GREEN QUAYS

Generic model of the implementation of the climate-responsive strategy

Introduction

In Breda, the river Mark is being restored to be once again navigable, which provides the opportunity to create an ecological blue and green connection at the edge of the city centre. The UIA GreenQuays project focuses on the 500-meters-long stretch of the river Mark situated between the high-density commercial core of the city centre and the mid-density adjacent residential areas. The design scheme this area was developed by the design team of the municipality of Breda with the goal of refurbishing this stretch of the river while bolstering climate adaptation, urban ecosystems and recreation. The cornerstone of the project is the re-naturing of the site through the planting of trees, shrubs, flowers, (quay wall) plants and mosses – a lush green urban landscape of varied flora and fauna as shown in the image on the bottom right page.

Regarding climate adaptation, heat stress is the focus because the intervention site presents few conditions for people to remain outside during summer or during heat waves. This is the result of the combination of full exposure to sun in the midday, predominantly hard-paved surfaces, near absence of vegetation and trees planted in places that do not provide shade where it is most needed (where people walk and stay). Wageningen University developed a climate-responsive design strategy addressing these problems. This strategy included a number of spatial design measures with potential to lead to cooling effects. These measures were translated into spatial interventions in the final design schema and, thus, incorporated in the implementation of the GreenQuays large-scale pilot (the first stage of buliding the design scheme).

This is the generic model of the climate-responsive design strategy developed for GreenQuays. Generic because we want to share the spatial design solutions included in this strategy in a way that is useful to similar nature-inclusive projects in other cities. This brochure also shows the dilemmas, the considerations and the choices that were made for the implementation of the GreenQuays project in what concerns to its climate-responsive component.

Climate adaptation in GreenQuays focused heat stress because the intervention site (the project's large-scale pilot area, indicated with a red circle in the image on the left) presents few conditions for people to remain outside during summer or during heat waves.

The design scheme includes also the improvement of urban ecosystems and recreation, with the re-naturing of the site being the cornerstone of the project.

The development of the GreenQuays climate-responsive strategy

Developing the GreenQuays climate-responsive strategy comprised three main phases: gathering relevant knowledge through the review of scientific literature on climate-responsive design and small urban water bodies; creating spatial design measures, that is, the climate-responsive strategy itself and testing their cooling effects with a simulation software; and implementing the strategy onto the GreenQuays large-scale pilot site.

Phase 1. Gathering knowledge

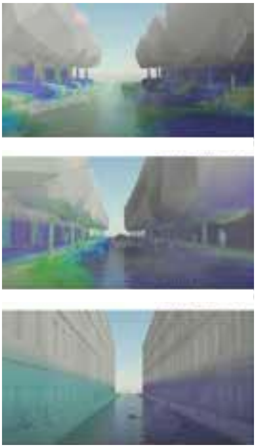
Addressing the climate adaptation challenges in the large-scale pilot site called, firstly, for gathering the most up-to-date knowledge on climate-responsive design and, in particular, about the role of small urban water bodies, such as the river Mark, in providing cooling effects. Climate-responsive design combines spatial elements in a way that provides protection from negative and exposure to positive aspects of climate during summer and winter. The focus is often countering urban heat build-up during summer periods, which is motivated by the severe impacts this phenomenon has on health and wellbeing, damages to infrastructure and the liveability of outdoor urban public spaces. Cooling down urban areas with climate-responsive design usually involves implementing vegetation and shading devices, resurfacing with 'cooler' materials and introducing water features.

In urban river restoration projects such as GreenQuays it is essential to acknowledge that although water is frequently assumed to deliver cooling effects, this might not always necessarily be the case. Research indicates that small urban water bodies lead to negligible cooling effects during the day and to insignificant warming effects during the night. Yet, there is also evidence of cooling effects, particularly when combining the water body itself with:

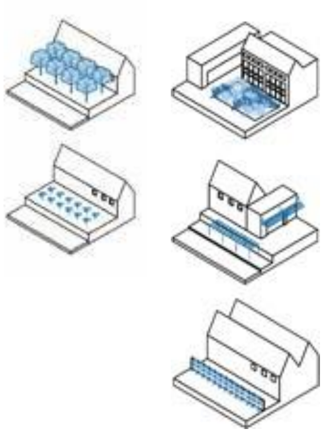
shade and evapotranspiration with trees near the water
natural ventilation (not blocking wind flow)
water evaporation features close to places where people stay
physical access to the water body

This idea can be traced back to the 'cooling urban water environments' concept proposed in the REALCOOL research. Since GreenQuays deals with the retrofitting of a small urban water body, this concept was taken as the cornerstone for developing the GreenQuays climate-responsive design strategy.

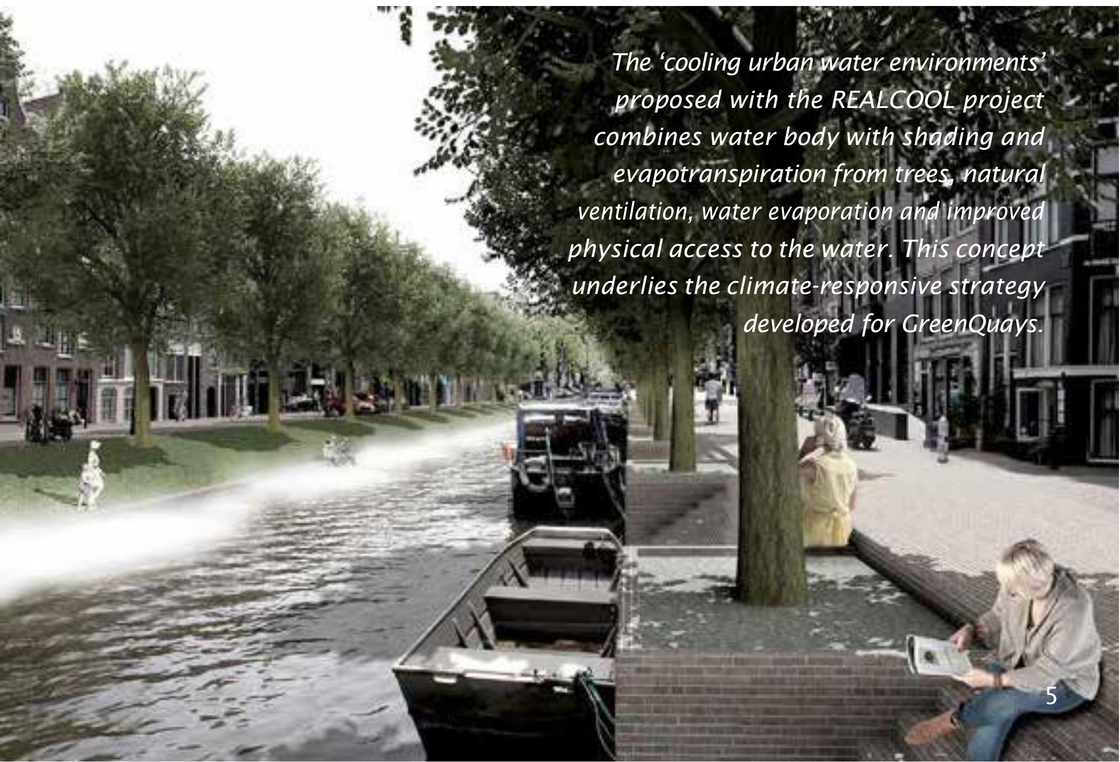
phase 1.
Gathering knowledge
research



phase 2.
Creating spatial design
measures
design



phase 3.
Implementation
real-life application



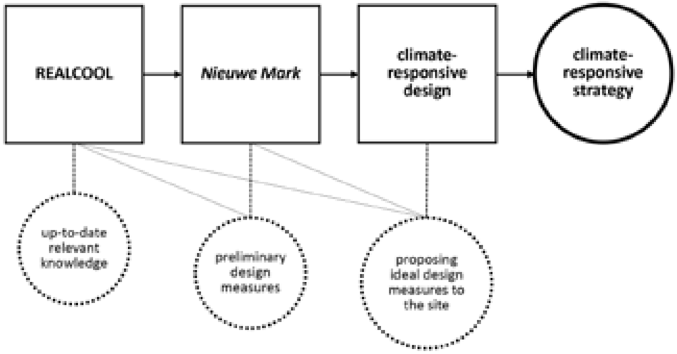
The 'cooling urban water environments' proposed with the REALCOOL project combines water body with shading and evapotranspiration from trees, natural ventilation, water evaporation and improved physical access to the water. This concept underlies the climate-responsive strategy developed for GreenQuays.

Phase 2. Creating spatial design measures | The strategy

The GreenQuays climate-responsive design strategy was developed by Wageningen University, in conjunction with the municipality of Breda. The objective of this strategy was to propose spatial design measures for addressing the urban heat issues of the large-sclae pilot site. Creating this strategy comprised three components (shown in the diagram on the top right):

- applying the REALCOOL knowledge on the cooling effects of small urban water bodies
- applying the outcomes of the Nieuwe Mark project (a research preceeding GreenQuays that provided preliminary climate-responsive design measures)
- a climate-responsive design for the site developed parallel to the design scheme by the municipality's design team, which comprised introducing deciduous trees along the river in an (interspersed) positioning not blocking wind, de-paving and/or replacing pavement by grasses at specific spots and introducing water misting at places where people stop and stay.

The climate-responsive design was particularly important as it embodied and translated spatially the knowledge from the other two components, and because it fed the climate-responsive design strategy with overarching design measures.



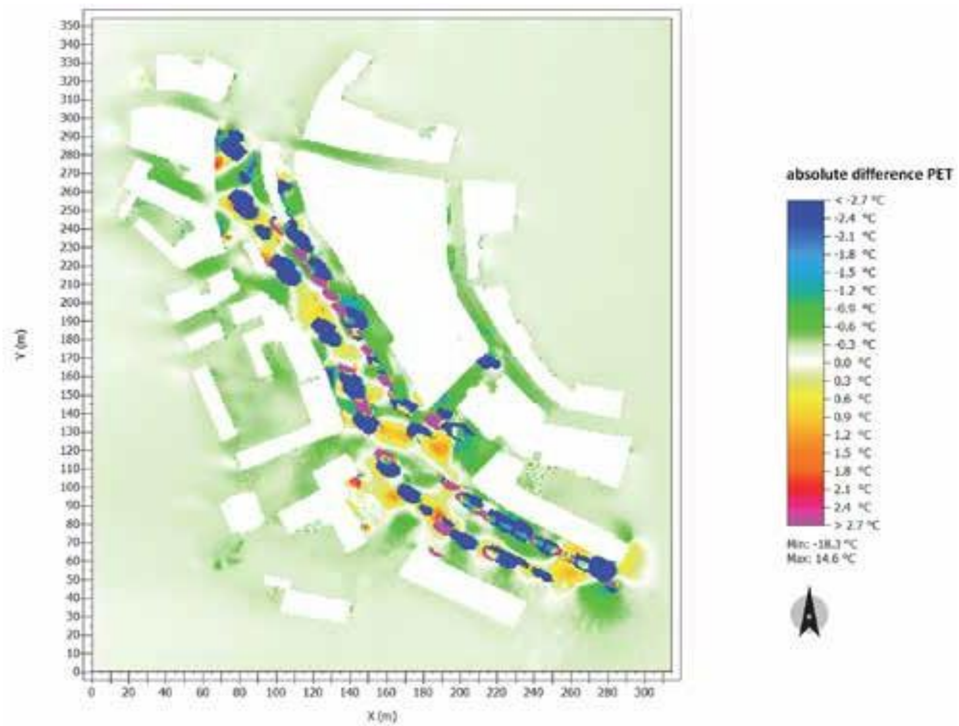
The three components of the GreenQuays climate-responsive strategy (the dotted circles indicate the objective of each component).

The climate-responsive design was of particular importance as its spatial design measures fed the climate-responsive strategy.

The measures brought from the design to the climate-responsive strategy were selected based on the Physiological Equivalent Temperature (PET) (broadly put, this means perceived temperature) reductions observed after testing them with ENVI-met (a popular software in this type of studies). The simulations were made for the 1st of July 2015: a hot day with a maximum air temperature of 34.9 °C, a gentle breeze (east direction as it is the prevailing direction during heat waves in Western Europe), mostly cloudless and with a relative humidity of 31%. The simulations were run between 11a.m. and 4p.m. CET, which is a heat-peak period and simultaneously when many people can be found outdoors.

The simulations broadly showed that the measures comprised in the climate-responsive design led to: more spots throughout the large-scale pilot site with relatively lower PET (mostly below 31°C) within a somewhat continuous previously sunlit area (largely because of the reduced air temperatures enabled by a larger area shaded with trees); slightly higher PET values, yet not problematic, in sunlit spots leeward of trees due to decreased wind speed values at these spots (because more trees mean more barriers to wind); and to relatively small cooling effects from water evaporation (as these are spatially limited).

Nine design measures were eventually brought from the design to the climate-responsive strategy **(see image on page 11)**. Each measure comprised a number of possible spatial design interventions. Measures and interventions were grouped per climate-adaptive phenomenon comprised in the 'cooling urban water environments' concept: shading/ventilation, water vaporization and long-wave radiation/water infiltration. The result was a 'toolbox' (image on the right, where "M" stands for measure), where measures were ranked according to their potential cooling effects with a colour code, with darker green indicating the most potential.



PET difference map (by reference to the pre-existing situation, that is, before the implementation of the large-scale pilot) made with ENVI-met for 11a.m. CET on the 1st of July 2015. The coolest spots are depicted in dark blue and other lower PET spots are depicted in tints of green.

Phase 3. Implementation

The climate-responsive strategy was incorporated into the design schema developed by the municipality and implemented in the large-scale pilot site. This strategy was not meant to be deterministic but informative to the design team. As a result, eventually some measures were deemed not applicable due to underground infrastructure and mobility. However, many final design inerventions did incorporate several measures:

Shading / ventilation:

- plants were added along the quays
- trees were added into the quay walls
- trees were added in the stairs to the water by the Franciscanessenplein
- openings were made in the planting scheme to improve wind flow
- more tree crown shapes were added in the planting scheme

Water vaporization:

- water vaporization nozzles were applied in the quay walls along the lower quays (where sun exposure was high and trees could not be planted)

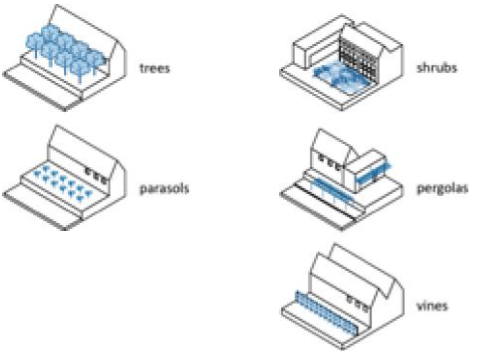
Long-wave radiation and water infiltration:

- some paved areas gave way to vegetated and more permeable surfaces

Accessibility to water:

- no measure was added since accessibility was already part of the design scheme

SHA!DING / V,ENTILATION •



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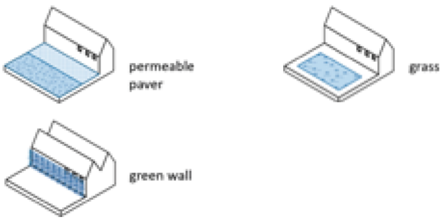

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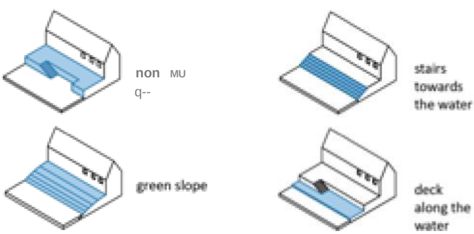

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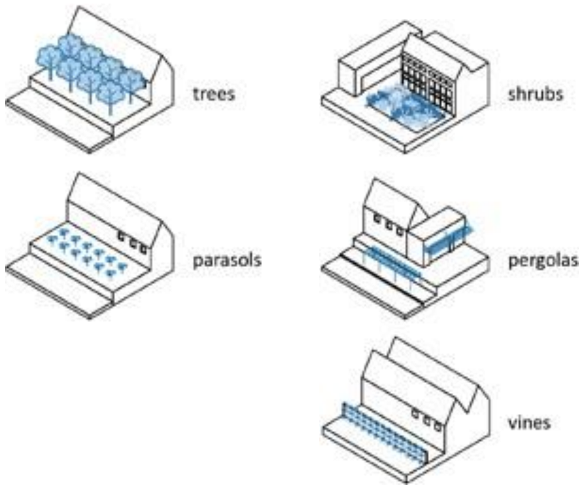
Dilemmas

The implementation of the interventions based on the climate-responsive strategy was faced with some dilemmas. It is in these dilemmas that we can find the most useful lessons to similar projects elsewhere. The dilemmas herewith presented were identified during a discussion between the climate-responsive design experts from Wageningen University and the municipality's team responsible for building the large-scale pilot. The following images synthesize the advantages of each intervention with regards to cooling effects, faced to the dilemmas found during implementation.

Shading / ventilation



Advantages

The planting of vegetation in urban areas is described as the most efficient of all spatial interventions in addressing heat stress. This is due to shade and evapotranspiration which, respectively, can block down to 50-70% sun and reduce air temperature between 2-5°C under the tree canopy. Next to this, there are psychological benefits and benefits for urban biodiversity.

Shading devices can be used as an alternative to vegetation when there is not space, budget or too much underground infrastructure. However, these are less preferable than vegetation because they only shade, so it might be that under the canopy it is not cooler.

Dilemmas

The compatibility between the positioning of plants where they are most needed and mobility needs. What is the best compromise?

Large differences between the groundwater level around the riverbed and the water level of the river itself. How to overcome these differences for ensuring the survival of plants?

How to create enough space for trees to grow to the size needed to provide cooling effects in a fully artificial structure?

The choice of the right tree species. What is the best compromise between climate adaptation, biodiversity and the provision of ecosystem services?

Water vaporization

M5 | add water fountains close to people and allow them to interact with the fountain's water, as the cooling effects of fountains tend to be low and spatially limited.

M6 | add water mists close to people, as their cooling effects tend to be low and spatially limited, **and place water mist nozzles preferentially above a standing adult's height** so that water can cool the whole body.

Advantages

Fountains can reduce air temperature by ≤5˚C in a radius ≤5m thanks to evaporative cooling. Depending on size and the dispersion of water particles, fountains need to be close to people for immediate cooling.

Water mists can reduce air temperature by ≤5˚C through evaporative cooling, but are also spatially and time limited.

Dilemmas

Unfamiliarity with the technical aspects of water misting devices. Is there extra time available for investigating these systems and conducting trial and error experiments?

The careful and meticulous orchestration between the system's components with underground infrastructure. Which technical solutions are less complex?

Impacts on public health. How to ensure that the system does not compromise public health (for example, legionella outbreak via contact with contaminated water)?

Long-wave radiation / water infiltration

permeable paver

grass

M7 | add permeable pavers and de-pave as much as possible as this enables long-wave radiation and water infiltration at the ground level.

M8 | apply green walls to the buildings' facades as to enable long-wave radiation.

green wall

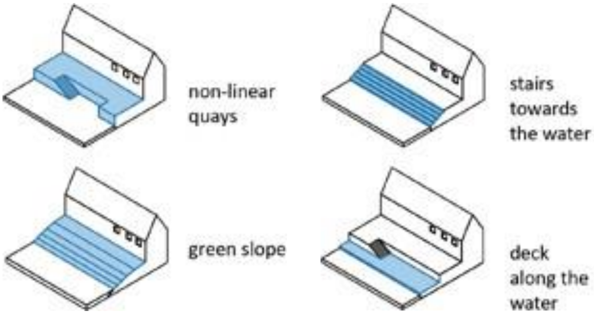
Advantages

Permeable ground surfaces can reduce surface temperature by ≤10°C thanks to evaporative cooling. They can also increase local water infiltration, which is important for the urban water cycle.

Dilemmas

The compatibility between soft-pavers and different public space usages, especially mobility. What is the best compromise between the microclimatic benefits of soft surfaces and the variety of functions outdoor public spaces need to fulfill?

Accessibility to water



M9 | remove physical and visual barriers between water and people as it can enhance physical (increased opportunities for staying outdoors and engaging in physical exercise) and mental health (the psychological benefits of seeing and being at green and blue spaces).

Advantages

Increased physical accessibility to water can enhance physical and mental health. Although this is not strictly climate-related, physical accessibility to water can enhance a feeling of wellbeing and coolness.

Dilemmas

Combining sojourn locations with the growth of plants. How to ensure, for example, that people can sit on the border of a quay with their feet in the water without being prevented from doing so due to plants?

Representatives of the Wageningen University and municipality of Breda teams during the discuss on the dilemmas of implementing the climate-responsive strategy in the large-scale pilot site.

GreenQuays lessons

This generic model presents an overview of the most important lessons learnt in GreenQuays with regards to the implementation of the climate-responsive strategy in the large-scale pilot site. This booklet makes these lessons available to other projects and cities dealing with climate resilience in urban river restoration projects. The goal is to assist spatial design professionals and decision-makers in undertaking climate resilience in urban rivers, particularly when it comes to reducing urban heat stress.

The table on the right presents all the lessons learnt for each design intervention based on the climate-responsive strategy and implemented in the GreenQuays large-scale pilot. We present these lessons as forseeable 'eases' and 'hurdles' while implementing a climate-responsive strategy in this type of projects. Based on the GreenQuays experiences, we divide these lessons into two main dimensions: spatial design and procedures. The former deals with lessons/aspects that can be designed and, thus, belong the fields of landscape architecture, urban design or urban planning. The latter is about lessons/aspects about more overarching considerations, such as multidisciplinary collaboration, teamwork or decision-making.

Implementation in GreenQuays was mostly faced with eases on procedural aspects, less on spatial design aspects. The reasons for this are varied, as shown in the table on the right. It is essential to acknowledge that the validity of the observations made in this table to another context should be made with care. For example, different building traditions, infrastructural aspects, different climates, soil types or groundwater circumstances, as well as different social, cultural and political contexts might bring nuances or even invalidate the insights herewith shared.

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Colophon:

This generic description of the implementation of the climate-responsive strategy was written based on our experience from the UIA GreenQuays project.

Pictures:

Municipality of Breda
REALCOOL project
Wageningen University
Man Du
ENVI-met

Texts:

João Cortesão (Wageningen University)
Sanda Lenzholzer (Wageningen University)

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GREENQUAYS.NL

Gemeente Breda

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