ENGAGING WITH WATER

AN APPROACH ON HOW A SPONGE BUILDING AND SURROUNDING AREA CAN COMBAT WATER PROBLEMS, WHILE USING WATER AS CONNECTING BRIDGE BETWEEN NATURE, HUMANS AND BUILDINGS TO ENHANCE OUR WELL-BEING AND SIMULTANEOUSLY USE IT AS AN EXAMPLE ON HOW TO BECOME MORE SUSTAINABLE FOR COMMUNITIES AND OTHER STAKEHOLDERS

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ABSTRACT

Accelerating climate changes are becoming more of a reality as we are dealing with water scarcity and water floods. This is a contradictory situation, asking for a closed water cycle, that can be reached through new design approaches integrating water sensitive interventions. Technical strategies for water sensitive designs are developed, but still need to be put into practice. However, first sustainable awareness needs to be reached among all stakeholders, since they hold the money capacity to invest. Biophilia and biomimicry are both visual pleasant design principles that help create understanding. These three topics could be combined using water as a connecting bridge, which led to the following research question: "How can the qualities and potentials of natural water cycles be embedded in our current city structure to connect water, nature, and buildings on different scales by translating research about biomimicry, biophilia and water sensitive design interventions into a design approach for an existing area?" It becomes clear that the transformation of an existing grey area suffering from floods is appreciated through the interaction with water that is created, because of the involvement of all stakeholders during the design process and motivating certification awards to create even better understanding and integrate their desires. By showing people the outcomes, it activates them to want to participate in realizing sustainable solutions, resulting in communities that exchange ideas and knowledge.

KEYWORDS: *High-water stress and water scarcity; water as communicational medium; symbolism of water; biophilic and biomimetic improving well-being; sustainable awareness and responsibility*

I. INTRODUCTION

1.1 The contradiction of water as our friend and enemy

In our current world we are experiencing accelerating climate changes. On a large scale, we are dealing with high-risk flood areas, due to the rising sea level and heavy rainfalls, causing unpredictable floods (Hunt & Watkiss, 2010). Heavy rainfall causes mud streams, provoking bursting riverbanks that wash away buildings, risking the safety of communities. These flooded areas in cities mostly contain a lot of grey infrastructure within their living environment, like concrete tiles. It results in more excess water that cannot be absorbed by the plants and ground, often referred to as green and blue infrastructure (Armour, Hargrave & Luebkeman, 2014; Cooper, 2019). Also, floods and erosion are caused, because the infiltration capacity is exceeded due to large volumes of rainfall. The soil becomes impermeable which leads to water scarcity, droughts, and lower river levels (Raes & Savolainen, 2021). Some cities are even experiencing a somewhat contradictory situation. London (United Kingdom) and Chennai (India) both combat with a shortage of potable water, while enough water is falling from the sky (Bloomberg News, 2021; Leahy, 2021). Also harbour cities are dealing with the rising sea level meanwhile facing a potable water shortage (Bin, Tain, Wang, Xu & Zhuang, 2023). Now, water gets a more negative character and is seen as an obstruction, rather than seeing it as an opportunity to collect and re-use the surplus water. Collecting the wastewater could then for example be used during times of drought to water agriculture (AghaKouchak et al., 2018). Thereby, expectations of our water consumption are to be increased by 40% by 2030 and therefore exceeds the available water supply. This all, because of our growing population and food consumption, the increased urbanization and climate change (Raes & Savolainen, 2021). Overall, it results in a growing need for water protection systems and closed water cycles.

Figure 1: Simultaneous challenges of water floods and water scarcity (image by author)

But, nowadays we are not using water to its full potential anymore. Whilst we are very aware of what is happening around us regarding the high-water risk, not enough action is taken to combat the current and future water problems. Most of the drainage systems are unprepared to withdraw the large volumes of extra rainwater. The sewer systems have been built over a hundred years ago and within ten to twenty years some of the sewage pipes might collapse as they are deteriorating. Unfortunately, the repair and maintenance of the sewage system is challenging and expensive (Raes & Savolainen, 2021).

Now, water gets two faces, since we need to protect our living environment from it, but we are also very dependent on it regarding our basic needs (figure 1). Collecting the water surplus could be a key to solving this problem to reduce floods, to use as cooling source in public spaces for instance or to filter to potable water. Only, in the existing largely paved city structures not enough space is available to retain large amounts of natural water and therefore ask for transformation (Raes & Savolainen, 2023). Moreover, the disconnection of water on humans is also sensible on a psychological level. In our current living environment, we have become used to living indoors, while this often leads to stress and depressions. Integrating water in designs can help solve the negative influence of living indoors as it has a positive effect on our health and can enhance our well-being and feeling of harmony (Parancola, S. (2019). Studies have shown that the sound of water has a relaxing effect on people and can help to relieve stress and better our performance (Calabrese & Kellert, 2015). On a larger scale, water can also be linked to our urban health (Angelakis, Koutsoyiannis, Tchobanoglous & Zarkadoulas, 2008; Arsénio et al., 2016). The close relation between water and humans can be related to biomimicry and biophilic design, which is becoming more relevant when designing buildings. Biophilic designing implements natural aspects into the building to bring occupants closer to nature again. Biomimicry on the other hand simulates natural systems that promotes sustainability (Calabrese & Kellert, 2015; Sageglass, 2016; Arpitha, 2023; Verma, 2023). But as designers might understand the effects of sustainability on our health and environment improvement, it might be difficult to understand for actors. Biomimicry and biophilia are both visible, pleasant translations of creative sustainable knowledge and solutions that can be used as mediums to communicate the importance of implementing collective water systems in our everyday life. Therefore, the following research question will be answered and supported with sub-questions:

"How can the qualities and potentials of natural water cycles be embedded in our current city structure to connect water, nature, and buildings on different scales by translating research about biomimicry, biophilia and water sensitive design interventions into a design approach for an existing area?"

It is remarkable that we are not aware of the full potential and qualities water has to offer regarding our mental and physical health. Raising awareness to the lack of sustainable responsibility and the forgotten effects of water on our health is a challenge for architects and designers as they must convince people of the positive effects of implementing water in designs. Therefore, the research is divided in smaller steps, trying to find ways how to integrate water in design on multiple scales. In chapter 2 the methodology and contextual approach will be discussed, followed by the result analysis in chapter 3, where the implementation of water in sensitive designs will be introduced, as well as an analysis of the health effects of natural elements in designs. The final chapter (4) will describe a conclusion with a proposal on how to design water resilience and implement water in our everyday life and built environment, closing with a discussion.

II. METHODOLOGY

2.1 Educating people: lack of sustainable awareness and social responsibility

Worldwide actions are taken by the government, engineers, and designers to make cities adaptable to climate change, specifically focused on water management. Only, among people there still is a lack of public knowledge and awareness of the necessity to become more sustainable regarding the water risks and health effects. Because if they are not directly threatened by floodings and water scarcity, why should they pay attention to it? Thereby, the consequences will mostly be carried by the elderly and low-income groups, which are the most vulnerable groups (IPCC, 2007). The challenge is to stimulate the political will of stakeholders, like investors and city planners to participate and finance the sustainable solutions, as they have the money capacity to invest. The institutional capacity is available, and studies about design strategies to solve water and health problems are already developed, but they still need to be put into practice (Dickinson, 2022, 28:04). The adaptation of climate change therefore brings social, economic, and governmental challenges to raise social responsibility (Douglas et al., 2011). Also, lack of knowledge forms a barrier when it comes to the engagement of the public with climate change. Letting people engage can create understanding of the climate policies and interventions taken by the government but can also help to bond society (figure 2). Besides, if a more sustainable and healthy living environment is the demand, then the potential solutions should be communicated in an easy-to-understand explanation for everyone (Buurman, Hoekstra & Van Ginkel, 2018). It can lead to a quicker adaptation to the changing climate (Dedekorkut-Howes, Howes, Khatibi & Torabi, 2021; Raes & Savolainen, 2021).

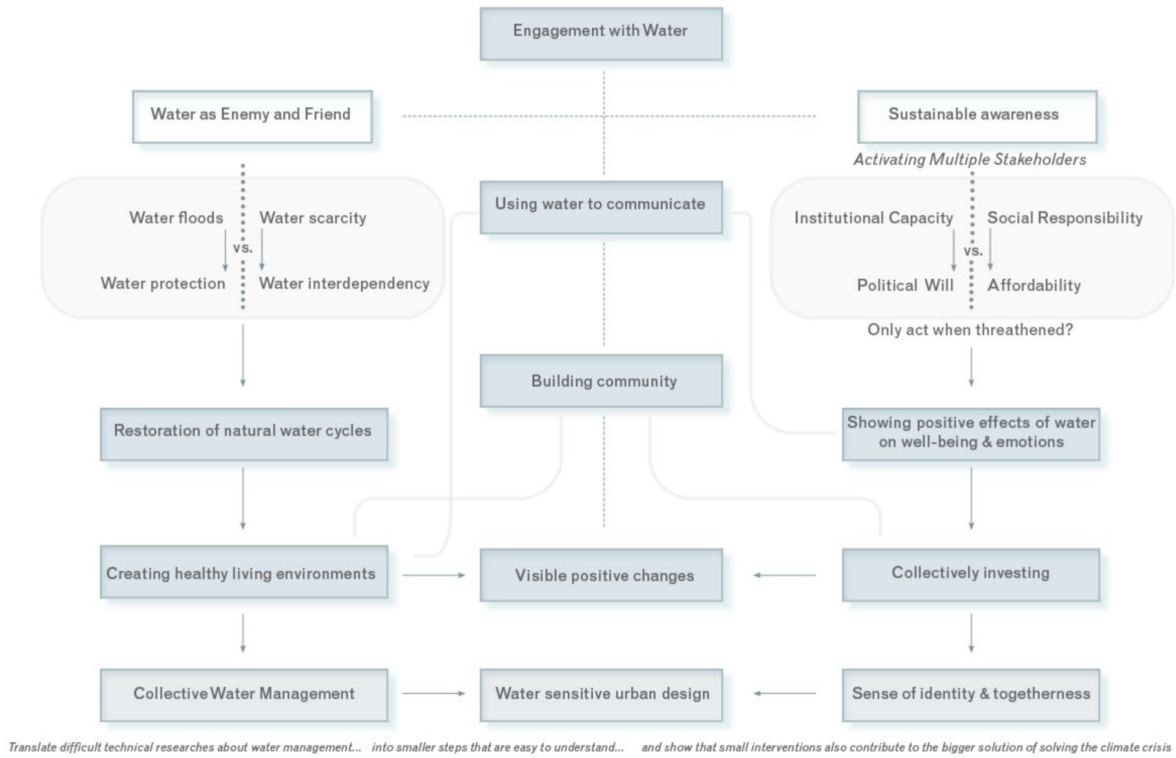


Figure 2: Interconnected systems diagram, detailed explanation in Appendix A (image by author)

2.2 Creating a guideline: translating technical research into practice

The goal of this research is to form a guideline for integrating water in a site-specific design approach that leads to more interaction and engagement of people with water by implementing water in designs on multiple scales. A literature analysis will be made of already developed strategies trying to invite water in our cities, like the City Water Resilience Approach (CWRA) and Design With Water 2.0 approach by Arup (Simpkins, 2024) (Appendix B, B1 and B2), the Long-term Initiatives for Flood-risk Environments (LiFE) (Barker & Coutts, 2016) (Appendix C, C1), and Healthy Water Cities by SWECO (Raes, S. & Savolainen, T. 2021) (Appendix D). Arup and SWECO are both engineering companies, focusing on informing stakeholders about the technical design solutions to cope with floodings. Meanwhile, the LiFE strategy is a complete approach that also focusses on the social influence water interventions can have. The LiFE approach divides four different scales where water interventions can be applied to, which are the region, city, neighbourhood and building scale to show how water in design be introduced instead of relying on the traditional flood defenses, which can be overwhelming (Appendix C2). A balanced approach emerges when the policy and frameworks are adjusted to the scalar approach (Barker & Coutts, 2016). During this research, three scales will be divided, which are the landscape water cycle scale, urban square scale, and social building scale. They form the base of the guideline, that could be used for design approaches to better cope with the complexity of developing water sensitive projects. The challenge becomes more approachable and manageable when dividing different steps during the design process. Like understanding the natural water cycle, while also relating it to water interaction and social responsibility (figure 3). Each city deals with its own conditions and characteristics. Therefore, the chosen site needs to be linked to its surroundings to understand the challenges of the area, like flood risks, to be able to develop a design approach. (Barker & Coutts, 2016).

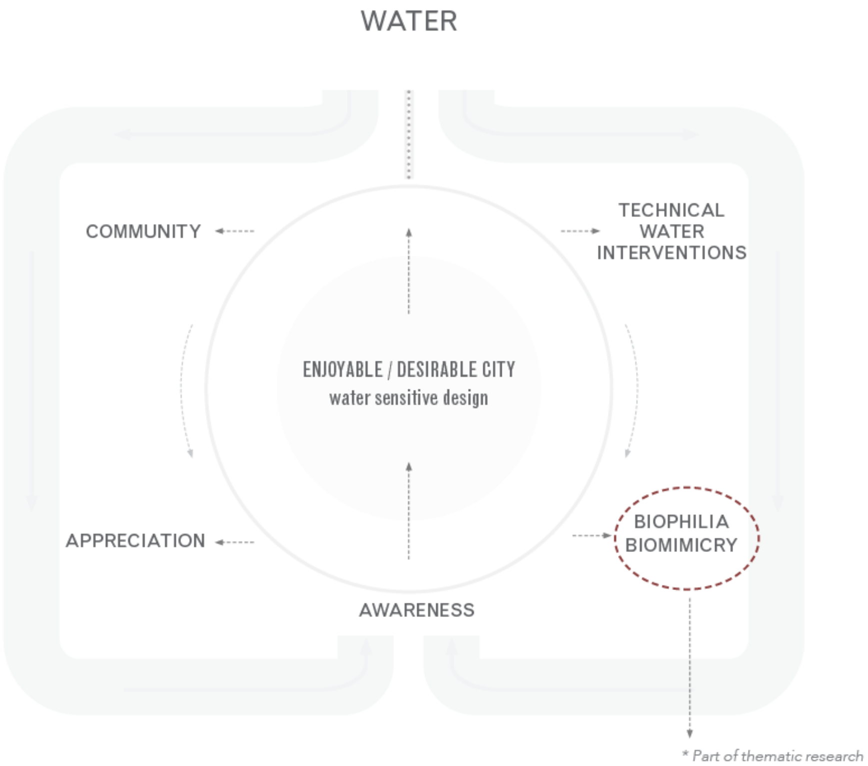


Figure 3: Flow diagram on how to motivate stakeholders to work on water sensitive designs (image by author)

2.3 Dividing the design intervention complexity into three scales

The landscape scale is the first step of the guideline, which is a general, governmental based data collection about the water flood defences and water problems the chosen city is dealing with on macro level to understand the natural water cycle of the city. The second step is the urban square scale, which looks more detailed into water sensitive design strategies and technical solution studies through an inventory catalogue of best-practice examples applicable in the public sphere and buildings. On a micro level, which will be the third step, the social building scale focusses on the positive health effect of water on our well-being and how to create positive interaction with water to develop understanding and awareness through quantitative literature studies and case-studies. The scales are interconnected to one another. An integrated approach rises when water systems are understood on all three levels. This research therefore focusses on the practical side of the implementation of water. Each subject contains a few sub-questions that help translate technical knowledge into a research and design approach. The following chapter is divided according the three scales, whereby the first part consists of a literature study about what flood risks the city is dealing with and the corresponding flood risk plans of the municipality to tackle the problems. The second part will be a best-practice analysis and inventory using qualitative literature, combined with quantitative literature about the implementation of water systems in designs. The last part discusses the implementation of interactive water interventions with technical water systems to create multiple benefits for both combatting flood risks and enhancing the human well-being. The final chapter (4) presents a proposal design guideline on how to implement possible water interventions in a building and surrounding area, based on the best-practice analysis and research.

2.4 London city as example for a contextual approach

If we now look our current existing city structures and the integration of water in designs, the disconnection of humans and water becomes even more clear. Many studies have analysed what cities are likely going to have to deal with flood risks in the near future, see figure 4. It shows what cities are facing a flood-risk increase when no action would be taken regarding the water protection systems. Therefore, cities need to enhance their natural infrastructure to become a so-called sponge city that absorbs and releases water when needed. In addition, they already have a natural sponge quality that only needs to be improved through interventions (CWRA Steering Group, 2019). Architects are then challenged to contribute to these new system developments, since buildings are also part of the urban planning designs. Since many cities are going to have to deal with the contradictory situation of not having enough storage for excess water and a water shortage, the chosen location for creating a water sensitive example building could be placed anywhere in an existing city. Multiple studies about what water problems cities will be facing in the future have been brought together in different maps. C40 (2022) even categorized how much additional costs per capita would have to be paid if no action would be taken regarding water protection systems.

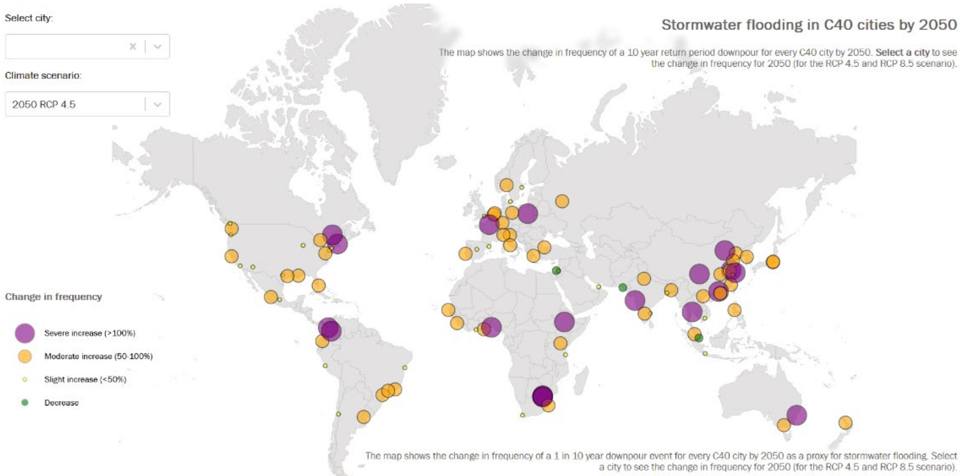
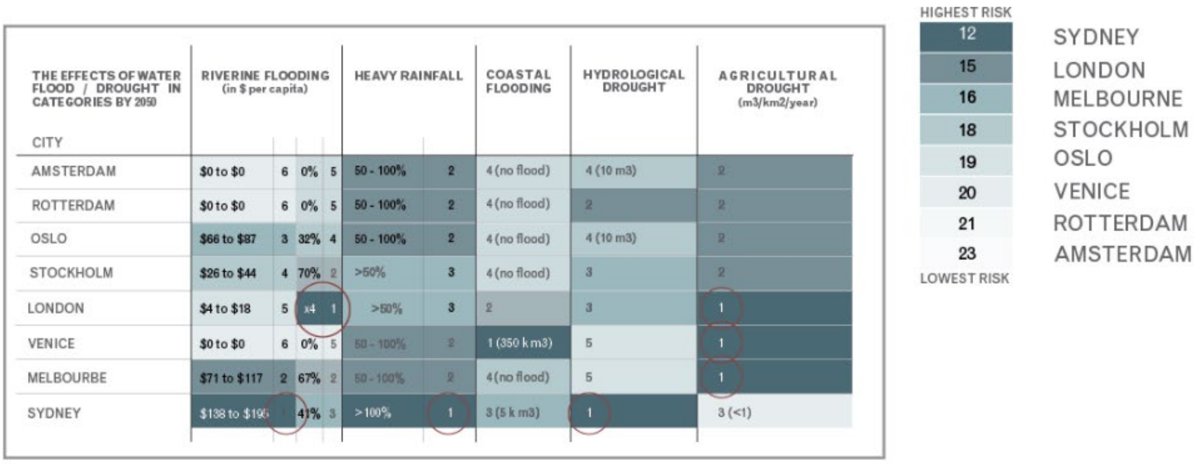


Figure 4: world map – water risks worldwide inventory by C40 Cities (2022).

Figure 5 shows a comparison of a few large cities that are categorized by multiple problem factors. One of the most problematic cities is London, capital city of the United Kingdom, with almost 10 million citizens (Macrotrends, 2023). The water resources are under great pressure because the population is still growing. Moreover, the rainfall intensity is increasing, and the sewage pipes are ageing, leading to bursts and leaks. Thence, the water supply needs for 20 million people are lost every day (Environment Agency, 2018). And over time, green spaces had to make place for impermeable ground, resulting in more water that needs to be drained via the sewage pipes (Cooper, 2019). All in all, enough challenges regarding the regulation of water that ask for a drastic change in the existing city structure and a need for water inclusive designs. A new design approach whereby water can be the connecting bridge between the three subjects of working with high-water stress, the lack of sustainability awareness and the positive impact water has on our well-being.



THE EFFECTS OF WATER FLOOD / DROUGHT IN CATEGORIES BY 2050	RIVERINE FLOODING (in $ per capita)				HEAVY RAINFALL		COASTAL FLOODING	HYDROLOGICAL DROUGHT	AGRICULTURAL DROUGHT (m3/km2/year)
CITY									
AMSTERDAM	$0 to $0	6	0%	5	50 - 100%	2	4 (no flood)	4 (10 m3)	2
ROTTERDAM	$0 to $0	6	0%	5	50 - 100%	2	4 (no flood)	2	2
OSLO	$66 to $87	3	32%	4	50 - 100%	2	4 (no flood)	4 (10 m3)	2
STOCKHOLM	$26 to $44	4	70%	2	>50%	3	4 (no flood)	3	2
LONDON	$4 to $18	5	x4	1	>50%	3	2	3	1
VENICE	$0 to $0	6	0%	5	50 - 100%	2	1 (350 k m3)	5	1
MELBOURBE	$71 to $117	2	67%	2	50 - 100%	2	4 (no flood)	5	1
SYDNEY	$138 to $195	1	41%	3	>100%	1	3 (5 k m3)	1	3 (<1)

HIGHEST RISK	
12	SYDNEY
15	LONDON
16	MELBOURNE
18	STOCKHOLM
19	OSLO
20	VENICE
21	ROTTERDAM
23	AMSTERDAM
LOWEST RISK	

Sydney has the lowest score, which means that it is the problematic city regarding the water systems in the city. By 2050, its citizens will have to pay 40% more (per capita) to be able to build-up the destroyed areas as a result of the riverine flooding when no actino would be taken regarding water management. Of the five measured impacts, Sydney scores as the number one problem city. London has the second lowest score with only 15 points. Compared to where Rotterdam and Amsterdam score, with 21 and 23 points, this is extremely low. Therefore, the city of choice will be London, since it is both combatting floods and droughts and is asking for new interventions regarding water sensitive designs.

Figure 5: City comparison identifying cities that needs the most attention regarding water resilience (image by author)

III. RESEARCH: A GUIDELINE FOR INTEGRATING WATER SENSITIVE DESIGNS IN CITIES

3.1 Creating interactive water architecture

London will be an example approach for other future projects on how to solve current and future water problems. The to be designed buildings should then contribute to closing water loops to become sponge buildings, that release and absorb water when needed and adapts to its specific natural environment. This research approach refers to the five stages of *'developing water resilience'* (appendix B, B1) (CWRA Steering Group, 2019). Understanding the system is the start of their method, which is similar to understanding the natural water cycle on a landscape scale in this research. The second step is about gathering the city's approach regarding water management and the current and future developments, whereas the third step focuses on developing an action plan using water interventions to build water resilience, which both will be part of the landscape scale to identify flood-prone areas. The last step of the CWRA is great importance during this research, as it is about analyzing and evaluating the already realized interventions to learn from its successes and failures, discussed in the urban square scale section. This last step is also present in the LiFE strategy (Barker & Coutts, 2016). In the end, these example interventions can be applied in other situations in a hopefully successful way. But overall, all the steps are trying to bind together stakeholder engagement and action plans. Engaging with stakeholders is of essence when sharing knowledge about technical water solutions. To learn and innovate from different target groups and inform different stakeholders about the ideas of others (Avello, Deunff, Jiménez & Scharp, 2016). Parties need to be informed correctly about their role and responsibility to be able to act right (Department for Environment, Food & Rural Affairs & Environment Agency, 2023a). In the end, the intention is to collect already conducted research about integrating collective water management in buildings and surrounding areas that enhance our well-being and translate them into understandable, graspable solutions brought into practice for everyone, hopefully reached through the integration of water systems on all three design scales.

3.2 The Landscape Scale: Understanding natural water cycles

The goal is to understand how the site for a specific project can contribute to managing the water cycles to prevent floodings. The landscape scale helps to understand the natural water cycles for riverine floodings, surface water floodings and the existing and future water protection systems of the city. The following supporting questions will be answered:

- *How does the natural sponge function (regarding release and absorption) of a city work?*
- *What areas in cities are currently dealing with high-risk flooding and water scarcity?*

3.2.1. The city's morphology: identifying water-problem areas

The morphology needs to be understood to indicate the sponge function of the city and identify flood-prone areas. Figure 6 visuals London's connection to the Thames River. The Thames has always played an important role for the transportation of products overseas and still characterizes the city today. Boroughs that border the riverside of the Thames all have their own approach for water management (Environment Agency, 2018). They are mostly located lower than the rest of the city, making them more vulnerable during times of high water or heavy rainfall, since surface water will collect here. The Thames Barrier helps to regulate the water tides and protects flood-prone areas.

Figure 6: City morphology of London showing the relation of the Thames River to the rest of the city structure (image by author)

Of course, the Thames barrier is supported by other flood defenses, but these are under pressure because of the climate change and have to close more frequently (McGlone, 2023). The current flood defense system cannot cope with the expected higher water levels (Department for Environment, Food & Rural Affairs & Environment Agency, 2023a). The Thames Estuary Plan 2100 therefore discusses the acceptance of designating assigned flood areas (Department for Environment, Food & Rural Affairs & Environment Agency, 2023e) (figure 7).

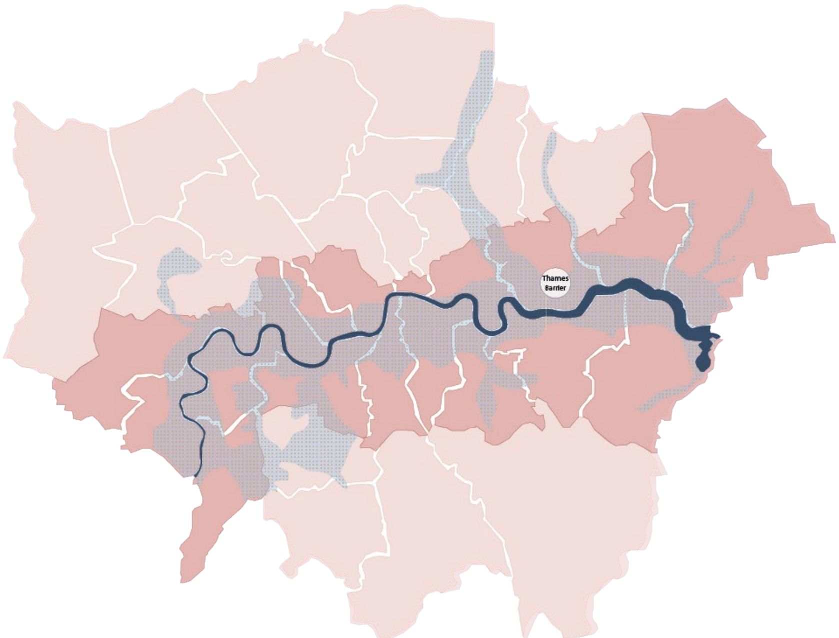


Figure 7: Relation and influence of the Thames River on the different boroughs of London combined with flood risk areas in times of extreme high tide (image by author)

3.2.1.a Types of urban water floods

Making the community and business prepared for floods is about resilience against water, to be able to react and recover quickly (Department for Environment, Food & Rural Affairs & Environment Agency, 2023a). Therefore, the different types of flooding need to be calculated and inventoried. Four types of urban floodings can be divided that determine the susceptibility to flooding in cities (Adeyemi & Lettieri, 2023; Department for Environment, Environment Agency & Food & Rural Affairs, 2023d):

- Fluvial or river flooding takes place when the water flow becomes higher than the volume capacity of the canals, river, and other channels.
- Pluvial or overland happens when the drainage system cannot withdraw, and the ground surface cannot absorb, the large amount of rainwater.
- Coastal floods because of storms.
- Groundwater floods happens when the water table is exceeded due to an increase in rainfall.

The type of flood risk is also determined by the type of environment a site is located in, such as the location of the site within the river catchment and sea border. Each location will ask for a different water design solution to combat water problems (Barker & Coutts, 2016). Moreover, parcs and grey infrastructure contribute to the sponginess. Other fluctuating factors to keep in mind land are the surface temperature and the ability to infiltrate and control water within the city structure. And also, the soil types and sewage systems to understand the infiltration capacity and get a full picture of the opportunities and challenges (Environment Agency, 2018). The Mayor of London worked with Bloomberg Associates (2023) and have mapped the risks of floodings, while also showing the most vulnerable neighbourhoods asking for adaptability. *'Climate vulnerability'* is about the impact of floods or heatwaves and the associated social factors that affect the citizens their ability to respond to risks. A more detailed explanation of what water risk maps to analyse can be found in appendix E.

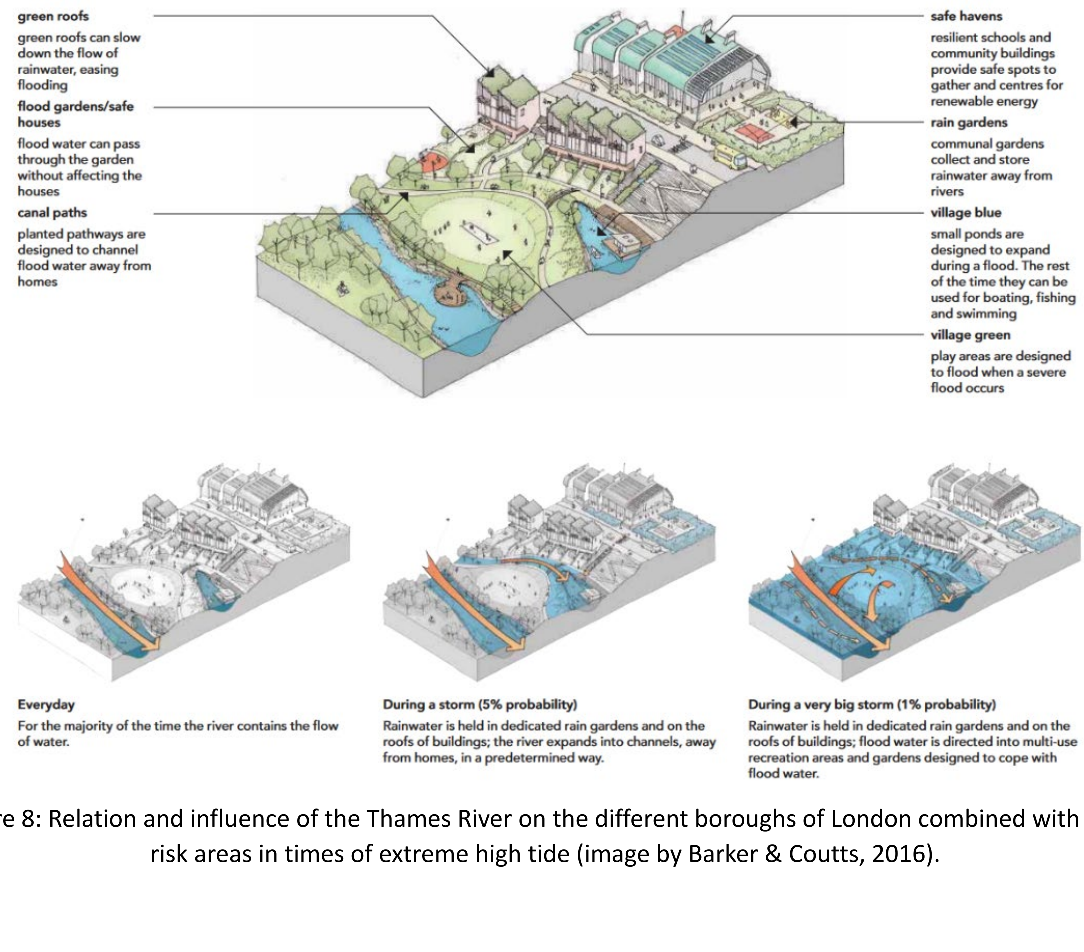


Figure 8: Relation and influence of the Thames River on the different boroughs of London combined with flood risk areas in times of extreme high tide (image by Barker & Coutts, 2016).

Besides, the determination of the annual rainfall can help decide what type of intervention should be applied to a certain area to find out how much a water reservoir can capture for instance. In London, the annual rainfall is 585 mm per square meters and the highest national rainfall intensity can be up to 0.023 l/s/m2 (Hebbert, M.J., n.d.; Alutec, n.d.). In 2080 new expectations have been forecasted, that predict extreme rainfall events exceeding 20 mm per hour but can also be four times more frequent than in 1980 (Fischer, Kendon & Short, 2023). Different scenarios and expectations of the weather due to changing climates in relation to its geography regarding the flood risk can be calculated. For instance, how much more frequent it will rain leaving the area flooded, to help understand the necessity of more sustainable water management (figure 8) (Barker & Coutts, 2016).

3.2.2. The city's approach on water management: suggested interventions

To be able to contribute to protecting and adapting the city from floodings and water scarcity, the to be designed building should fit within the city's plans for water management. Understanding the city's governmental intentions regarding water management through the whole process, a better support for stakeholders can be reached (CWRA Steering Group, 2019). The Thames Estuary Plan 2100 (2023e) shows the intentions of the government regarding water management and discusses the options for future water protection systems. Each city will have their own approach, so identifying these documents is therefore essential. Now, the city is protected by the Thames Barrier that opens and closes when tides are high. If the sea level rises, they will need to adapt to the changes, but they are only saying that by 2040 they will have made a decision for water protection adjustments (Department for Environment, Food & Rural Affairs & Environment Agency, 2023a). According to Jonathan Bambe (expert in sea level rises) and Hannah Cloke (environmental modeller and forecaster) the decision needs to be made faster, as the sea level rise occurs faster than expected. Suggestions for making the city climate adaptive regarding water management are heightening the flood walls and embankment with at least 1 m. To prevent the riverside from becoming inaccessible because of the elevation, the Environment Agency also developed a riverside strategy that focuses on reducing the tidal flood risk, resulting in saver living conditions for inhabitants with more recreational areas and riverside paths. Also part of the future agenda are the creation of saltmarshes and storing natural carbon. Along the riverside, they want to create good, attractive, and green public spaces that promote health and biodiversity, while protecting the landscape (Department for Environment, Food & Rural Affairs & Environment Agency, 2023b; 2023c). To reach these goals, communities and other stakeholders need to be involved to exchange ideas and ambitions for the riverside (Department for Environment, Food & Rural Affairs & Environment Agency, 2023d). Water sensitive design can help reach these goals, as they invite the water in, while bringing and educating communities about water management.

3.3 The Urban Square Scale: Analysing technical and social water interventions

The second step of the guideline is choosing water intervention types that can be integrated in the existing city structure. But the question that then arises, is what type fits best within a specific type of location. This will also depend on the scale of the project. Therefore, a best-practice analysis will be made, that identifies the different water intervention types and links them to three scales, the different type of city typologies and the functional, social identity of the interventions. If, for example, the technical intervention is raising the river embankment with one meter, like they are planning to do so in London, on a landscape scale it reduces the short-term water risk, while on the social building scale the interventions are not very user-friendly. It blocks the accessibility to enter the riverside and obstructs the direct connection to the water through a considerable height difference. Therefore, the urban square scale has the main focus during this research approach, since it connects the landscape and social building scale together, while functioning as the most ideal scale to attract multiple stakeholders (CWRA Steering Group, 2019). Sub-questions that will be answered in this part are:

- *What design interventions can be taken to restore grey infrastructure to a more connected natural environment to stimulate people to participate in water management design as a community?*

3.3.1. Best-practice testing framework using developed strategies

There are many engineering companies that are working towards a climate resilient world and specifically focus on protecting vulnerable neighbourhoods. The problems can be tackled by dividing the to be carried out interventions into smaller steps. A best-practice analysis using the smaller steps will be discussed next. The steps are based on the guidelines developed by ARUP (CWRA Steering Group, 2019; Simpkins, 2024), SWECO (Healthy Water Cities) and the LiFE strategy (Barker & Coutts, 2016). All these documents formed the base of the research framework for the best-practice analysis that will determine the qualities and success of projects and what can be learnt from them. The strategies and approaches are combined into a step-by-step approach on how to divide the different intervention types on different scales and project types to test project or proposals.

3.3.2. Best-practice analysis: Water Resilient Testing Framework

Building water resilience stands central during the best-practice analysis, which is the ability to adapt to changes of water resources, water supply and demand, because of climate change and changing social-ecological factors. There are many intervention types available and being tested, to be able to apply them successfully in projects. Important is to divide two types of intervention intentions. Dry proofing is connected to technical solution systems designed by engineers, intended to prevent water from entering a building. Technical solutions that are most common when solving water problems. On the other hand, we have wet-proofing systems that embrace the fluctuation of weather types and climate change and adapt to the circumstances and changes (Detail, 2019). One of these system types is the Sustainable Urban Drainage System (SuDS) that mimics the natural drainage processes to slow down the water run-off, retain it for a longer time of period and simultaneously benefit biodiversity. Often these systems are combined with green infrastructure (GI) to create habitats for animals and offer recreational areas to communities, stimulating social cohesion. They can function as aesthetic-functional element, while also purifying the air and water to improve the microclimate (Parancola, 2019). Finally, the drainage systems can visually educate children and citizens on water sustainability. Educating children and citizens is of great importance to address the lack of social responsibility and therefore filtering on sustainable urban drainage systems receive more attention for the best-practice analysis.

For the research, mainly projects built in Denmark and The Netherlands are used as examples, since water resilience already gets a high priority due to changing weather patterns and rising sea levels they face. Denmark has developed a Cloudburst Management Plan to prevent areas from flooding with fundings from water tariffs. But in Demark in general it became clear that a change of mindset is the key element to activate leaders. Ambitious targets are reached when change is the main aim (EurEau, 2017). In the Netherlands, the focus on dikes and deltas, or protection from water, is also shifting to a more working-with-water way of thinking, like the introduction of floating houses. By reflecting on projects, all stakeholders and parties can learn from changes and successes and integrate it in their next designs to create better adaptation to the water risks a city is facing. Indicators to consider when reflecting and analyzing a project's success are; leadership and strategy; planning and finance; infrastructure and ecosystems; health and wellbeing. But also, the type of wastewater problem-solving and function of the project (public, private, housing) (CWRA Steering Group, 2019). See Appendix B1 for an extensive explanation of the four factors.

To create an overview of the possible water interventions that can be applied, a catalogue that identifies different types of water solutions according to site characteristics is formed (figure 9). Successes of projects can immediately be tested according to the framework, which relates to the last step of the CWRA approach: evaluating and learning from projects (CWRA Steering Group, 2019). For the analysis, first the technical aspects are looked at, like the area type and the types of interventions applied, according to the LiFE approach toolkit and waterfront types (Appendix H, H1& H2). Lastly, testing the social connection of the project is of importance, as it will give more insight on how to educate people about sustainable water management and how to get them to interact with the water. See the testing framework design booklet for the step-to-step instructions on how to analyse the water resilient project. The LiFE approach has already created a summary of suggestions for successful waterfront plans based on their research of example projects and an intervention type overview (appendix C2). According to the research, each waterfront typology has their own characteristics, therefore people use each area differently. Successful harbours, for example contain a mixture of commercial and leisure functions, mostly build-up out of promenades and walkways combined with larger landscape areas and tall buildings. The intervention types applied are mainly to build protection and resilience, not really inviting the water in. Successful residential areas will mostly be found in disused docks, wharfs, and quays, but also next to rivers and lakes. They are combined with commercial and leisure functions. Compared to coasts and deltas, which are mostly used for the accessibility to the enjoyable waterfront, meaning for public and recreational use (Barker & Coutts, 2016). Therefore, eight different project types have been selected, divided under four project typologies to be able to create a diverse framework, which are place and community; parks and squares; buildings and streets; and housing (extensive explanation in Appendix H, H1 & H2). Most of the projects are public, expect for the residential projects. Nevertheless, they are mostly combined with public spaces, such as parcs, playgrounds and swimming area. In appendix I the best-practice framework analysis can be found for a clearer review of figure 9 of the project's successful applied interventions in relation to the waterfront type and social success.

Figure 9: Water Resilient Testing Framework overview of the best-practice examples (image by author)

3.3.3.a Place and community: bio-filters, rainwater harvesting and rain gardens

The harbour baths in Copenhagen and Dongyuan Xianxun centre in Suzhou are both public accessible functions, being a harbour bath and community centre. The location of the community centre, whereof the district was known for its predominated water characteristics, was placed in between the historical water district and newly developed urban sprawl. By integrating these characteristics within the building, it would become a common carrier of both, supporting socialness and naturalness, while focussing on openness and cohesion. It attracts multiple age groups through a combination of social activities. In this project water is used as a psychological, biophilic element that enhances peacefulness, while providing water for plants. Curved roofs resembling waves have been designed, combined with a water garden. Rainwater gets easily collected in the lowest point of the roofs because of its wavy form structure and water gets drained through free fall or pipes into the water basins that provide water for the green spaces, using a biomimetic method. As a result, the reflection of the building is visible in the water basins, making the basins an actual part of the community centre, whereby surface water is used as a medium to promote relaxation and peace (Detail, 2019; Archdaily, 2017) (figure 10).

The harbour bath in Aarhus only makes use of a bio-filter (Figure 12), which formed an inspiration for other cities to make harbours more attractive and vibrant. To create the opportunity to filter and use the water's quality for leisure and recreational purposes. The natural flow of high and low ties, a biomimetic principle, was used for filtering the water (Kurzreuther, 2022). In Copenhagen a bigger approach is used, whereby rainwater is collected and filtered in reservoirs, dodging the contamination of the harbour. Transmitter constantly check the water quality for save swimming conditions (International Water Association. n.d.; Raidt, 2015). Thus, the harbour baths could be placed anywhere, without having to adjust to the environmental characteristics. As a result, many ideas arose from locals themselves to create maritime kitchen gardens to grow seaweed, mussels, and oysters, but also activities like kayaking and canoeing were organised, making the waterfront an extension of the public realm. The water interventions applied stimulate more exercising activities and inspiration to connect with the waterfront (figure 11). In both cases, the improved water quality is used to enhance well-being in forms of relaxation, leisure and thereby promotes having more direct contact with the water, which became a source of inspiration for people to use the water for more than just swimming (Mains, 2022; The Stylewise Reportage, 2009; Hérnandez, 2018).

Figure 10: Community centre with water basin for rainwater harvesting (Detail, 2019).

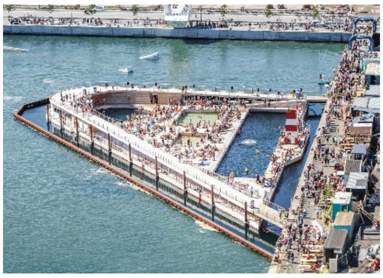


Figure 11: Harbour bath in Aarhus, Denmark with water bio-filter (Hernandez, 2018).

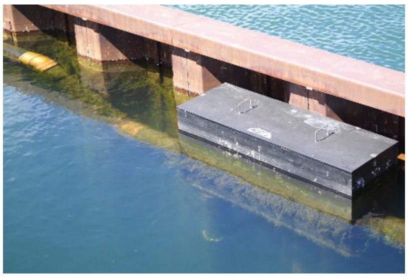


Figure 12: Bio-filter with retaining wall, harbour bath Aarhus (Kurzreuther, 2022).

3.3.3.b Parcs and squares: raingardens and floodable water fountains and playgrounds

Public realms are always easily accessible to everyone, mostly bordering building blocks and host multiple functions or activities, also known as public squares. Two public squares in Copenhagen have been analysed, whereby both have been transformed from being a parking area to a multi-functional, open accessible space. Before the transformations pluvial floodings occurred frequently. Israels Plads serves as a transition area to move and escape from the big city to the quiet oasis, while accommodating functions such as a skatepark, flea market and a schoolyard. The combination of activities is still functional today. Intervention types applied, according to Barker & Coutts (2016), are floodable playground and water square. On the square water is visually collected and guided through an artificial creek to the bordering green area during times of rainfall. The mimicking a real creek is then a biomimetic method (figure 13). It becomes multi-functional as it irrigates the park but is also used as an interactive playground area. Although, water only runs through the stream when it rains, making the square look very paved and grey area with only a few trees on the platform (article). It could also become a closed water cycle by placing a water reservoir underground, making the water run through the creek constantly which leads to more interaction of humans with water by also making it more functional as cooling element during the summer. The success of the square can be traced back as historic events brought back and the integration of natural elements, while hosting functions for various target groups to support inclusiveness (Cobe, n.d.; State of Green, 2015). For Tasigne Plads locals have worked together with landscapers, engineers, and artists, which resulted in an interactive garden design. To let people engage with water metal umbrellas that open and close are placed that provide shelter from rainfall, but simultaneously collects and stores water, while being a visual addition to the square (figure 14). The umbrellas are alternated with raindrop formed elements, from which water can be pumped for children to play with. It then streams onto the service and is led to green retention areas by applying different tile heights (figure 15) (Appendix F for water system). To make the water cycle system understandable for both adults and children, information panels are placed. The combination of intervention types for Tasinge Plads are water fountain squares combined with raingardens that together form the concept of a floodable playground. Engaging citizens with water by letting them participate in the design process to come up with ideas and reconnect them better with nature has led to an integral plan, whereby the community identity and ownership are reached and responsibility for collective maintenance is formed (Klimakvart, n.d.; Bravo, 2018; LYTT Urban & Landscape Architecture, n.d.-a).



Figure 13: Israels Plads, Denmark, with floodable water fountain. Hjortshøj, R. Copenhagen's Urban Carpet — 2014 [Online]. Copenhagen: Cobe. Available from https://cobe.dk/imagecache/images/ansel_high_qual/1687/180_cobe_israel_plads_exterior_collage-5cc8306f77e15_71318731b48aacf0a18965ad7e07d9f2.jpg

Figure 14 & 15: Tasinge Plads, interactive water playground water capturing umbrellas and rain garden (Bravo, 2018; LYTT Urban & Landscape Architecture. n.d.-a).

3.3.3.c Buildings and streets: dry proof (water exclusion strategy), swales and ponds

Different typology projects have been selected, being an existing residential area in Rotterdam, and primary school in Llanelli in the United Kingdom both suffering from pluvial floodings because of the large amount of grey infrastructure within the area. For the streets of the residential area a new street profile was created whereby green infrastructure (GI) is used to reduce the stress on the sewage system and function as retention area, by means of wadis and buffers (figure 16). When the wadi reaches its capacity, the water is lead to a second buffer placed underneath, consisting of infiltration boxes and capillary canvases. To make this possible, cars had to be removed from the street and in combination with the replacement of the cars with greenery, the biodiversity and air quality have increased. Finally, the water from the infiltration boxes is re-used for the communal garden and greenery, which also stimulates social cohesion by connecting different age groups (De Boer, Hinterleitner & De Jonge, 2020). (figure 17). Housing associations are beginning to understand the essence of becoming more sustainable to reduce the environmental and psychological impact of water damage also to limit additional costs but are still struggling on how to tackle the challenge. Meeting the right stakeholders on regular basis ensures that all objectives of the parties are considered and integrated. Even for the primary school stakeholders had to be convinced, like the local education authority and community, but also the school governors. During the transformation process, children were also involved as stakeholders, which resulted in the inclusion of an outdoor classroom, pond, and bug hotel. For this, cars have been removed and replaced with swales with underneath a geo-cellular storage zone combined with the small pond. By transforming an existing neighbourhood and school suffering from water floods to water system integrated streets and squares, it leads to educating schoolchildren and the community about water runoff (figure 18). It is important to spread the wider message of reducing sewer overflow and becoming more water-efficient to all age groups and to ensure the acceptance of work undertaken, reached by co-designing that could lead to the mitigation of the future potential for neglect or vandalism and stimulate identity (Susdrain, n.d.; Landscape Institute, 2015).

Figure 16: Residential project *'Van natte last naar groene lust'* combining rainwater harvesting and green roofs with communal food garden (De Boer et al., 2020).

Figure 17: Residential project Rotterdam transforming flooded streets to green oasis (De Boer et al., 2020).

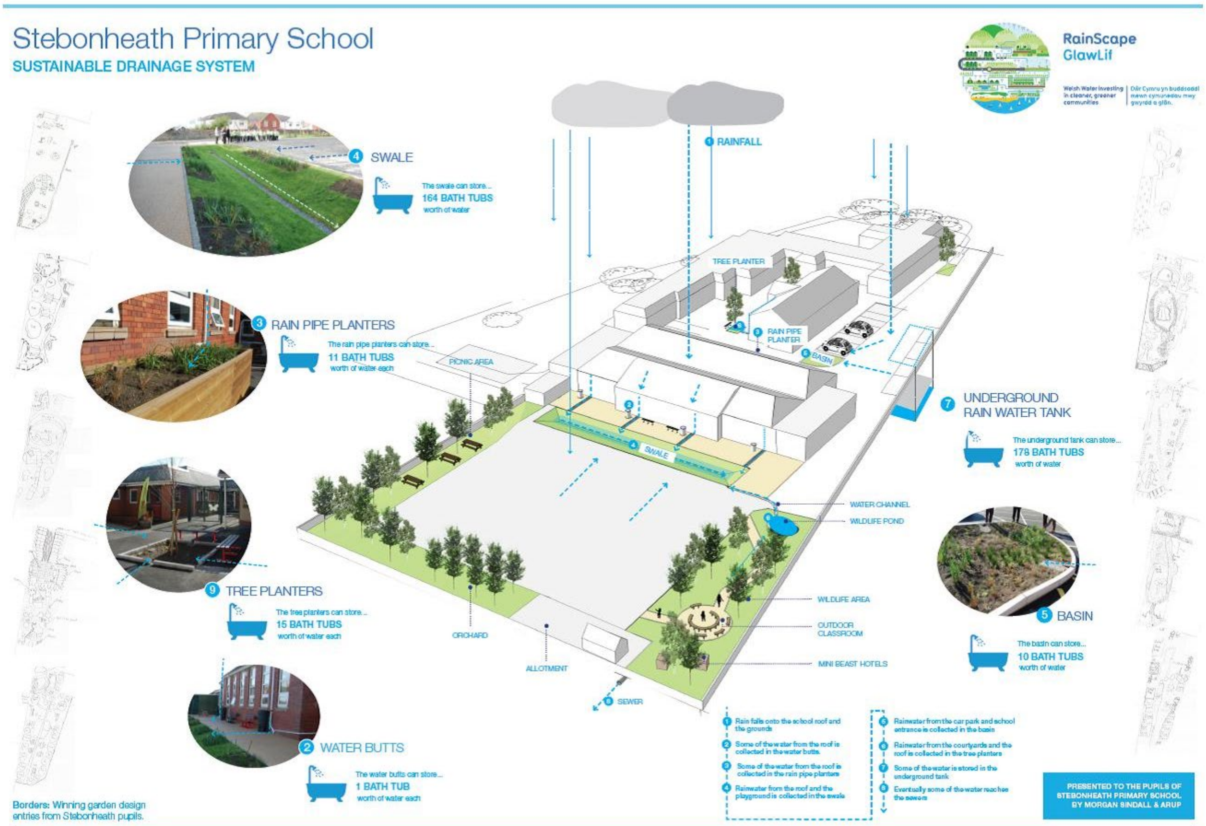


Figure 18: Transforming existing landscape surrounding primary school Stebenheath in Llanelli, United Kingdom, in an understandable way for locals through involvement of all stakeholders during the design process (Susdrain, n.d.).

3.3.3.d Housing: rain gardens, terraced waterfronts and water squares

The existing buildings of the residential project Kroyers Plads in Copenhagen have been transformed into sustainable housing combined with green playgrounds to collect wastewater. The residential blocks now have a very close connection to the harbour waterfront as residents and visitors can swim or can enjoy the view from a terraced waterfront. Terraced waterfronts are designed to evenly drain and filter water of impermeable areas, mostly combined with other SuDS (Barker & Coutts, 2016). Moreover, it includes a raingarden and water square where water gets stored, making visual and functional use of green infrastructure (GI), which will lead to an increase of the biodiversity too (figure 19). Till this day, the waterfront is used optimally and widely appreciated by citizens. Locals have been involved during the design process to discuss their perspective, which might also lead to a higher satisfaction level. But since the existing area was highly valued by citizens, the incorporation of historic value in the new design might also have contributes to its success (Schoof, 2018; LYYT Urban & Landscape Architecture, n.d.-b; . Difficult when re-using buildings is the challenge to prepare the building for the rising sea level, since the building cannot be raised easily and respond to the changing tides. The other residential project, located in Ijburg Amsterdam in the Netherlands, was located in a quay. Both projects had historical trading backgrounds with shipyards and warehouses. To design a good waterfront plan along a river or a quay, it should be a mixed-use area combining housing and commercial functions (Barker & Coutts, 2016). In both plans, this is done by integrating swimming areas, playgrounds and even a cinema. The building is designed as an inviting heart for the neighbourhood. A walking path crosses right through the building, making the ground floor of the plot accessible to everyone. Moreover, the waterfront has become a softened border between land and water by giving back water (a part of the plot was demolished) and replace it with green island and vegetation combined with mussel reefs that naturally improve the water quality. On the rooftop, greens roofs collect and slow down the water run-off. An artificial stream, that at same time functions as a walkable skylight on the roof, can be seen from inside the atrium of a building (figure 20 & 21). The water that flows over the glass creates a pattern and when the sun is shining its reflection pattern on the inside arises, while it also works as a cooling element during warmer summer period times on both interior and exterior (Orange Architects, n.d.; Pintos, 2023a). Those are visible aspects that translate the idea of integrating water into design as am enhancing health factor but were not necessarily connected to stimulate people to understand the importance of saving water and becoming sustainable becoming both functional as biophilic and biomimetic element. The building namely does have a water reservoir where water is re-used for flushing the toilets but is invisible from any corner of the building and is not public accessible. This reservoir is not connected to the closed circular water system on the top, that is only used as visual and pleasant health enhancing resource. A missed opportunity to show and communicate what the positive effects of sustainability could mean for us, but it is a good start to show what water can offer us by inviting it into the building.

Figure 19: Rain garden of new developed industrial area Kroyers Plads (LYTT Urban & Landscape Architecture, n.d.-b).

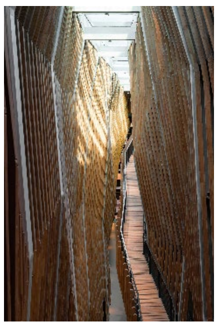


Figure 20 & 21: Water interaction with residents on roof and interior for the residential building JONAS (Orange Architects, n.d.)

3.3.3.e Example of integral approach water interactive design UK

In the book Aquatecture (Barker & Coutts, 2016) many examples are gathered and analysed to determine what could be learned from case-studies regarding water management. But also, proposals are presented for London. These locations are suffering from different types of floodings, depending on the river catchment. For this research, a case-study located in Hackbridge is interesting, since it focusses on a neighbourhood scale project that shows how to tackle the water problem and form a design proposal for the site, located in the upper catchment of the river Wandle consisting of industrial areas now disused. The site was dealing with an excess of surface water due to grey infrastructure. As rainstorms could occur due to climate change, also the probability of fluvial, or river flooding within the upper catchment increases (Food and Agriculture Organization & The World Bank, 2015). To cover this problem, space-making to slow and store water was a key concept, while creating multifunctional open spaces to play sports and capture water, while increasing biodiversity. The redevelopment of the site would consist of a combination of residential housing blocks, a primary school, and a rain garden playground. A riverside trail to enjoy the water view was made possible, because of a low-lying flood shelf along the river. The SuDS applied were green roofs, rain gardens, pools and ponds, swales, and flood parks. Regarding the buildings, flood-resilient construction was placed close to the river, consisting of a mixed-use program (figure 22). The ground floor would have commercial spaces, whereas housing only began from the first story to reduce the vulnerability and risks of the community, which could become a base for to be developed projects.

Figure 22: Flood risk inventory map example for a site, the Thames Ironworks, in London (image by author)

3.3.4. Choosing a vulnerable site asking for change

After indicating the most flood-prone areas of the city asking for a change and having gathered the intervention type options, a location can be selected in one of the vulnerable neighbourhoods, suffering from high-water stress and heavy rainfalls, while maybe even facing water scarcity in drier summer periods. It should be an area that asks for transformation. The most optimal location would be a site where no function is located currently and contains a lot of grey infrastructure. The location of the example sponge building should be carefully considered, as the focus is placed on raising social awareness among residents, the municipality, investors, and the government. For example, a historical valued building could be used to create appreciation, since they are widely appreciated by all citizens. It reflects the memories and events of the past. A vacant building that is now left in despair, could be redeveloped to its original state and could become an even more vibrant area, which shows a visible change. This was also the case for Kroyers Plads, whereby locals were involved in the transformation process. Many of the analysed projects, like the primary school and public squares were already existing areas suffering from water stress that needed for a change. After its transformation, wishes of the citizens were incorporated, which contributes to the satisfaction and success factor. Water was used as a revitalization element to strengthen the identity of the area. The citizens then might appreciate its restoration which is an extra stimulating factor on why to maintain the building with collective water management (flow diagram figure 23).

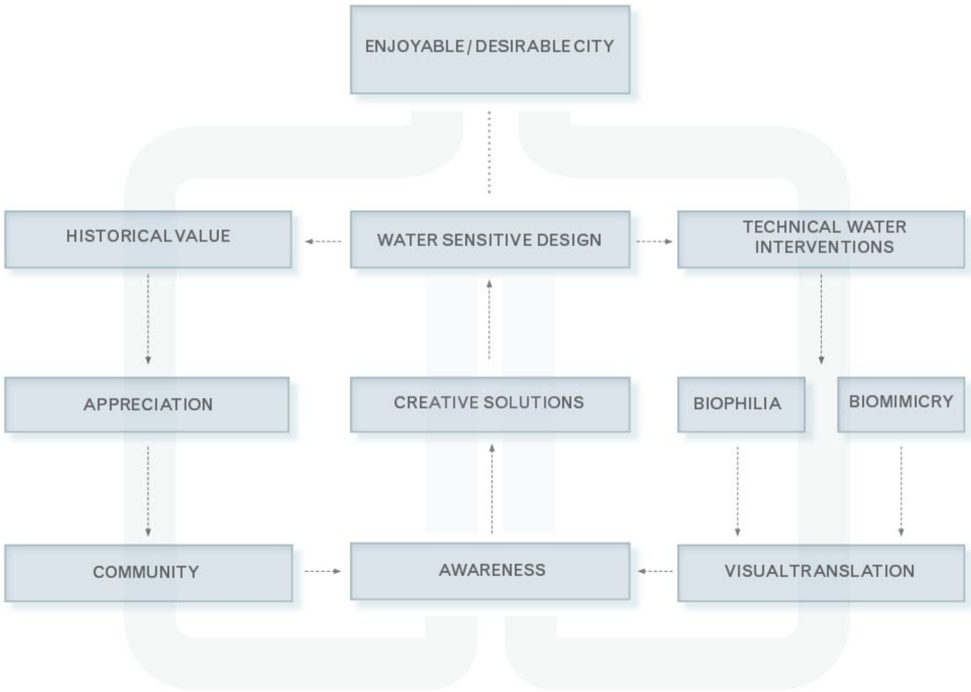


Figure 23: Flow connection system of influential aspects leading to the activation of stakeholders to develop water sensitive design strategies (image by author)

More of this aspect, will be discussed in the last scale, the social building scale, that discusses how to activate communities to participate and engage in sustainable water management. In the example city London, three locations on industrialized ground with a historic background have been selected, whereof the flood risk maps were layered on top of each other to identify the weakest spots (see appendix E for location analysis). The risk inventory map can be used to show what water risks share common ground of the surrounding area of the plot to confirm the opportunities and challenges of the location. All the locations are at risk of riverine flooding when the sea level rises, meanwhile facing surface water risks from heavy rainfall (see appendix G for the analysis). Thames Ironworks and Shipyards showed the most potential, as can be seen in the risk inventory map (figure 24).

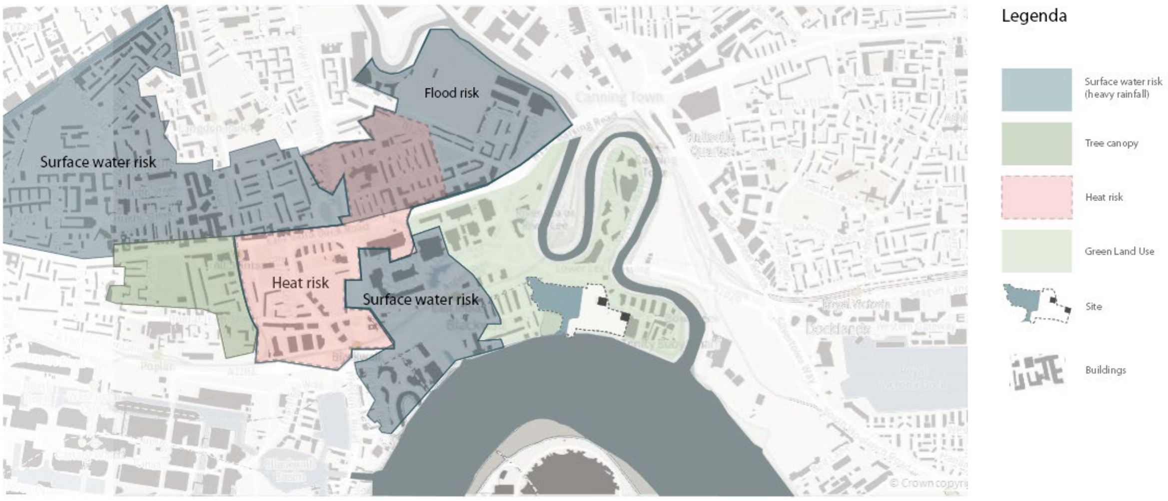


Figure 24: Flood risk inventory map example for a site, the Thames Ironworks, in London (image by author)

The government of London already pointed out potential areas ready for new developments, or moreover forgotten amenities that need a transformation, which also includes the Thames Ironworks. Thames Ironworks is located close to the riverside, making it possible to create a public building embracing the different water flows while adding value to the neighbourhood and creating connection to the waterside. Also, despite the different uses of water, in London it almost always ends up in the mixed sewage system, after which is dumped in the rivers and sea. Most of the upper part of London do not have separate sewage systems where rainwater is separated from the black water sewage system and is visible as a clear division between the two river sides. All in all, enough opportunities on a vacant site, whereof its history can be embraced and revitalized through the integration of a water sensitive sponge building.

3.4 The social building scale

The social building scale will be about communicating the effects water can have on our health. By making the effects of water sensible, it might help as a stimulating factor to make people more aware of becoming sustainable and the qualities of integrating water into our buildings and everyday life. As already mentioned in the introduction, biomimicry and biophilia are both stimulating factors when it comes to enhancing our well-being and can promote relaxation. Biophilia are mostly visible interventions that connect nature to people, think of adding greenery in buildings, that users can connect to an improvement of their health. While on the other hand, biomimicry can be both pleasant to the eye and enhancing health, while they can also have effect without being visual or physical, such as natural air circulation within the microclimate of a building. Sub-questions that will be answered during this part are:

- *What are the effects and experiences of water on our well-being reflecting on history?*
- *How can the usage of biomimicry and biophilia in a building design enhance our living environment?*
- *How do you teach people about sustainable solutions?*

3.4.1. The history and symbolic use of water in architecture

The disconnection between humans and water is remarkable since we are very water dependent and have always been surrounded by water. Water has been the main heart of origin for all civilizations. In the earlier times, a whole village was dependent on the tides of the river regarding the irrigation systems of the land, like in ancient Egypt on the coast of the Nile. Rivers were seen as a symbol of time and life. This makes water a historical and cultural symbol. Besides, water was used as a way of communication in art and design. For example, the design of the Versailles gardens in France (figure 25), where infinite sightlines were created by using large longitudinal water basins. Also, in Italy water was being integrated into the urban structure and buildings during the Renaissance (Parancola, 2019). They used it as an element to enrich their living environment. Fountains, to name an example, would become a place for meeting people, while providing a pleasant microclimate in within the city. These were architectural-artistic solutions just like canals, arcades, and paving. Water had become the symbol of the flow of life and contemplation that promotes prosperity, progress, and technical power (Mikhailova, 2018).

Figure 25: Garden design of Palace of Versailles: Water basins are placed to create infinite sightlines.

Chateau de Versailles. (2021). *Palace of Versailles*. https://en.chateauversailles.fr/discover/estate/gardens

3.4.2. Different water patterns as aesthetic and physically pleasing element

Water can become dynamic and can change the sensory appearance and symbolism it can radiate. It can echo different sensations, like connection and unity with nature, but also vitality and renewal. When water is calm, it becomes a mirror, evoking serenity (Ghisleni, 2023). Both functioning as aesthetic and therapeutic element, while guaranteeing the purification of air. In the summer, water in motion reaches its maximum effect of cooling and helps regulate humidity, like cascade fountains and waterfalls. During winter they function very well in combination with radiators, as they produce negative ions that are important for a good air quality and lead to high serotonin levels (Parancola, 2019; Al-Bakry, AL-Tuhafi & Mahmoud, 2022). The Apple Pavilion in Milan, Italy, is example of using the movement of water that evokes relaxing sounds, visual satisfaction, and physical influence such as cooling air to create interaction. The project serves its purpose to revitalizing the historic piazza in the buzzling city centre and draws visitors to the piazza as the vertical streams of water splash against the glass service. The entrance leads to the sunken apple store, while forming a backdrop of the outdoor amphitheatre. Using water and stone were common elements to use on a piazza and the glass portal therefore creates a multi-sensory experience as the cascading fountain wraps itself around the visitors when walking down the stairs (figure 27) (Designboom, 2020). Children can play with the fountains adjacent to the glass-façade (figure 26). The idea of walking through a fountain without being able to get wet is a child's dream to come true (Foster + Partners, 2018). Throughout the day, the alternating pattern of the sun position changes the way the pavilion is received (figure 28). During the day, sunlight is filtered through the water, causing reflections, meanwhile at nighttime the ceiling creates some kind of kaleidoscopic effect with the reflections of the lights against the water façade. On the interior, the glass façade connects the exterior with the interior through the warm sunlight that falls into the sunken store (Architect Magazine, 2018; Foster + Partners, 2018).



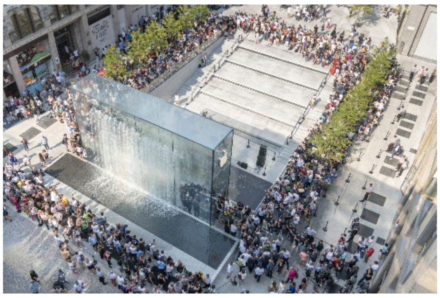


Figure 26, 27 & 28: Apple Pavilion showing a perspective view; staircase view and bird-eye perspective (Designboom, 2020).

Dark, closed-off spaces without fresh air and natural daylight, or just no connection with a natural environment, have proven to cause sickness and a decrease of our productivity (Calabrese & Kellert, 2015). At least, an attempt in bringing nature closer into the building and humans can be reached, whereby water is of vital essence to understand nature (Herzog et al.,2000, p. 341). An example project where water is invited into the building to strengthen the vitality of the place is the SESC Pompeia project in Sao Paulo. It is open community brick shed for leisure, health, and culture, where heritage is maintained and combined with new volumes (Wong, 2023). Water streams through the big interior space, thus subconsciously divides the large, open space into smaller areas, which refers to the Sao Fransisco River that divides the northeastern of Brazil. The mineral landscape with pebble-lined channels optimizes the social experience of the transformed building, which is a Japanese conception of space. To generate appropriation and belonging, noticeable in seeing children cross the water without fearing it to become wet (figure 29 & 30) (Ghisleni, 2023). Water brings people together in leisure activities. Through the use of water channels inside the building, it improves the micro-climate, just like the refreshing effect of ponds, plants, and waterfalls because of its evaporation (Parancola, 2019). The complex is still one of the most used and appreciated community facility buildings (Sesc em São Paulo, 2016).

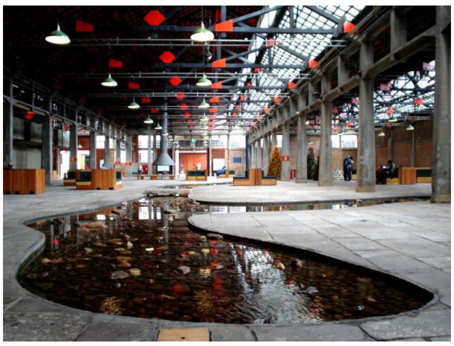



Figure 29 & 30: Community Centre SESC Pompeia with flowing water in the interior resembling a river (Paulisson Miura/Flickr. CC BY 2.0; Photo Antônio Saggese).

The Changi Airport in Singapore showcases the use of waterfalls on the interior of a building, leaving people with the experience of being in nature in combination with leisure activities. More than 10.000 gallons of water per minute flow five stories downwards, which promotes airflow and cooling in the landscape environment. Rainwater from heavy thunderstorms is collected, circulated, and reused through the building, making it a visual pleasing and thermal comfort element through the cooling of the building element for visitors (figure 31, 32 & 33) (Pintos, 2023b; Changi Airport Group, 2020). To conclude, the enrichment water can bring to us regarding our spatial experience and well-being is not used optimally in our contemporary architecture and living environment, as it can communicate multiple symbols and meanings that leads to an enjoyable architectural environment where visitors can enjoy the functional and ornamental qualities as a fundamental element of art (Ghisleni, 2023).

Figure 31 & 32: Changi Airport Singapore with a 5-story waterfall (Changi Airport Group, 2020).

Figure 33: Close-up of pipes channeling water to the waterfall (Changi Airport Group, 2020).

3.4.3. Using biomimicry and biophilia to become more sustainable and optimize our water experience and knowledge

Water has multiple qualities when it comes to boosting our health. According to Klaus Daniels (2000) saving energy through the creation of closed water cycles and rainwater harvesting are part of biomimetic research to harness climate regulation. Biomimicry stands for the mimicking of the functional, biological processes and forms produced by nature to initiate sustainable solutions (Prawlyn, 2016). Like with streaming water the air becomes cooler. Water can also be a visual satisfactory, like the patterns of the rippling water and reflections of the surface and sun. Context, motion, clarity, sound, and colour are part of the experience and perception of water that can be linked to biophilia (Kistemann & Völker, 2011). Sound of water has many different hearings, such as the delicate, soft sounds of dripping water, or the thundering roar of a big waterfall (Burmil et al., 1999, pp. 100–104). Whereas calm water is soothing to the occupant, just like the experience of the community centre in Suzhou with its water basins. The presence of water can enhance the sense of being in a safe environment. The change of sound and appearance of water can be used as an enrichment within the building and surrounding environment and can be linked to biophilia (Çağatay Seçkin, 2010, p .7). Biophilia is about the contact of humans with nature and the increased quality of life it has influence on, but also the significant positive effect on people's mental health, performance, and well-being (Kellert 2012, Browning et al., 2014). In healthcare, research has been done about the reduction of stress, improvement of illness recovery and more pain relief when patients get exposed to nature (Calabrese & Kellert, 2015). For instance, the children hospital in Melbourne, where a big aquarium is placed in a central hall. Contact of children with the aquarium and fountains resulted in a closer connection with natural systems, since the tank is home to approximately 530 fish of 32 different species that can be found within the Great Barrier Reef, Australia (figure 34) (AlShanwany, Azem, El-Ibrashy & Sabaa, 2022). This principle of using water in design, can contribute to a high-quality environment. Also, the appearance of water in a park was one of the primary elements that granted people joy, but the preference of appearance in a certain environment is different for everyone (Al-Bakry et al, 2022). The memorial fountain of Princess Diana in London is an example of using the different velocity movement and corresponding sound characteristics of water that resemble the princess' life. It flows from its highest points to a calm pool, passing swirls, bubbles, and rills, integrated into the natural slope of Hyde Park. The water is constantly refreshed from a storage tank with about 100 litres per second. (The Royal Parks 2016-2023 Head Office, n.d.). It represents the openness and humanity of Diana and is designed to attract people through using different detailed grooves and channels made of Cornish granite that radiate energy formed into an oval shape (figure 35 & 36). The memorial is popular among people as they can experience and engage with the water in different ways and is received as one of the most high-profile landscape projects (Archdaily, 2017; Gustafson Parker + Bowman, n.d.; Liudmila, 2016).



Figure 34: Aquarium in hospital. The Royal Children's Hospital Melbourne, (n.d.). Accessed on 07 January 2024, from https://www.rch.org.au/info/az_guide/Aquarium/

Figure 35 & 36: Princess Diana Memorial in Hyde Park showing the different flow patterns and human interaction (The Royal Parks 2016-2023 Head Office, n.d.).

3.4.3. Motivating stakeholders: BREEAM rules and awards

To activate stakeholders, communicating and showing the way we consume and use water is crucial. Therefore, the actions taken by the government, engineers, and architects to save water need to be visible to the eye. Water sensitive urban designs were first mostly initiated by the government as part of the policy strategy but has now gotten more attention because of the realization that water and other natural aspects are an important aspect of sense of place (Hedgcock & Mouritz, 1993). In the end, it can even establish a community identity (Vernon & Tiwari, 2009). But the typical installations like sewage pipe systems and flushing toilets are mostly hidden water systems invisible to the user's eye and cannot be changed easily. Looking more technically to the advantages of being more aware of integrating nature's smart functioning, is water reuse. Water reuse is one of the recent developments that is applied more frequently in newly developed plans. But for instance, flushing toilets have been introduced already in the nineteenth century and are still almost functioning the same to this day, using almost half of the total water consumption of the building. In the United Kingdom and Australia for each discharge nine litres of clean water goes wasted, compared to twenty litres in the United States. Nowadays, toilets using six to four litres per flush are available. This mechanical system could be optimised, like the flushing of toilets with captured rainwater. But moreover, rainwater can be used to irrigate greenhouses, toilets, washing machines and gardens after its purification. Particular notice should be paid to industrial areas where water could be contaminated by polluting substances. The degree of pollution should carefully be researched before designing and integrating collective water systems in buildings. Thus, equipment can be integrated in the water purification system that eliminate the hazardous substances. The filtering and reuse of water could destress the public sewage systems which leads to less need for large-scale purifiers, while improving the environment and climate of the city. But this water saving system ask for a more economical and sensitive attitude of the user, which can only be desired and not enforced in showing taken interventions that contribute to environmental consciousness of humans

(Parancola, 2019). Of essence to keep in mind when activating stakeholders, is the scale of the project where water management is integrated to in order to target specific groups:

- building scale from 1 – 20 inhabitants / eq. (single-family house, semi-detached house, terraced houses);
- building scale from 20 – 100 inhabitants / eq. (terraced houses, PEEP, condominiums, sports facilities, small businesses);
- urban scale from 100 – 500 inhabitants / eq. (neighborhood portions, subdivisions);
- urban scale from 500 – 1.000 inhabitants / eq. (parts of cities, small municipalities, mountain communities, water parks);
- territorial scale from 1,000 to 10,000 inhabitants / eq. (industrial areas, agricultural areas, medium-sized communities, etc.) (Parancola, 2019).

But defining target groups is not the only aspect to consider when convincing stakeholders of the integration of water in designs. The investors play a huge role when it comes to making design decisions, since it is the investment money of the client. The BREEAM-NL certification is a method that judges how sustainable buildings are according to a point system to help clients integrate sustainability in projects. Projects awarded with this certification, for example the outstanding BREEAM award, serve as a best-practice example for sustainable buildings. The score for the outstanding BREEAM-certificate needs to be higher than 85%. One of the score-points is the reuse of grey waste or rainwater to flush toilets and diminish the potable water supply. Another credit is obtained when the use of potable water to irrigate plants is reduced. The expected outcome is a higher standard in comparison to the legal minimum and free of choice for the client. Thus, once the architects and client have committed to obtaining this award, renunciation is difficult as the goal of acquiring the award was already communicated and agreed upon with the municipality, leading to a certain expectation. In an interview with ORANGE Architects, architects of residential JONAS building, pointed out that BREEAM was of huge influence when it comes to making decisions regarding the integration of water systems in a building. Normally, water management is not the highest ambition of the investor as it is does not generate profit, but because it is a crucial part of receiving an award it becomes a high-priority element to integrate in a design. It becomes clear that both the municipality and certain feasible certifications determine the success of a project, because of the requirements imposed, which work as a motivating factor to become more sustainable (BREEAM, n.d.-a; n.d.-b; n.d.-c).

IV. CONCLUSION

In a world, where water scarcity and water floodings are becoming more frequent due to climate change, it asks for a different design approach where we invite water in our buildings and living environment. This can help strengthen the sponginess of a city and can combat the water problems by capturing or releasing water when needed. Governments, engineers, and designers are already trying to prioritize the integration of water sustainable management and systems, as they understand the flood risks and therefore the necessity of becoming more sustainable. However, these intervention systems are difficult to understand for other actors due to lack of knowledge. Moreover, lack of knowledge is also present on a psychological level. Water has natural characteristics that can enhance our well-being, which can be integrated into buildings, known as biophilic and biomimetic design strategies. Meanwhile, our current indoor climate leads to depression and stress. Therefore, the importance of the presence of water in our everyday life needs to be communicated in a visual and easy-to-understand explanation for everyone, looking at the opportunities water has to offer. A complex challenge for architects and city planners, since understanding needs to be created among all stakeholders, including investors who have the money capacity to invest in water sensitive designs. But biomimicry and biophilia are noticeable changes are visual interventions that could lead to a better understanding of the importance of water integrations in our cities. The following research question helped forming an answer for this complex design approach:

"How can the qualities and potentials of natural water cycles be embedded in our current city structure to connect water, nature, and buildings on different scales by translating research about biomimicry, biophilia and water sensitive design interventions into a design approach for an existing area?"

By letting people engage, understanding of the taken climate policies and interventions is formed. To reach this goal, a guideline was created, separating the complexity of water sensitive designs into smaller steps was created divided over three scales: the landscape scale, the urbans square scale and social building scale. The landscape scale shows that understanding of the natural water cycle, means understanding the water flow system on a bigger scale, like indicating flood risks of the city and the waterfront type the site is located in. An example approach for London was used, whereby the Thames is of great influence of the future existing of the city if the water level will rise. The government of the city has developed strategies for the maintenance regarding the water protection of the city, which are important to consider when proposing a water sensitive design. Sometimes a different suggestion can be proposed, because these strategies can be the common technical intervention types that do not stimulate a different design-thinking approach, like for example the heightening of the embankment with 1m in London. By showing new possibilities of building next to the waterfront a different view for water management can be developed.

To determine what the intervention types to apply, its successes were tested and compared according to the health and well-being effects, the involvement of stakeholders, as well as the social interactivity of the water interventions. A water resilient testing framework was created to test eight best-practice projects based on the already develop strategies. Most of the strategies and technical interventions are developed, but still need to be put into practice. Identified were waterfront types, sustainable urban drainage systems (SuDS) and green infrastructure (GI) according to the LiFE toolkit, and finally the social interaction and appreciation factor of the project among visitors and locals. To have a wide scope of projects, four project typologies were selected, each located in a different waterfront type. The typologies were as followed: place and community; parcs and squares; buildings and streets; and housing. According to the best-practice analysis framework mostly applied to place and community projects were inviting calm waters promoting relaxation. An improved water quality led to new initiatives among locals. The waterfront had become an extension of the public realm, which was not possible earlier due to contamination of the water close to industrial areas in harbour waterfronts.

In the parcs and squares typology a different approach was used, combining water storage with educative activities about water management. By creating understanding more appreciation for the interventions is reached. Buildings and streets typologies are more closely connected to a buildings' interior. Rainwater harvesting and green roofs were the most applied intervention types, making the realisation of a communal garden with an irrigation system from rainwater possible. The communal garden then stimulates social interaction among different age groups. Bigger housing projects could integrate landscape design better within the building, which has led to an improvement of the micro-climate as the water's qualities used to cool and filter air, while creating a visual interesting reflection in interior spaces.

It turned out that the transformation of an existing grey area suffering from floods are appreciated through the interaction with water that is created, but also because of the involvement of all stakeholders during the design process to create even better understanding and integrate their desires. The understanding is also partly created through the own experience the visitors now have with the water. Water evokes multiple emotions, because of the different patterns and characteristics it communicates. For example, the purification of air, the sound of streaming water, the cooling effects, and its reflective changing appearance. But therefore, the applied systems, especially in buildings need to be shown visually, as most of the systems are hidden from the user of the building. Therefore, a more sensitive attitude of the user can only be reached if users are aware of the sustainable water systems within the building. Involving people in the design process can lead to a better engagement of humans with water, which leads to a better understanding of the water systems and necessity to become more sustainable, specifically focusing on our everyday water consumption. Other stakeholders mostly get motivated when certifications awards as BREEAM are involved, because they work as a motivating factor to receive prices. Of course, the essence of why to integrate water sensitive systems is of greater importance, but it functions as an extra stimulator. On a smaller social scale, the necessity of raising sustainable awareness needs to be addressed to motivate multiple stakeholders like the municipality, inhabitants, and investors, to contribute to the collective water management system, reached by letting people engage more with water. Biophilic and biomimetic design principles hereby function as visual translator and communicator. By showing people the outcomes, it activates them to want to participate in realizing sustainable solutions, resulting in communities that exchange ideas and knowledge. The design focus is then related to both indoor and outdoor and tries to create a connection between the two spheres, by means of a multifunctional building that connects private and public spaces through water sensitive projects. In the end, the building should become an example for future projects regarding the design of water sensitive buildings and cities and create water conscious communities.

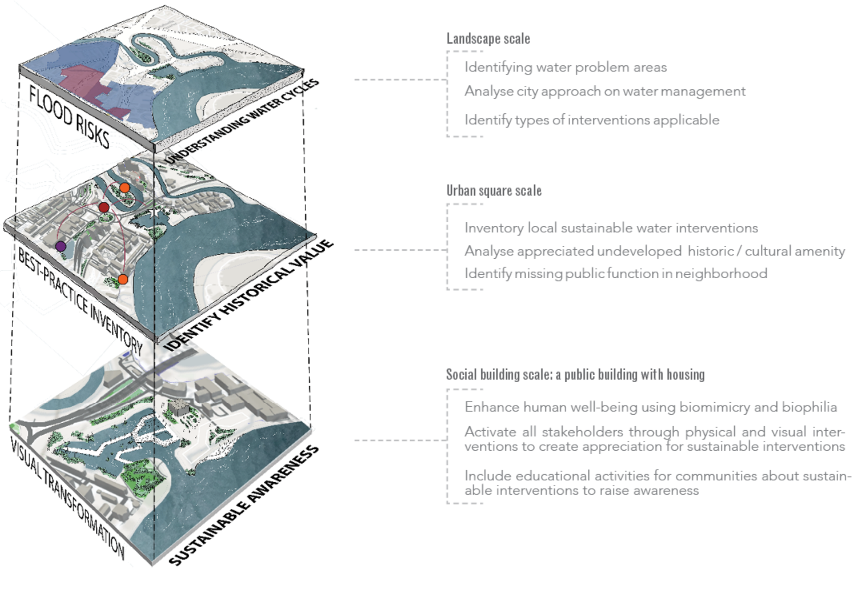


Figure 37: Research design guideline: connecting scales with water sensitive designs (image by author)

V. DISCUSSION

The research has covered many aspects, as focus was put on multiple interconnected scales. However, the choice for best-practice analysis could be mor extensive. There are way more possibilities regarding the integration of water sensitive interventions. As understanding among all stakeholders needs to be reached in order to create water sensitive designs, the essence of why to become sustainable needs to be communicated clearly. Not all stakeholders prioritize creating places that enhance our well-being above their profit. Therefore, certifications and awards that can be received are a bit misleading. They might be a motivating factor to reach sustainable goals, but it is not the desired way of thinking about sustainability that should be reached. Rethinking these certifications is of essence, since projects awarded with these certifications serve as an example for future projects. By adding more quality requirements, a higher sustainability factor is reached. Only, the question that occurs is how to show the essence on why to invest more in well-being enhancing elements. Moreover, to create an integrated water design approach, architects and landscape architects will have to work closely together, which is not very common in today's design process, as they mostly work past each other. The integration of the landscape and architectural designs is something that could not be further researched but is of great importance to propose a well-considered water sensitive design approach that fits within the multiple scales of the landscape scale, urban square scale and social building scale.

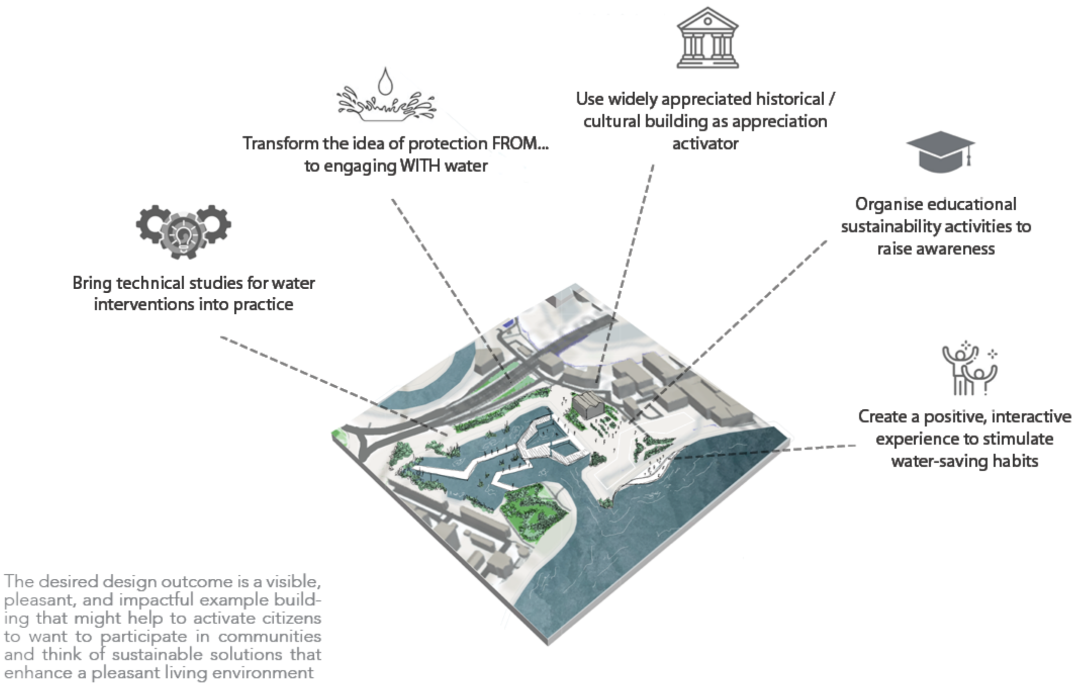


Figure 38: Desired design approach that leads to understanding of water principles (image by author)

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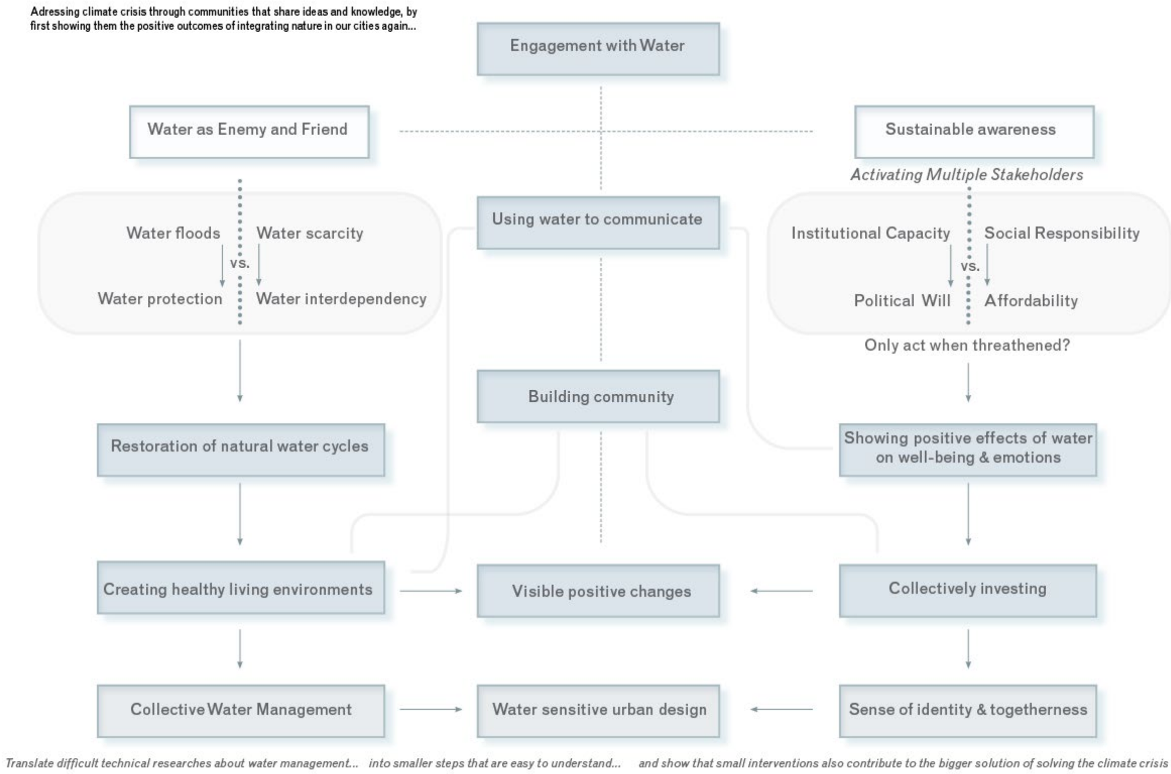
APPENDICES

APPENDIX A

Interconnected systems diagram explaining how engagement with water can be reached through design.

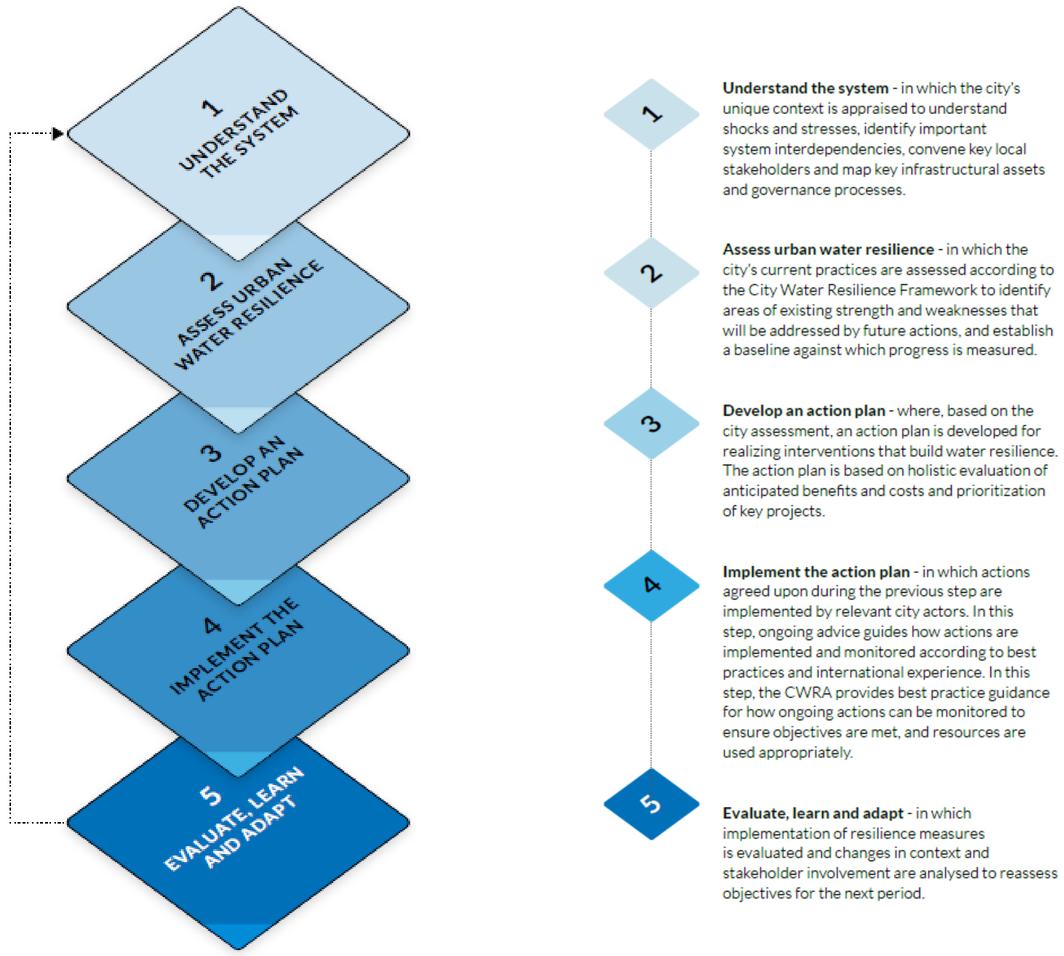


Using water as a medium to connect humans, nature and the built environment

Already, many studies about integrating water systems into our city structure have been conducted, but still need to be brought into practice. On a bigger urban and landscape scale, the floods and droughts need to be tackled by restoring the natural water cycles. Water sensitive urban designs will lead to fewer risks in the currently designated flood areas. This might be doable, as the city already has a natural sponge function and only small interventions will be needed to put into motion. On a smaller social scale, the necessity of raising sustainable awareness needs to be addressed to motivate multiple stakeholders like the municipality, inhabitants, and investors, to contribute to the collective water management system (ARUP, n.d.). Showing them the positive outcomes of implementing water in our city structure leading to a healthier living environment, it activates them to want to participate in realizing sustainable solutions, resulting in communities that exchange ideas and knowledge. Water will be the guiding theme that connects humans, nature, and buildings since water can help to enhance our health and enrich our environment in a positive, interactive, and mainly visual way. In the end, the building should become an example for future projects regarding the design of water sensitive buildings and cities.

Appendix B

City Water Resilience Approach (CWRA) by ARUP (CWRA Steering Group, 2019)

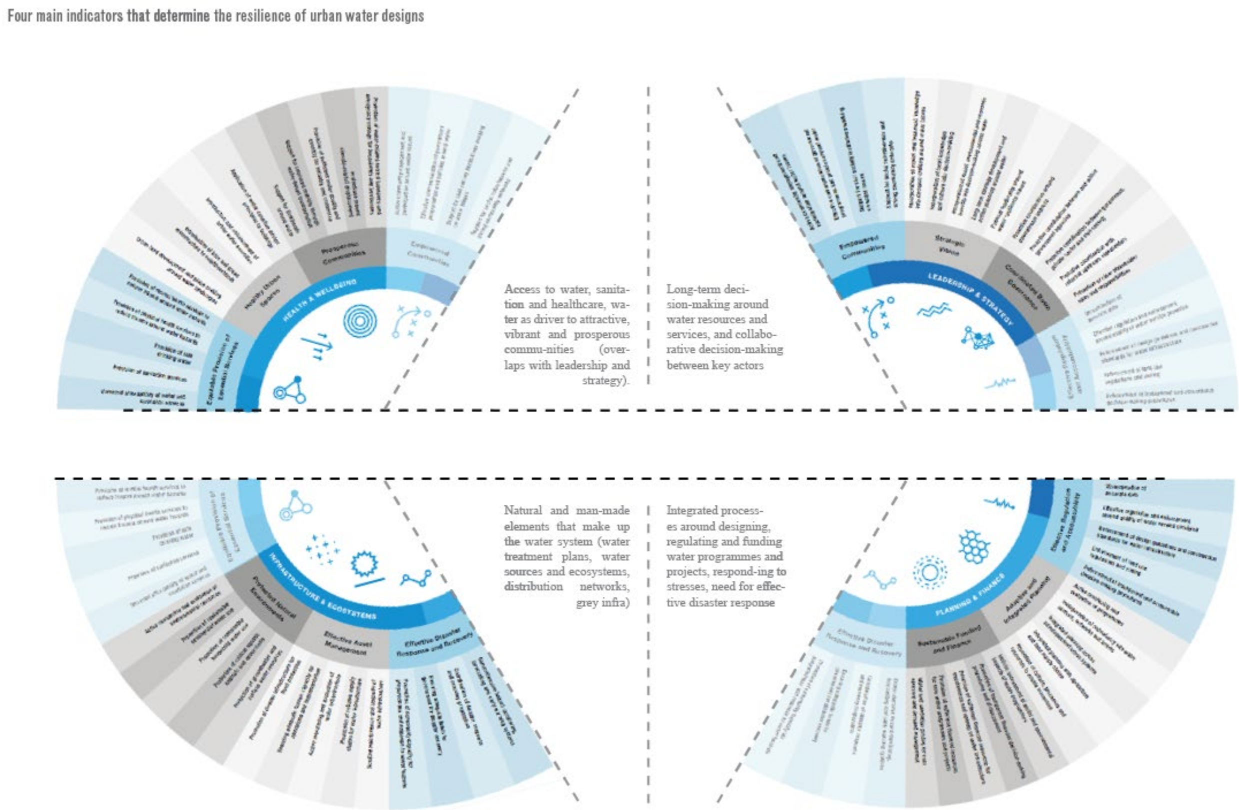


The five steps of creating water resilient projects according to ARUP that focusses more specifically on informing actors and help them form visions from bigger to smaller scales.

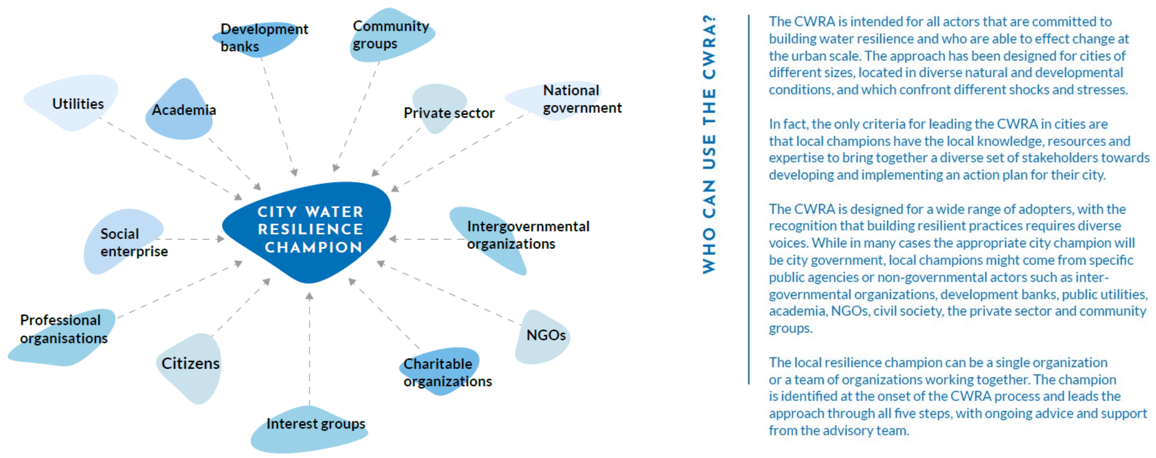
A roadmap developed by ARUP mainly focuses on informing leaders and citizens about water issues and how to find executable interventions that also cover economic and social challenges. To help prepare for the changing use and demand of the water supply and improve the outcomes for citizens living in a safe and healthy water system city. Moreover, it focusses on protecting citizens from water hazards through the creation of water resilience (CWRA Steering Group, 2019).

APPENDIX B1

City Water Resilience Approach (CWRA) by ARUP (CWRA Steering Group, 2019).



Explanatory diagram of the four factors to keep in mind when designing water resilience according to ARUP.



APPENDIX B2

Design With Water 2.0 (DWW) by ARUP (Simpkins, 2024).

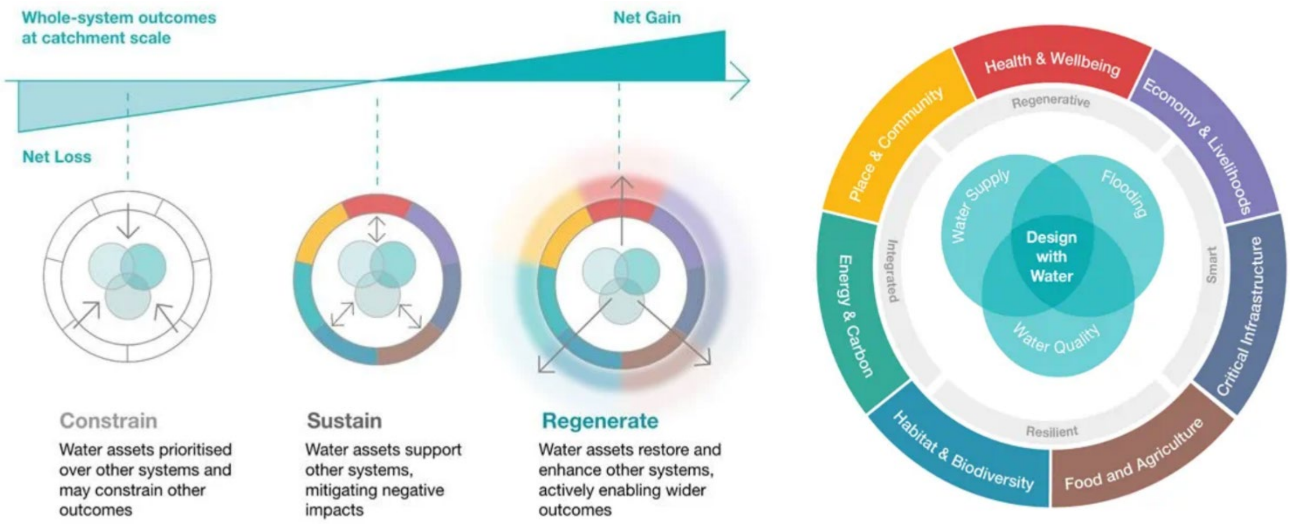


Diagram of the framework Design With Water consisting of four pin points that are part of the approach, namely an whole-system approach that binds together technical and non-technical disciplines (integrated) and combines technological, social and cultural innovations (smart). It is developed to build water resilience and support all stakeholders when necessary (resilient). And finally, the principle of regenerative design that improves and enhances existing systems and structures (regenerative).
An increase of the resilience, well-being of humans and restoring natural systems stands central. The strategy is a starting point for accommodating different user-needs, resources, and project context and thus a bit more detailed scale. But moreover, also helps communities to create a better experience with water (Simpkins, 2024).

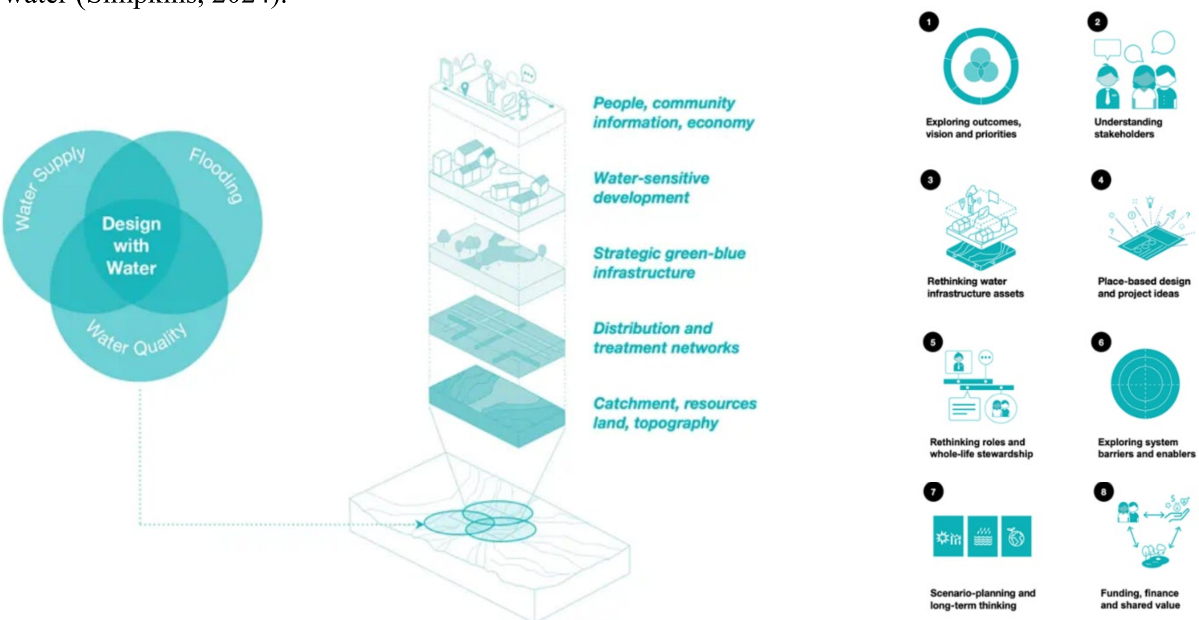
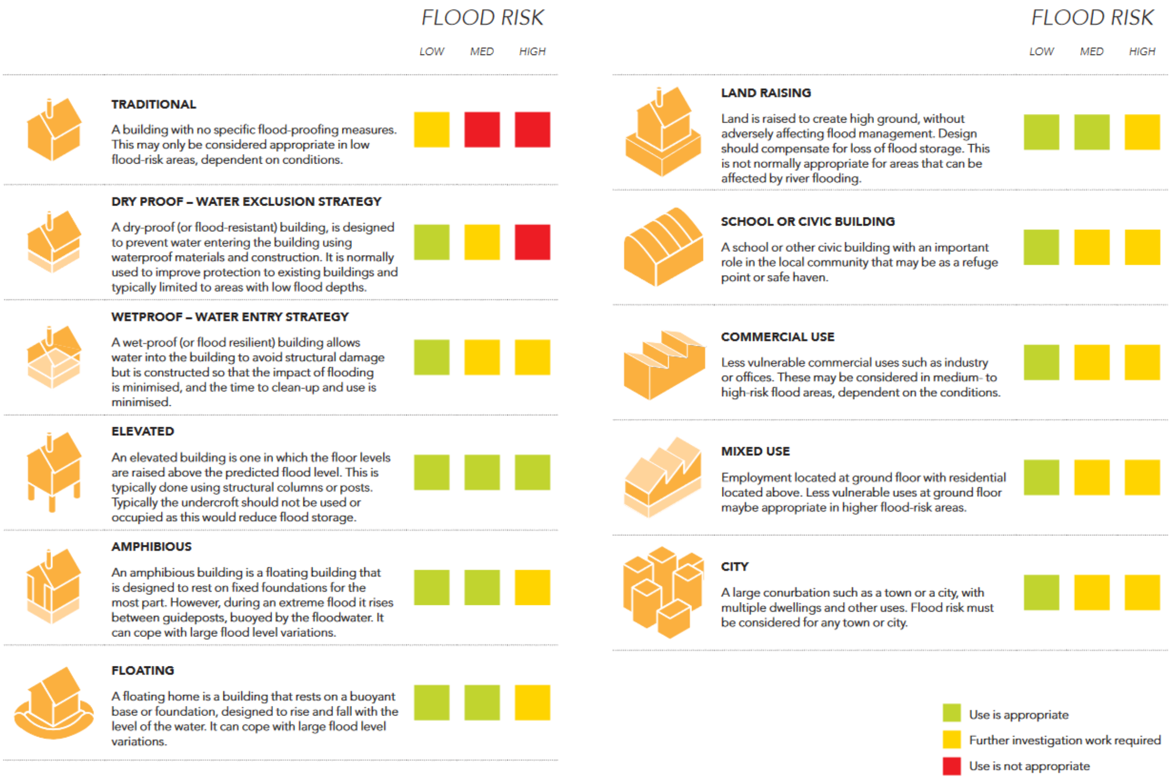


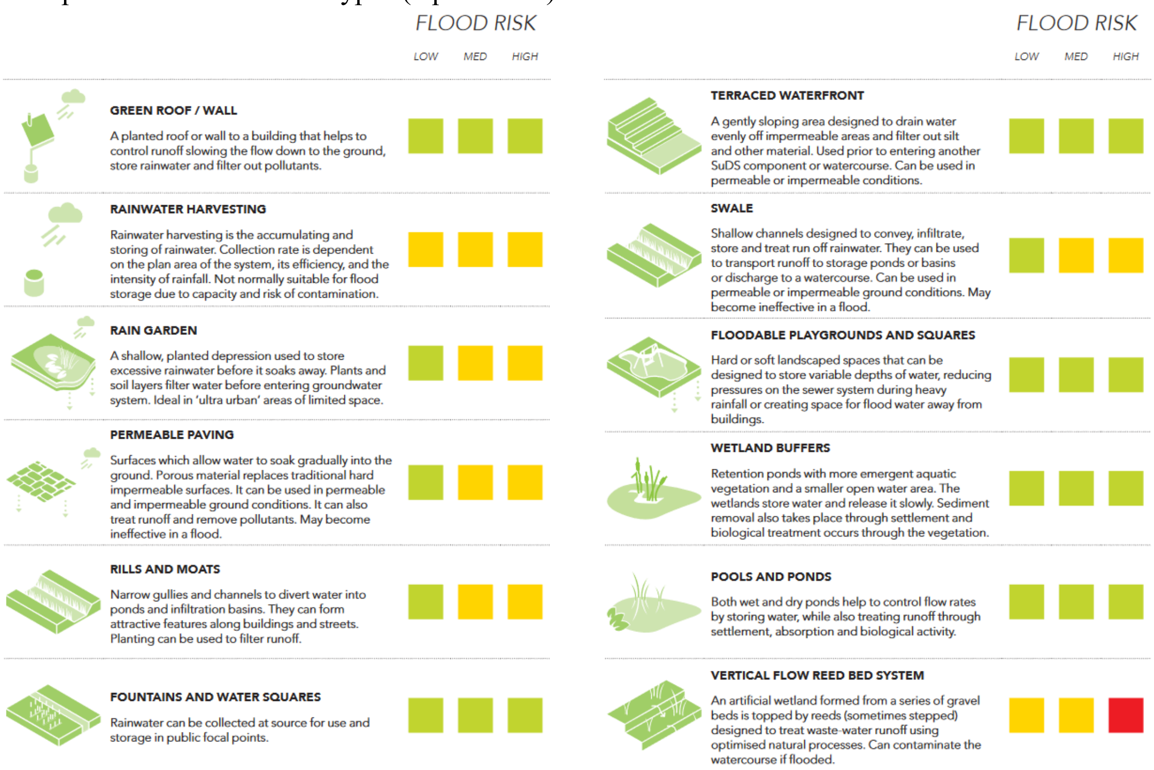
Diagram of how building water resilience helps to improve the water quality and water supply, but decreases flood risks, which affects multiple scales and sectors.

APPENDIX C

Long-term Initiatives for Flood-risk Environments (LiFE) by Barker & Coutts (2016).



Look-up table of construction types (aquatecture)



Look-up table of sustainable urban drainage systems

APPENDIX C1

Long-term Initiatives for Flood-risk Environments (LiFE) by Barker & Coutts (2016)

Intervention	Description	Flood risk: Low	Flood risk: Med	Flood risk: High
URBAN FLOOD STORAGE	Urban components such as car parks and roads can be designed to store excess rain or river water.	Use is appropriate (green)	Use is appropriate (green)	Further investigation work required (yellow)
FLOOD PARKS	Parks that serve as flood storage areas, often combined with inflow gates, flow controls, and filtration systems.	Use is appropriate (green)	Use is appropriate (green)	Use is appropriate (green)
ARTIFICIAL BASINS	Depressions that detain, retain or infiltrate water. A detention basin is a dry pond that temporarily stores water releasing at a controlled rate. A retention basin includes a permanent pool of water, which also improves water quality. An infiltration basin retains storm water that is then slowly released through permeable soils to groundwater.	Use is appropriate (green)	Use is appropriate (green)	Use is appropriate (green)
WATER MEADOWS, LAKES, RESERVOIRS	Artificial lakes and reservoirs designed to retain freshwater supply. Sluices and control devices manage runoff rates and can be linked to power generation.	Use is appropriate (green)	Use is appropriate (green)	Use is appropriate (green)
CITY WETLANDS FLOODPLAIN	Wetlands can play an important part in the city, often helping to manage secondary water courses. Deculverting rivers can help to increase capacity and reduce runoff.	Use is appropriate (green)	Use is appropriate (green)	Use is appropriate (green)
WET WOODLANDS	Regeneration of woodlands in the upper catchment of the river can retain and slow runoff rates. Beavers naturally create this landscape.	Use is appropriate (green)	Use is appropriate (green)	Use is appropriate (green)
MANAGED RETREAT	Coastal defences are removed or relocated inland to allow the sea into sacrificial areas, reducing pressure on defences particularly in high impact areas.	Use is appropriate (green)	Use is appropriate (green)	Use is appropriate (green)
MANGROVES AND REEF REGENERATION	Artificial reefs, made from old boat hulls or concrete formers can provide offshore wave energy reduction and protect juvenile mangrove growth from waves.	Use is appropriate (green)	Use is appropriate (green)	Use is appropriate (green)
FLOOD RELIEF CHANNELS	Artificial channels designed to divert water from one part of a river to another during periods of high river flows, away from major settlements. Naturalistic or artificial.	Use is appropriate (green)	Use is appropriate (green)	Use is appropriate (green)

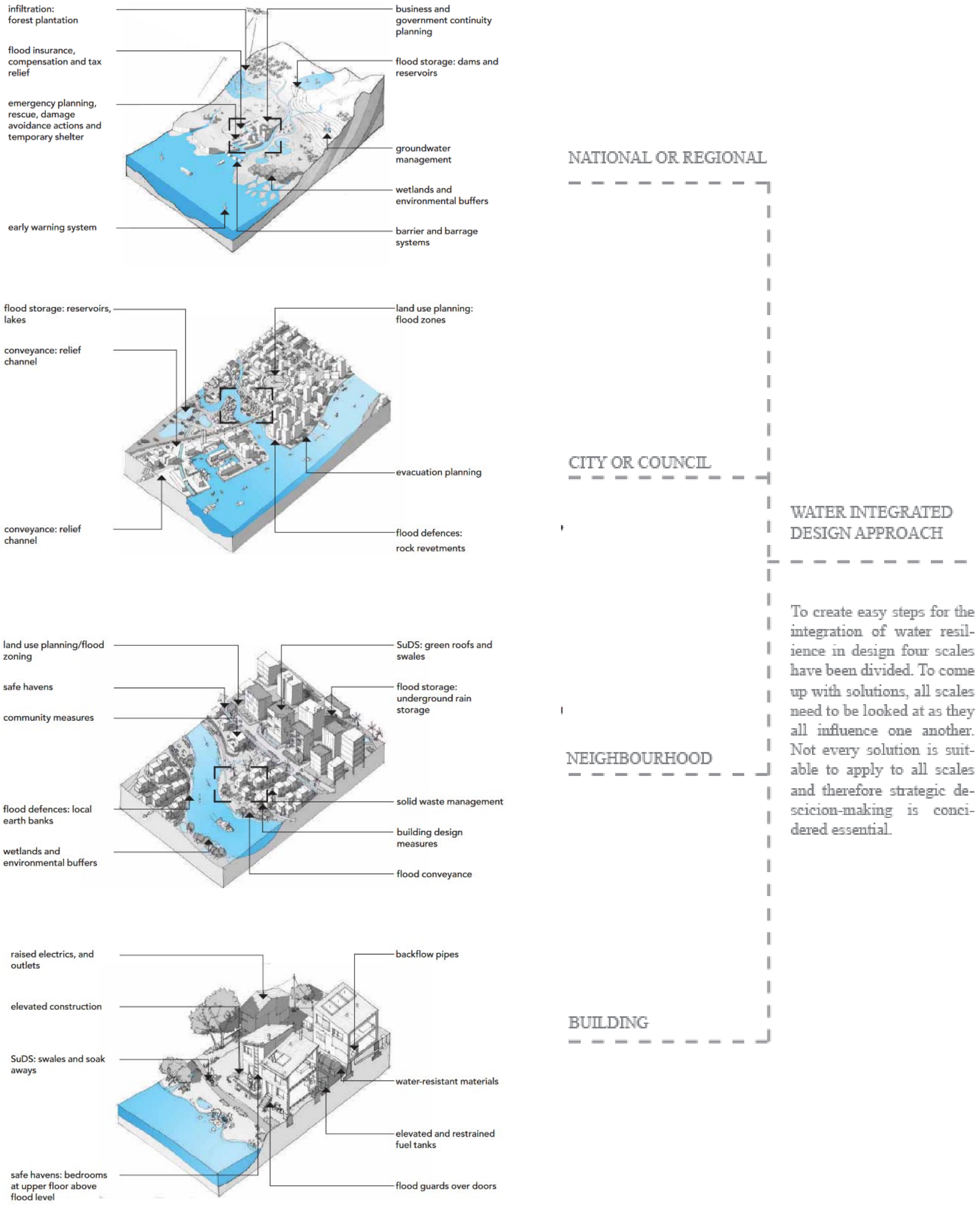
- Green: Use is appropriate
- Yellow: Further investigation work required
- Red: Use is not appropriate

Look-up table of landscape sustainable drainage systems

Overview of look-up table of possible intervention types that are part of the LiFE-toolkit to work towards flood-resilience in communities. The toolkit helps to develop plans for the local government. The tables provide guidance and sort out the possibilities of what intervention type can be applied to a location, divided in the subjects: planning; sustainable drainage options (landscape); renewable power options (infrastructure); where to plan safe routes; and the type of construction and where to use (Barker & Coutts, 2016).

APPENDIX C2

Long-term Initiatives for Flood-risk Environments (LiFE) by Barker & Coutts (2016).



Division of different scales to focus on regarding the integration of sustainable drainage systems or water management.

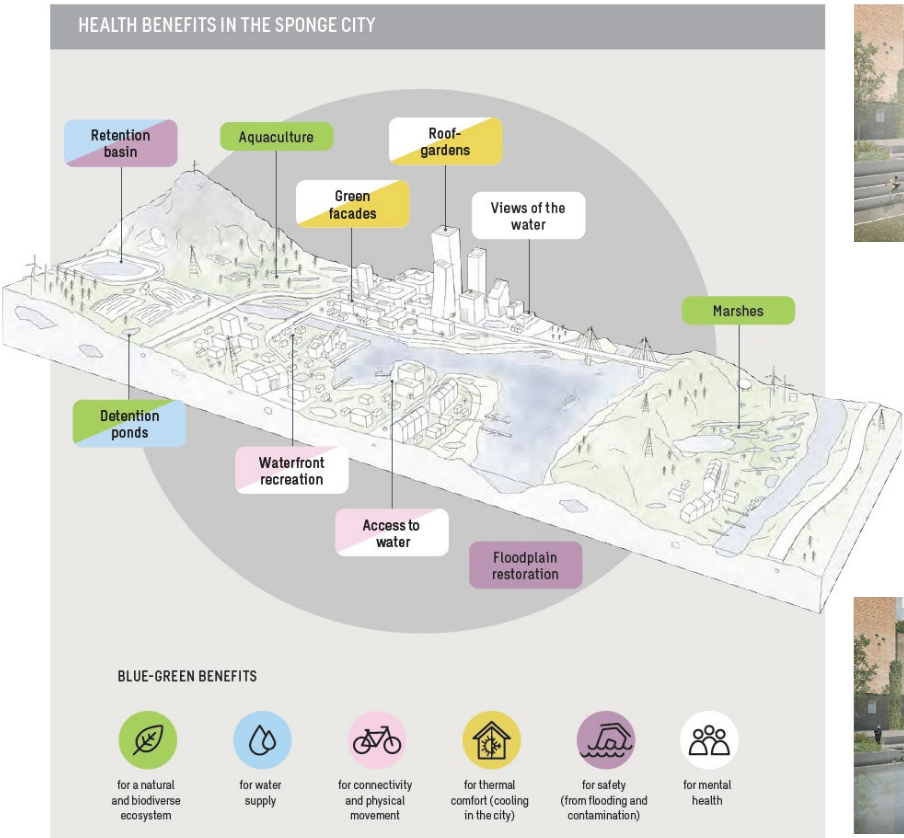
APPENDIX C3

Summary overview successful waterfront planning according to Barker & Coutts (2016).

	Flood-risk measures	Activity	Public realm	Buildings	Landscape	Uses
Rivers	Conserve natural conveyance paths within the floodplain.	Transport, boating, leisure, recreation, wildlife.	Generous public space with accessible river fronts.	Should avoid conveyance zones, or where necessary not impede flows.	Establish, or conserve and enhance riparian habitat and wildlife corridors.	Mixed-use.
Lakes and reservoirs	Avoidance or flood resilience to residual risk.	Leisure, recreation and wildlife.	Public spaces at strategic points with connecting pathways.	Can support a range of densities with space between buildings. Visual impact within landscape important.	Establish, or conserve and enhance woodland or forestry.	Residential and leisure.
Canals	Protection and maintenance of infrastructure and network.	Transport and moorings, wildlife, leisure and recreation.	Spaces between buildings or waterside pathways. Allow for dense mooring and access points.	Up to the water's edge or set behind public walkways.	Establish or conserve and enhance wildlife corridors that run parallel to the canal network.	Private with interspersed semi-public buildings.
Harbours and marinas	Protection and resilience.	Transport and mooring, industry, termini, boating, fishing.	Public promenades and walkways balanced with secure moorings.	Up to and over waterfronts, often with tall buildings.	Landscaping opportunities along promenades, squares, and roofs of buildings.	Mixture of commercial and leisure.
Disused docks, wharfs and quays	Protection of surrounding structural defences.	Boating, sports, floating development.	A mixture of scales, often with shared surfaces. Public promenades and access to water.	Up to, and on occasion in, the water. Disused docks can sustain dense development due to their scale.	Often limited opportunity for soft landscaping. Floating landscape an option.	Mixture of commercial and residential.
Coasts and deltas	Avoidance and protection.	Industry, transport and mooring, industry, termini, recreational.	Generous and mixed. Opportunity for multi-functional civic spaces for large events.	Set back with regular gaps in between.	Urban sites can be multi-functional. Rural sites can utilise landscape as storm buffer.	Public and recreational.

APPENDIX D

Urban Insight Report: Healthy Water Cities by SWECO (Raes & Savolainen, 2021).

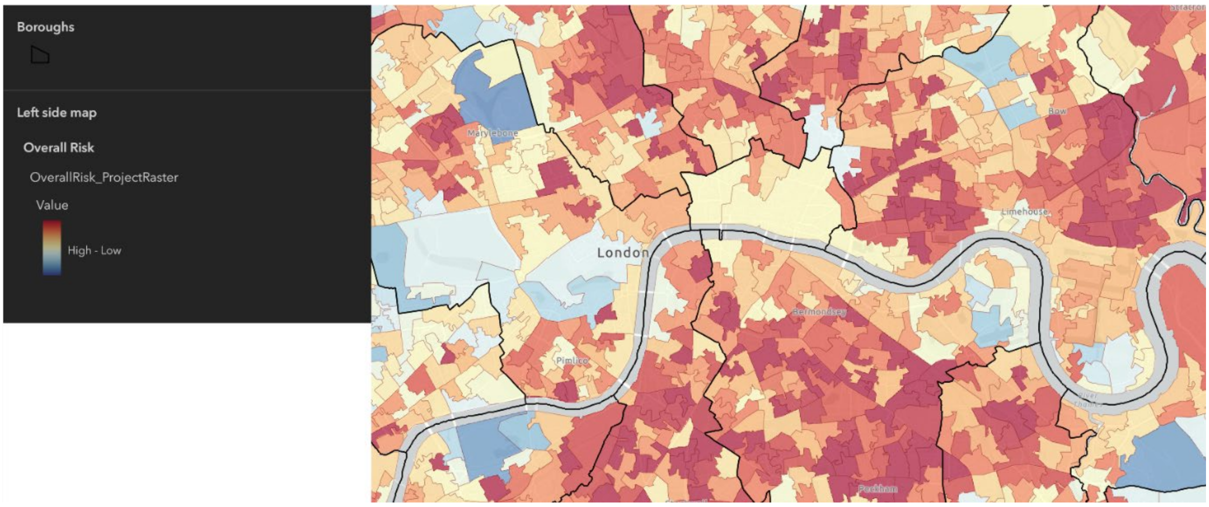


Visualisation of creating sponge cities that can absorb and release water when needed. To support this, three strategies have been developed by SWECO, focussing on restoring space for water and people; reintroducing nature in cities; and reduce, reuse and purify wastewater. The left-over space to develop such areas is limited, and therefore the current city structures need to be transformed and have to include sustainable water systems. Functions need to be combined, like rainwater harvesting on accessible rooftops, or urban furniture that can function as rainwater tanks, or squares that capture heavy rainfall during storms and form retention basins (Raes & Savolainen, 2021).

APPENDIX E

Flood risk exposure and vulnerability analysis regarding climate change in Greater London (Bloomberg Associates & Greater London Authority, 2023).

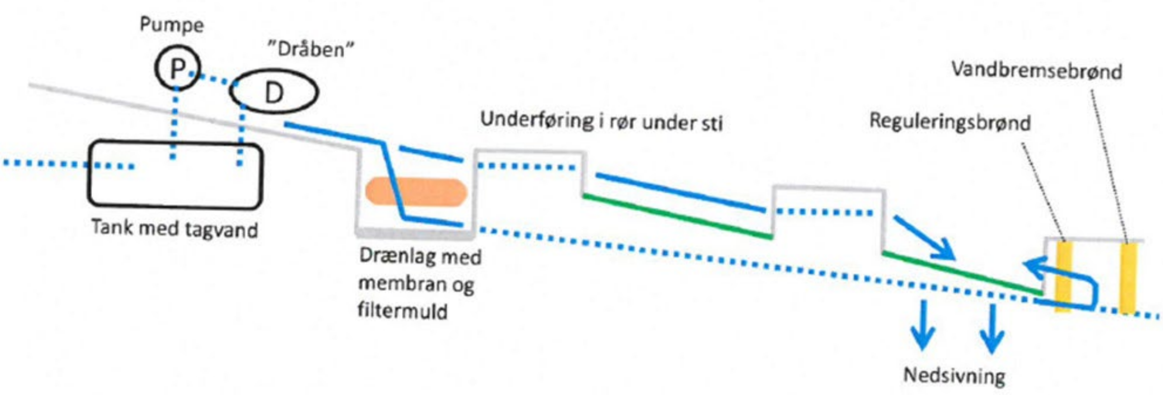
Flood risk analysis of London that can be used as overlay on top of each other to indicate the climate risk and vulnerable spots that need strenghening.



Overall Risk Map combining multiple risk maps based on their vulnerability

APPENDIX F

Water System of Tasigne Plads showing the waterflow through multiple water reservoirs



DNNK. (n.d.). Tasinge Square. Accessed on 23 November 2023, from https://www.dnnk.dk/taasinge-square-eng/

APPENDIX G

Historical vacant building flood hazard analysis using Greater London Authority Climate Risk Map

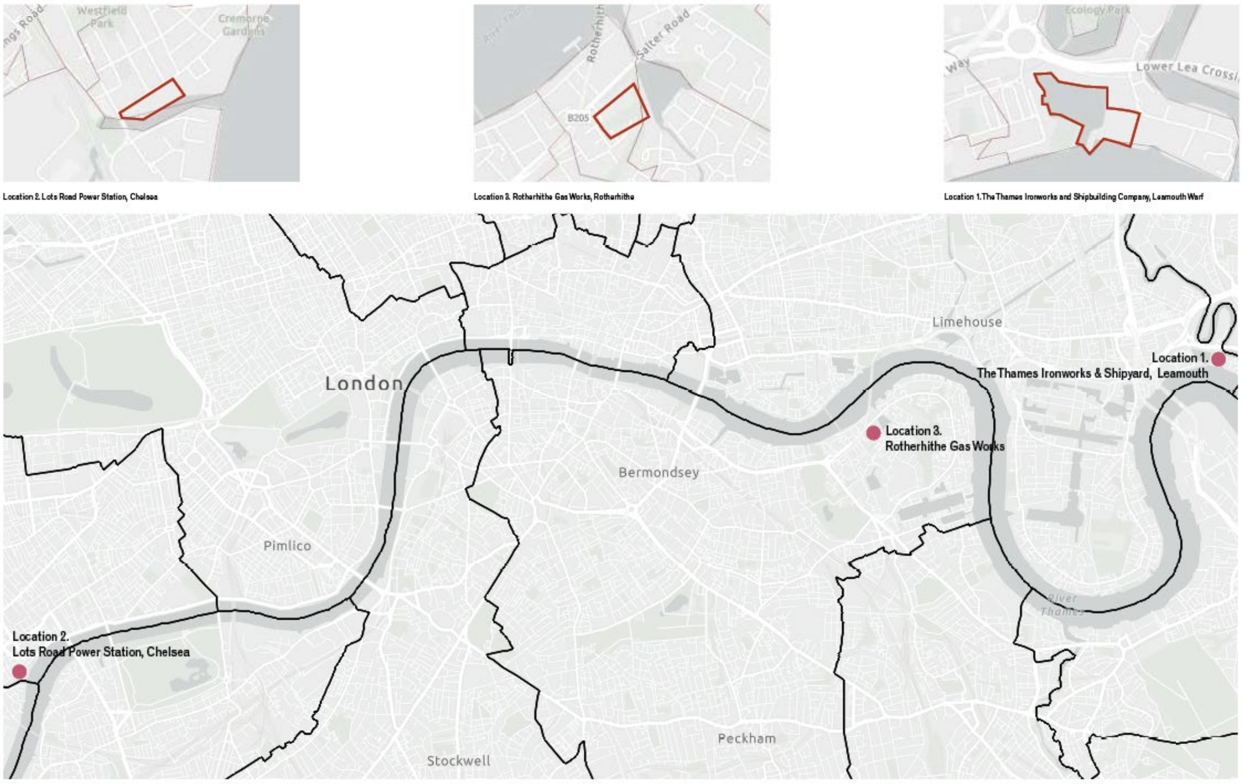
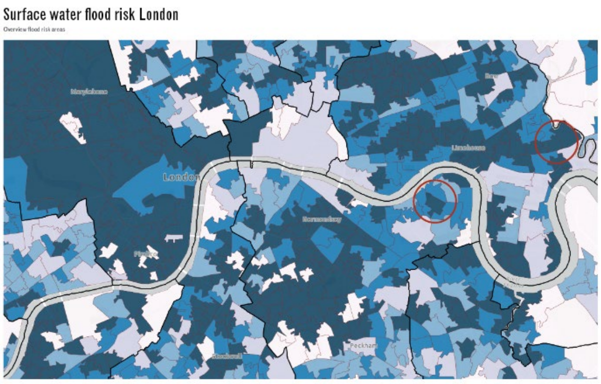


Figure 1: Location selection historic valued buildings London suffering from flood risks



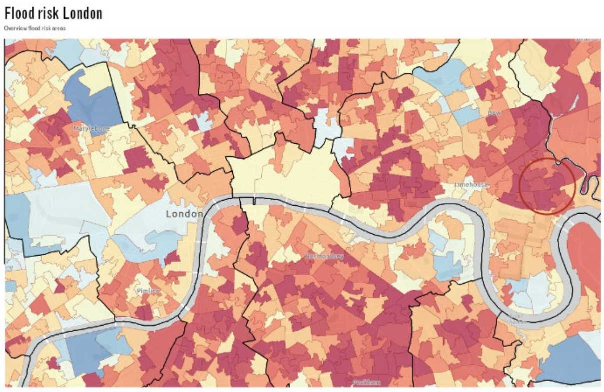
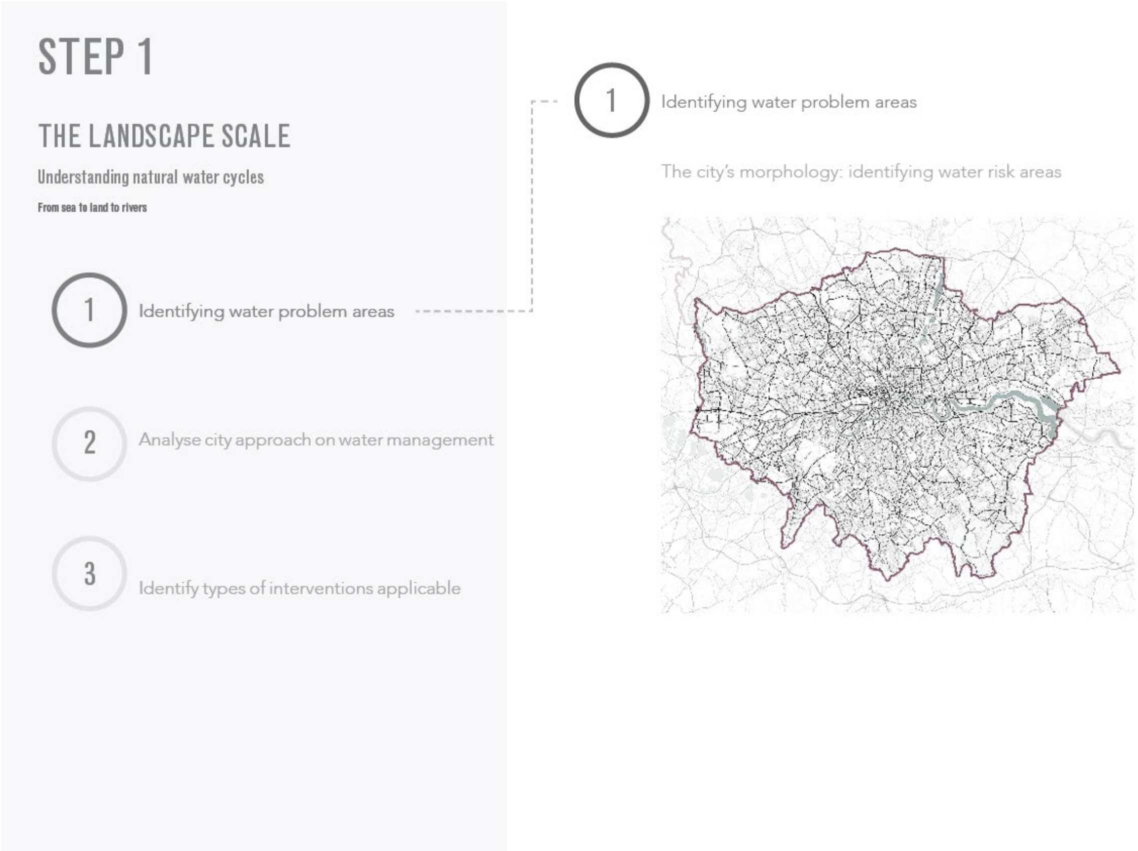
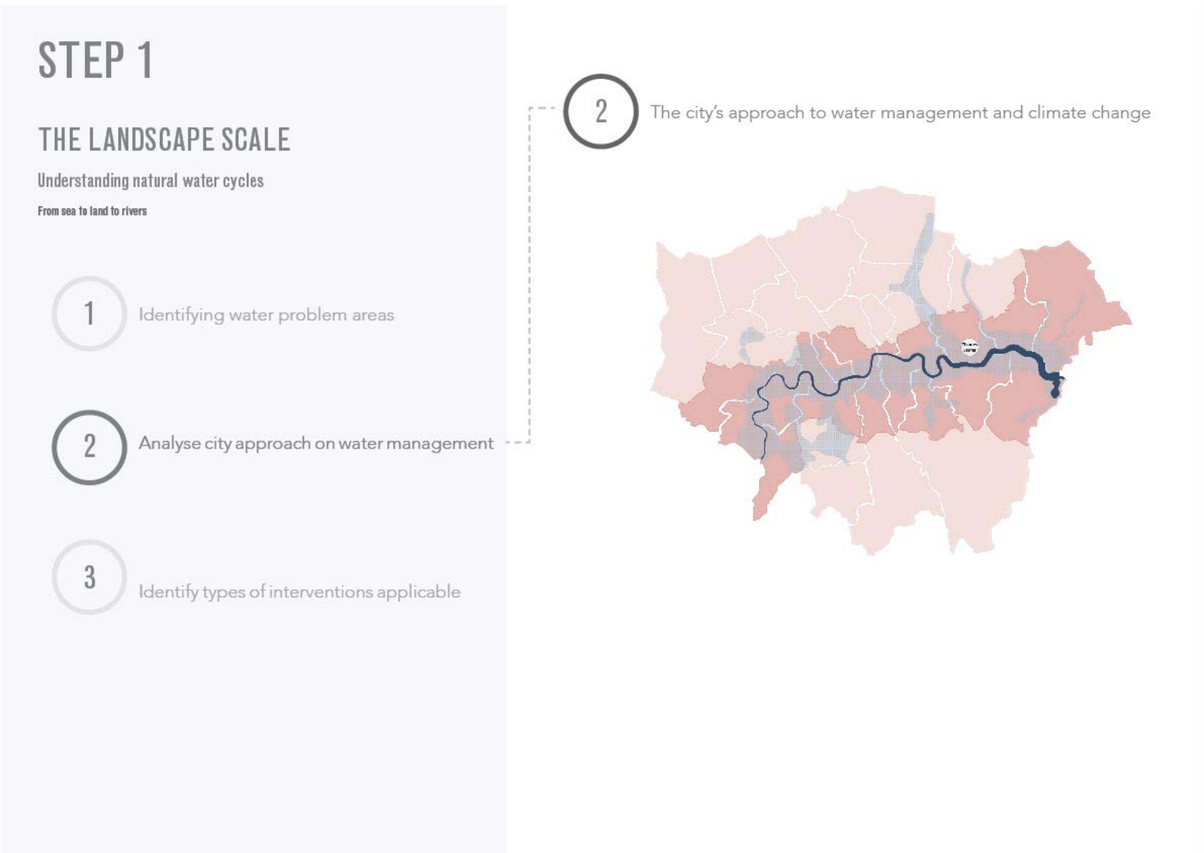


Figure 2 & 3: Flood risk analysis of surface water and overall flood risk; 3 sites comparison (Greater London Authority & Bloomberg Association, 2023).

APPENDIX H

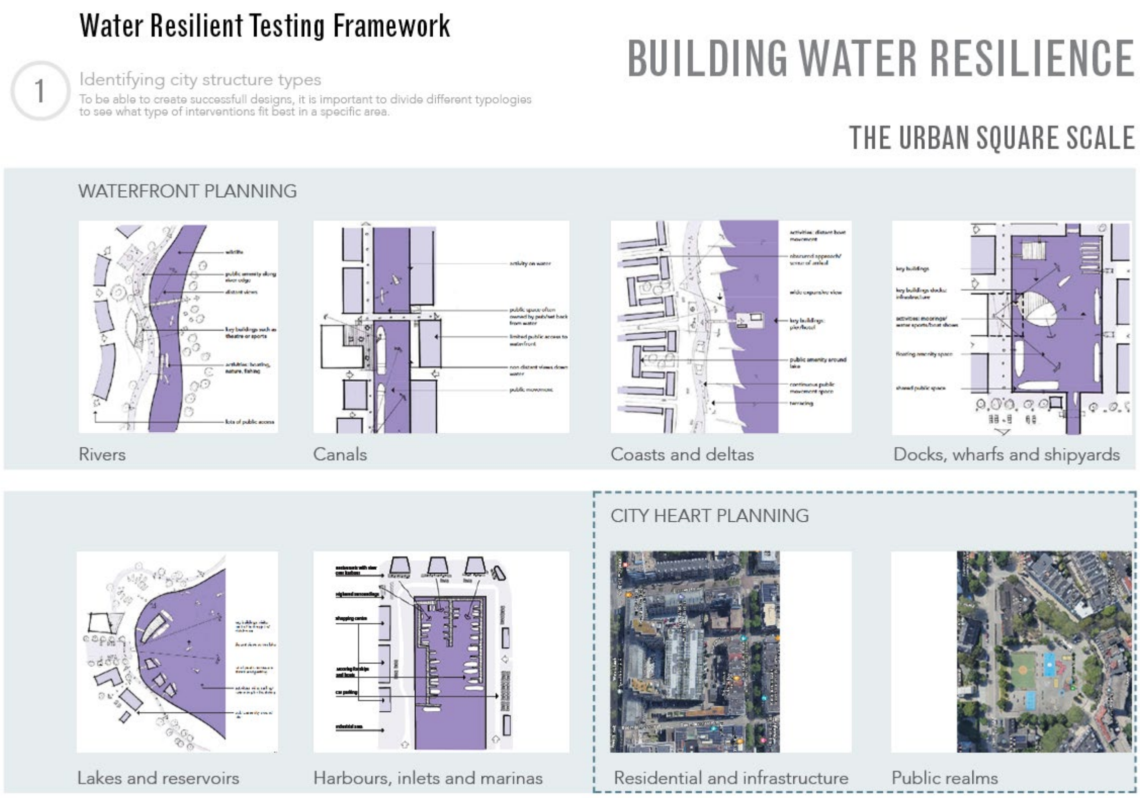
Design approach guideline steps landscape scale (images by author)





APPENDIX H1

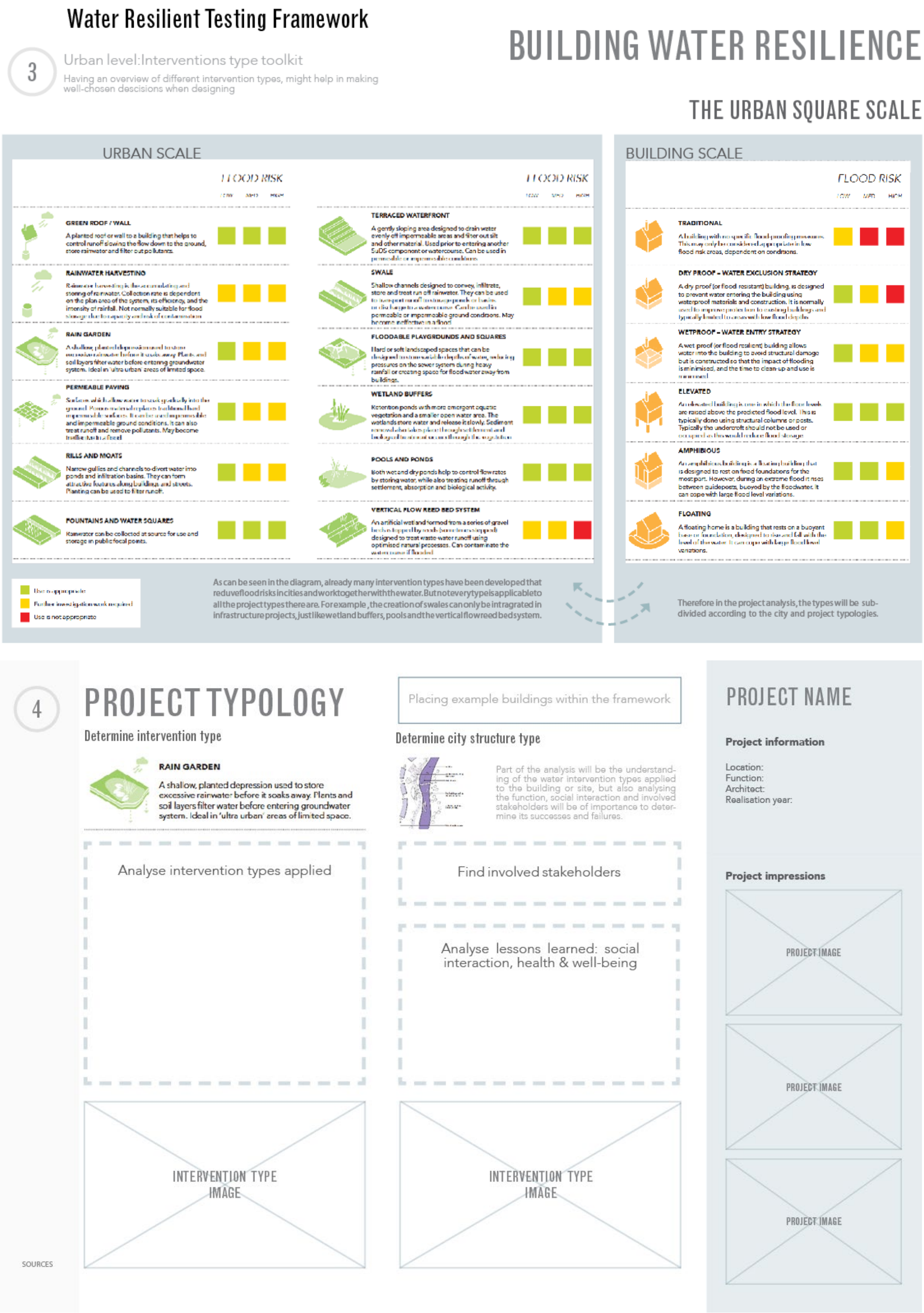
Design approach guideline steps urban square scale (images by author)



Waterfront and project typology selection for the water resilient testing framework (image by author)

Appendix H2

Design approach guideline steps urban square scale (images by author)

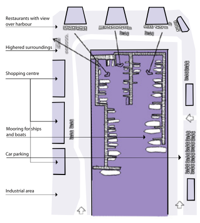
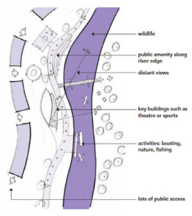
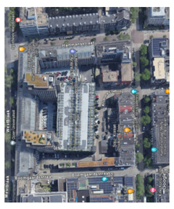
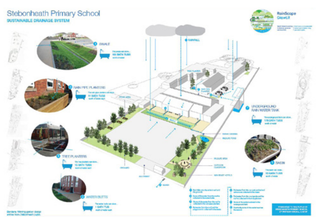
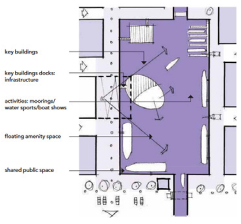
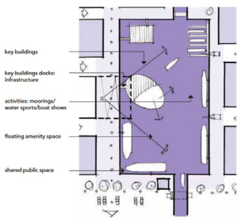


Interventions types and best-parctice framework for the water resilient testing framework (image by author).

APPENDIX I

Best-practice analysis scheme according to the four defined typologies tested with the water resilient research Framework based on the theories of appendix ... (image by author)

Water Resilient Testing Framework

PROJECT	WATERFRONT TYPE	INTERVENTIONS APPLIED	LIFE TOOLKIT INTERVENTIONTYPES	SOCIAL SUCCESS	
HARBOUR BATHS Location: Aarhus & Copenhagen, Denmark Mission of municipality involving al types of age groups	Harbour 	Floating harbour bath with retaining-wall with biofilter 	Biomimetric elements: high and low tides process **FLOATING** A floating home is a building that rests on a buoyant base or foundation, designed to rise and fall with the level of the water. It can cope with large flood level variations.	Lessons learned: social interaction, health and well-being - Clean harbour water leads to new initiatives by locals including moving activities as sports like kayaking - Biomimicry: using natural processes that show how nature's qualities can be used in our advantage	**PLACE & COMMUNITY**
COMMUNITY CENTRE Location: Suzhou, China Mission of municipality involving al types of age groups	River 	Rainwater harvesting for water basin 	**RAIN GARDEN** A shallow, planted depression used to store excessive rainwater before it soaks away. Plants and soil layers filter water before entering groundwater system. Ideal in 'ultra urban' areas of limited space. **RAINWATER HARVESTING** Rainwater harvesting is the accumulating and storing of rainwater. Collection rate is dependent on the plan area of the system, its efficiency, and the intensity of rainfall. Not normally suitable for flood storage due to capacity and risk of contamination.	Lessons learned: social interaction, health and well-being - Still water causes reflection and promotes peace and relaxation - Water basin gets multifunctional purpose as water source for plants and psychological relaxation element - Biophilic elements: water to enhance well-being	
WATER SQUARE Location: Copenhagen, Denmark Mission was to remove the parking lot and replace it with multi-functional square	Public Realm 	Artificial creek to enrich square 	**FLOODABLE PLAYGROUNDS AND SQUARES** Hard or soft landscaped spaces that can be designed to store variable depths of water, reducing pressures on the sewer system during heavy rainfall or creating space for flood water away from buildings. **FOUNTAINS AND WATER SQUARES** Rainwater can be collected at source for use and storage in public focal points.	Lessons learned: social interaction, health and well-being - Rainfall has a positive influence as it enriches the quite grey sqaure during drier periods - Children actively use the creek to play (water visual pleasing element) - Biomimcry: Using the qualities of an artificial creek to guide water	**PARCS & SQUARES**
EDUCATIVE SQUARE Location: Copenhagen, Denmark Investment area to revitalize urban development	Public Realm 	Educative water activities with SuDS 	**FLOODABLE PLAYGROUNDS AND SQUARES** Hard or soft landscaped spaces that can be designed to store variable depths of water, reducing pressures on the sewer system during heavy rainfall or creating space for flood water away from buildings. **RAIN GARDEN** A shallow, planted depression used to store excessive rainwater before it soaks away. Plants and soil layers filter water before entering groundwater system. Ideal in 'ultra urban' areas of limited space.	Lessons learned: social interaction, health and well-being - Visitors are educated by combining water activities with SuDS, also through showing how the system works on information boards - Water can be pumped from reservoir to create water interaction while also storing water	
GREEN STREETS Location: Rotterdam, The Netherlands Transforming flooded streets to a new street profile that includes wadi's and buffers	Residential & infrastructure 	Rainwater basin for GI 	**GREEN ROOF / WALL** A planted roof or wall to a building that helps to control runoff slowing the flow down to the ground, store rainwater and filter out pollutants. **DRY PROOF – WATER EXCLUSION STRATEGY** A dry proof (or flood-resistant) building, is designed to prevent water entering the building using waterproof materials and construction. It is normally used to improve protection to existing buildings and typically limited to areas with low flood depths.	Lessons learned: social interaction, health and well-being - GI combined with SuDS leads to environment pleasant to the eye - Communal garden watered through collection of rainwater stimulates mutual contact among age groups (Water is not physically used as biophilic element to stimulate this, but GI)	**BUILDINGS & STREETS**
LANDSCAPE RETROFIT Location: Llanelli, United Kingdom Transforming existing playground area of primary school to solve water problems using SuDS and GI	Residential & infrastructure 	Educating about combining SuDS 	**SWALE** Shallow channels designed to convey, infiltrate, store and treat run off rainwater. They can be used to transport runoff to storage ponds or basins or discharge to a watercourse. Can be used in permeable or impermeable ground conditions. May become ineffective in a flood. **POOLS AND PONDS** Both wet and dry ponds help to control flow rates by storing water, while also treating runoff through settlement, absorption and biological activity.	Lessons learned: social interaction, health and well-being - Also children can be involved during the design process, as they come up with natural ideas how to interact better with nature: outdoor classroom, bug hotel - Educating through information boards and visual divert water	
LANDSCAPE DESIGN INTEGRATION Location: Ijburg, Amsterdam Enhancing social interaction by integrating inviting landscape to the building	Docks, wharfs & shipyards 	Rainwater as cooling water stream 	**GREEN ROOF / WALL** A planted roof or wall to a building that helps to control runoff slowing the flow down to the ground, store rainwater and filter out pollutants. **FOUNTAINS AND WATER SQUARES** Rainwater can be collected at source for use and storage in public focal points.	Lessons learned: social interaction, health and well-being - Bringing people closer to the water by integrating water streams in the building - Biophilia: Water experience on the roof as physical cooling element, combined with water reflection visible on the inside triggering the visual experience	**HOUSING**
GREEN HERITAGE REDEVELOPMENT Location: Copenhagen, Denmark Transforming existing industrial area, making the harbour accessible for visitors and locals	Harbour 	Better accessible waterfronts 	**RAIN GARDEN** A shallow, planted depression used to store excessive rainwater before it soaks away. Plants and soil layers filter water before entering groundwater system. Ideal in 'ultra urban' areas of limited space. **PERMEABLE PAVING** Surfaces which allow water to soak gradually into the ground. Porous material replaces traditional hard impermeable surfaces. It can be used in permeable and impermeable ground conditions. It can also treat runoff and remove pollutants. May become ineffective in a flood.	Lessons learned: social interaction, health and well-being - Involving locals in the design process leads to a building being more appreciated - People can use the waterfront to swim, now that it is made accessible again and is still actively in use	