

## When water does not cool: A Different Use of Water in Urban Design

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*ABSTRACT: This paper explores the implications that recent evidence on the negligible cooling effects of water can have for urban design practice. It tackles the misconception of using small urban water bodies to cool down urban areas and addresses a different approach to employing water in climate-responsive urban design. The “Nieuwe Mark” project, Breda, The Netherlands, is presented as to illustrate and develop these ideas. The results of an online questionnaire sent out to the design team of Nieuwe Mark show an unanimous acceptance about the misconception of using water as a coolant and indicate a change of mindset for future water-related projects. The article discusses the results obtained and concludes about the long-term implications that such change of mindset can have to the employment of water in urban design. The main outcome is that when water is not necessarily a coolant, urban design practice has the opportunity to rethink its approach to small urban water bodies by embracing holistic design approaches combining water body, shade, wind and water vaporisation.*

*KEYWORDS: urban water bodies, climate-responsive, design tools, Research Through Design, transdisciplinary*

### 1. INTRODUCTION

Water bodies and water features are particularly popular and appealing design elements [1]. Aesthetical and recreational considerations are frequently considered during its employment in urban design. Water is also often employed as a coolant, based on the assertion that it necessarily leads to cooling effects. However, new knowledge on the cooling effects of water has been challenging the way landscape professionals commonly use it in their designs.

Excluding the cooling effects of the sea [2,3], water seems not to have a significant cooling effect. Previous research indicates that large urban water bodies, such as rivers or lakes, have quite limited daytime cooling effects and might originate night-time warming [4-6]. Research on the cooling effects of small urban water bodies, like ponds or canals, indicates that the cooling effects of water are negligible [7,8]. These studies basically point out that the cooling effects of water should not be taken for granted.

But when water is not necessarily a coolant, what does that imply for urban design practice? To answer this question, this paper presents the “Nieuwe Mark” project as an illustration of what to do when water is not a coolant, and to explore what long-term implications this can have to the employment of water in urban design.

The *Nieuwe Mark* project (Fig. 1) redesigned and daylighted the river Mark, in Breda, The Netherlands. The goal was to create added value to the area on

different parameters, amongst which cooling microclimates along the water body. To assist the municipal design team with achieving this goal, the municipality of Breda assigned Wageningen University (WU) to develop evidence-based design tools tailored to the area.

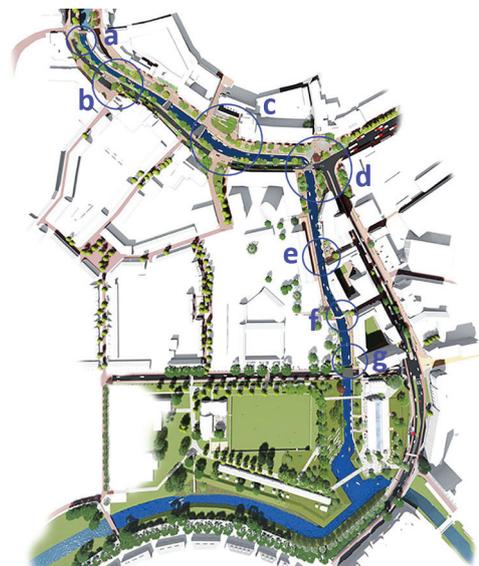


Figure 1: The Provisional Design of the Nieuwe Mark (the blue circles indicate the seven areas focused in the research). Source: Breda municipality.

The tools were to be applied into the project's provisional design (PD). For the sake of efficiency, these

tools were developed for seven areas within the PD (Fig. 1) that represented typical spatial layouts of the project. These areas were defined upfront by the design and research teams together, based on two criteria: need for climate-responsive measures and replicability within the PD.

The tools developed by WU were meant to communicate generic climate-responsive design measures. These measures dealt with adding or revising design elements in designated areas of the PD (see Methodology) and were indicated over 3D perspectives of those areas (Fig. 2). A colour code ranked the effectiveness of each measure in order to help prioritising design decisions, if necessary. Dark blue conveyed the highest potential for microclimatic improvement. The expected summer effects were indicated for all measures. Winter effects were not indicated when no significant effect was likely to result from a design measure.

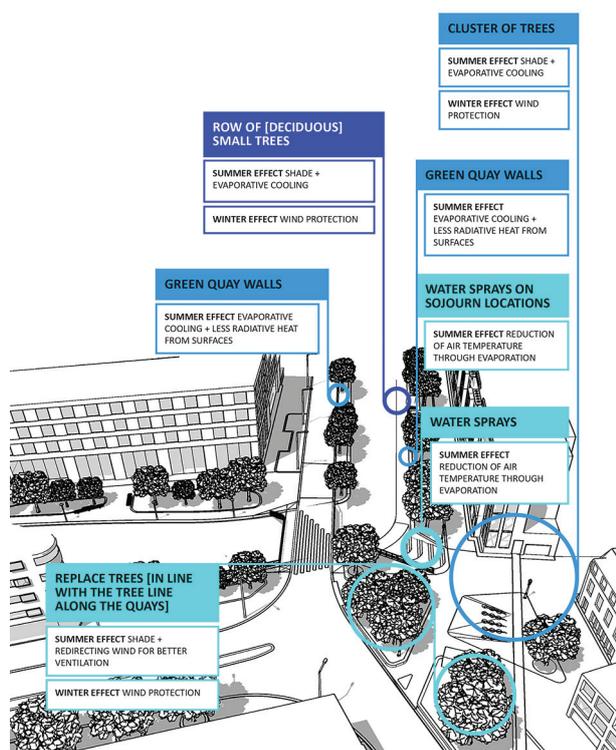


Figure 2: Example of a climate-responsive design tool for the Provisional Design of the Nieuwe Mark project.

Eventually, the *Nieuwe Mark* project was an interplay between design research and practice around up-to-date knowledge on the cooling effects of small urban water bodies. It provided a real-life 'lab' to new knowledge on the cooling effects of water, shedding light upon the misconception of using water as a coolant and, on that basis, upon a different approach to designing urban water bodies. This paper addresses the

likely long-term implications this had for the design activities of the *Nieuwe Mark's* design team. The article concludes by expanding this subject beyond the *Nieuwe Mark* project.

## 2. METHODOLOGY

### 2.1 Overview on the *Nieuwe Mark*

The project was developed within a consortium bridging research and practice. On the research side, the WU team gathered experts on climate-responsive urban design and meteorology. Design practice was represented by the landscape design team of Breda municipality. The project's consortium also gathered experts on urban ecosystems, project management, heritage, and representatives of local associations of residents and businesses.

The design tools were developed with Research Through Design (RTD) [9] along three iterations comprising the production of potential design solutions and their testing (Fig. 3). The first iteration looked into achieving ideal microclimate effects. Operability aspects were excluded in order to apply evidence-based design knowledge on the topic as integrally as possible. The second iteration focused on finding a realistic match between the microclimate effects developed in iteration 1 and operability parameters such as maintenance requirements, traffic circulation or underground infrastructures. The third iteration refined this compromise as to achieve applicable design tools.

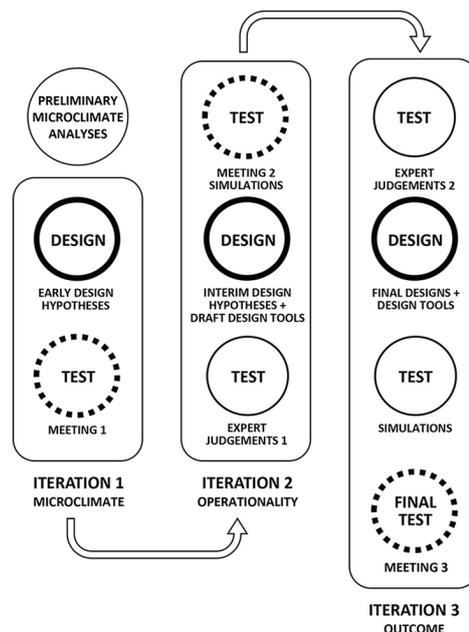


Figure 3: The Research Through Design process of the *Nieuwe Mark* project.

The research started with preliminary microclimate analyses. These preceded the RTD as to adequately inform the designing activities about the measures to be implemented. The analyses dealt with sun and wind, the variables mostly influencing the microclimate of small urban water bodies, and were made with consideration to a typical heatwave day in the Netherlands. The chosen date was July 01, thus, near the annual maximum of solar elevation. The sun/shadow analyses were made with the Sketchup model. As the model indicated 1 p.m. to present the highest exposure to sun, this was the period that the design measures referred to regarding excessive solar radiation. The meteorology and climate-responsive urban design experts from WU discussed the analyses. The results of these discussions were synthesised graphically in 3D perspectives produced with the Sketchup model (Fig. 4).

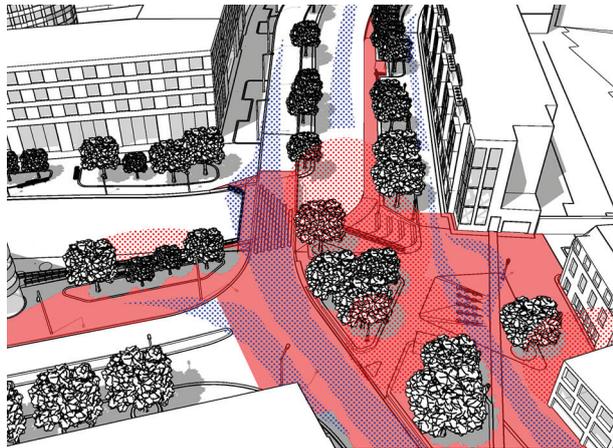


Figure 4: Preliminary microclimate analysis for area D, within the Provisional Design of the Nieuwe Mark project.

Within the RTD, the different potential design solutions dealt with increasing shade with trees along the quays and on their walls; allowing air to flow as unobstructed as possible; introducing water mist in sojourn locations; and depaving areas without heavy motorised traffic. These design measures were retrieved from the design prototypes for cool urban water environments developed in the “Really cooling water bodies in cities” (REALCOOL) research project [7], [10]. In REALCOOL, the combination of these design measures reduced the Physiological Equivalent Temperature (PET) around water by as much as 9°C [10].

The potential design solutions were subsequently evaluated through two expert judgements sessions, micrometeorological simulations with the Envi-met model, and during three meetings with the project’s consortium. In more detail:

- The expert judgements dealt with educated-guesses, within the research team, on the main micrometeorological issues behind the potential design solutions. This allowed evaluating the cooling potential of each potential design solution before plotting it into Envi-met.
- The simulations with Envi-met described and quantified the micrometeorological processes of the PD and of the design solutions with highest potential for cooling effects. This potential was assessed by comparing the design solutions with the PD (reference situation). Figure 5 shows an example of these simulations, made for one of the areas within the PD of the *Nieuwe Mark* project. In line with the results of REALCOOL, all simulations showed negligible reductions in air temperature from water itself, but that the design measures applied in *Nieuwe Mark* – the combination of shading with trees, natural ventilation and water vaporisation – led to PET reductions by as much as 14°C. No field measurement was conducted due to the time available for the study. The follow-up project GreenQuays, co-funded by the European Regional Development Fund through the Urban Innovative Actions Initiative, is conducting field measurements for validating new design solutions.
- The consortium meetings were used for discussing the potential design solutions and the results of the Envi-met simulations with the project’s stakeholders. These meetings provided insights on the operability issues raised by the potential design solutions, and on how well did these meet the stakeholders’ expectations and the goals of the project. Each meeting resulted in bringing down the three to four potential design solutions developed per area to one design solution per area.

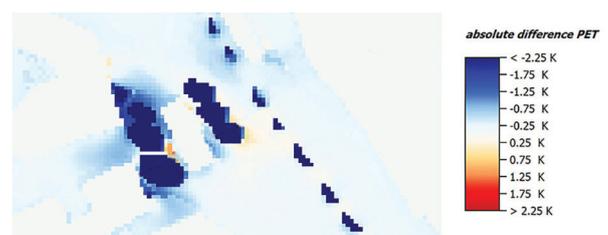


Figure 5: PET map obtained with the micrometeorological simulations with Envi-met for area B, within the Provisional Design of the Nieuwe Mark project.

The consortium meetings were of particular importance in addressing the question: when water is not necessarily a coolant, what does that imply for urban design practice?

The cooling effects of water was a recurrent topic of discussion during these meetings, fuelled by the results of the simulations with Envi-met. From the first meeting, light was shed upon the misconception of using water as a coolant based on evidence on its negligible cooling effects. Because the design measures applied in *Nieuwe Mark* led to significant PET reductions, these measures were presented and discussed as what to do when water is not a coolant.

The consortium meetings adopted an open and clear communication, where professional jargon was replaced by laymen terms. The aim was to actively engage the stakeholders, to keep their expectations real, and to building a base of trust and mutual understanding with the research team. The outcome were design tools based on (scientific) evidence around their expected cooling effects, endowed with the necessary (practical) conditions for real-life implementation.

## 2.2 Ex-post online questionnaire

Albeit their relevance, the consortium meetings did not look into the broader impacts that a new view on designing with water would have on long-term design activities beyond the *Nieuwe Mark* project. To address this issue and, thus, answer the research question explored in this paper, a short online questionnaire was sent via email to the design team after completion of the project.

The questionnaire, originally in Dutch, included two close-ended statements and one close-ended question:

1. *"The design tools fulfil your needs and expectations"*, in order to understand if the research had successfully answered its assignment and fitted properly the current and future goals of the project;
2. *"This project changed your perception about the cooling effects of water (namely that water does not necessarily cools its surroundings)"*, to confirm whether the misconception on the cooling effects of water had been accepted;
3. *"If your perception about the cooling effects of water is now different, which changes will it bring to your design activity beyond the Nieuwe Mark project?"*, in order to understand if the new knowledge provided with the research would have only short-term effects (i.e. *Nieuwe Mark*) or long-term effects (i.e. future projects) on design decisions.

Statements 1 and 2 were answered on a seven-point Likert scale, ranging from "strongly agree" to "strongly disagree". Question 3 was answered with multiple choice, namely: *"you will use urban water bodies the same way you have been using so far (e.g. for aesthetics or recreation)"*; *"you will start designing urban water bodies based on a combination of water, shade, wind and water features (e.g. sprays)"*; and *"you will no longer use urban water bodies"*. Question 3 also included an optional open-ended possibility for indicating missing aspects in the questionnaire. The questionnaire was built with the online tool Typeform.

## 3. RESULTS

Regarding the first statement, all respondents to the questionnaire indicated that the research fulfilled their needs and expectations, i.e. climate-responsive design measures applicable to the PD.

Relatively to the second statement, all respondents referred that the project changed their perception about the cooling effects of water.

For question 3, all respondents indicated that they will start designing urban water bodies in future projects based on a combination of water, shade, wind and water features.

## 4. DISCUSSION

Regarding the first statement, earlier positive feedback given by Dutch designers on the applicability of the REALCOOL prototypes can help interpreting the results obtained. Two aspects revealed by that feedback on REALCOOL can be called forth in interpreting the results obtained for the first statement: RTD process and communication options for the design tools.

First, the design tools are the outcome of a cumulative RTD process systematically steering the research towards evidence and applicability. The effects of each design measure on both cooling effects and applicability to practice were secured throughout the RTD. This is a procedural matter complying with the principle that, in design, phenomena are investigated through modelling, pattern-formation and synthesis, under the values of practicality and appropriateness [11]. Second, the design tools embody knowledge on how to perform tasks around the design of cooling urban water environments, expressed visually. This was to respond to visual thinking, an essential design activity [12]. Furthermore, as the challenges currently posed to urban areas prevent designers to collect, assimilate and process alone all information needed to solve design problems [13], visual tools and appraisal methods hold the potential to more effectively

communicate to practitioners than, for example, textual resources [14].

Together, the development of potential design solutions with a good understanding of each design measure, and the option to communicate them visually, allowed creating the aimed applicable evidence-based design tools. This can explain why all respondents indicated that the design tools fulfilled their needs and expectations.

The feedback given on the second statement suggests that the misconception on the cooling effects of water was realised and accepted. This result can be explained with three activities carried out during the consortium meetings: informing the design team about the misconception of using water as a coolant; informing the design team about the creation of cooling urban water environments; developing the design measures for the PD through a close cooperation between WU and the design team.

The consortium meetings constituted moments of transdisciplinary cooperation where experts, designers and the project commissioner were engaged in steering the project towards its goal. Questioning the conception of water as a coolant and informing about a different approach to designing urban water bodies took place smoothly. Progressively, this new knowledge sunk into the design team. Building trust and mutual understanding was the key, which can be understood in light of the benefits of participatory process reflecting the knowledge of experts and the wishes of a project commissioner [15].

The results obtained for question 3 further substantiate the feedback obtained on the second statement. These indicate long-term effects resulting from the new knowledge provided, i.e. a new mindset for the design of urban water bodies. Beyond the fact that all respondents stated that they will “*start designing urban water bodies based on a combination of water, shade, wind and water features*”, no respondent chose the option “*you will use urban water bodies the same way you have been using so far*”. Furthermore, the absence of votes on the option “*you will no longer use urban water bodies*”, suggests that water kept its attractiveness to designers.

The unanimity of responses to the questionnaire suggests that the *Nieuwe Mark* project was able of making the design team aware that water is not necessarily a coolant. More importantly, it informed about a different approach to designing urban water bodies. This approach was synthesised in evidence-based design tools expressing visually the application of shading, ventilation and water vaporisation measures around the river Mark.

## 5. CONCLUSION

The *Nieuwe Mark* project confirmed in real-life evidence from previous research on the cooling effects of water: water does not seem to significantly reduce air temperature in the air layer adjacent to the water surface. However, it is possible to create cooler urban water environments by zooming out from the water body itself. Significant PET reductions, therefore improved conditions for outdoor thermal comfort, may be achieved by combining water body, shading with trees, natural ventilation and water vaporisation. The results obtained are valid for typical heatwave days in the Netherlands. We would expect variations to the results obtained for other climatic regions, and between different properties of water (e.g. turbidity) and characteristics of the water body (e.g. flow rate or depth).

Based on this study, the likely long-term implications that such change of mindset can have to the employment of water in urban design are:

- Water bodies and features will keep being employed but the decision to do so will no longer be made under the assumption that water necessarily leads to cooling effects;
- The mindset of landscape professionals engaged in water-related urban design projects will be widened from the water body itself to the whole environment surrounding it, e.g. an urban canyon;
- The designing of these urban water environments will be holistic – it will synergistically combine water body, shade, natural ventilation, and water vaporisation in ways to be specified by each project;
- This holistic designing will count on more and better transdisciplinary practices, bringing urban design closer together to fields as varied as architecture, built heritage or hydraulic engineering;
- Aesthetical, recreational and symbolic considerations often made around the use of water are not excluded in this new mindset.

The underlying message of this article is: when water is not necessarily a coolant, urban design practice has the opportunity to rethink its approach to urban water bodies by embracing holistic design approaches combining water body, shade, wind and water vaporisation. When water does not cool down, urban water environments designed under this frame are likely to. The climate adaptation of urban areas can largely benefit from implementing these cooling urban water environments.

The different approach to designing urban water bodies has the potential to gain momentum in practice. The change can take place smooth and swiftly provided that: firstly, evidence on the negligible cooling effects of water is shown to practitioners; secondly, that practitioners are appropriately informed on what to do then, through evidence-based design principles for cooling urban water environments. Design research can play a vital role here by providing landscape professionals with the appropriate conceptual tools [16]. But perhaps more importantly, as illustrated with the *Nieuwe Mark* project, a close cooperation between researchers and practitioners in developing these tools can *per se* trigger such role as much as the tools themselves.

Research indicates that there is room for expanding the benefits of urban water bodies from common purposes to climate-resilience. The principles to be utilised by landscape professionals in their designs should be distilled from further systemic thinking with porous boundaries between academia and practice.

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