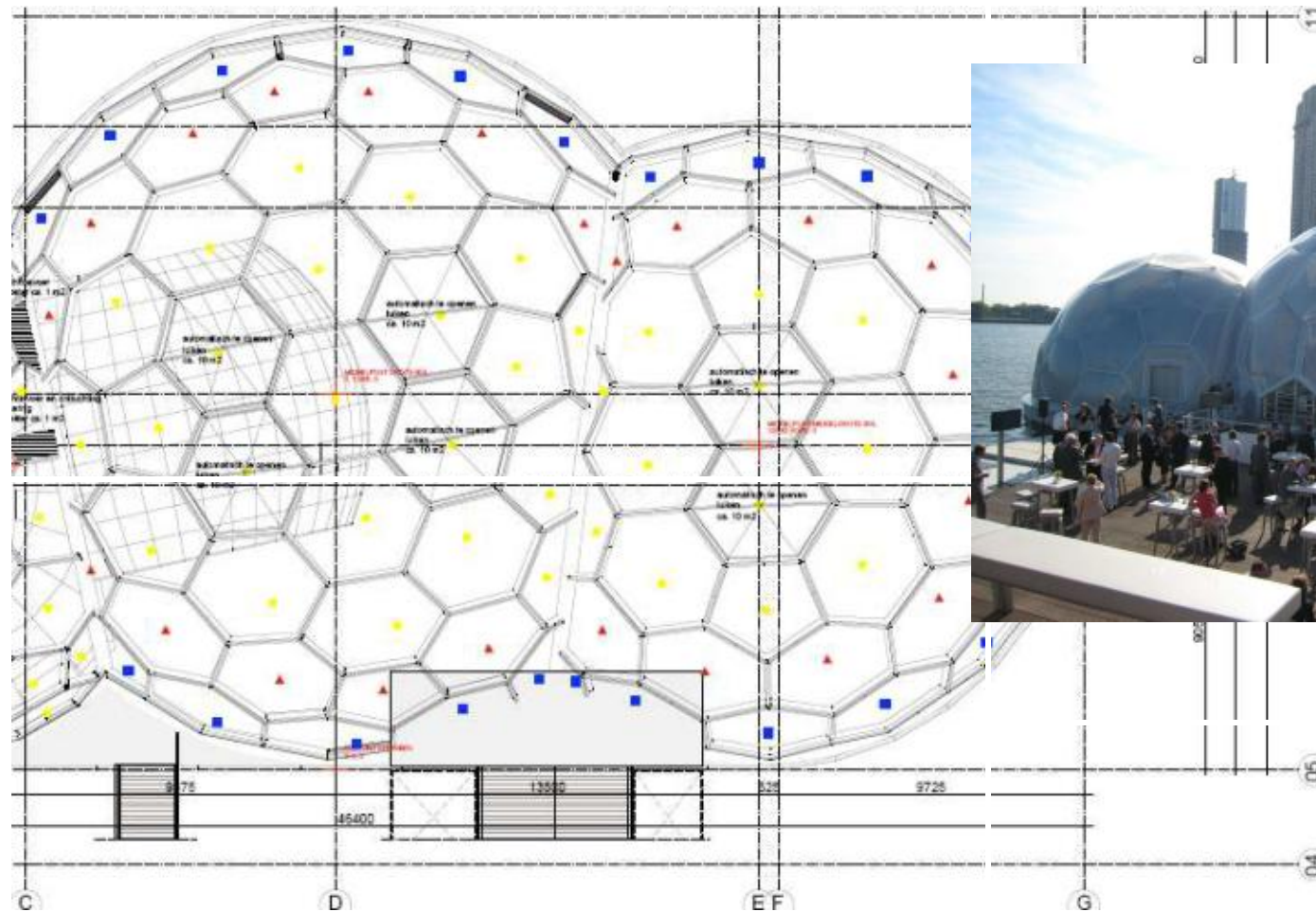


Floating Pavilion, Rotterdam | Sustainability



Source: DeltaSync and Public Domain Architecten, 2010

Floating Pavilion, Rotterdam | Transparent dome

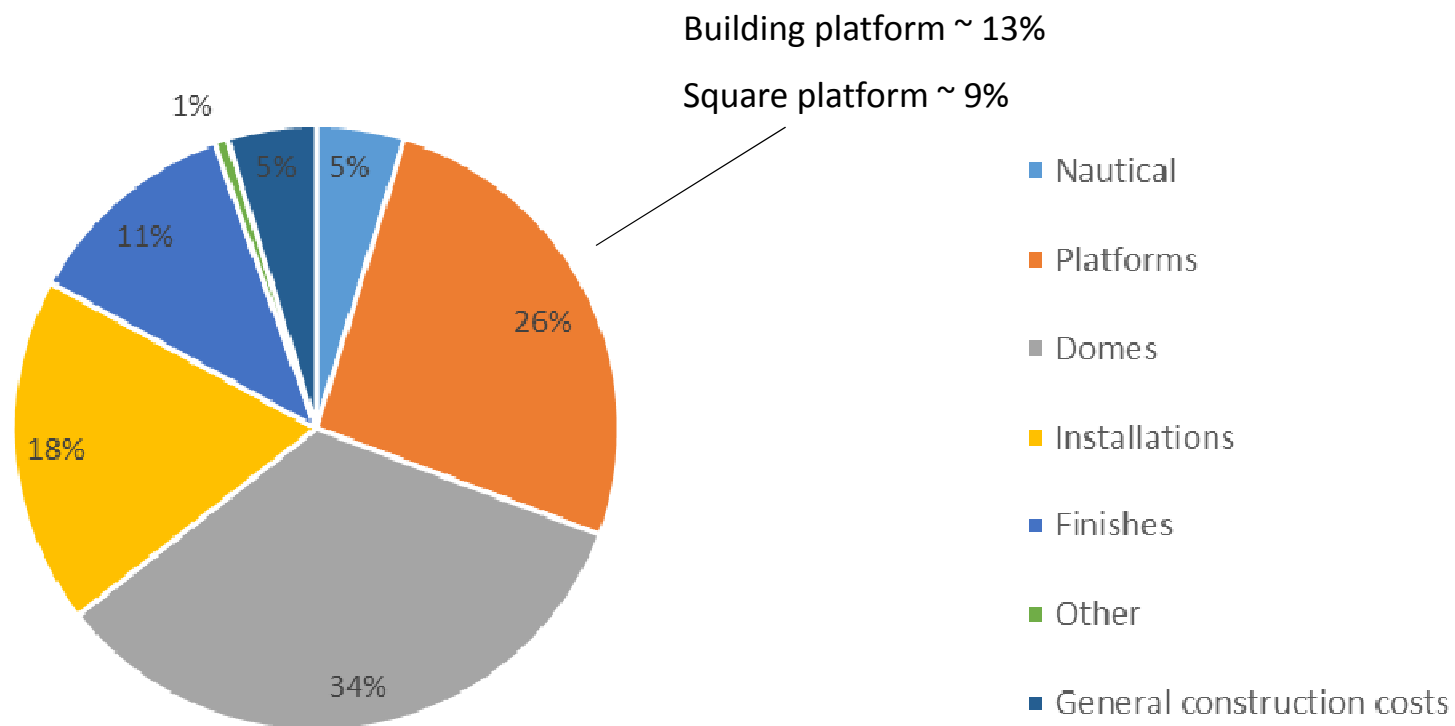


■ Gevelvlak bekleed met ETFE-folie
LTA- en ZTA-waarde = 0,9



Floating Pavilion, Rotterdam | Costs

- Total project costs: €4.6 million
 - Total construction costs: €4.1 M



Cost distribution of various construction activities

Bottlenecks | Floating Pavilion

- Building legislation: deconstruction and construction in terms of moving
- Fire department: escape route, oil spill fire (oil tanks present at harbor)
- Port of Rotterdam: collision issues (cycling bridge placed in the front)



Success factors | Floating Pavilion

- Process approach vs. Blueprint
- Innovative approach: building team approach
- Time pressure (1 year), intensive daily working
- Political drive (WorldExpo 2010)
- Political leadership in terms of permit
- Pilot project (remain for 5 years)



Implementation – Case study II



Harnaspolder, Delft

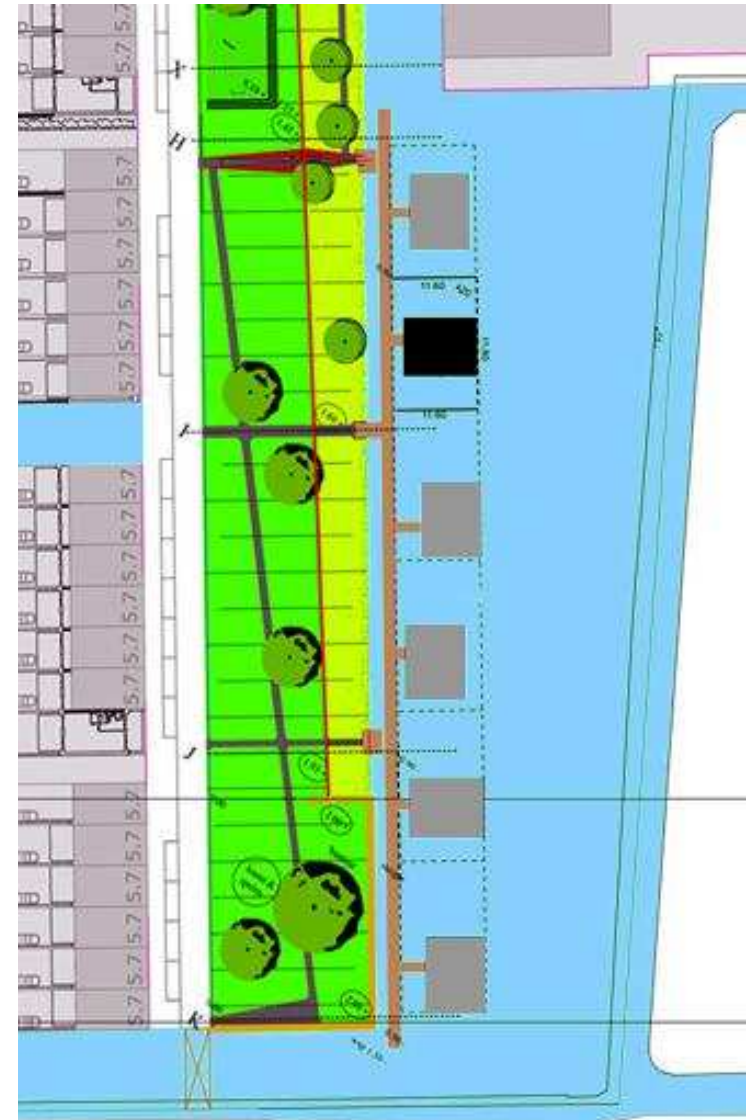
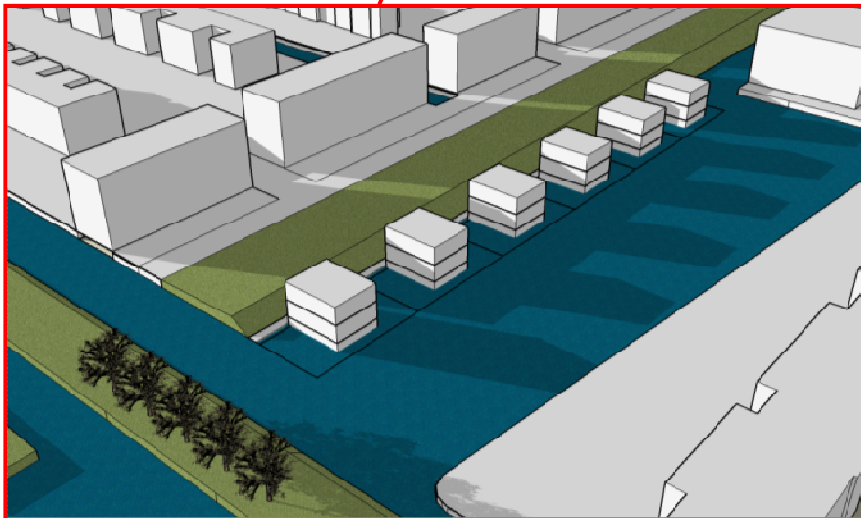
Source: Google maps, 2017

Harnaspolder, Delft | Location



Source: Foka, 2014, Bing maps

Harnaspolder, Delft | Plan



Source: DeltaSync 2009

Harnaspolder, Delft | Plan

- *Collective Private Initiative (CPI)*: group of citizens developing the project together
- DeltaSync: advise on sustainability and technical issues related to floating construction



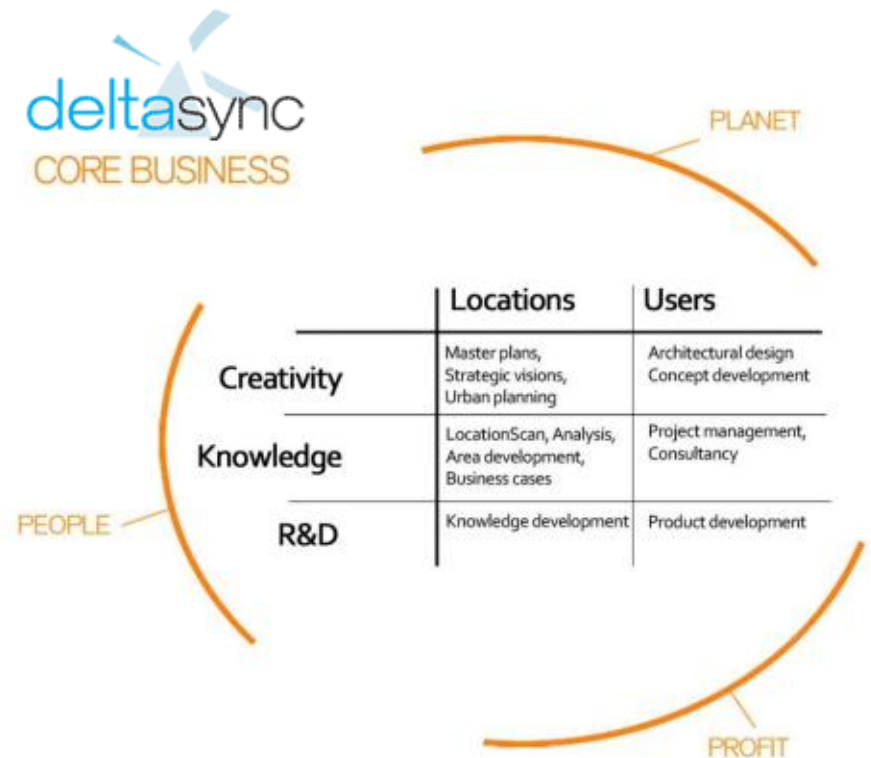
Harnaspolder, Delft | Citizens as project developers



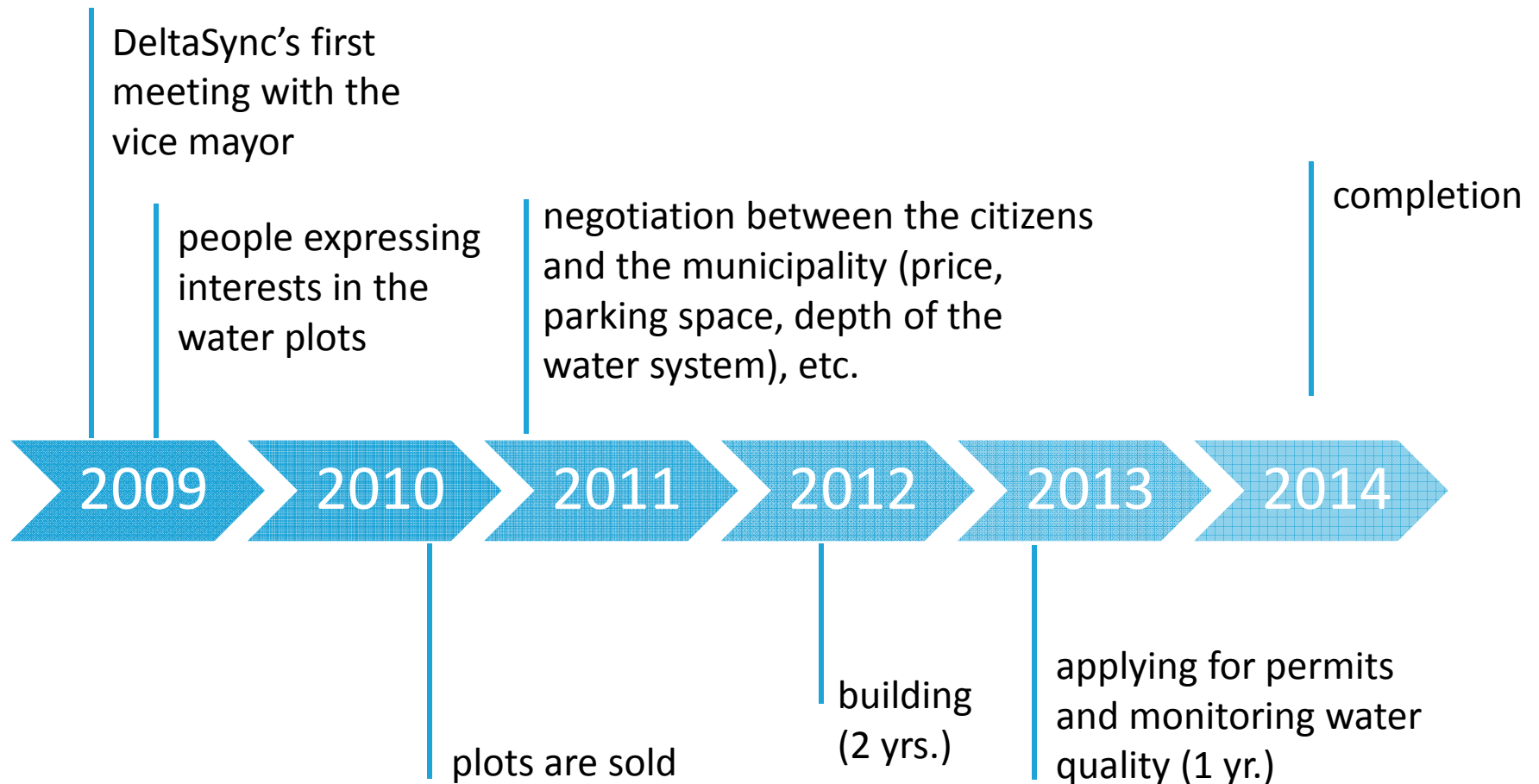
Olaf Janssen, citizen and developer of a new floating technology and floating house, founder of new company **Balance d'eau** (www.balancedeau.nl) Source: Delft op Zondag, 2013

Harnaspolder, Delft | Role of DeltaSync

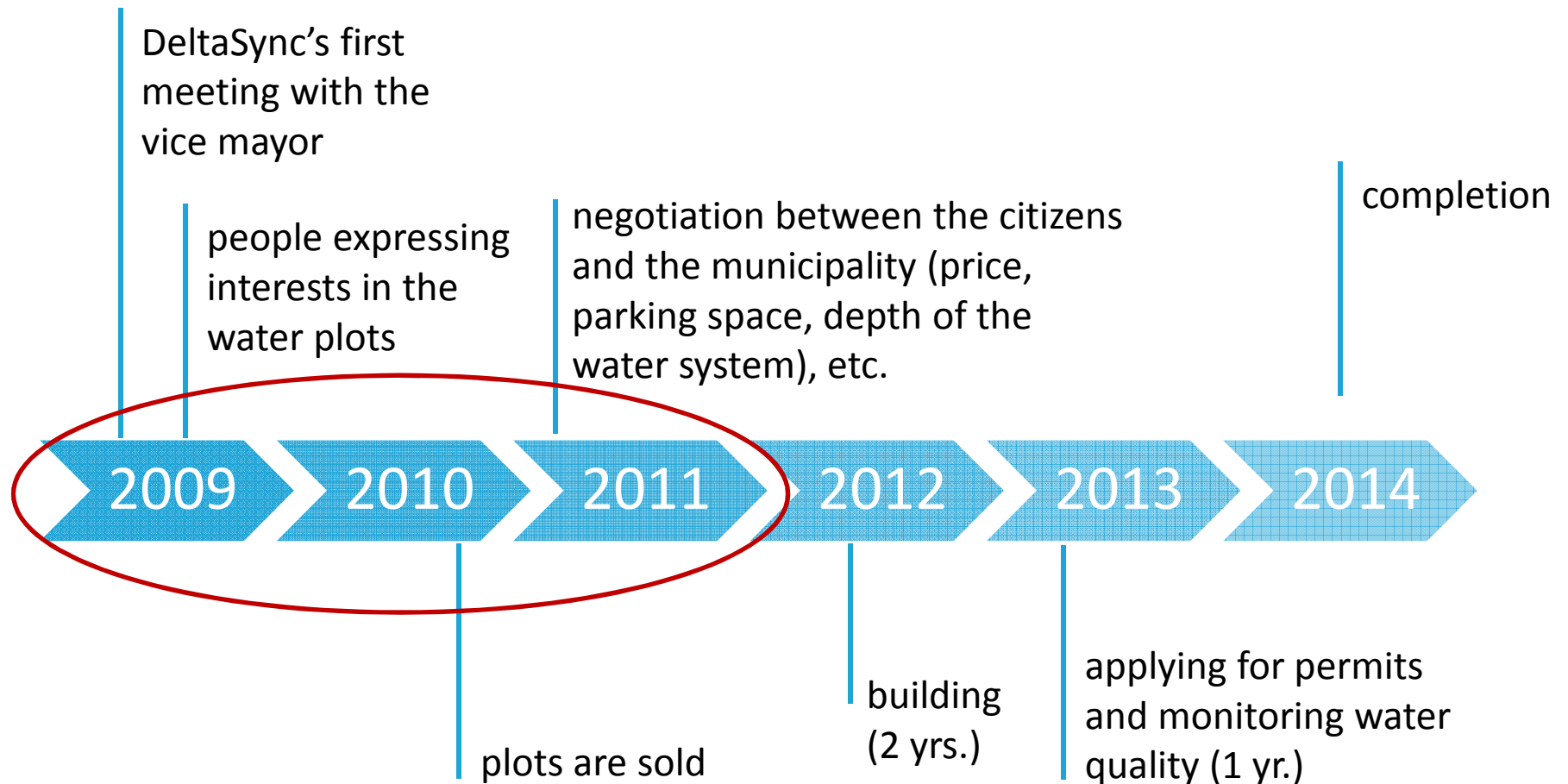
- Knowledge
- Design and concept development
- Cost estimations
- Feasibility studies
 - Technical (e.g.: draft, systems)
 - Economic
 - Planning, legal
 - Water quality and ecology
- Technical integration
 - Floating systems
 - Utilities
 - Sustainability
- Stakeholder management



Harnaspolder, Delft | Process

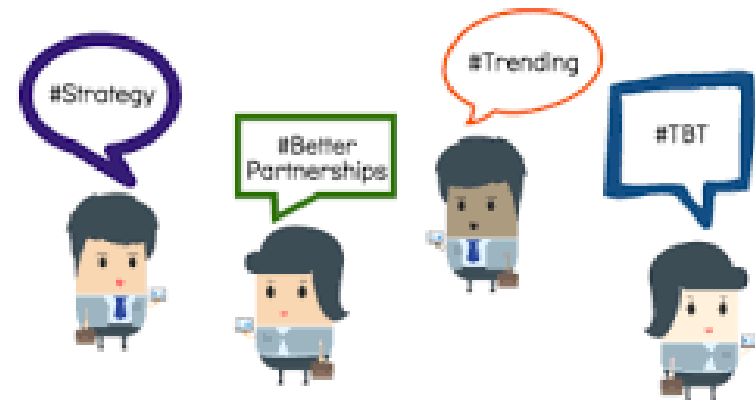


Harnaspolder, Delft | Process



Harnaspolder, Delft | Main stakeholders

- Municipality of Delft (Gemeente Delft)
- Waterboard (Delfland)
- Future citizens
- DeltaSync
- Utility companies
- Banks



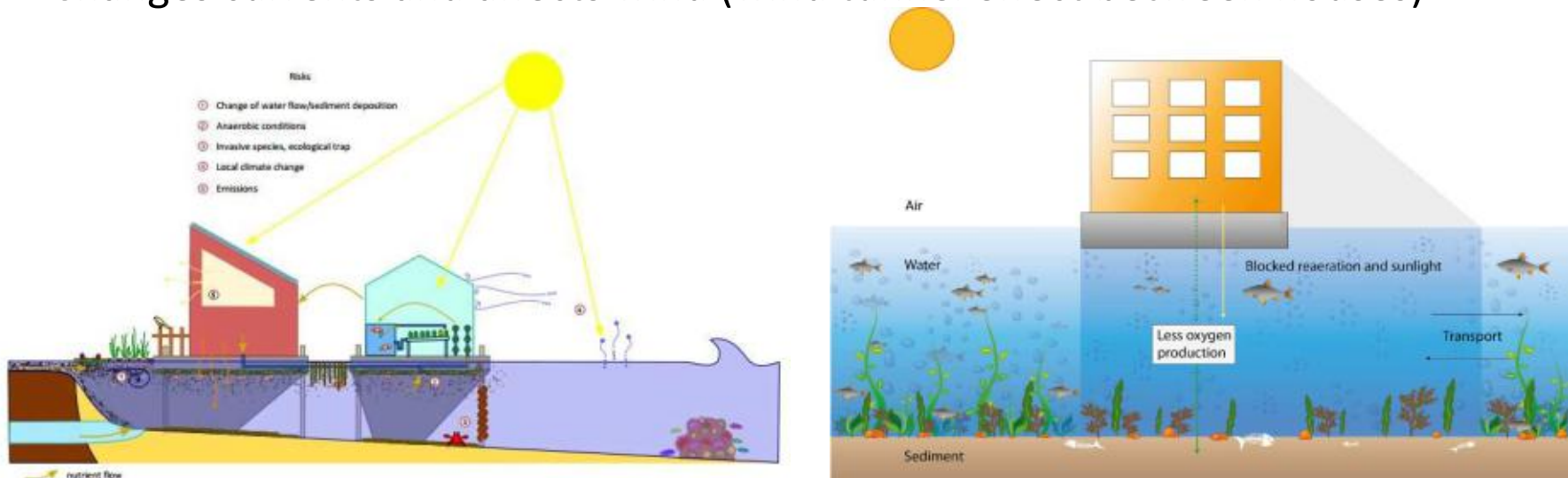
Harnaspolder, Delft | Bottlenecks

- Banks not willing to give mortgage or offered a very high interest rate
- Utility company not wanting to be responsible for the connection on floating structure
- Waterboard not wanting to give the permits

Water quality research | Knowledge gaps

Lack of knowledge about impacts was hindering new projects:

- Reduction of the area available for air water interactions,
- Blocking penetration of light
- Provide surfaces that organisms can use to attach themselves
- Changes currents and affects wind (wind tunnel effect between houses)

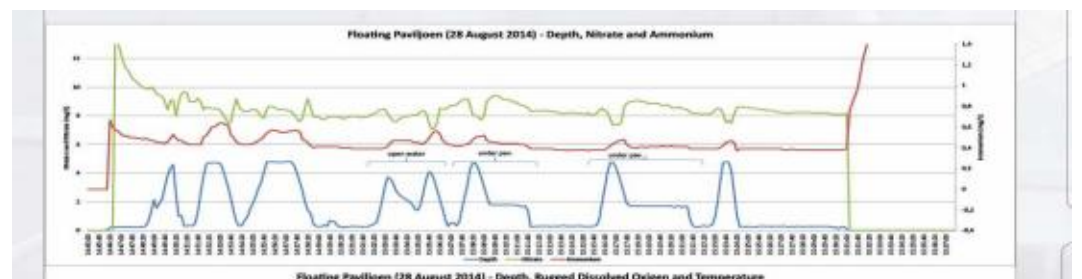


Not much literature available about this subject. Some monitoring but:

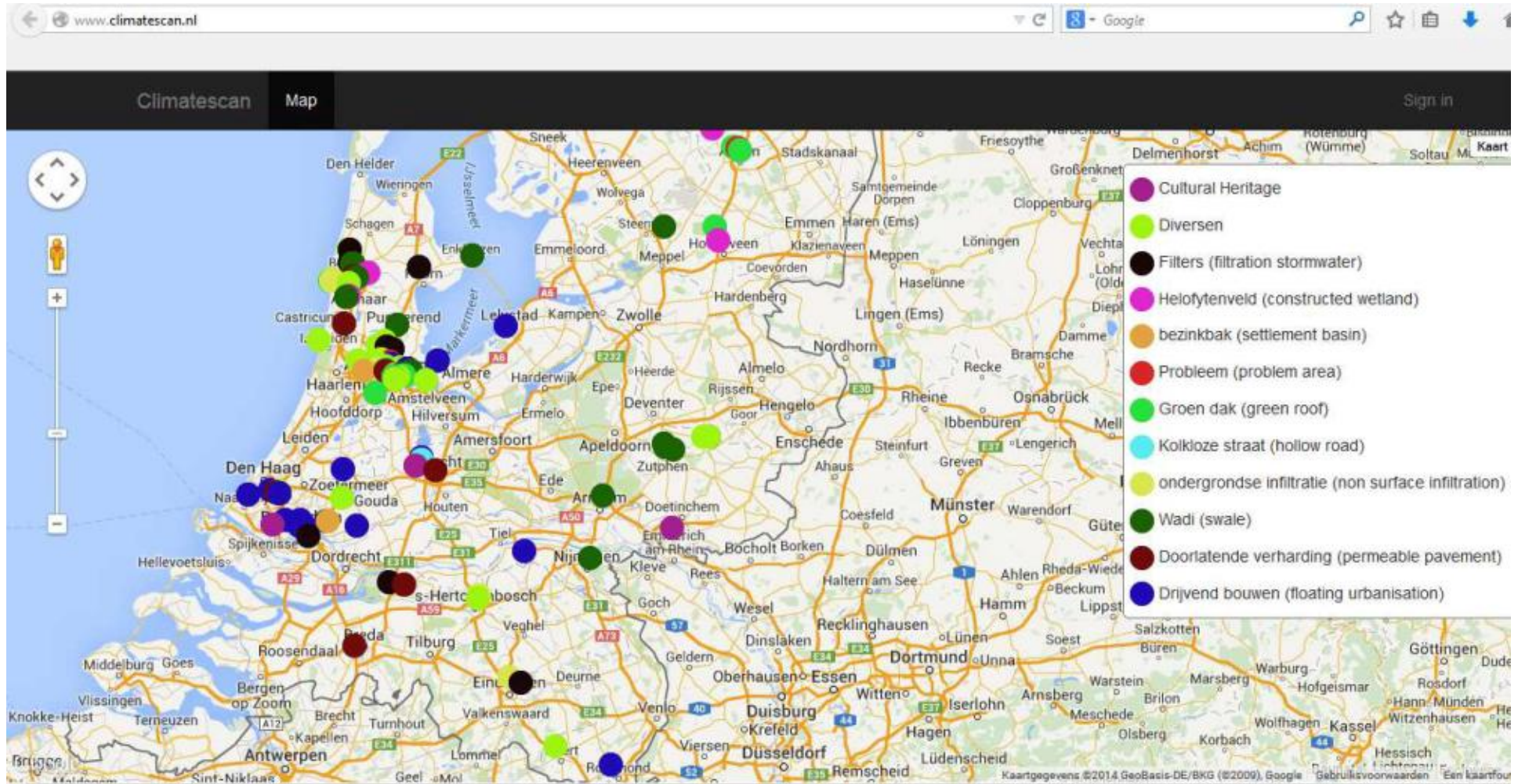
- Research methods ineffective (grab samples)
- Water under the structures never included

Attached Equipment:

- (1) In-situ TROLL 9500 Sensors:
Nitrate and Ammonium ISE
Rugged Dissolved Oxygen
- (2) CTD Diver :
Temperature
Pressure
Conductivity
- (3) Diving light
- (4) HD Video Camera (GoPro 3+)



Water quality research | Results on www.climatescan.nl



Water quality research | Monitoring



indymo



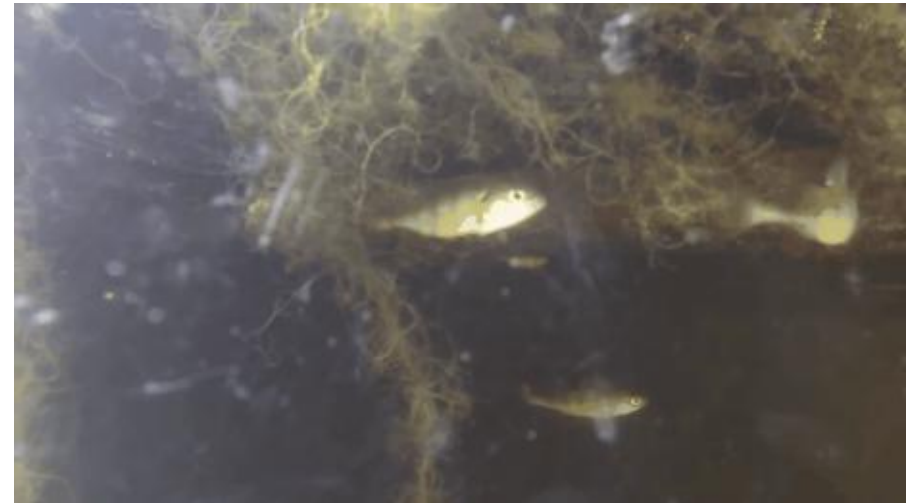
RDM
CENTRE
OF EXPERTISE

Water quality research | Effects on the ecology

Visuals – Life under floating platforms

Insight into the aquatic environment.

The type of fish and aquatic organisms present and bio-diversity, are indicators of the ecological state of water bodies.



Water quality research | Application of underwater drones

Added value of using drones:

- Fast and versatile monitoring tool
- Allow to reach places of difficult access, usually expensive/difficult with other methods
- Provides multi-dimensional data (4D) Rare characteristic of monitoring techniques
- Allows mapping of parameters (spatial distribution and variation in depth)
- Still some challenges to overcome (underwater navigation, underwater data transfer, limited battery life)



Water quality research | Harnaspolder

- Conclusions from modelling (Eftimia) and measurements (Rui)

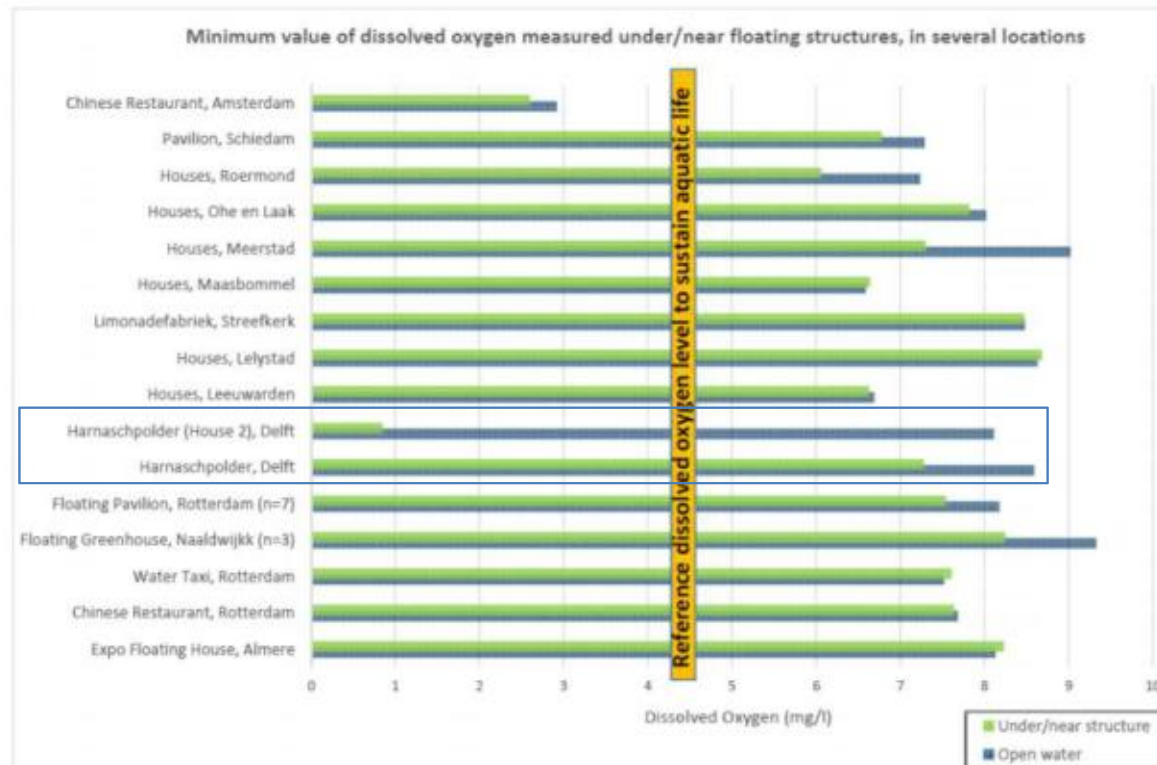
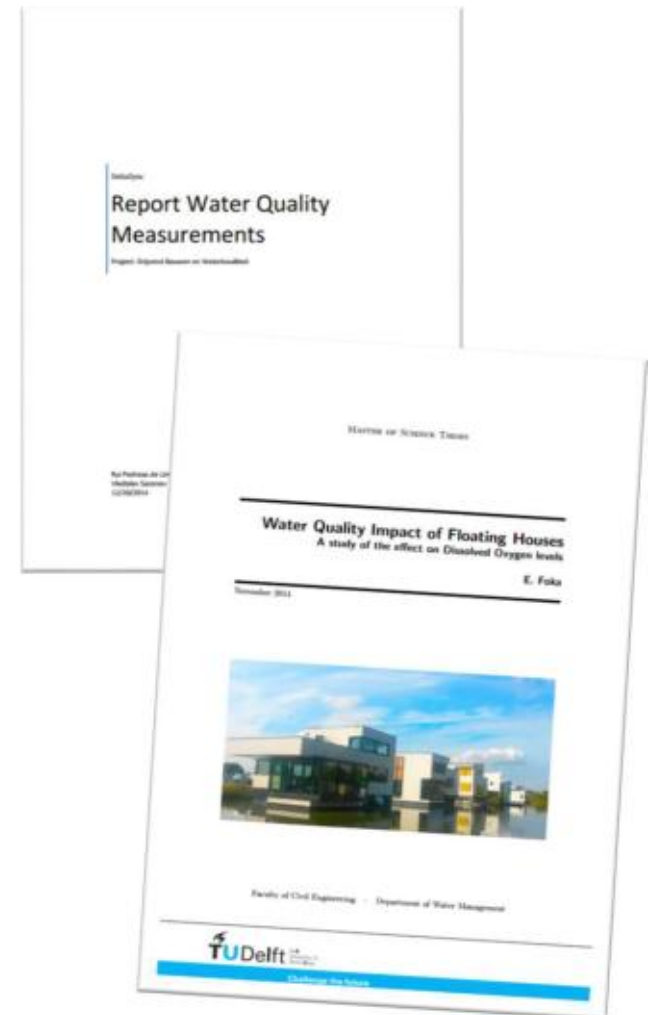


Figure 17. Minimum value of measured dissolved oxygen in several locations.



Harnaspolder, Delft | Building process



Source: DeltaSync 2013

Harnaspolder, Delft | Built homes



Source: Olaf Janssen

Water plot price

Project	Location	Price/m ²	Surface (m ²)	Water plot price
Blauwe Hart	Leeuwarden	€ 192	522	100.000
Terwijde	Utrecht	€ 549	91	50.000
Harnaschpolder	Delft	€ 535	257-292	137 - 156.000
Waterbuurt	Amsterdam	€ 980	132	129.000
Stadswerven	Dordrecht	€ 780	174-196	143 - 152.000



Source: Balance d'eau

Success factors | Houses in the Harnashpolder

- Innovative people within the Municipality
- Commitment of citizens
- Communication and stakeholder involvement

Recommendation:

- Importance of including floating development experts from beginning to the end of the project



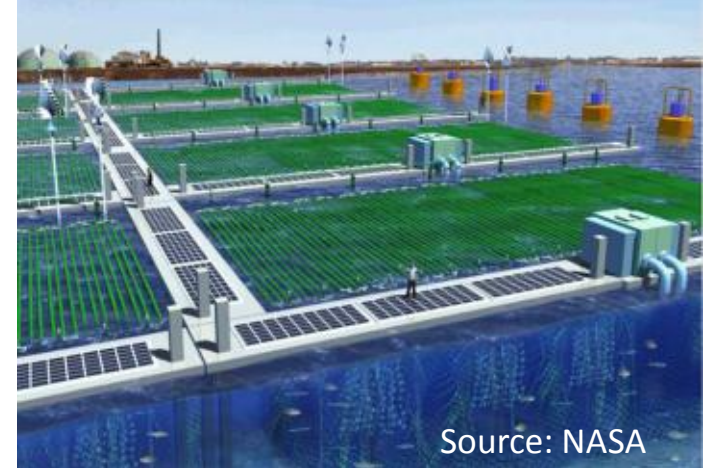
Opportunities | More than just floating “houses”



Source: DeltaSync, 2008



Source: Aquaponics.blog



Source: NASA



Source: DeltaSync



Source: wastewateralternatives.com




Source: Marinetek

Challenges| Floating development

- Not complying with the NTA
- Integration floating buildings in the zoning plan
- Uncertainties about management and maintenance of water basin
- Lack of knowledge by residents, architects and construction companies
- Uncertainty about legal status movable/unmoveable property
- Permit by the water board (water quality issues)
- Financing and cooperation of banks
- Connection to utilities by utility companies (not big bottleneck anymore)
- Fire safety concerns

Conclusions and recommendations

- **Floating development**
 - climate change adaptation AND mitigation strategy
 - infinite potentials for various functions
 - helps to preserve valuable land for other purposes (e.g. food and energy production)
 - modularity allows the development to “grow”
 - high density is possible
- **Understand local context**, including environmental conditions (waves, tide, ecology, etc.)
- **Involve relevant stakeholders** from the beginning to the end
- **Have sufficient knowledge** about floating development (e.g. engineering) in the development to avoid failures
- Much research is still needed, as well as fast implementation (start with **pilot projects**!)



**Thank you for your
attention!**

... questions?

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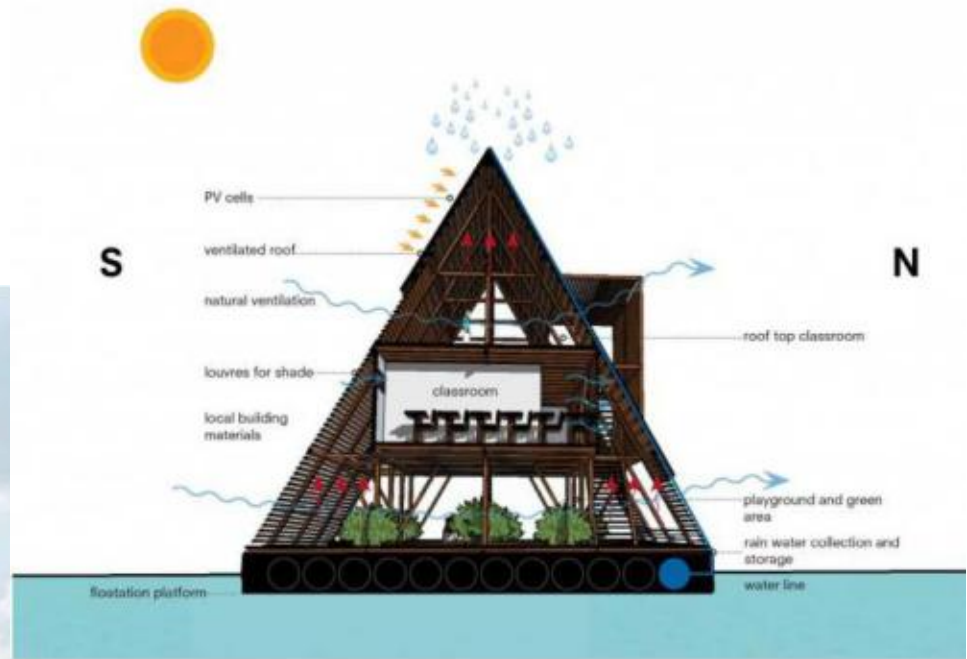
www.indymo.nl

Opportunities | Affordable floating buildings



Source: DeltaSync, 2015

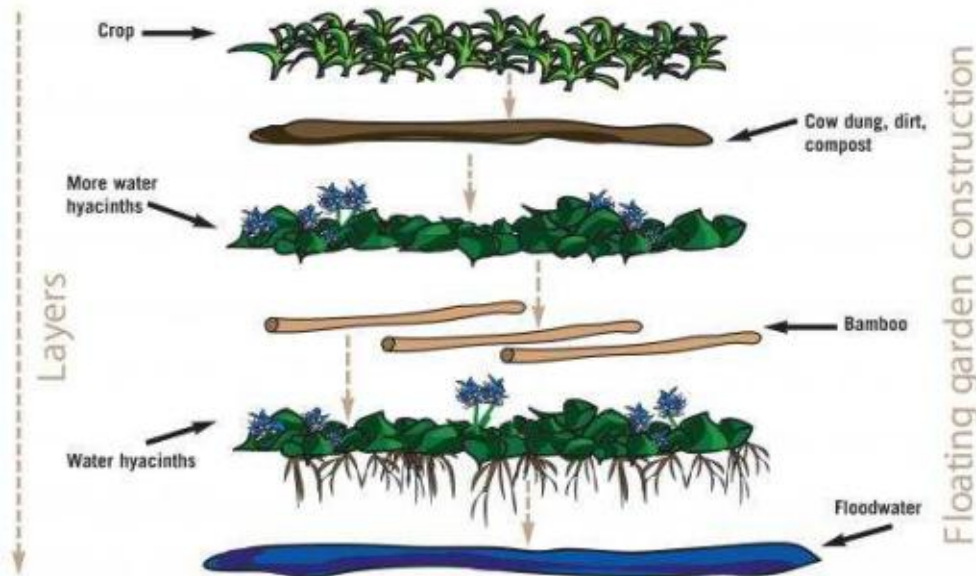
Opportunities | Affordable floating buildings



Source: NLE'

Floating farm, Bangladesh

- **Practical Action** developed a technology to allow farmers to grow food on flooded land in Bangladesh



Source:
<https://practicalaction.org/floating-gardens>
<https://www.youtube.com/watch?v=oz8SniS9p-I>

Floating toilet, Cambodia

- The HandyPod

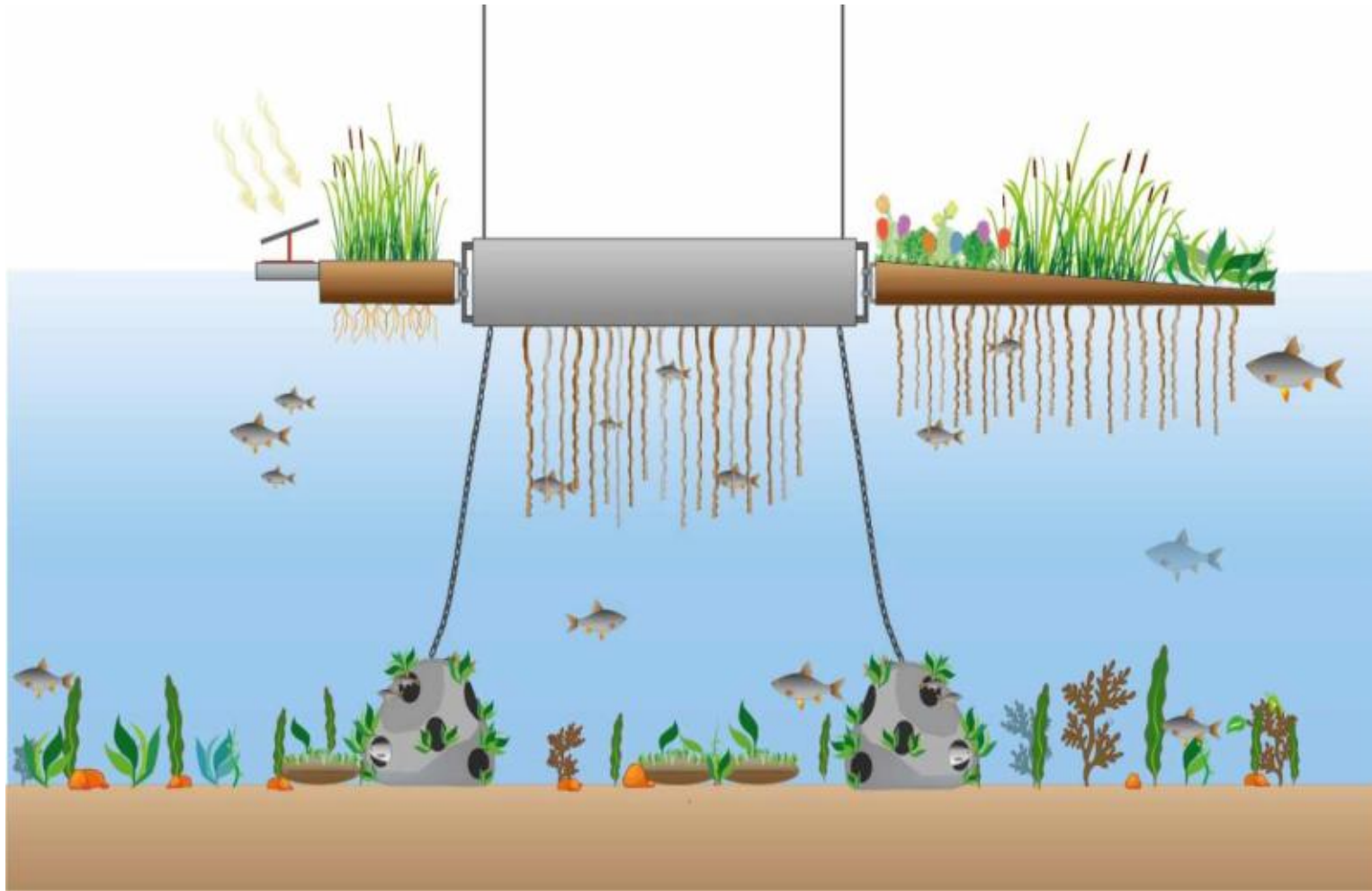


Source:

<http://www.wateraid.org/news/news/sanitation-for-floating-communities-in-cambodia>

<http://www.wateraid.org/news/blogs/2017/march/the-handypod-chronicles-cambodias-floating-toilets-two-years-on>

Opportunities | Ecosystem oriented design



Positive impact in aquatic life: opportunity for the implementation of eco-measures together with floating projects to ensure/maximize/enhance ecosystem services

Floating solar array, Japan

- **Advantages:**
 - Conserve valuable land & water
 - Higher electrical conversion efficiency
 - Prevent water loss from evaporation
 - Limit algae growth and potentially improve water quality



Source:
<https://cleantechnica.com/2015/10/28/construction-begins-europes-largest-floating-solar-plant/>

Blue21's database to be launched...



Floating Development Database: A collection of global floating projects

Categories Phase



Sebit Dungdungseom

"3 Floating Lantern Islands, or Seoul Floating Islands, are part of a large scheme on revitalizing the water landscape. They are also part of the Han ..."

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X-float

"X-float features a collection of lightweight and eco-friendly floating holiday homes that were built as part of the 'X2 River Kwai Resort' in the are ..."

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OFF Paris Seine

"OFF is the first floating hotel and bar in Paris. At size of 80 m by length and 20 m by width, OFF is currently the largest floating vessel moored on ..."

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BioHaven Floating Islands

"BioHaven Floating Islands are made from recycled polyester drink bottles that are bonded together with marine-grade foam as a floating mat. Biofilter ..."

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Aqua Biofilter project in Lake Taihu

"Lake Taihu is China's third largest aquaculture lake. It suffers severe algal blooms in particularly summer time. However, a technology that helps to ..."

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Floating Garden

"The Floating Garden project was firstly designed and constructed by Dutch visiting experts, Bart van Bueren and Willem van Doorn, with the help of st ..."

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Floating Classrooms

"A trio of floating classrooms, or islands, is expected to function as a community centre and provides outdoor 'aqua learning' and water sports traini ..."

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A Fleet of Floating Schools

"Locally known as 'Noukay School,' the first floating school was introduced in Singra upazilla of Natore in 2002. Floating schools have been provided t ..."

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Makoko Floating School

"Makoko school was built as a prototype for flood-resilient buoyant building for African regions with little or no permanent infrastructure. It was al ..."

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SAFE+

"SAFE+ survival pod is designed for those await rescue while floating on water in the event of a tsunami. It comes in two models with capacity for 10 ..."

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Floating Post Office

"As the first and the only floating post office in India, such post office is naturally a tourist hot-spot. More than just a floating post office, it ..."

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Hydroelectric Waterfall Prison Power Station

"Located in the Pacific Ocean near the Canadian coastline, the floating prison is expected to sit atop a floating tension-leg platform that is tethered ..."

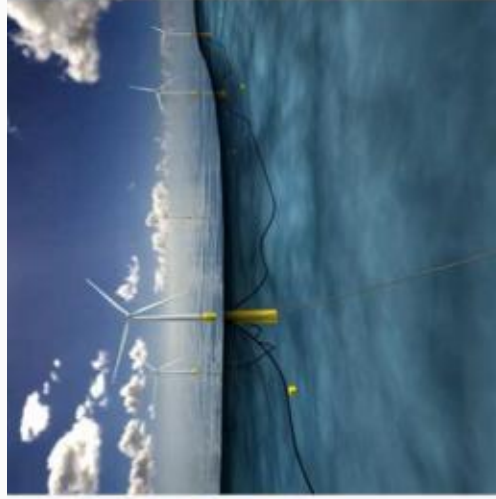
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Floating Solar Power Plant

"Kyocera's fourth floating solar project is currently still being built on Japan's Yamakura Dam reservoir. This solar plant will generate 13.7 MW with ..."

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Hywind Scotland Pilot Park

"The pilot park is expected to locate at 25-30 km off the coast of the town of Peterhead in Aberdeenshire. The project aims to showcase cost-efficient ..."

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Floating Brewery

"The German cruise ship, AIDAblu, is equipped with a complete brewery. A variety of specialties are brewed, including AIDA-Zwickel and Eisbock. The b ..."

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