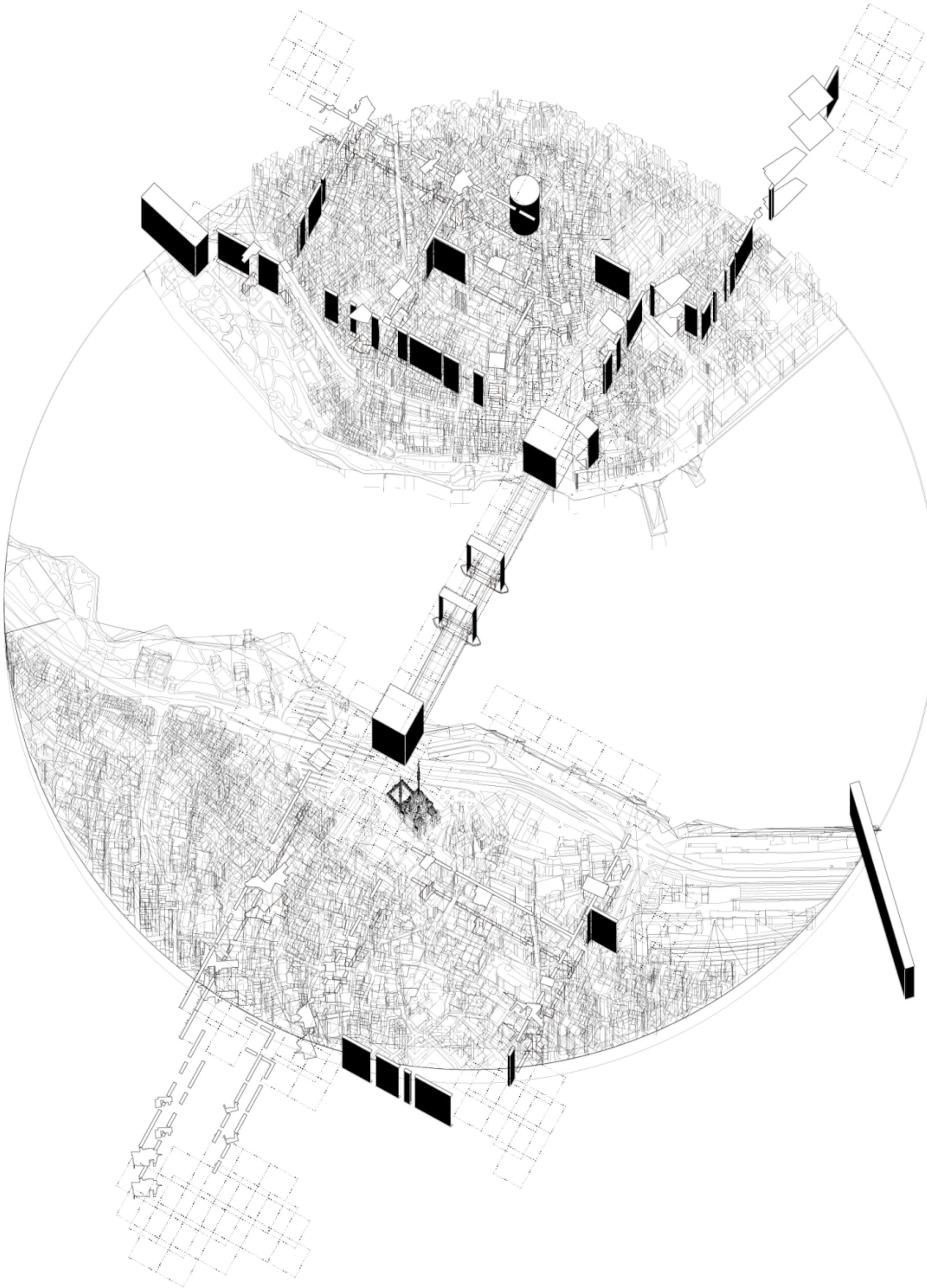
Delft University of Technology. Faculty of Architecture.
Department of Urbanism. MSc 4 Urbanism **Graduation Studio:
Design of Urban Fabric**



VERSATILE LONDON

WATER RESILIENT URBAN DESIGN IN FAST-CHANGING CONDITIONS.

ANDRUSENKO EKATERINA. 4326474

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WATER RESILIENCE URBAN DESIGN IN FAST-CHANGING CONDITIONS

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Delft University of Technology. Faculty of Architecture. Department of Urbanism. MSc 4 Urbanism

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AR3U100 Urban Transformations & Sustainability. Graduation Studio: Design of Urban Fabric

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climate change, regenerative design, resilient urban morphology, urban reaction rate, land- use.

CONTENTS

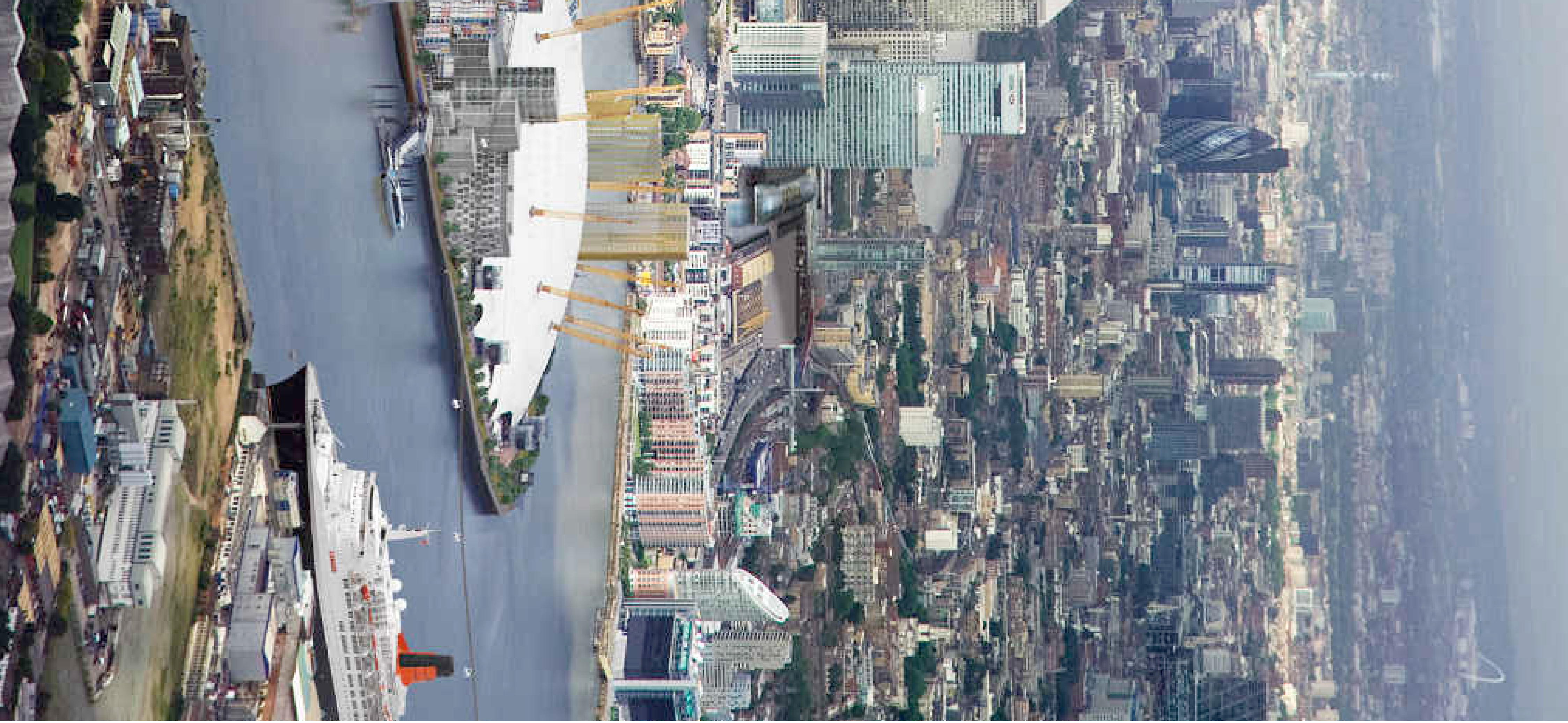
1. **INTRODUCTION**/ GRADUATION ORIENTATION

ThisThesis Plan has the title “Versatile London. Water resilient urban design in fast- changing conditions” describes a definition of the main topic of this graduation project, ways that the subject will be investigate and findings of the design proposal. This graduation project took place within the Studio of Design of Urban Fabric at the Technical University of Delft, Faculty of Architecture, department of Urbanism. It aims to find a solution for the task in view, form a multiscale research, going from literature review to practice and discover a resilient design solution for the chosen project site.

My personal fascination for this subject was driven by tension between generally accepted goal of sustainability and my personal interpretation and understanding of this issue. The climate change is an irreversible process, which has negative effects on our urban environment if we do not adapt to it. More over the sustainability becomes a trend and publicity stunt to get more profit from some new developments. My strong believe is that do not need a commercial or political propaganda to have an implementation. But it should be attractive, livable and catching for the people. It will be meaningful for them. On the other hand the issue of how space can adapt and deal with effects of climate change in limited time. Moreover how urban form will look like after these transformations? Both these physical and non-physical problems for a sustainable future led me to the subject of this graduation project. For this reasons the Studio of Design of Urban Fabric is the most attractive for me, because it allows to explore and find out how spatial interventions within existing urban fabric can solve the problems framed by such a complex problem field. I should also point out that in this particular project the main focus is referred to the spatial properties of the space and existing urban fabric, able to cope and resist to Climate Change effects, while this “effects” themselves is no more than testing machine and driving force for the future interventions.

This project focuses on the creation of a generic toolbox as a basis for this project and strategy of entire city through small scale interventions. This Preliminary Thesis Plan provides an overview of investigations on this subject, which are divided into 9 chapters.

The chapter of Introduction describes a structure of the Thesis Plan and gives an idea of evolution of graduation project. The further chapters will indicate an motivation for the project, aims and objectives, define a problem statement and formulate a main and sub research questions. The chapter of methodology provides an overview of the methods used in the search for answers on the research questions while theoretical framework will provide a knowledge and comprehension of what already was done in that field. The issue of urgency and significance of this project will be formed by both human and academic relevance. In the final part of thesis plan you will find the personal time- schedule and literature review. The first one provides you information about all steps heading toward the main design goal and also points out deliverables and deadlines. The second one furnishes with the literature review, which was used up to this time.



London waterfront. 2013 Source: http: //www.seanews.com.tr

PROBLEM STATEMENT/ AIM AND FOCUS / **RESEARCH QUESTIONS** / METHODOLOGY

2. PROBLEM STATEMENT

The climate change is a fact that we use to. It is not a surprise or extraordinary condition. Every year all over the world we can hear from newspapers and news briefs about some disasters related to it. The most extreme effects take place in dense urban areas. Flooding events, rainfalls, heat waves and extreme weather conditions almost all of those became a part of "big city's life".

In European context climate change is not only an environmental issue but also part of social, economical and political dimension. The greatest interest is represented by dense cities close by deltas areas. Many cities are not fit yet to the effects of climate changes such as flooding, rain falls, hit waves and etc. In this case London is an interesting example. Grown along the river Thames, the city from the very beginning located crucial elements and main landmarks up to the riverfront. Waterfront is backbone, attraction and part of the city brand. Furthermore a lot of people live in the area, subjected to flooding, so protection of this area is decisive for future development.

Current statistics indicate that the River Thames is rising on average approximately 3mm per year. Due to the fact that a significant proportion of the city lies in the flood plain of the river and its tributaries, London is exposed to a high potential of flooding than any other urban area in the UK. Moreover 15% of London is in the floodplain, which includes 49 railway stations, 75 underground stations and 10 hospitals. (Statistics analyst, BBC News.2014). Moreover the flooding areas are a substantial housing and commercial development, which is on low lying land of the flood plain. Climate change poses potential threats to London worth an estimated £80 billion. (London Assembly Environment Committee, 2005).

London's flood risk comes from several different sources – tidal, fluvial, surface, sewer and groundwater (pic. 1, 2). The first one is risk of flood by tidal, which is basically an overtopping of existing defenses due to a severe storm surge in the North Sea. The second one are fluvial floods.

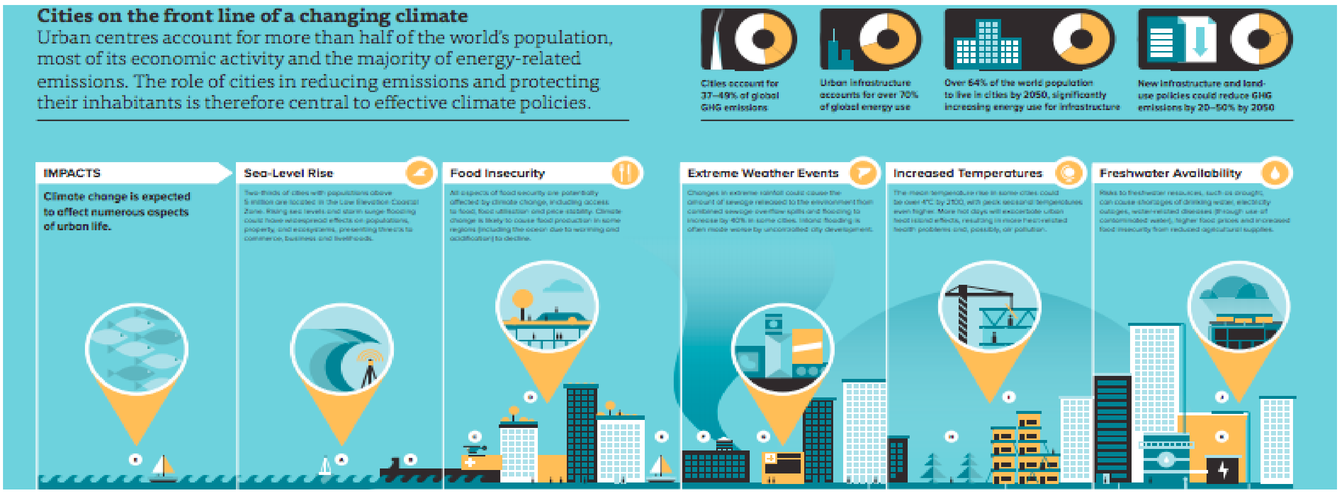


Fig. 2.1 Climate Change Effects on the urban environment. Source: http://www.desmogblog.com/sites/beta.desmogblog.com

They occur due to freshwater flows in a tributary that exceeds the capacity of the channel especially if undefended or breached. Tne next one is risk of flood by surface water. Usually these events serve as the result of intense rainfall in a summer thunderstorm that exceeds the capacity of the drainage system. The following may also increase flood risk: sewage, water main burst, groundwater and contained water, for example reservoirs.

Facing such a huge flooding risks, up today London is using a sustainable urban drainage system as a guide model for the city protection. This system can be represented as a complex of flood defenses, which will protect city from environmental disasters. Nowadays the major of them are: The Barking Barrier, Royal Docks Impounding Flap, the Gallions Reach Flood Gate, The King George V Flood Gate, The Thames Barrier and the "supersewer", where the last one is in the process.

The "supersuwage" is stretched underground along the riverfront. This project constitutes a huge pipe, which will collect the water from the surface and then pump it out. The system itself is a gigantic project, which is very costly. Citizens will pay around 80 pound per month to maintain it. Becides the process of colecting warer upstream and than pumping out it is very power-consuming. Another critical point is limitation of this system, it means that there is a predicted amount of water that the supersewer can collect. As we knows climate has a changeable nature that meansthat what "we expect" can mismatch with "we assume" in the end. It means that project with low resilience for changes can easily fail. In this sense such a project is even more unsustainable from economical point of view as well as from social and environmental.

Another example of this hard infrastructure is the Thames Barrier, upstream sea walls, and 32km of embankments downstream were designed to provide a 1 in 1000 year level of protection up until 2030 for London and surrounding areas. Between 1983 and 2001 the Thames Barrier was closed 62 times to protect London from tidal flooding. By 2100 it is estimated that the Thames Barrier will need to close about 200 times per year. Unless further investments into flood management measures are continued, current flood protection systems will not be able to cope with the increased risk of flooding that are associated with climate change predictions.

Beside of these issues, floodings will lead to lack of important services and public domains. They become unacceptable or gone. For the city, where the riverfront is a place of attraction, lack of houses, infrastructure, and public space is impermissible. In that way redistribution of needs and facilities or multiple use of space becomes a main issue for the city, affected by flooding. Speaking about current land- use along the river Thames, it is important to point out another moments, which needs to reconsider. Current developments along the river are mainly focus on dwelling and getting bigger profit from selling a "water view". That does not do anything with the waterfront apart from getting residents an idea that they bought an apartment with the river view. So the protection, which can be not only a hard structure, but a public space and identity of the area, more open and attractive, is a main issue of graduation project.

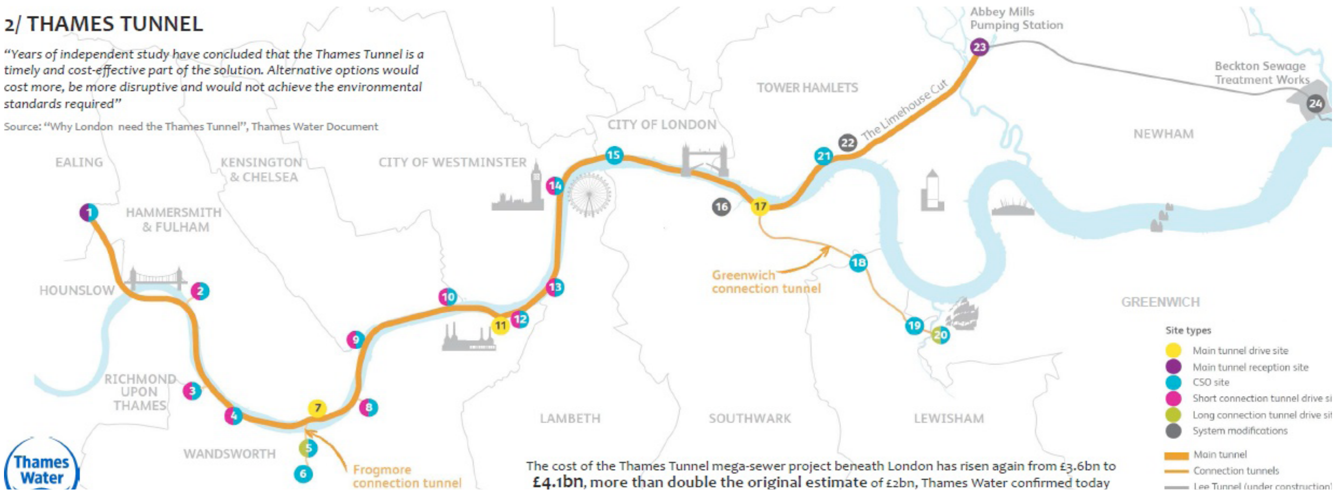
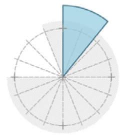


Fig. 2.2 Scheme of the Thames Tunnel. Source: http://www.nce.co.uk,NewCivilEngineer

PROBLEM STATEMENT

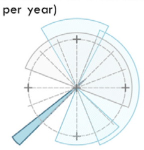
LONDON TIDAL FLOOD MAP

1 FLOODED AREA (%)



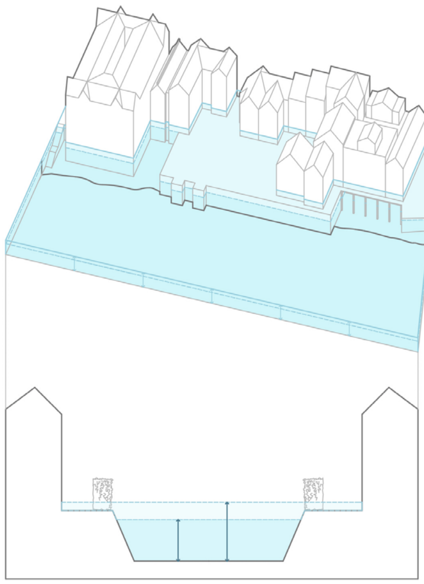
11%

PROBABILITY OF OCCURRENCE (% per year)



2%

PROCESSES OF FORMATION



TIDAL type of flood is basically an overtop-ping of existing defenses due to a severe storm surge in the North Sea. (picture 1)

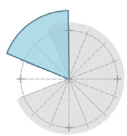
0 1 2 3 4 5 km

own illustration based on data from http://maps.environment-agency.gov.uk

LEGEND: flood area, main water reservoirs, main greenery, local roads, main infrastructure

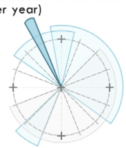
LONDON FLUVIAL FLOOD MAP

2 FLOODED AREA (%)



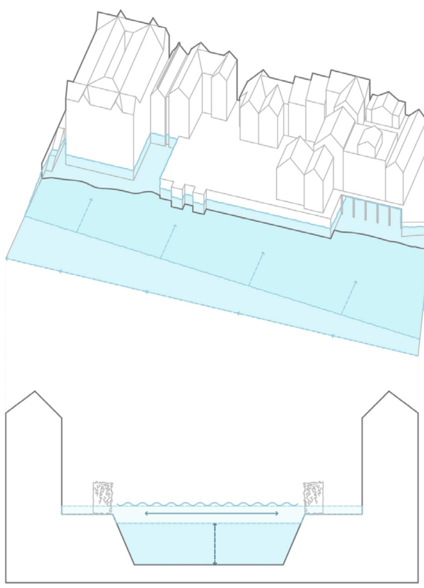
21%

PROBABILITY OF OCCURRENCE (% per year)



2%

PROCESSES OF FORMATION



FLUVIAL floods occur due to freshwater flows in a tributary that exceeds the capacity of the channel especially if undefended or breached. (picture 2)

0 1 2 3 4 5 km

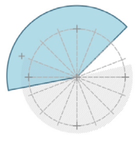
own illustration based on data from http://maps.environment-agency.gov.uk

LEGEND: flood area, main water reservoirs, main greenery, local roads, main infrastructure

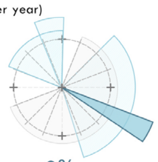
ANDRUSENKO EKATERINA

LONDON SURFACE FLOOD MAP

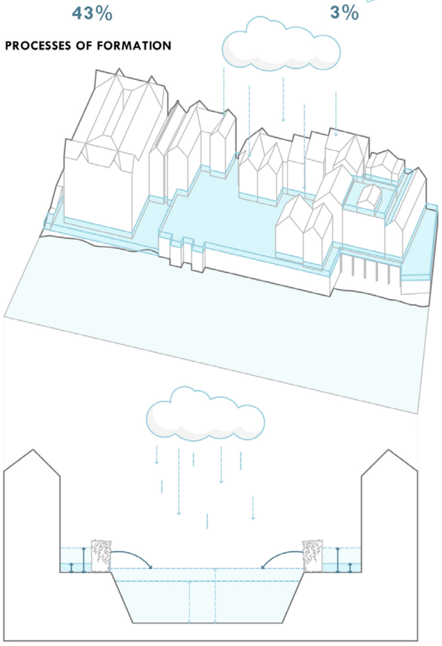
3 FLOODED AREA (%)



PROBABILITY OF OCCURRENCE
(% per year)



PROCESSES OF FORMATION



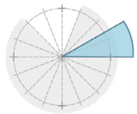
own illustration based on data from http://maps.environment-agency.gov.uk

LEGEND: flood area, main water reservoirs, main greenery, local roads, main infrastructure

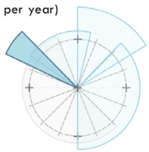
Floods by **SURFACE** water usually serve as the result of intense rainfall in a summer thunderstorm that exceeds the capacity of the drainage system. (picture 3)

LONDON GROUNDWATER FLOOD MAP

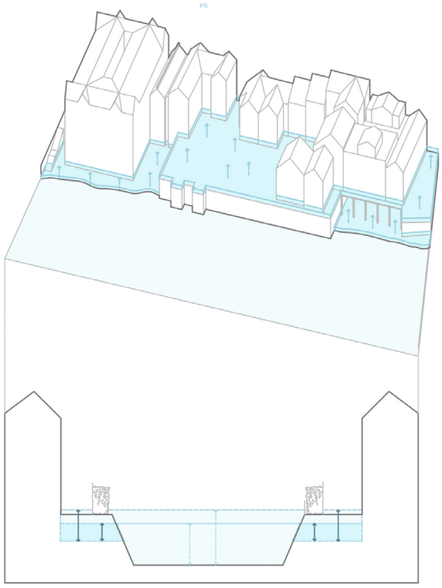
4 FLOODED AREA (%)

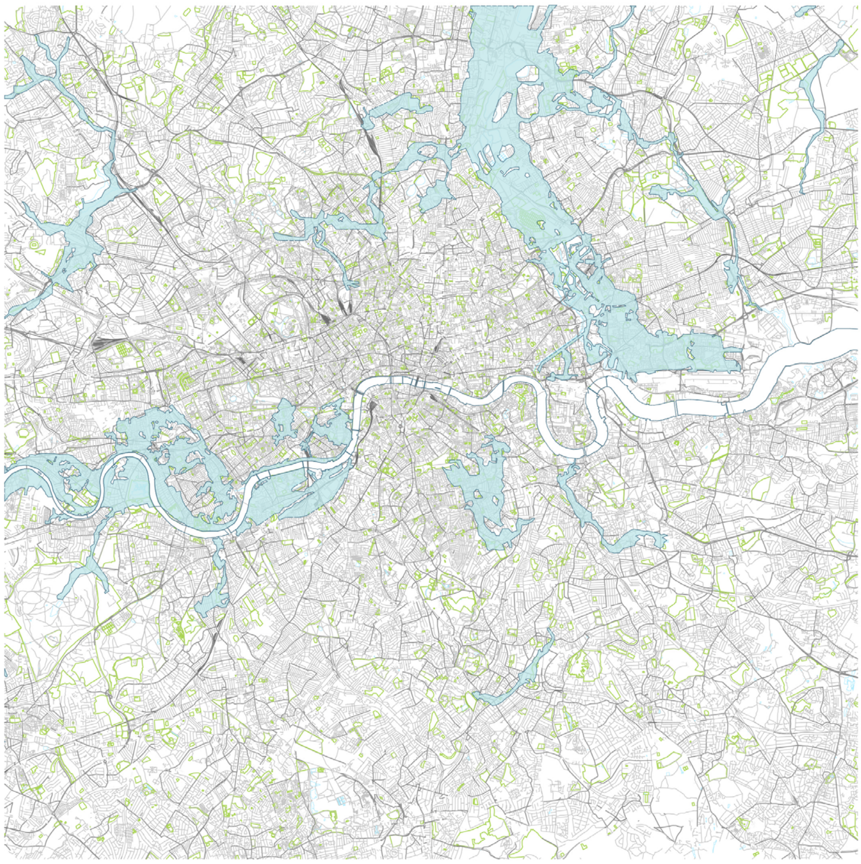


PROBABILITY OF OCCURRENCE
(% per year)



PROCESSES OF FORMATION





own illustration based on data from http://maps.environment-agency.gov.uk

LEGEND: flood area, main water reservoirs, main greenery, local roads, main infrastructure

SEWAGE, water main burst, **GROUNDWATER** and contained water, for example reservoirs may also increase flood risk.(picture 4)

« ... It is not a question of how much we have prepared to achieve a sustainable urban environment. It is not a question of loss. It is a design challenge in order for us to increase the quality of life... »

Bjarke Ingels, Architect. 2011

We should understand that it is not only flooding that constitutes the Problem Statement. It is just one of the many complex issues of a city's future development. It means that 'fooling' is a testing machine for the problems that currently exist in London, namely: densification, social and spatial segregation, infrastructure provision, ecological sensitivity. (The London Assembly Environment Committee. 2005) These obstacles are increasing in number and becoming much stronger under the influence of flooding. This is a «litmus paper» for a city's troubles.

Confronting climate change in London should lead to a systems approach. (The City of London Climate Change Adaptation Strategy, 2010). What is important within these guidelines is the integration of social, economic, political, cultural and ecological dimensions in the process of urban development and final physical interventions.

3. AIM AND FOCUS OF THE RESEARCH AND DESIGN PROJECT

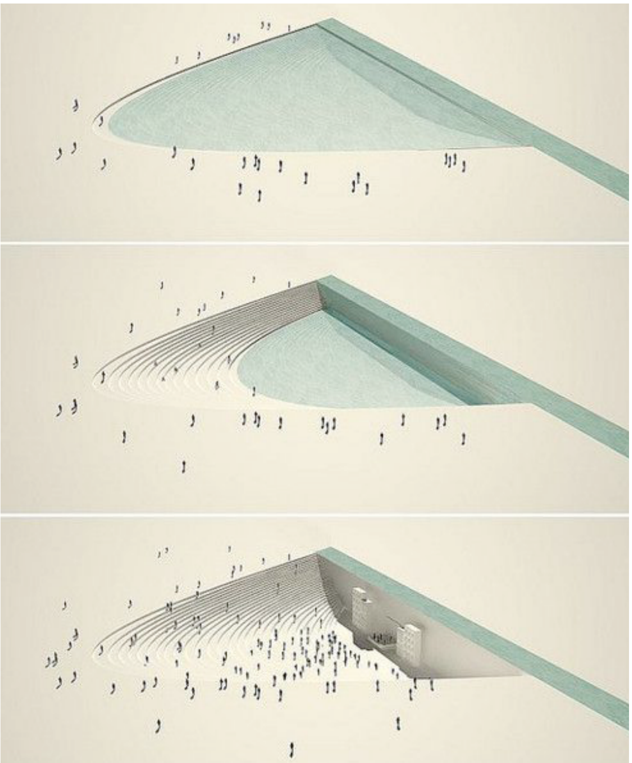


Fig. 3.1 Open air theater and rain water collector. Resilience as main design concept in the project by Paisajes Emergentes estudio de arquitectura .Source: https://www.flickr.com/photos/20959784@N07/2982084053/in/photostream/

The aim of this graduation project can be divided into two parts: one is general goal while the second one is more specific. The general one is directed to find a solutions to cope with flooding issues in dense urban areas. Moreover understand how urban form and it operation can influence a performance of the space. Based on this knowledge the goal is to create a toolbox of interventions, directed to increase the capacity of existing urban fabric to cope with floods. This toolbox should be transferable to any urban environment with the same issues. In this case, to any dense urban areas with a threat of flooding.

The specific goal based on the desire to create a resilient urban environment which will retrench the pressure in existing areas, reduce the need for the «super sewer». Moreover the investigation and phases of the transformation from existing space to a new form, or function, or facilities becomes crucial. In this case the aim is to illustrate how shape can change and how fast this changes can occur.

4. RESEARCH QUESTION

The pressure, which big cities experience every year, increases more and more. Cities such as London is not only a megapolis with 8,5 millions people, but also big amount of investments. After several flooding events during last decade government shift their attention to sustainable development and protection of the city.(2008, London Environment Agency)

By sustainable development the Environment Agency looking for the project's approach of: considering tidal defences in a wider context; seeking to reduce flooding risk by avoiding development on high risk areas; managing areas as inundation zones to deflect flood water. Although defences will be important the EA assume that in the future we cannot just block out higher tidal surges. Therefore debates on what can be done from sustainability perspective to protect city still open. It is getting harder in a way that city expanded areas along water for years, densify waterfront. Nowadays waterfront has no space and «right tools» to protect himself. In this case «tools» mean any opportunities depended on scale, form or capacity of urban fabric that can be used as a protection from flooding. Besides, the biggest amount of proposals directs to «fighting» with natural processes and in a way have limitation of protection. It means that those solutions assume defined level of protection, which sometimes can be deceptive considering inconstancy of natural processes. The tension between those components of problem statement formulates the research question. In a way the main research question is very general and can be applied to other metropolitan areas with same issues:

How can spatial interventions within one river catchment of the river Thames help to make London more resilient to flooding? (main research question) To be able to answer the main research question and structure the investigation of this project, the following subquestions are divided into two parts:

4.1 First part of subquestions related to flooding issues:

1. *How can we deal with processes that are limited in predictability?*
2. *What resilience measures can be taken for flood protection?*
3. *How implement water adaptive scenarios? How to model them?*

4.2 Second part of Sub questions is related to urban fabric:

1. *What component of the city can act as a flood protection in the limited space and dense urban fabric?*
2. *What kind of alternative ways of usage existing space could be during flooding events?*
3. *How fast space can change in order to adapt for climate change?*

The main research question indicated is very broad. It could also be applied to other metropolitan areas with the same issues. This part of the project consists of two parts. The first part of the main research question aims to investigate the spatial interventions as solutions to flood-prone areas; and the second is focused on the Resilience concept, its definition, attributes, and its translation into spatial properties. The question is set to test if Resilience could in fact be an answer to such a complex problem, and to find out whether flooding is really an issue or not.

To answer the main research question and move forward to the investigation of this project, the following sub-questions have been divided into two groups. First one is related to the urban fabric, its characteristics, potentials and limits, while the second group of sub- questions is focused on the effects (e.g. floods, heavy rainfalls and etc), which act as a testing machine and an “indicator” for the design proposal and the investigation(s) on the urban fabric itself.

1.What component of the city can act as flood protection in the limited space and dense urban fabric?

The main issue for such megapolises as London is that the city has a very dense urban structure. It means that there is no space to accommodate and store water during floods. In this context arises the question of what kind of urban form can act as a water storage in the absence of open space. It also leads us to explore new ways of land use and try out a combinatorial approach. Mixing and matching urban forms and its functions can help to achieve a livable, safe and attractive urban environment.

2. What alternative ways of usage do existing spaces have during flooding events?

The primary issue for the cities exposed by such hazards as floods is the loss of their major facilities, properties, and infrastructure. Some of these facilities become inaccessible on such events. Some even gone. In order to prevent these troublesome consequences, an urban fabric should have the ability to transform itself and be flexible to such changes. This question aims to examine ways on how to transform space, change its function, and to make it adapt to its surrounding environment.

3. How fast can space change in order to adapt to climate change?

An urban adaptive rate is very crucial in fast-changing conditions. During floods, rain falls or storms many people, and cities depend on the speed of reaction to these types of events. Also, every urban scale has its own rate. This makes some urban unit adapt or cope with changes fast, while several blocks or districts deal with them slow, and cities even slower. This process can be learned from complex adaptive systems which include different scales. In this context, the goal of this sub-question is to discover the relation between scale and its adaptive rate. The data from this research can be useful for the prediction of future scenarios and the design proposal.

4. How can we deal with processes that are limited in predictability?

The most difficult section in this graduation project would probably be how to measure the consequences of Climate change effects. In our case, this will be a kind of evaluation for the design proposals and act as a testing machine to indicate weak points of the final design. However, the main purpose of this sub- question is still to investigate the properties that will help us measure these processes, and to predict the unpredictable, in order to avoid a lot of mistakes.

5. What resilience measures can be taken for flood protection?

This question is driven by the desire of understanding the Resilience concept. In other words, to comprehend the physical properties of space that can be referred to «resilient to floods». The very aim of this sub- question is to make a translation of the concept’s definition based on the theoretical review, into spatial characteristics appropriated for the the project site.

6. How to implement water adaptive scenarios and how to model them?

This question, on the other hand, is fuelled by the curiosity to investigate ways of predicting and imagining the future. Climate change effects have become tricky because the nature of such events itself is a very dynamic phenomena. So therefore, the aim of this question is to find ways of describing visuals and testing as unpredictable occurrences like Climate change effects (in this case, floods, rainfalls and etc). Another important factor to note, is that the process of modeling these events should be understandable and based on no less than accurate data.

5. METHODOLOGY

The role of methodology consists in determination of means and techniques of getting knowledge, developing framework for analysis, defining the structure of future investigations. Through them the concrete research project can be archived. Provided by right tools and systemized knowledge, methodology gives opportunity to explain the ways of project progress and get the answer to the research question.

5.1 Methodology for the entire Graduation Project

The investigation process of the design project can be divided into three different stages: Project Definition, Theoretical and Analytical Framework and finally Vision Part (figure 5.1).

First chapter consists the project definition's early stages. The main research question and its spatial application are assigned through such actions as data - analysis, mapping, observation, literature review and case study. These actions are aimed towards formulating the right research question and subsequent research goal.

Second stage «Theoretical and Analytical Framework» merges two compounds in one. It is deliberately made in order to achieve the main research question: How can change of land- use along the waterfront of Thames help to make London more resilient to flooding? The first step to get the answer is to understand the meaning of the Resilience concept and its main spatial properties, which can work against flooding issues. The Theoretical Framework is mainly focused on this intent, as well as on the review of the origin of the concept, its particular application in current urban projects, and the criticisms involved. This is done by literature study and publication reviews, and articles from various disciplines. After establishing the main definition of Resilience, it is nessasary to investigate the spatial attributes of the Resilience properties. For this aim, the Analytical part takes place right after the Theoretical Framework. Studying the attributes that space should have, to cope with Climate change effects is significant on this stage of the project. Towards the end, the concept of « Form - Operation- Performance» made by A. Tzonis (1991) was considered a model for the Analytical framework. The concept illustrates the idea that one can explain a specific or other occurrences through its form and operation or vice-versa. The main attributes of «Form» and «Operation» were developed in parallel with the definition of Resilience and its main properties. So «Form» represents static properties of space that will allow one to explore and analyse the adaptive capacity of the chosen territory, whereas «operation» provides information about the processes that are happening in the area. This part of the Analytical framework will give us an understanding of the functions of the project area and its formation. By analysing both «Form» and «Operation», there is a possibility to achieve a proper, accurate and deliberate vision for a particular site in the city.

The third section is the conclusion of the Analytical part, and a reflection on the investigations that were made in the previous section. 'Vision' is comprised of several parts that can be elaborated through each stage. First one is 'Scenario Testing' that evaluates the vision made according to the conclusion from the Analytical part. The outcome of this stage will be the pattern for the development, strategy formulation, and development principles. The Final part is the Materialization and fairy tales. The former is a graphical representation of the project, while the latter is its verbal description. This phase can be an evaluation part of the scenario development, that will showcase some mistakes or the weak points of the Vision, which in turn will lead to the «Scenario Testing» phase again, its improvement and elaboration.

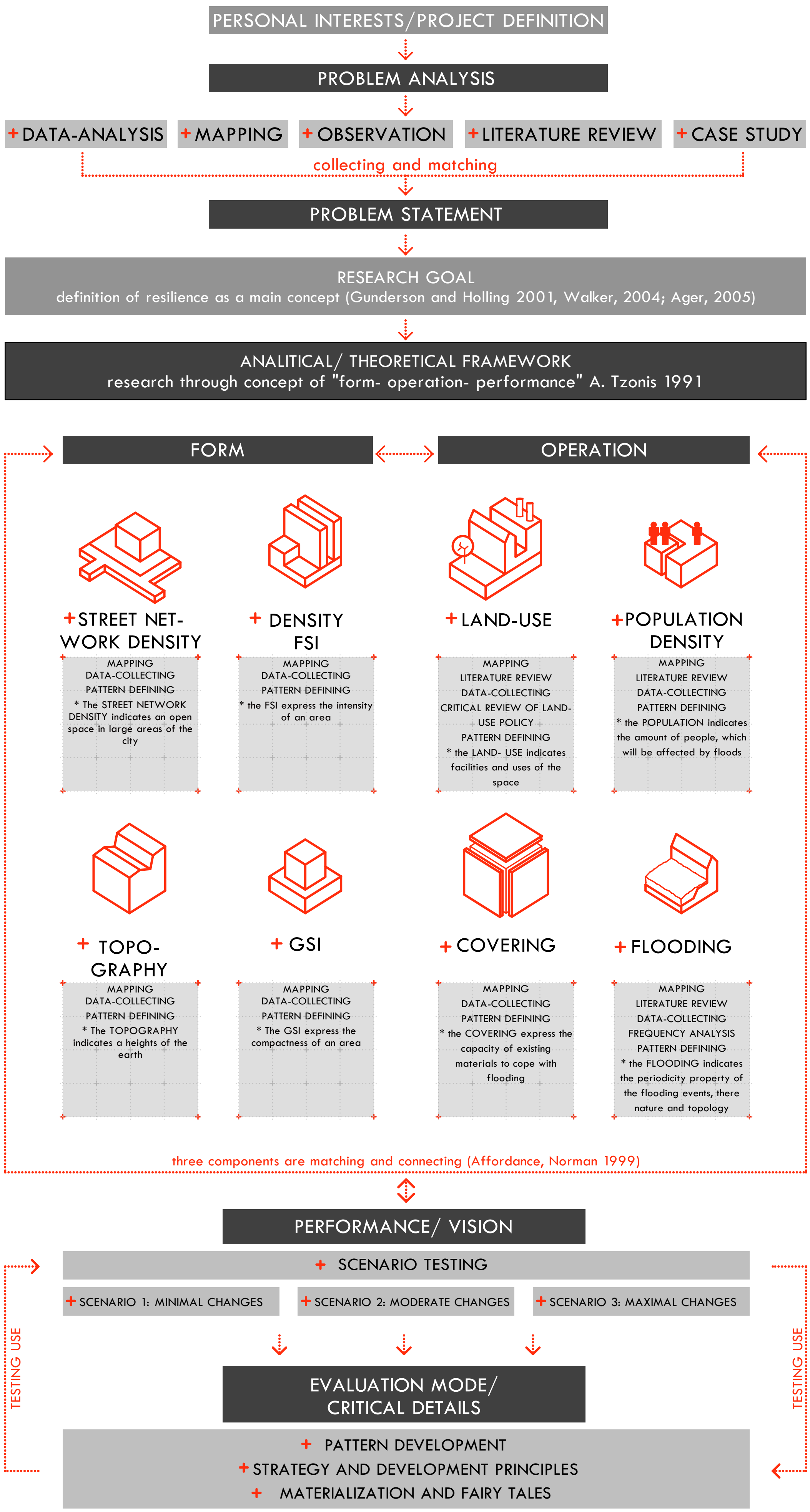


Fig. 5.1 Methodology scheme. Own illustration

5.2 Connection with research questions

For more convenience and better understanding of what actions should be done in order to answer to sub questions, the methods, used in this graduation project, will be correlate to them. It means that every subquestion will be followed by list of actions, which need to be done to answer them.

1. What component of the city can act as a flood protection in the absence of space and dense urban fabric?

This question directs to understanding of form and it operation. In order to answer this question an analysis of urban morphology should be done. It means type, shape, amount of open space and it covering will be analyzed. It provides information about existing capacity of the space. In order to understand what function can be replaced or used as a flood protection, firstly we should understand how the system is working right now. To get this the series of maps with current land-use will be made.

2. What kind of alternative ways of usage existing space could be during flooding events?

The results of literature review and case study can be used as a basement for the answer for this question. The literature review is aimed towards digging deep the theories and knowledges that have already been researched by scholars in this field. By analysing and getting information for this review, we will discover the cause / origin of existing situations. Most importantly, we will also be able to know what has already been done and learn from past cases. It is important to include the critical review of land-use policy and current development projects as well as mapping of main facilities of the project site. This methods can provide knowledge in current land-use structure, it formation through the time. Moreover it will allow to find out a solution of how to do a mix-used shift, and the same time form a comprehension of possible limitations.

3. How fast space can change in order to adapt for climate change?

Last question related to urban fabric is aimed to investigate the urban rate reaction for the climate change effects. Flood scenarios will test pieces of the project site, different in the scale. After this this urban slots will be compared to each other from it scale, form and operation of the space and the time rate. This will help to understand how fast space can change.

4.How can we deal with processes that are limited in predictability?

The answer of this question is very difficult and can be defined through a literature review and scenarios development. The first one gives a certain knowledge about nature of climate processes, it dynamics and possible consciences. Based on the knowledge, got from the literature review, it is possible to work out a serious of possible scenarios and test through them a future design. It will allow to look at the resilience capacity of the design proposal.

5. What resilience measures can be taken for flood protection?

First of all the notion of resilience should be define, in order to understand how to measure it. In this case literature review is the base method to investigate those questions and get knowledge from theories which already exist in this field.

6. How implement water adaptive scenarios? How to model them?

This question mainly related to the "critical detail" part of the project. In this chapter the main method will be scenarios development, which can be used as a testing machine of design proposal. "What if...?" is the main question, which lids to use the action structures to stimulate scenarios and create narratives. It also gives opportunity to think what can be possible agents in the design. Scenario testing method is based on our desire to imagine the future. "What could happen if…?" This desire drove us to construct life frames which we described at first verbally, followed by text, and then visualised with the use of pictures and graphs based on data, and made predictions of the future most livable cities . The result of this manipulations will indicate strong and week points of design proposal as well as test it for resilience. Along with this, scenario testing can be a critical point in design project, which will indicate an accuracy of the earlier decisions. Besides creating a frame of future occurrences, the result of such frames will also act as a testing mechanism for the design proposal. This means that every proposal in this Graduation project will be evaluated through possible future events in order to investigate the livability, adaptiveness and effectiveness of the design idea.

London bird eye view. 2014. Source: http://www.informazione.it/pruploads/a3472e0d-88fe-48fa-a476

THEORETICAL FRAMEWORK / ANALYTICAL FRAMEWORK

6. THEORETICAL FRAMEWORK

This chapter provides the key aspects of graduation project, according to the literature review. The aim of the theoretical framework is understanding of the problem field through theories and body knowledge that already exist. Comprehend it primary structure and evolution. All this will help to answer for the main research question and subquestions.

1 Introduction

In European context, Climate change is not only an environmental issue but also a part of social, economical, and political dimensions. The greatest interest is represented by dense cities close to deltas areas. Many cities are not yet fit to the effects of Climate change such as flooding, rainfalls, hit waves and etc. According to Carlo Jaeger (2010), the key challenge for cities nowadays is to improve the ability to cope with such risks. During heavy rainfalls and flooding urban fabric exposed by multitude proof tests, which leads to lack of important services and public domains, they become unacceptable or gone. Moreover it affects on many people lives due to loss of their houses. For the cities nowadays, lack of houses, infrastructure, and public space is impermissible. This raises the question of what kind of quality and attributes should a city have to be able to cope up with such problems? Flood risk can be reduced through implementation of resilience concept, first introduced by Holling in 1973. Absence of proper public domains and services bring adverse effects to civilizations in times of heavy rains. Floods destroy not only urban infrastructures, but also cause damaging physical and psychological effects on people. At present, lack of appropriate housing infrastructure and other pertinent services is impermissible and unacceptable. To invest on flood prevention techniques is a must, as it allows properties to adapt to the aftermath of floods, and over time, be able to recover to its initial state (Klein et al. 2003).

However, cities are complicated social-ecological systems with many interactive components that make resilient, equitable, sustainable development difficult to achieve. Besides it, Climate change's Urban resilience depends on the urban system's ability to simultaneously maintain social and ecological functions (Abel & Stepp 2003). Thus the main purpose of this paper is to investigate the potential of the resilience concept in water adaptive urban design. In other words, it is a test to prove if Resilience can be referred to as an answer to the effects of Climate change within dense urban areas.

The starting point of this theory paper is the overview of the notion of Resilience. It starts with a brief history and description of the concept's origin, followed by its evolution process and how it transformed to a multidisciplinary approach. The next step is to find out the definition of Resilience, which can be implemented especially for flood adaptive urban development. The aim of the chapter is to disclose the main characteristics or properties, which make a space resilient to flooding. It also examines the elements needed for a city to acquire these properties.

The following chapter is mainly focused on the resilience cycle and its role in urban design. The chapter cites examples of cities where the resilience concept serves as a guideline to current developments. These examples will showcase the benefits and weak points of the concept.The purpose of the third chapter is to look at the resilience concept from different points of view. This part includes some criticism of the main topic, covering such aspects as possibilities and limitations of the concept, its definition and practical application.

And finally, the last section contains a conclusion or a summary of the theory paper. All outputs and findings made during theoretical review as well as the impact of the theory to the current graduation project are introduced in this chapter.

2 Genesis of the resilience concept

Before getting to the definition of Resilience, I would like to start off by describing the origin of the concept. Although the idea is now widely used in current urban projects, it continues to develop and revolve around several discussions on its real position in Urbanism.

Holling (1973) believes that Resilience came from Ecology. Along with the paper of C.S. Holling on Resilience and Stability in Ecological Systems emerged other surveys made by Lewontin, 1969; Rosenzweig 1971 and May 1972. Most of these works belonged to the field of Ecology and focused on the interaction of the populations and their functional responses.

Through time, the Resilience perspective started to influence areas around Ecology as Anthropology. One of the early scholars who used the concept of Resilience in this field were Vayda and McCay in 1975. They tried to explain Culture as a balance-based system. Furthermore, the concept of Resilience was also used in different studies as Environmental Psychology (Lamson 1986),Cultural theory (Thompson et al. 1990), Human Geography (Zimmerer 1994), Management (King 1995), Sustainability Science (Kates et al. 2001) and Sociology (Scoones 1999; Abel & Stepp 2003; Davidson-Hunt & Berkes 2003)

Due to the universality of the approach, it is now used in a great variety of interdisciplinary work concerned with the interactions between people and nature (Gunderson 1995; Hanna et al. 1996; Berkes & Folke 1998; Kinzig et al. 2003; Gunderson 2000; Gunderson & Holling 2002)

From Human Science and Ecology, it moved towards Urban practice and is nowadays used as a guiding principle for managing complex systems within cities (Lee & Wood 1991; Bolund & Hunhammar 1999; Adger et al. 2005; Fabian 2012; Hansen & Pauleit 2014; Schewenius et al. 2014). It did not only evolve and developed a sphere of applications, but also led to the formation of new models for further improvements. Most of these models were based on different definitions of Resilience, and how to find the best match for a water adaptive urban design becomes the challenge.

2.1 Main definitions of the Resilience notion

There are many definitions for “Resilience”. The very first was described by Holling in 1973. He proposed “Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes from state variables, driving variables, and parameters, and still be able to persist” (Holling 1973, p.17). The main feature of this description is the “ability of a system to absorb changes”. It is a crucial property of space during flooding events because it means that any space can cope with changes and be able to withstand its impact.

The definition of Holling (1973) served as the foundation for other researches. Later came heaps of other Resilience explanations, but for the purpose of this study, will be limited to descriptions closely related to the Climate change framework only. One subsequent definition was formulated by Holland in 1995 which referred to Resilience as “a complex adaptive system” and divided the idea into four basic properties: aggregation, non- linearity, diversity and flows. From this definition, the prime segments are diversity and non- linearity. The first one means that space is furnished well to cope with climate change affects and equipped with enough amount of properties to resist, whereas the second is more related to the flooding component itself. The point is natural processes have a dynamic nature and are difficult to predict. In this case, a non- linear component gives a comprehensive picture of flooding effects as a complex phenomenon that requires complex approaches and solutions.

A third complementary definition is based on the work of Brian Walker and others, "Resilience, Adaptability and Transformability in Social-Ecological Systems," Ecology and Society, 9 (2004). Resilience, in his opinion, is the capacity of a system to absorb extension and transformation while undergoing change in order to retain the same function, structure, identity and feedbacks. That means that a system can absorb changes, transform accordingly, and still be able to function despite external forces.

Furthermore, Resilience can be redefined as the ability of a system to maintain its identity in the face of internal change and external perturbations (Walker & Salt 2006; Walker & Salt 2012). Identity is an important factor of space in cities. When there are floods, keeping a city's identity and maintaining the accessibility of space are the hardest challenges. After examining different definitions of the Resilience concept, we move on to the specification of its framework based on the effects of Climate Change.

2.2 Resilience as a tool against climate change effects

To consolidate, compare, and contrast is the main definition of Resilience described in the first section in terms of climate adaptive design. It consists of several properties that an urban space should possess in order to cope with such effects: Adaptive capacity (Holling 1961, 1973, 2001), Adaptive rate (Holling 1973), Cross- scale interactions (Gunderson 2000), Transformability (Dietz et al. 2008), Flexibility (Folke 2006), Diversity (Folke 2006), Connectedness (Barthel S. et al. 2013), Openness and Accessibility (Walker & Salt 2006; Walker et al. 2012). Adaptive capacity means the ability of space to receive, resist, and withstand the effects of Climate change. Cross-scale interactions lead to the understanding that everything is linked. Moreover, flood proof interventions need a multi-scale approach to archive Resilience. Transformability is another important property, which is the ability of space to change appearances or displace functions in order to cope with environmental disasters. The next attribute of Resilience is Flexibility and can be represented as a load-following and space re- organizing capability. Diversity is multiplicity of the space, which means that combining different properties in one space could provide better livability and resilience to flooding.

Connectedness is a property, which means that every part relates to each other, crated a continuity and coherence system. The last one is Openness and Accessibility. The former refers to the ability of space to accept and conform to changes, while the latter is more focused on the capability of space to stay available and efficient during flooding events. All of these competent factors allow an urban space to adapt, cope and regenerate during and after flooding. It keeps cities attractive and functioning.

3 Resilience time- cycles and their role in urban design

Another important factor in further investigation is time rate. In fast changing conditions, this component of urban environment is crucial. During flooding, rain falls or storms many people and cities depend on the speed of reaction to these types of events. Furthermore, every scale has its own rate. This makes every urban unit adapt or cope with changes fast, while several blocks or districts deal with them a bit slow and cities much slower. This process can be learned from complex adaptive systems, which include different scales. The complex adaptive system was represented by Holling (1973) and revised by Gunderson and Holling (2002). It has three cycles with each having a different scale and reaction rate. With several processes, these cycles connect to each other, spill over and lock into a continuous system. The concept has a lot of positive and negative reviews. But before admitting a theory as a main design concept, various aspects and viewpoints should be considered.

This concept further evolved and crossed different fields of knowledge. One of the backward interpretations of this model was introduced by Barthel S., Colding J., Ernstson H., Erixon H., Grahn S., Karsten C., Ivlarcus L., Torsvall J., in their work "Principles of Social-Ecological Urbanism case study; Albano Campus, Stockholm" (2013). The model indicated the main phases of the resilience cycle, which is appropriate for ecological systems as for the urban environment. According to Barthel S., Colding J., Ernstson H., Erixon H., Grahn S., Karsten C., Ivlarcus L. n.d. the graph below illustrates how the ecological system evolved over time, thus we will use this illustration as basis for adapting to the urban environment.

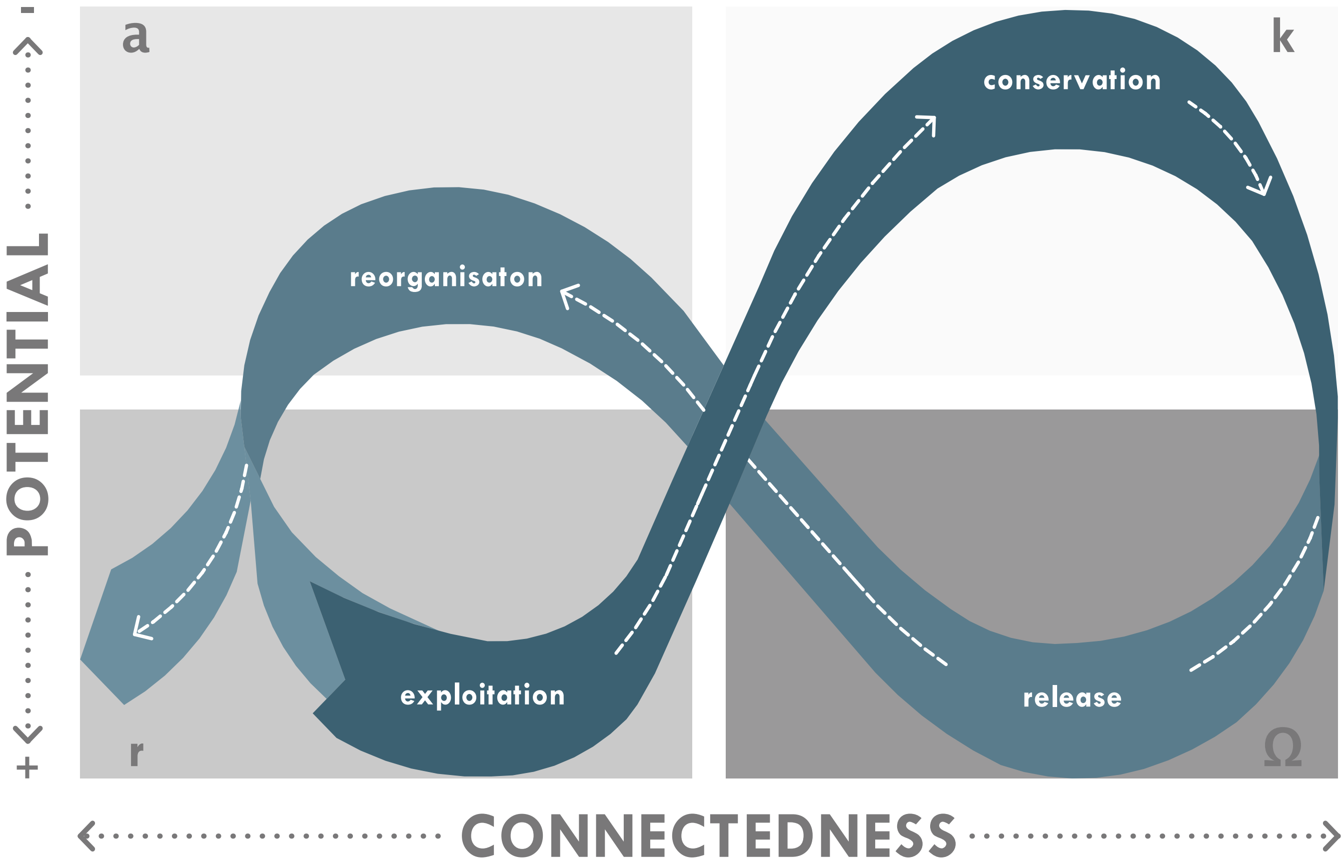


Fig. 6.1 Graph of the Resilience cycle in environmental context. Source: Principles of Social Ecological Urbanism (Barthel S., Colding J., Ernstson H., Erixon H., Grahn S., Karsten C., Ivlarcus L., Torsvall J.,2013)

On the lower left corner of the graph is the R- phase. R-phase represents the establishment or exploitation of existing land. For instance, land According to Barthel S., Colding J., Ernstson H. et al., at this stage the land has great potential for development. Furthermore it stimulates diversity and the capacity of the new structure to establish. Apply this concept to Urbanism during the project's start-up stage, and this could lead to new developments and increase the site's popularity and it permeability.

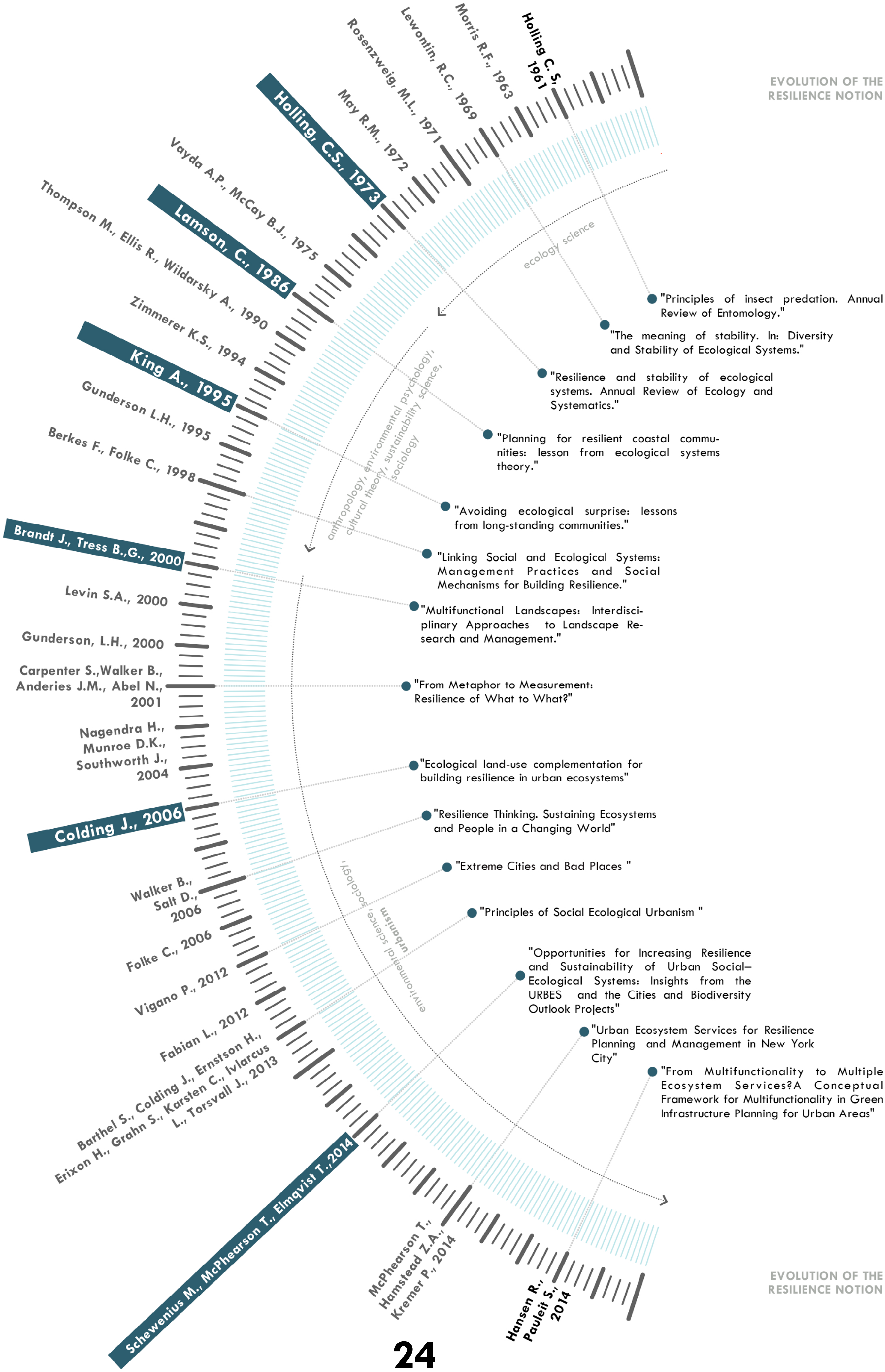
Second phase is called K-phase or conservation. In this period the system is dominated by few strong competitors and diversity renders the system vulnerable to disturbance. In a city context, this phase can be translated to as the "suspense" time. Even if new developments and growths do not happen, the structure is maintained still with its main features during this stage. «The K-phase is an accident waiting to happen» as Holling phrased (Holling 1973).

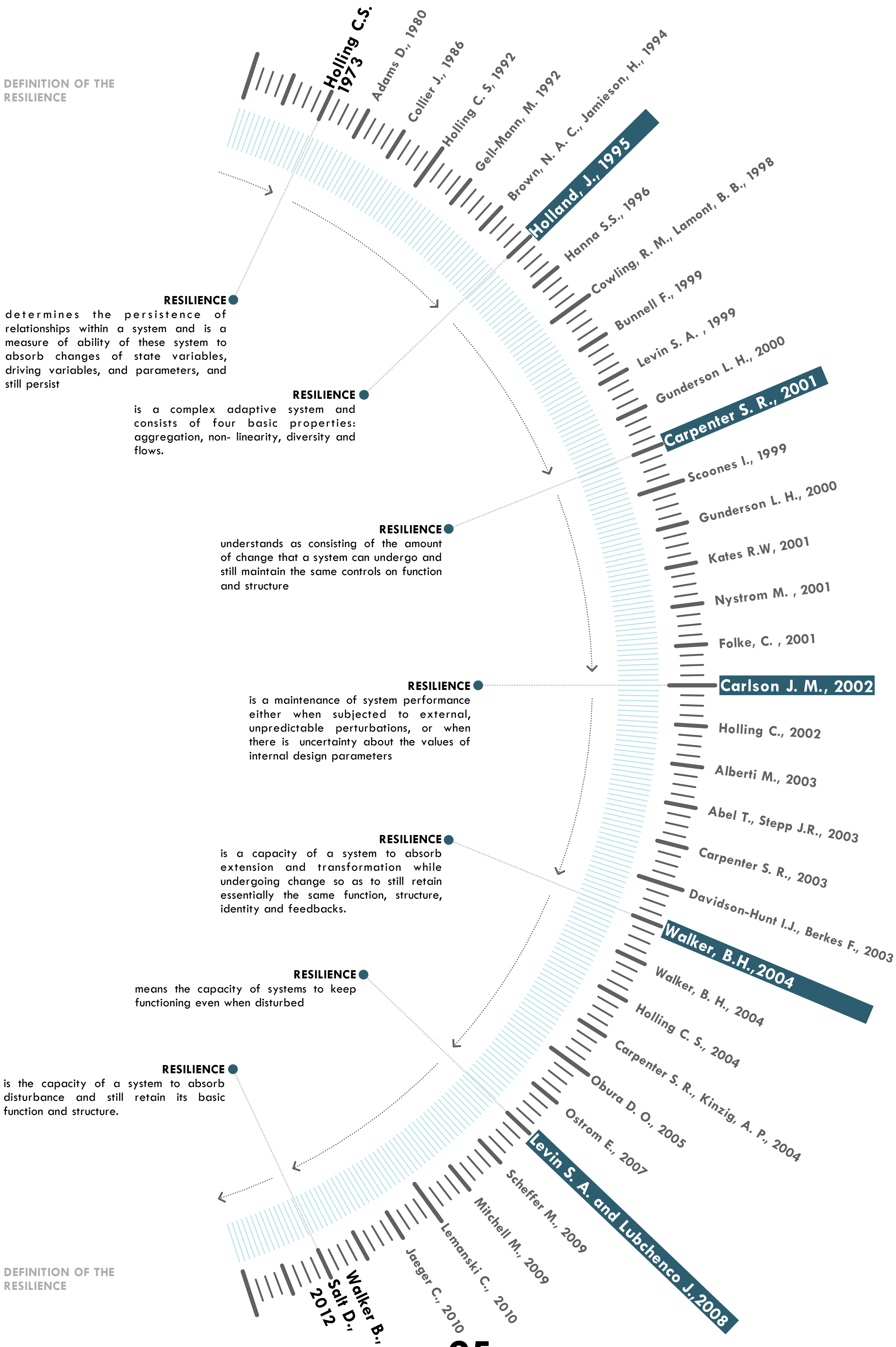
The lower right corner is the Omega phase. This stage represents accidents or disturbances. In the illustration above, it is referred to as the release phase. Barthel S., Colding J., Ernstson H. and others notes that this period characterized by crisis of the existing functioning of the system, breaks and loses its primary identity. The last one is the alpha- phase, which can be described as the "reorganization and renewal of the system after the accident" (Barthel S., Colding J., Ernstson H., Erixon H., Grahn S., Karsten C., Ivlarcus L., Torsvall J. "Principles of Social-Ecological Urbanism case study; Albano Campus, Stockholm", 2013, p.10). To a great extant this stage responds to the ability of the system to recover after collapse and "memory" in order to return to phases R and K.

However, it is important to note that besides different stages, it is also important to include scale factors (Folke 2006). It is especially important in the field of urban theory and practice, because different scales will have different time periods for each phase as described above. The Adaptive renewal cycle model is generic and can be transformed and implemented in different fields of urban theory and practice.

The graph below illustrates a genesis of the resilience concept. The left one describes the process of it formation through different fields of knowledge, while the right one indicates the main definitions of Resilience.

GENESIS OF THE RESILIENCE CONCEPT





own illustration based on the theoretical review

3.2 The Resilience Concept in urban practice.

To know how the resilience concept is implemented in practice, one must first identify the properties that make an area a "flood resilient urban design". For this purpose, I reviewed different projects where resilience was defined as a guiding principle, or a key concept for the design proposal. Three projects, which varied in scale, will be described further on.

The first project is the New York City Department of Environment Protection (DEP), described by Timon McPhearson, Zoe A. Hamstead and Peleg Kremer in their work "Urban Ecosystem Services for Resilience Planing and Management in New York City" (2014). This example illustrates an interpretation of the resilience concept into Urban Ecosystem Management and Urban Planning. The second one is the Eiffel Urban Recovery Project, studied by Studio Associato Bernardo Secchi and Paola Vegano (2008), where the resilience concept directs to enhance the spatial qualities of the project site against flooding. And last, the project of Albano Campus in Stockholm (2013), referred as the world's first university campus that specialized on resilience principles, examined by researchers Henrik Ernstson and Johan Colding Barthel.

The New York City Metropolitan region is a classic example of a socio - ecological system (Cadenasso et al., 2007). In 2014, Timon McPhearson, Zoe A. Hamstead and Peleg Kremer made a review on the current state of the ecological system and management in New York City. Their work included an analysis of the current regulations, policies and land-use restrictions, which aimed to enhance the resiliency of the region.

The aim of this paper is to investigate actions and regulations necessary to increase resilience on coping up with flood risks, pollution and other ecological disasters. Our main interest is the current flood regulation in NYC. The biggest issue for the region besides heavy rain events, storm water quality and flooding, is the overflowing of their sewer systems, and the lack of space for water storage (McPhearson et al. 2014). It is of great interest to present the current flood regulations in NYC.

The PlaNYC strategy was first archived in 2007. The scheme assumed a green infrastructure approach as a solution for pressure reduction from sewer overflows, heavy rainfalls and floods. It also remedied other problems and improved qualities of urban green and open spaces, minimized CO2 emissions, and enhanced the ecosystem quality within NYC (Rosan 2012). In addition, NYC's Department of Environment Protection has created a number of green structure strategies in 2010 (McPhearson et al. 2014).

Fig. 6.2 New York City Green Infrastructure. Green infrastructure includes city parks, green streets, and community gardens. Sources: NYC Department of Parks & Recreation and NYC Department of Information Technology & Telecommunications

This is reflected on different projects over the last four years, as "blue roofs" that hold rainwater, large street green infrastructure that react as a water storage, spongy concrete-paved parking lots, and gardens. This strategy uses both big and small-scale green infrastructure developments in order to achieve a more sustainable and resilient region against storm water and floods (McPhearson et al. 2014). This makes the Resilience Concept not only a guiding principle for New York City, but for the whole region. Hence, makes it a multi-scale approach.

The Eiffel Urban Recovery Project was aimed to recover one of the former industrial clusters of Bordeaux, France into a new neighborhood for about 7,000 new residents (Viganò 2012). Located on the right bank of the river Garonne, the project site faced the risk of flooding. Paired with its highly industrialized past, dangers of contaminated soil and water were also a problem. All these issues called upon a proposal incorporating the resilience concept.

Upon completion of the project, several "spatial actions" were developed to incorporate the flood resilient design: (1) restraining building areas where water can reach the maximum average (1 meter higher existing ground level); (2) inhibition of building construction closer to 100 meters from the existing protective wall; (3) application of building

Fig. 6.3 Model of the Garonne Eiffel urban recovery project on the right bank of the Garonne River, with residential and office/ commercial buildings, a park, and elements from its industrial past Source: Studio Associato Bernardo Secchi Paola Viganò.

higher existing ground level); (2) inhibition of building construction closer to 100 meters from the existing protective wall; (3) application of building design with floors with designated flood flow areas which will allow the possibility of flooding of the first floor and is equipped with designated footpaths. This way it will maintain accessibility in case of flooding; (4) increase sea level height to an area of NO Build Zones to act as a protective layer for the residential area at the back. All these actions were proposed at a multi- level approach, to allow the area to gradually shift to a more resilient, flexible and flood proof development.

The last example illustrates an implementation of the resilience concept in small- scale interventions. The goal of this project is to create a Science Center that has a totally resilient structure. The project site is located between two vital parts of the city, the NorraDjurgarden and NorraStationsomradet. According to the Development plan of Stockholm (2010), these two areas are appropriate for future housing developments, while the area in between should become the connection and the new city center (Barthel S., Colding J., Ernstson H., Erixon H., Grahn S., Karsten C., Ivlarcus L. 2013). Moreover, with its location at the edge of the city, this area represents the transition zone between

Fig. 6.4 Scheme of functional synthesis. This leads to a diverse blend of functions , actors and activities. Source: Principles of Social Ecological Urbanism (Barthel S., Colding J., Ernstson H., Erixon H., Grahn S., Karsten C., Ivlarcus L., Torsvall J.,2013)

city and nature. As such, this project should consider the idea of having a new university campus. Also, the strategic location of the Albano Campus could also coincide with its aim to create a new knowledge center on request of Akademiska Hus and Stockholm University. With these considerations, the project required a new way of looking at the problem. Thus the resilience concept was considered as a possible strategy for the future design proposal.

During the planning stage, several resilient properties were formulated to help achieve the aims of the project: (1) Urban accessibility, to create a transport network to and from the project site; direct and clear passages and sight lines through the area, including open public access of parkland areas along the valley. (2) Diversity. The property is aimed to bring different functions to the vicinity, which will make it attractive, livable and more resistant to changes in land-use.

(3) Synergy. This property is focused on ecological sustainability. For this purpose the project incorporates flood water treatment, noise barrier, dispersal corridor for water-living species, wind breaking, sun screening, and visual extension of the park. All these elements were brainstormed to enhance resiliency of the project site and make it more sustainable to future changes.

Based on the foresaid project reviews, we can see that the resilience concept can be implemented on different environments and scales. With the considerations of the project sites and understanding its nature and objectives, the resilience concept can prove its versatility and capabilities to adapt. However, it is important to note that the resilience concept is currently a new approach in urban practice and has its share of criticism.

4 Criticism of the Resilience Concept

Besides the broad perspective on the implementation of the Resilience concept, and its noted advantages, it still faces a lot of criticisms pertaining to inaccuracy.

Its main criticism is towards the notion itself. Resilience originated from Ecology, thus to find another meaning to it from other fields of knowledge is difficult. Moreover, this notion is often used in order to explain the complexity of certain environmental behaviors, phenomenon or occurrences. In an attempt to include all factors and complexities, many authors make the definition very vague (Folke, 2006). Another observation marked by Folke in his work “Resilience: The emergence of a perspective for social- ecological systems analysis” is conceptual substitution. He mentioned that Resilience often addresses events in terms of properties, appropriated for the living organisms or biological systems (like the notion recovery), ommitting the fact that recovery can be irrelevant for the majority of sciences where the Resilience concept also takes part. Therefore, scholars usually avoid the use of “recovery”, and would rather prefer definitions as “renewal” and “regeneration”, because these terms do not implicate the ability of a system to revert to its former shape without changes (Bellwood et al. 2004).

Another important remark is the gap between theory and practice. The fact that the Resilience concept is relatively present in urban development practice, it is hard to translate Resilience properties in physical dimensions (Hansen & Pauleit 2014). There are no distinct criteria for the proper interpretation that clearly describe the notion of Resilience in urban form, thus everyone translates the idea according to their own interpretations, and in turn, lead to further discussions. These controversies lead to the understanding of the fullness and complexities of the Resilience concept especially in fields where this notion is not well defined.

5. Conclusion

With the relative evidences mentioned, one could conclude: The Resilience Concept can be implemented into urban areas with serious environmental issues (Viganò 2012). However, due to the recent use of this concept, the definition and its properties vary, as various areas require different approaches and aims, and depend on the specifics of any project site. It means that there are no specific rules or patterns on how to come up with one resilient design. Consequently, the process of searching a fine solution, definition and main properties has become a new resilience thinking approach (Walker & Salt 2006). This way of thinking, in turn, helps to shape a main strategy or design concept for the flood resilient design proposal.

In addition, a city can be resilient and be able to survive through time and changing events, and be open for future adjustments (Fabian 2012) .Considering all these factors, a conclusion can be made that instead of developing a defensive solution or building structures that contradict the flow of nature, the emphasis could be on how to make a city more resilient to flooding instead, by using these properties: Adaptive capacity, Adaptive rate Cross- scale interactions, Transformability, Flexibility, Diversity, Connectedness, Openness and Accessibility. As Lynch (1972) stated in “What Time is This Place”, the cities that have best “interfered time” are those that have these characteristics. In fact, the Resilience concept is being more widely used in current developments, urban practices and adaptive designs.

7. ANALYTICAL FRAMEWORK

This part of the Graduation Project is multipurpose. It consists of three different stages. The first one defines the Project site; the second part discloses the existing spatial attributes in accordance with the Resilience Concept; and the third stage investigates the preliminary solution for the project site based on the results of current spatial features.

1. Introduction

This chapter is a «natural extension» of the Theoretical Framework. It serves both as a translation and representation of the Resilience concept, defined in the previous part as spatial properties of the city. Thus, definition of the Resilience concept, which consists of nine properties (adaptive capacity, adaptive rate, cross- scale interactions, transformability, flexibility, diversity, connectedness, openness and accessibility), will be translated into spatial qualities performed through a graphical analysis of London. It means that every property as adaptive capacity or accessibility and etc. will be represented in this chapter by means of analytical maps, graphs and schemes that represent this quality in relation to urban fabric, its structure, and quality of life among citizens.

The aim of the first stage of the Analytical Framework is to define the project site in order to find out the most vulnerable slot in the city and work around it. However, in order to narrow down the scope of the analysis, it is crucial to find out the definition of vulnarable space. For this reason, the definition of Spatial Vulnerability Index was taken into account and translated into a graphical analysis of urban space.

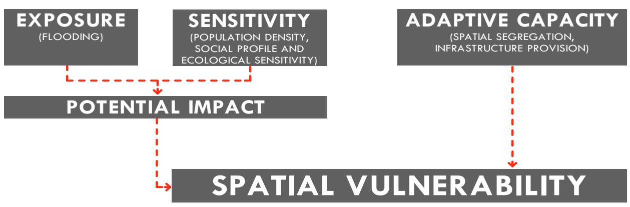


Fig. 7.1 Spatial Vulnerability scheme. «Spatial metrics modeling to analyse correlations between urbanform and surface water drainage performance» by T.K. Bacchin, 2011

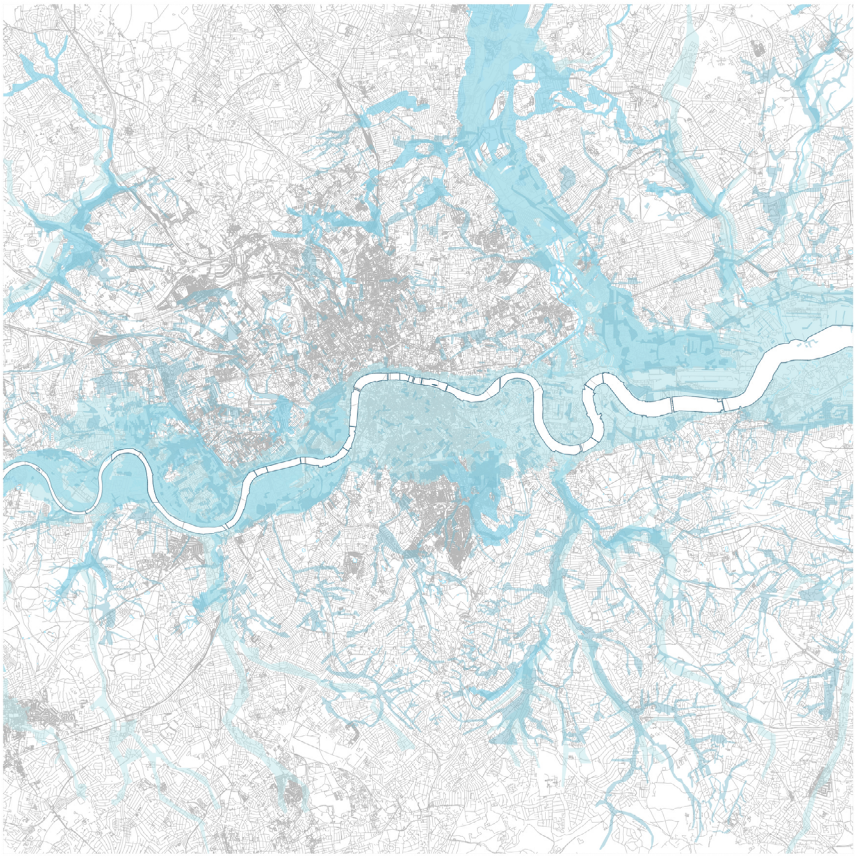
2. Spatial Vulnerability Index

The Spatial Vulnerability Index is used as an accurate reference to determine city areas that are exposed to different hazards. It is comprised of the following elements: exposure, sensitivity, adaptive capacity and potential impact. (T. K. Bacchin, 2014) In the context of this Graduation Project Exposure, Flooding being the subject, it serves as a testing machine for all components of the future design proposal. Sensitivity of space signifies liability of the space area to hazards. In this particular project, it is represented by several attributes, namely: population density, social segregation, ecological sensitivity. Population density indicates how many people will be affected by floods. Social segregation displays areas of the city which have poor spatial conditions, lack of facilities and influenced by gentrification. Ecological sensitivity is represented by open «green» and «blue» networks, its quality, size, and openness, which in turn are able to reduce pressure of Climate Change effects.

The final component of the Spatial Vulnerability Index is Adaptive Capacity, with Spatial Segregation and Infrastructure Provision as its components. Spatial segregation means accessibility of the space and its openness to exposure , while Infrastructure provision indicates connectedness of all facilities and allows a city to work as one smooth system. Altogether, these components allow us to reach a proper site definition (properties included), which influence not only the safeness of the space, but also contribute to the overall life quality standards of the people affected.

1. Flooding

As mentioned in the Problem statement, the city of London is exposed to different types of flooding every year. Moreover, the frequency of such events becomes more rapid as the years pass. As urbanists, however, the nature of these events is not much significant compared to its spatial location within the city. It is important to note that different types of floods affect various parts of the city and areas of distribution differ. Thus, defining flood-prone areas is the most crucial part in determining the most vulnerable site of the city. For this purpose, I marked the maps with different types of flooding. The map on the right is the outcome of this work. The range of colors represent risk levels involved with the severity of various types of flooding. The most destructible areas have the darkest colors.



0 1 2 3 4 5 km

own illustration based on data from http://maps.environment-agency.gov.uk

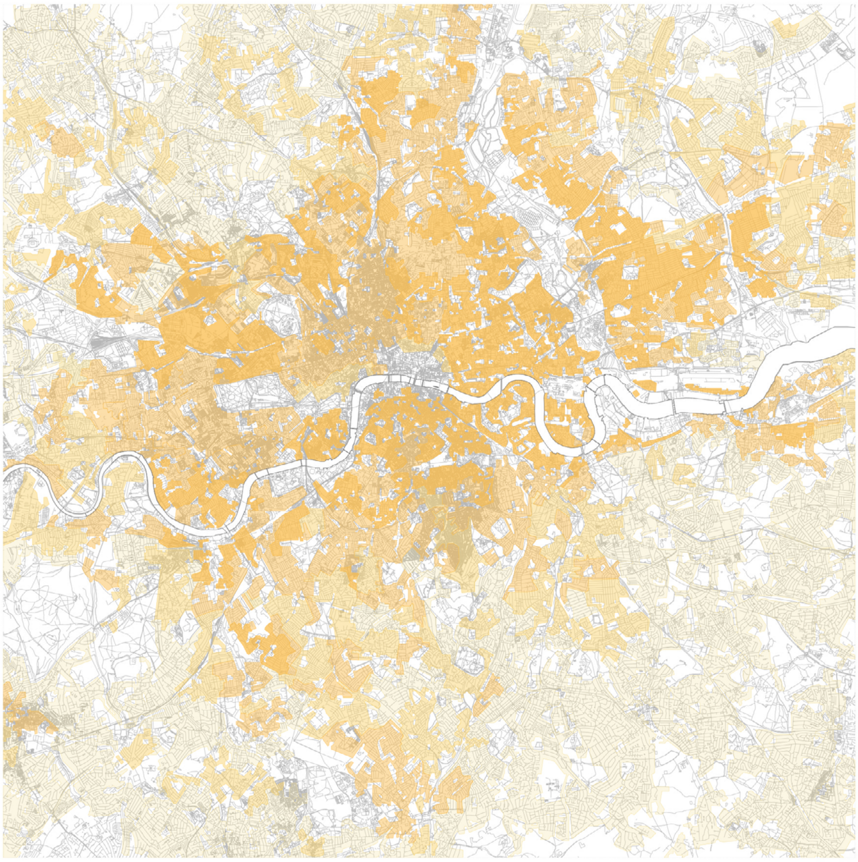
LEGEND

low level of flood
moderate level of flood
significant level of flood
high level of flood

2. Population Density

Flooding alone cannot be considered the main determining component. Some areas, as indicated on the «Flooding Map» above, illustrate a certain resistance level. These areas have less population, parks, natural greeneries and big open spaces. This shows the importance of density in areas affected by floods. If two areas have the same hazard level, the more populated one will undoubtedly be more vulnerable than the other with lesser people.

The result of this analysis shows the population distribution in the city of London. Based on the map, the most dense districts are: Hammersmith, Fulham, Lambeth, Westminster and Tower Hamlets. (ONS Census data on Population)



0 1 2 3 4 5 km

own illustration based on data from http://blogs.casa.ucl.ac.uk/2013/09/04/launching-luminocity-gb-urban-form-and-dynamics-explorer-2/

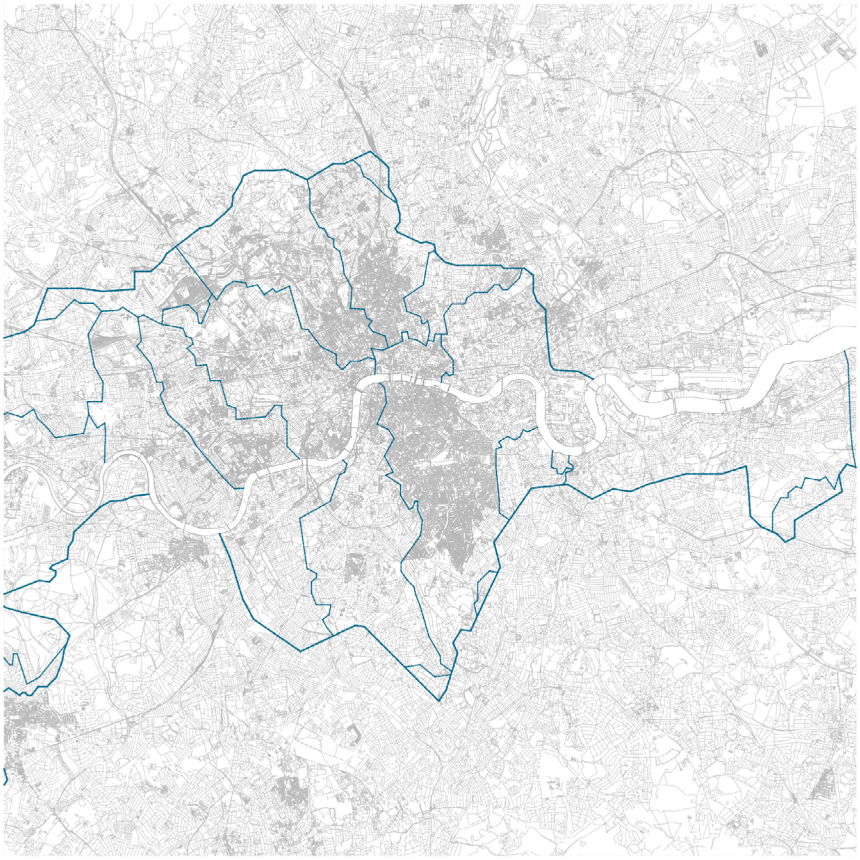
LEGEND

120-285 persons per 1 ha
90-120 persons per 1 ha
70-90 persons per 1 ha
19-70 persons per 1 ha

3. River Catchments

As previously mentioned, it is extremely important to understand that a city is a complex system of connections. Water System is no exception. To define the most appropriate solution for flooding issues in dense urban areas, it is best to work on one river catchment. The river catchment is «an area of land where surface water converges to a single point at a lower elevation (usually the exit of the basin), where the water joins another body of water such as a river, lake or another water reservoir» (North American English usages).

Location of the project site in one river catchment will allow us to enhance the Resilience capacity depending on the solution for each section : upstream, middle- stream and down stream areas.



0 1 2 3 4 5 km

own illustration based on data from http://www.therrc.co.uk/lrap.php

LEGEND

city structure

main catchments

the borders of the river Thames catchments

4. Social Profile

Social vulnerability is of utmost importance in speaking about spatial sensitivity or receptiveness of the space to environmental changes. This characteristic implicates accessibility to the basic needs and uses (as hospitals, schools, public transport and etc.), scope of functions, and social segregation.

The map on the right is a graphical representation of all properties listed above. The darkest color represents the most vulnerable areas in the city. It means that these areas need more protection and that to improve Resilience against flooding can be a challenge to increase the quality of life in the area

0 1 2 3 4 5 km

own illustration based on data from http://blogs.casa.ucl.ac.uk/category/deprivation/

LEGEND

the most socially deprived areas

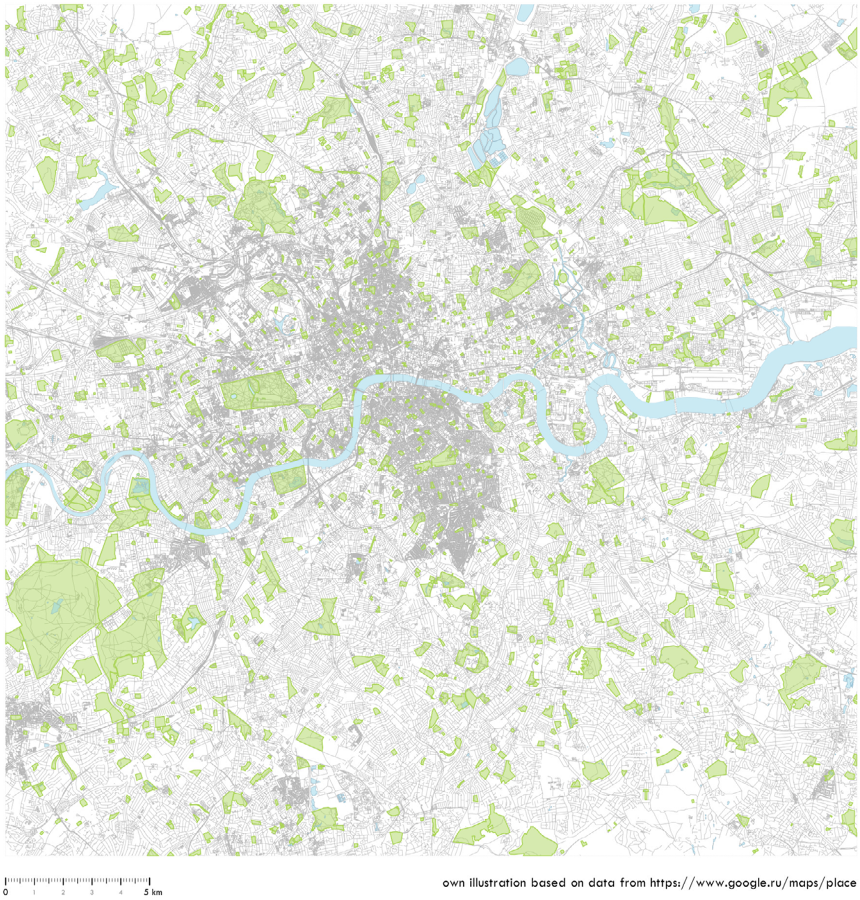
less socially deprived areas

the least socially deprived areas

5. Ecological Sensitivity

Another important component which forms the Spatial Vulnerability Index, is Ecological Sensitivity. This phrase means ecological capacity of the space. In other words, this component represents open «green» and «blue» networks, its quality, size, openness, that reduce pressure of Climate Change effects. Areas located close to big parks, open space with greenery, and etc. have a higher level of protection against flooding.

The map on the right shows the «green» and «blue» network in the city. In combination with other analytical maps, it provides us with areas that could serve as water storage, reduce heat wave effects, and serve as ecological buffers for the city.



own illustration based on data from https://www.google.ru/maps/place

LEGEND

main water system

main greenery system

city structure

6. Connectedness

Connectedness is one of the properties needed in order to define an appropriate project site. This characteristic determines such phenomenon as spatial segregation. Basically, infrastructure includes all the facilities that citizens need. The better-connected the area is, the lower the level of spatial segregation, the smoother the activity, and there is more efficient distribution of services. This property is crucial during flooding because it gives an opportunity for water to get in and out of the subject area.

The analytical map on the right shows the transport network in the city of London. Besides public transport and roads, it also includes train roads and the underground.

own illustration based on data from https://www.google.ru/maps/place

LEGEND

train lines

public transport

main highways

7.1 SITE SELECTION

The main objective of this stage is to define the most vulnerable part of the city. This means that definition of the project site is not only to find the flooding area, but also the other factors that make an area vulnerable.

1. «Sharing Affairs» Concept

This concept arises from the arrangement of the water system within one river catchment and helps to define a project site. One river catchment consists of three areas: upstream (the highest area within one water catchment), middle- stream (the space in between upstream and low lying areas)and downstream (the lowest area within one water catchment). These three areas are all connected but have different pressure levels during floods, heavy rainfalls and etc. Upstream areas perceive precipitation only within its area, while middle- stream expect precipitation within its scope, plus the excess more which have not been absorbed upstream. Only the downstream area is exposed to precipitation and river floods, and has to cope with the excess water from both upper and middle streams.

2. Meaning for the project

This concept presents the notion of «sharing» the impact of Climate Change effects within the urban tissue body. It means that attempted solutions, through enhancing the adaptive ability of the urban spaces on the upper- and middle- streams will reduce pressure on the downstream area. As a result, the solution presented for the downstream area becomes more economical and environmentally sustainable. Moreover, this approach will allow different combinations of proposals for every area, and provide a more flexible and efficient design.

CONCEPT SCHEME

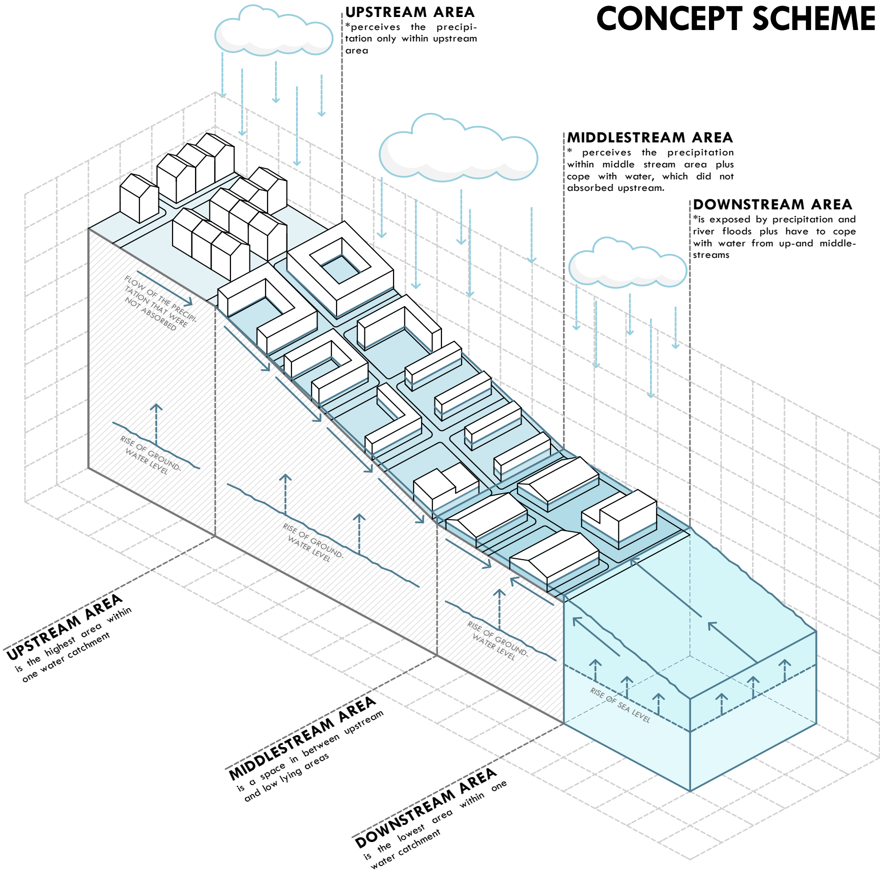


Fig. 7.7 Own illustration based on the paper «Spatial metrics modeling to analyse correlations between urbanform and surface water drainage performance» by T.K. Bacchin, 2011

3. Site selection Scheme

The components of the Spatial Vulnerability Index are Spatial Sensitivity (population density, ecological sensitivity, social segregation), Adaptive Capacity (spatial segregation, represented by analysis of the city's transport network) and Exposure (flooding). For the site selection, all maps with properties listed above were combined. The final map includes all six layers but with an edited hierarchy system. To make the final map more comprehensive, I made a value range within factors that is included in the analysis. Thus, the most important properties became Density and Hazard of flooding. The combination of these two factors indicates the number of people affected. The second one is Social and Spatial segregation. This shows the adaptive capacity of existing space and its ability to resist and cope with Climate change effects. And lastly, Ecological Sensitivity.

This property reduces the pressure or the negative impact of flooding and enhances adaptive capacity. According to the Spatial Vulnerability Index, each area has a different color gradient. In order to work with one water system, the project site is located in one river catchment. Another important factor is the areas that vary in height levels, such as upstream, middle stream and downstream. All three have different permeability, amount of precipitation and influence of flooding. All are connected and do influence each other, which leads us to include the «Sharing Affects» concept.

1 PROJECT SQUARE /
UPSTREAM AREA

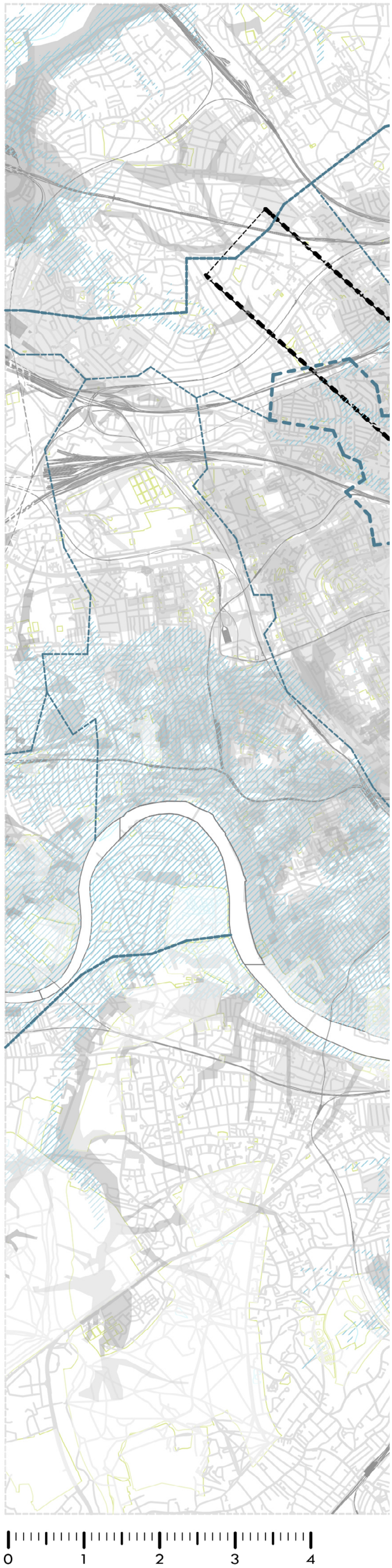
LOCATION:	WESTMINSTER
DENSITY:	26,000 sq mi (10,000/km^2)
POPULATION:	219,600
RISK OF FLOODING:	SIGNIFICANT LEVEL

2 PROJECT SQUARE /
MIDDLE-STREAM AREA

LOCATION:	WESTMINSTER
DENSITY:	26,000 sq mi (10,000/km^2)
POPULATION:	219,600
RISK OF FLOODING:	VERY HIGH LEVEL

3 PROJECT SQUARE /
DOWNSTREAM AREA

LOCATION:	LAMBETH
DENSITY:	29,000 sq mi (11,000/km^2)
POPULATION:	304,500
RISK OF FLOODING:	VERY HIGH LEVEL



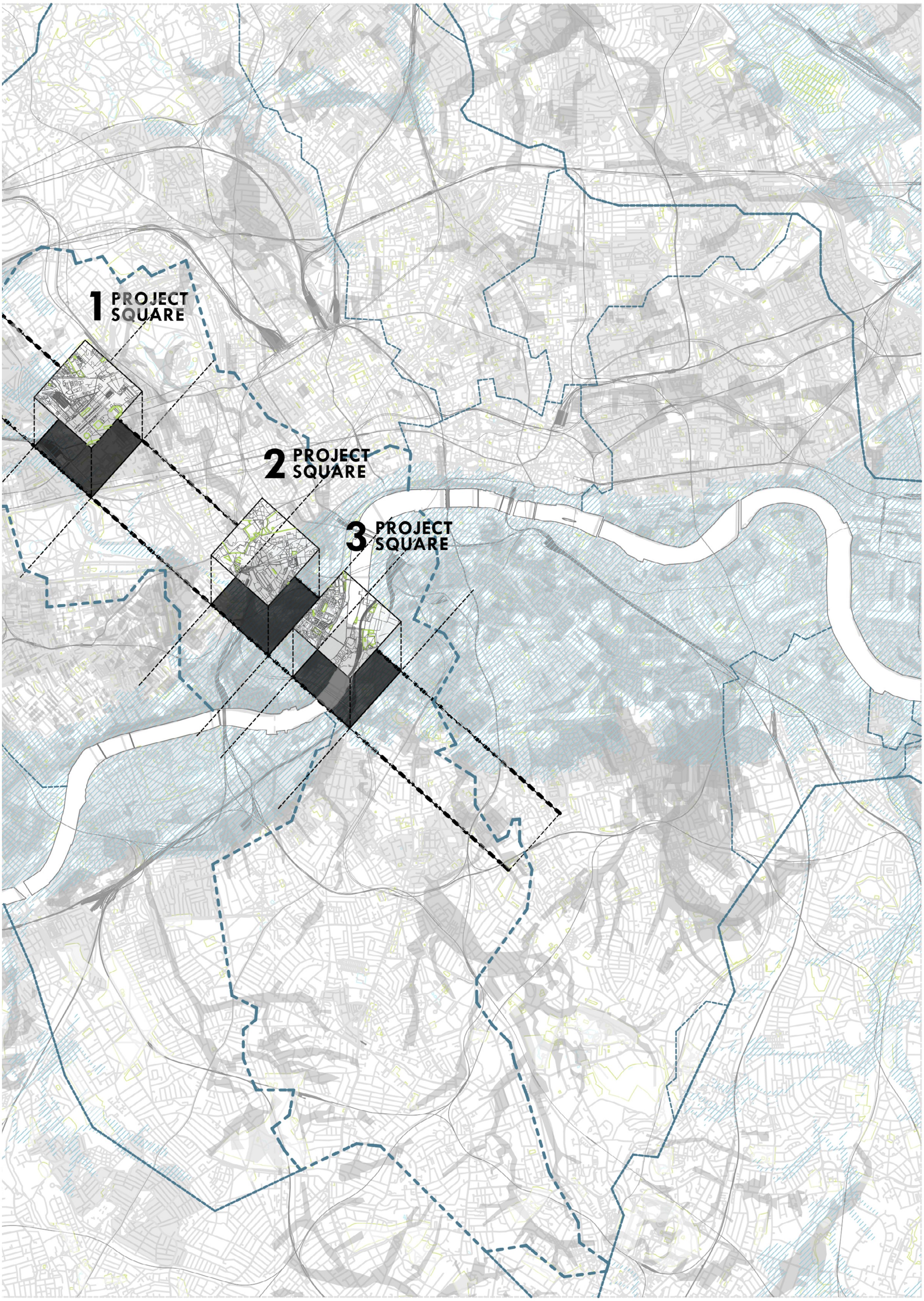


Fig. 7.8 Own illustration based on the vulnerability analysis

LOCATION ANALYSIS

HOW TO READ

Analysis is arranged from large to small scale and for each scale respective parameters of suitability for water transfer and storage identify limits and potentials of each level. Moving from city to local scale helps to make use of natural qualities of the area and integrate water management function in existing urban fabric. Understanding the volume, source and directions of water flows plays important role in development of methodology and design principles.

At the level of river catchment, determining factors for construction of water management system are: city-scale sports of water storage - lakes and parks; relief of the landscape; directions of main streets in relation to relief and location of elements that cannot be used in the system - evacuation streets and architectural monuments. In result of this analysis, it is possible to identify which streets can be used as urban waterways in extreme situations and which streets can act in normal situations. This system is connected to city-scale spots of water storage, located in the parks, so the water can be distributed according to capacity of each storage spot. Limits, imposed by protected elements of the city, allow to construct complete system of water management.

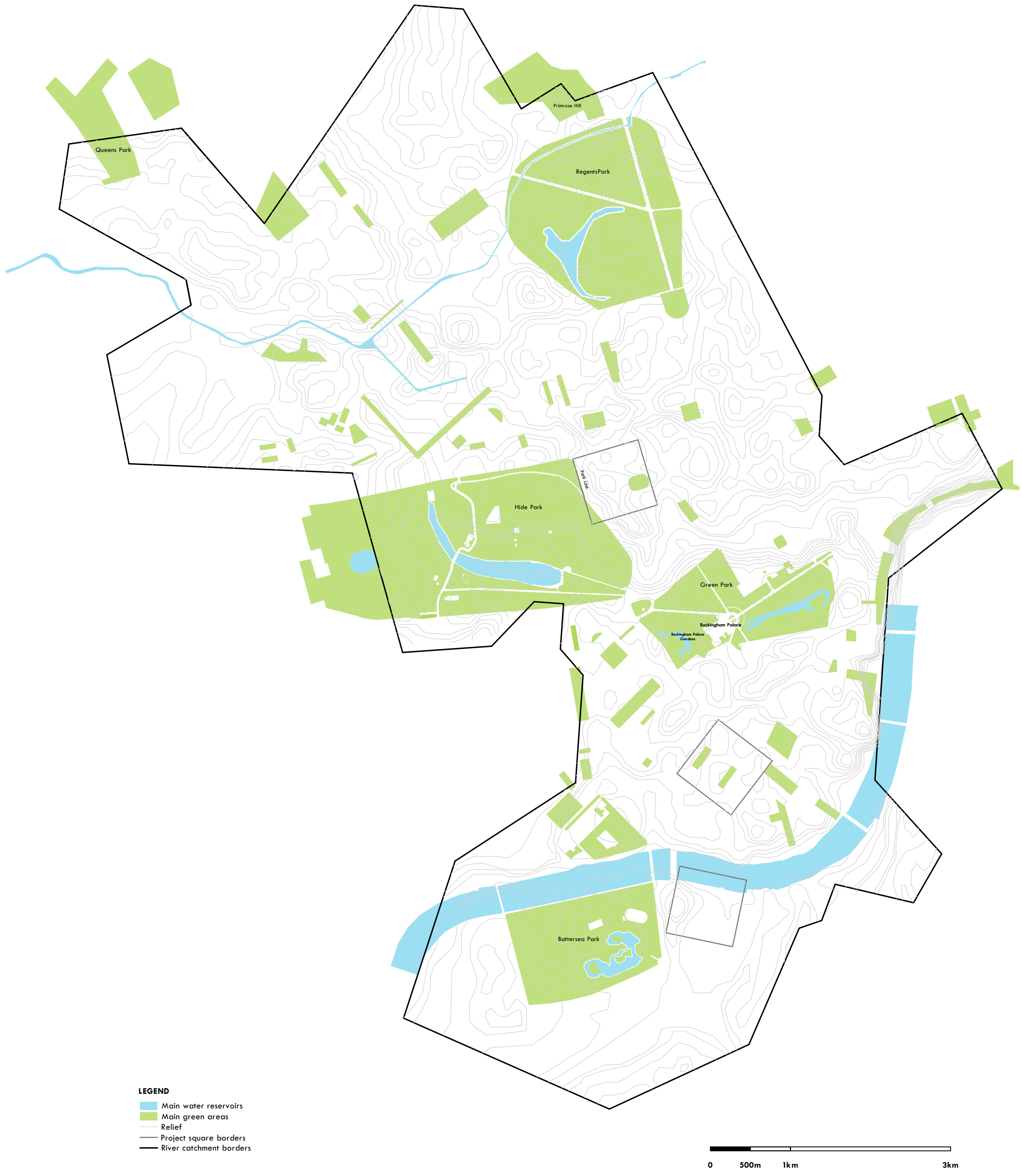
At the level of middle scale, represented by 3 chosen project sites, each one at respective level of river catchment area. Within these sites determinants of water management system are: functional content of each site; openness and accessibility of inner space in the urban blocks; connectivity and density of street network. Combination of these parameters identifies perspective potential of each site for water storage and transfer of it to lower areas of river catchment area. Every lower site perceives surplus water from upper sites in addition to its own loads of water.

Finally, local scale analysis is focused on analysis of urban blocks within each site. Potential usability of each block depends on 3 parameters: compactness (index of built-up area), intensity (index of m2 of building total area to m2 of the lot) and openness of the area (amount of unbuilt space). Resulting set of indexes for each block helps to determine which ones can easily adopt new function and be included in the system.

Findings of the analysis provide data for the matrix, which is then used as methodological framework for development of design solutions for each scale and respective role of the elements.

This sequence of analysis helps to make maximum use of existing qualities of current urban fabric at every scale. In addition, key elements of local identities are saved and advanced further. In many cases, small improvements and optimisations can save public spaces in their authentic condition, while their resilience to flooding and extreme weather events is significantly increased. Therefore, developed design solutions treat the city with attention and respect, enhancing performance of public space in times of heavy rainfalls. In addition, project contributes to better connectivity of green networks in the city and creation of new levels of semi-public spaces within urban blocks, what affects social and cultural activities in the area.

GREEN AND BLUE NETWORK



Analysis of green and blue networks shows that river catchment, forming the background situation for project sites, contains 4 major green bodies and each of them has blue component. Relief within the catchment is hilly in character, but it gets lower in the direction from North to South. In addition, water is regulated by 2 pumping stations: one next to the Parkline, another next to the Battersea station. Rainwater is first collected to the lakes within major parks, then transferred to the river by means of tubes.

STREET NETWORK DENSITY

The map shows detailed street networks for project sites and network of main streets that is influencing the sites. Main streets regulate the amount of water, which comes to the sites from outside and is added to the volume which sites perceive within their own network. Highest parts of the street show the most dry elements of street network, while orange parts show the direction of water flows. This map shows the way through which water can be transferred from upstream to downstream and what streets can act as river streets.

ANDRUSENKO EKATERINA

LIMITATIONS

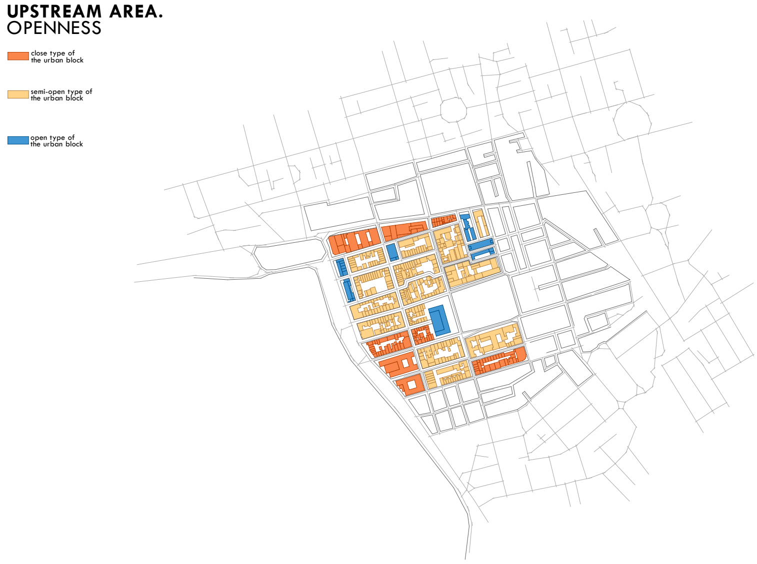
This map adds the overlay of street network by parts of the city that cannot participate in the transfer of water. Among those parts there are infrastructural elements like evacuation roads, connecting hospitals and fire-stations, and historical monuments, like Westminster Abbey. These areas dictate limitations to the overall plan and identify streets and blocks, which are used for water management.

ANDRUSENKO EKATERINA

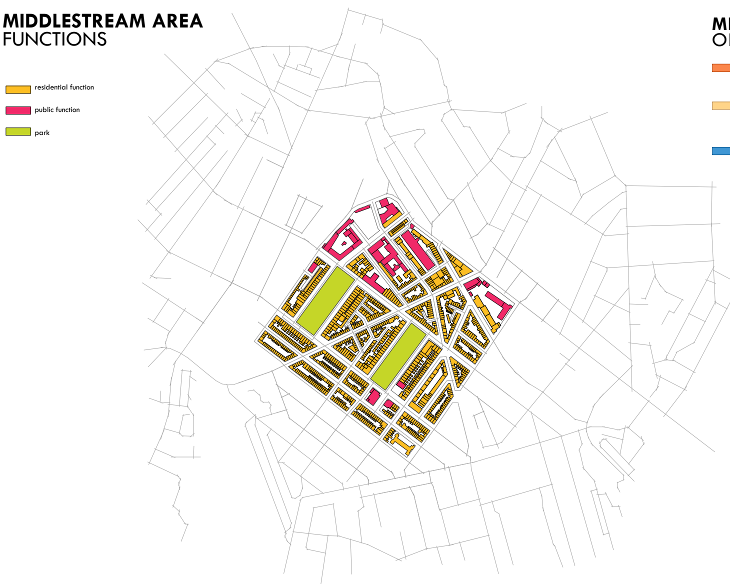
PROJECT SITES ANALYSIS

UPSTREAM AREA
FUNCTIONS

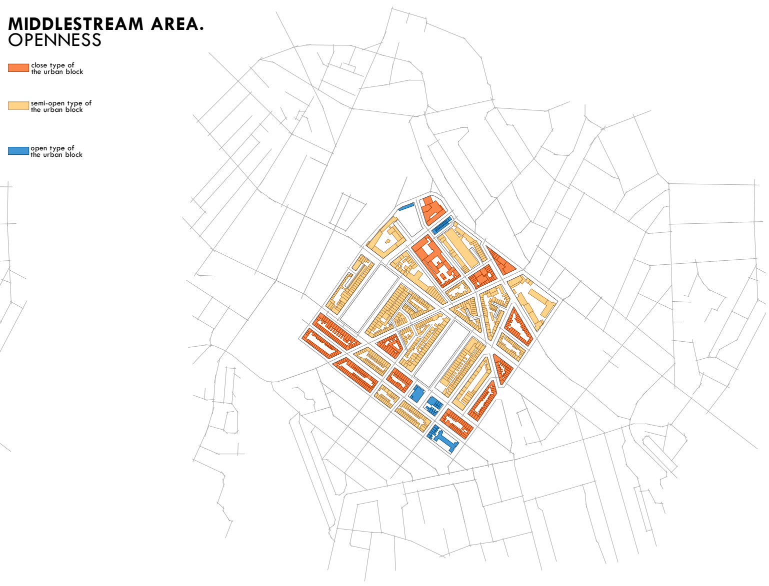
UPSTREAM AREA.
OPENNESS



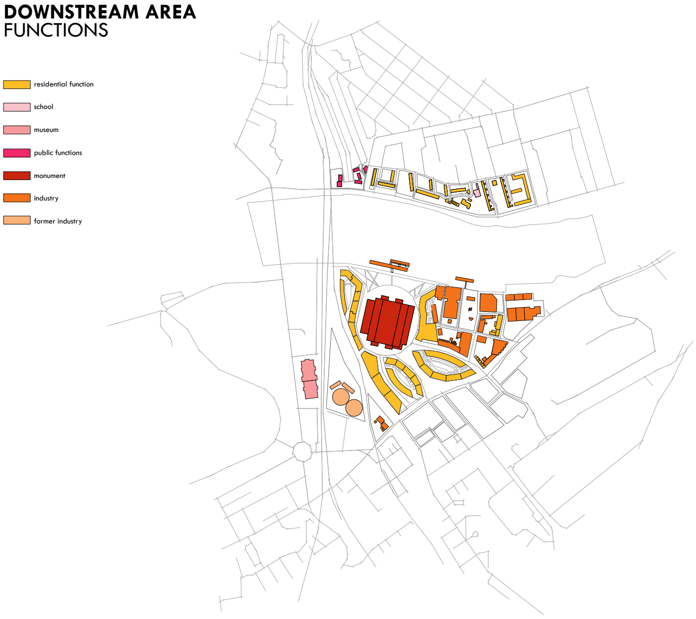
MIDDLESTREAM AREA
FUNCTIONS



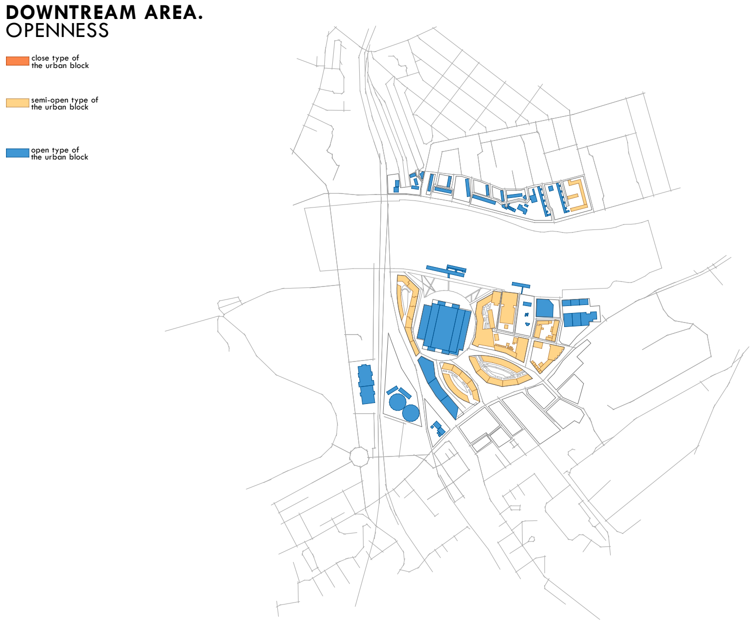
MIDDLESTREAM AREA.
OPENNESS



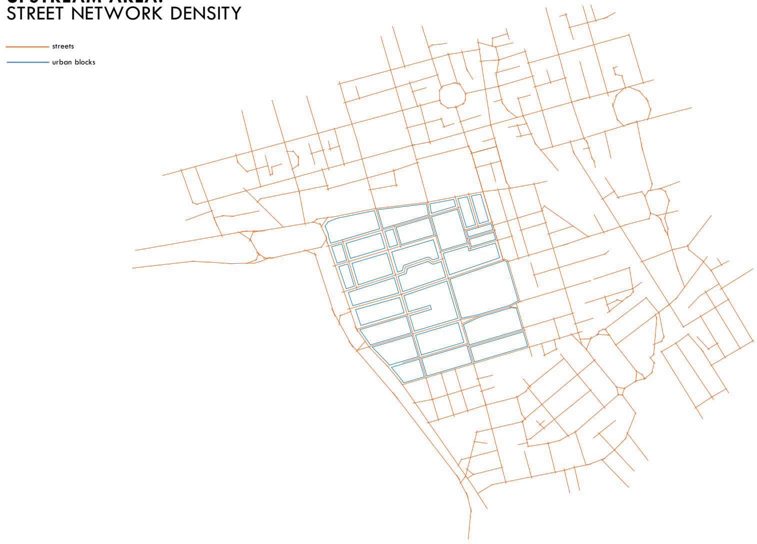
DOWNSTREAM AREA
FUNCTIONS



DOWNTREAM AREA.
OPENNESS

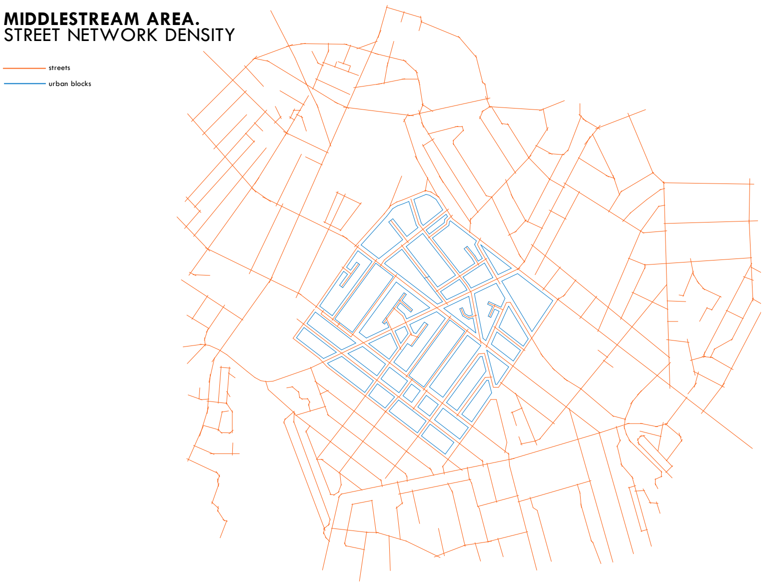


UPSTREAM AREA.
STREET NETWORK DENSITY



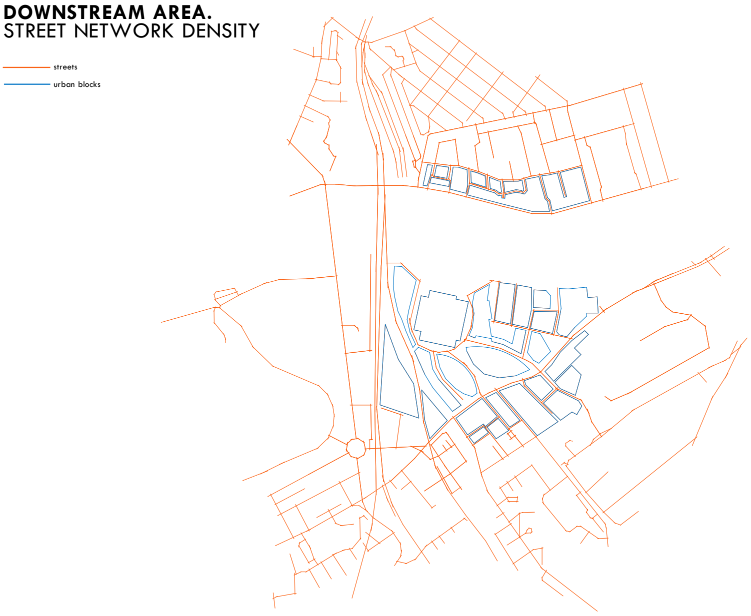
Upstream area is very multifunctional and has almost no residential function. Consequently, majority of blocks are semi-open or open, what makes them suitable for participation in the project. However, area is actively used because of many shops, offices and restaurants, so transportation of water to the lower areas is more desirable. Connectivity and density of street network allows to increase the capacity of transferred water. Storage is organised in green zones, gardens and on the roofs.

MIDDLESTREAM AREA.
STREET NETWORK DENSITY



Residential area in the middlestream zone is relatively monofunctional and quiet neighbourhood. Streets in the area are relatively well-connected, but their direction limits their suitability for transfer of coming water to lower areas. However, many blocks within the area are semi-open and their inner space can be used for water storage and redirection of water flows through them. In result, area can perceive much more incoming water and store considerable amount of it within its limits.

DOWNSTREAM AREA.
STREET NETWORK DENSITY



Riverfront is currently occupied by the industry and newly built housing, but urban fabric is composed of mostly open and semi-open blocks, which allows to use plenty of public space for purposes of water management. Nevertheless, connectivity and density of street network should be improved in order to redirect water flows and introduce missing connections. In addition, use of layered landscapes and floating constructions can make area keep functioning in parallel to its role in water management.

GSI, FSI, OSI
UPSTREAM SITE

GSI
(compactness of the area)

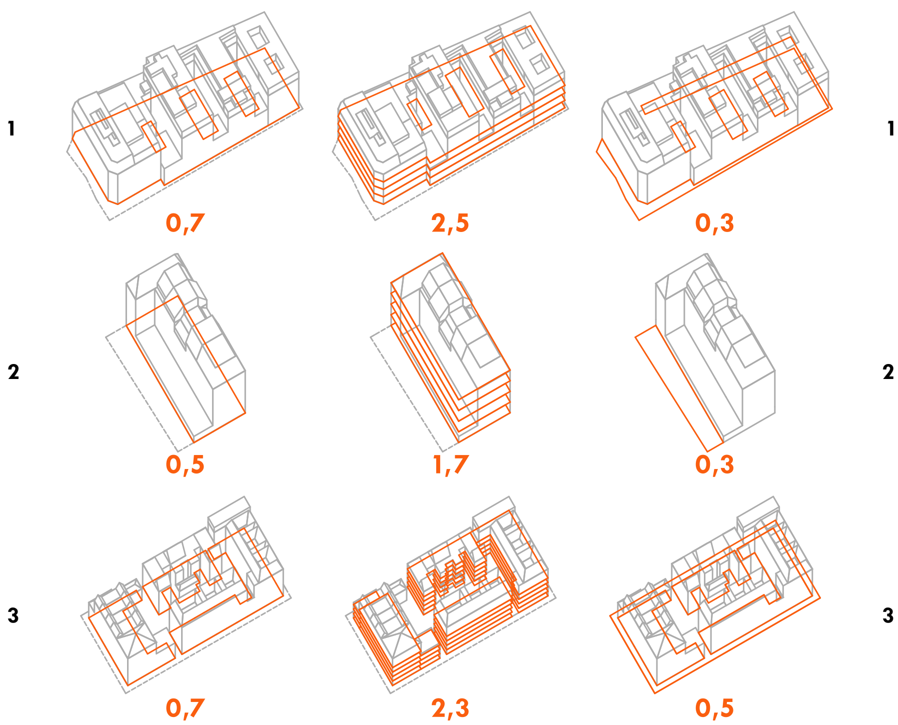
$$= \frac{\text{Build Area}}{\text{Plan Area}}$$

FSI
(intensity of the area)

$$= \frac{\text{Gross Area}}{\text{Plan Area}}$$

OSI
(openness of the area)

$$= \frac{\text{Plan Area - Build Area}}{\text{Plan Area}}$$



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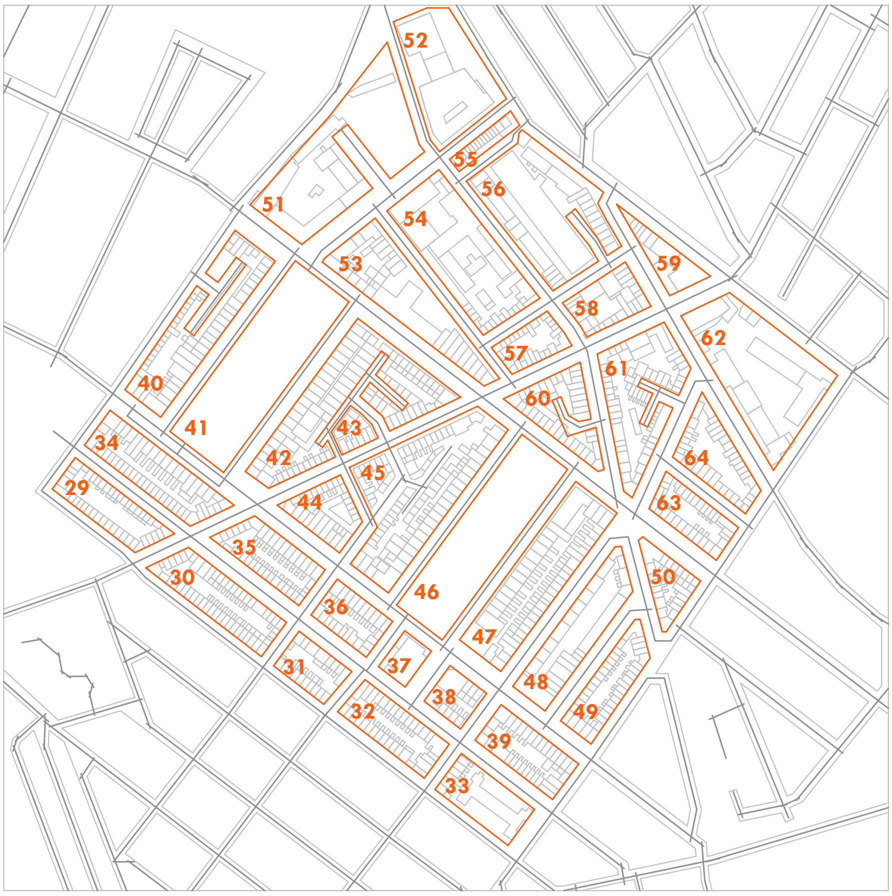
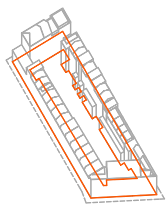
GSI, FSI, OSI
MIDDLESTREAM SITE

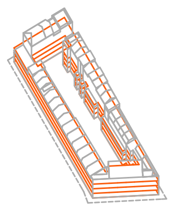


GSI (compactness of the area)	FSI (intensity of the area)	OSI (openness of the area)
$= \frac{\text{Build Area}}{\text{Plan Area}}$	$= \frac{\text{Gross Area}}{\text{Plan Area}}$	$= \frac{\text{Plan Area - Build Area}}{\text{Plan Area}}$

29



0,6



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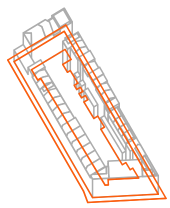
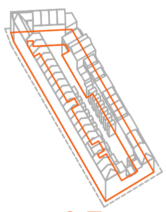


0,5

29

30



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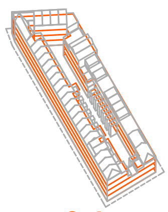

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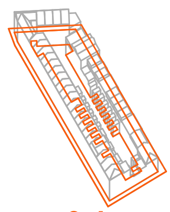

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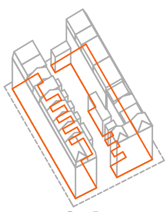
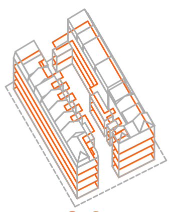
30

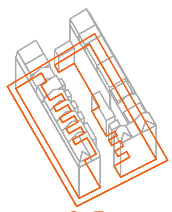
31



0,6



2,3



0,5

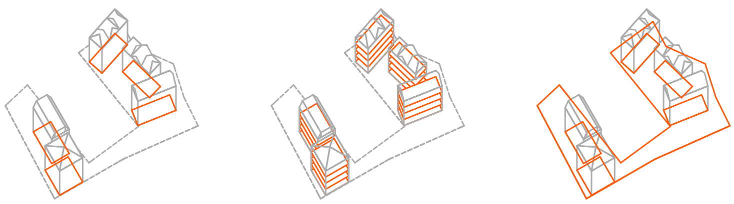
31

GSI, FSI, OSI

DOWNSTREAM SITE

GSI (compactness of the area)	FSI (intensity of the area)	OSI (openness of the area)
$= \frac{\text{Build Area}}{\text{Plan Area}}$	$= \frac{\text{Gross Area}}{\text{Plan Area}}$	$= \frac{\text{Plan Area - Build Area}}{\text{Plan Area}}$

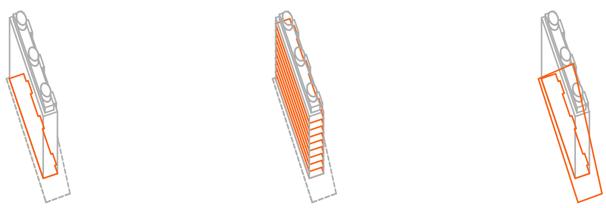
65



0,4	0,8	0,5

65

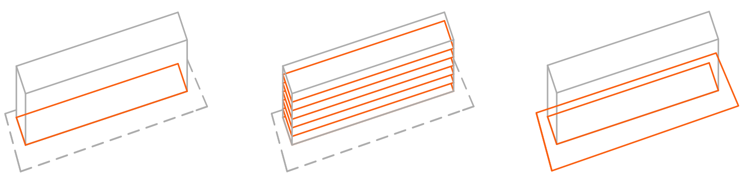
66



0,4	3,2	0,6

66

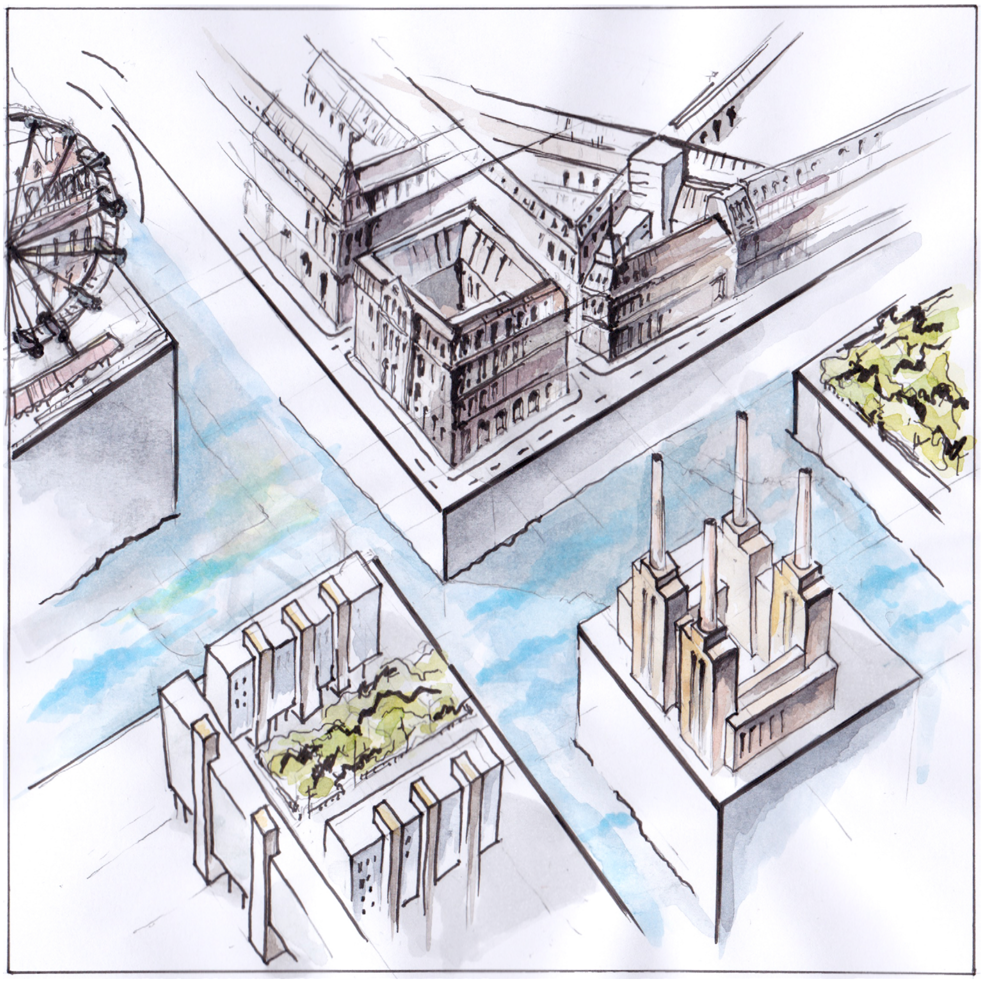
67



0,4	2,1	0,6

67

CONCLUSIONS



Resulting number of parameters, arranged in scales and role in water management, allows to react on various types of flood threads. The analysis is summarized and structured in the matrix, which acts as methodological framework for design solutions.

Matrix is arranged according to scales and roles in water management - transfer or storage of incoming water. Each segment of the matrix identifies the most effective design solution in relation to performance of this element in the system, while aesthetic and functional parameters can be added independently from this. Use of matrix can start from large scale or small scale.

Starting from large scale, parameters of location reveal whether existing green and blue elements of the city can be used for the system. If this is not possible and the site is too far, smaller elements of the city can perceive water volumes, and if that is not possible too, the danger of flooding can be addressed at the smallest scale, within urban blocks.

The bigger is expected flood, the larger urban system can manage the water flows. Smaller threads can be resolved at the small scale, while significant rainfalls require multiscalar approach.

Matrix takes into consideration not only amount of water and scale of responding system, but also the way in which water management can affect functionality of urban environment. Thus, water is not taken only as an enemy but also as a friend.

Design solutions, proposed in the matrix, are aimed to enhance social interaction and aesthetic quality of intervention spots. In addition, the element of changeability allows to use elements of the system differently in dry and wet periods, what creates more opportunities for public life and activities. In this way, flood resilience contributes to more attractive and vital urban fabric. Matrix is followed by examples of designs solutions, applied to various parts of the system and illustrating the impact of designs on resilience and liveability.

MATRIX

SET CONDITIONS | COMBINE SETTINGS MAKE NEW NARRATIVES | SET CONDITIONS

START FROM THE BIG SCALE → [XL CITY SCALE] [L RIVER CATCHMENT SCALE] [M SQUARE 500 * 500 m] [S ONE URBAN BLOCK] ← START FROM THE SMALL SCALE

ANALYSIS / MATRIX

LARGE CITY SCALE

OPERATION	CLOSE BY EXISTING BLUE AND GREEN NETWORK *Element that is closely located to big parks, lakes,greenery, natural resources and etc	ISOLATED FROM EXISTING BLUE AND GREEN NETWORK *Element that is isolated from big parks, lakes,greenery, natural resources and etc
MOVE		TRANSITIONAL LANDSCAPES THAT INFILTRATE RAINWATER AND ENABLE NEW FOR OF SOCIAL LIFE AND INTERACTION **SAFELY MOVE WATER FROM UPPER LAND TO DOWNSTREAM**
		TRANSITIONAL LANDSCAPES THAT INFILTRATE RAINWATER AND ENABLE NEW FOR OF SOCIAL LIFE AND INTERACTION **SAFELY MOVE WATER FROM UPPER LAND TO DOWNSTREAM**
	NETWORK OF CANALS AND LANDSCAPE ELEMENTS THAT ALLOW SAFE MOVEMENT OF WATER TOWARDS STORAGE AREA **SAFELY MOVE WATER FROM UPPER LAND TO DOWNSTREAM**	
	ELEMENTS OF LANDSCAPE THAT ALLOW TO FILTRATE AND MOVE WATER INTO RIVER **SAFELY MOVE WATER FROM UPPER LAND TO DOWNSTREAM**	
STORE	LANDSCAPE THAT RETAINS RAIN WATER, WORKS AS RECREATION SPOT FOR SOCIAL INTERACTIONS **FIND A SPOT INSIDE GREEN BLUE NETWORK**	TRANSITIONAL LANDSCAPES THAT INFILTRATE RAINWATER AND ENABLE NEW FOR OF SOCIAL LIFE AND INTERACTION **CREATE NEW STORAGE INSIDE URBAN TISSUE**
	LANDSCAPE THAT RETAINS RAIN WATER, WORKS AS RECREATION SPOT FOR SOCIAL INTERACTIONS **FIND A SPOT INSIDE GREEN BLUE NETWORK**	TRANSITIONAL LANDSCAPES THAT INFILTRATE RAINWATER AND ENABLE NEW FOR OF SOCIAL LIFE AND INTERACTION **CREATE NEW STORAGE INSIDE URBAN TISSUE**
	LANDSCAPE THAT RETAINS RAIN WATER, WORKS AS RECREATION SPOT FOR SOCIAL INTERACTIONS **FIND A SPOT INSIDE GREEN BLUE NETWORK**	MULTI LEVEL LANDSCAPE THAT INCREASE RESISTANCE CAPACITY OF THE AREA **CREATE NEW PROTECTIONAL STRUCTURE**
OPERATION	*Element that is closely located to big parks, lakes,greenery, natural resources and etc **CLOSE BY BLUE AND GREEN NETWORK**	*Element that is isolated from big parks, lakes,greenery, natural resources and etc **ISOLATED FROM BLUE AND GREEN NETWORK**

upstream / middlestream / downstream (MOVE)
upstream / middlestream / downstream (STORE)

LARGE (RIVER CATCHMENT)

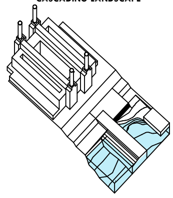
MEDIUM (SQUARE 500 * 500 m)

GROUND
*Modification at the surface of the ground

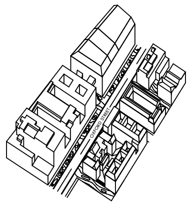
ENVELOPE
*Modification at the surface of the buildings

CREATION OF NEW NARRATIVES IN THE CITY

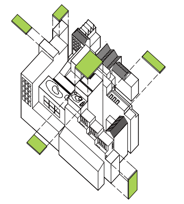
FLOATING ARTIFICIAL ISLANDS/ CASCADING LANDSCAPE



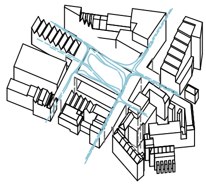
OPEN STEEN DRAINAGE SYSTEM



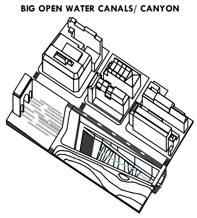
INTENSIVE GREEN ROOF



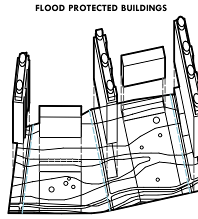
HOLLOW ROADS/ URBAN FORESTS



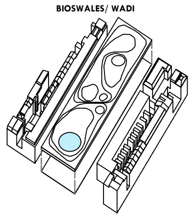
BIG OPEN WATER CANALS/ CANYON



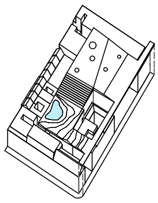
FLOOD PROTECTED BUILDINGS



BIOSWALES/ WADI



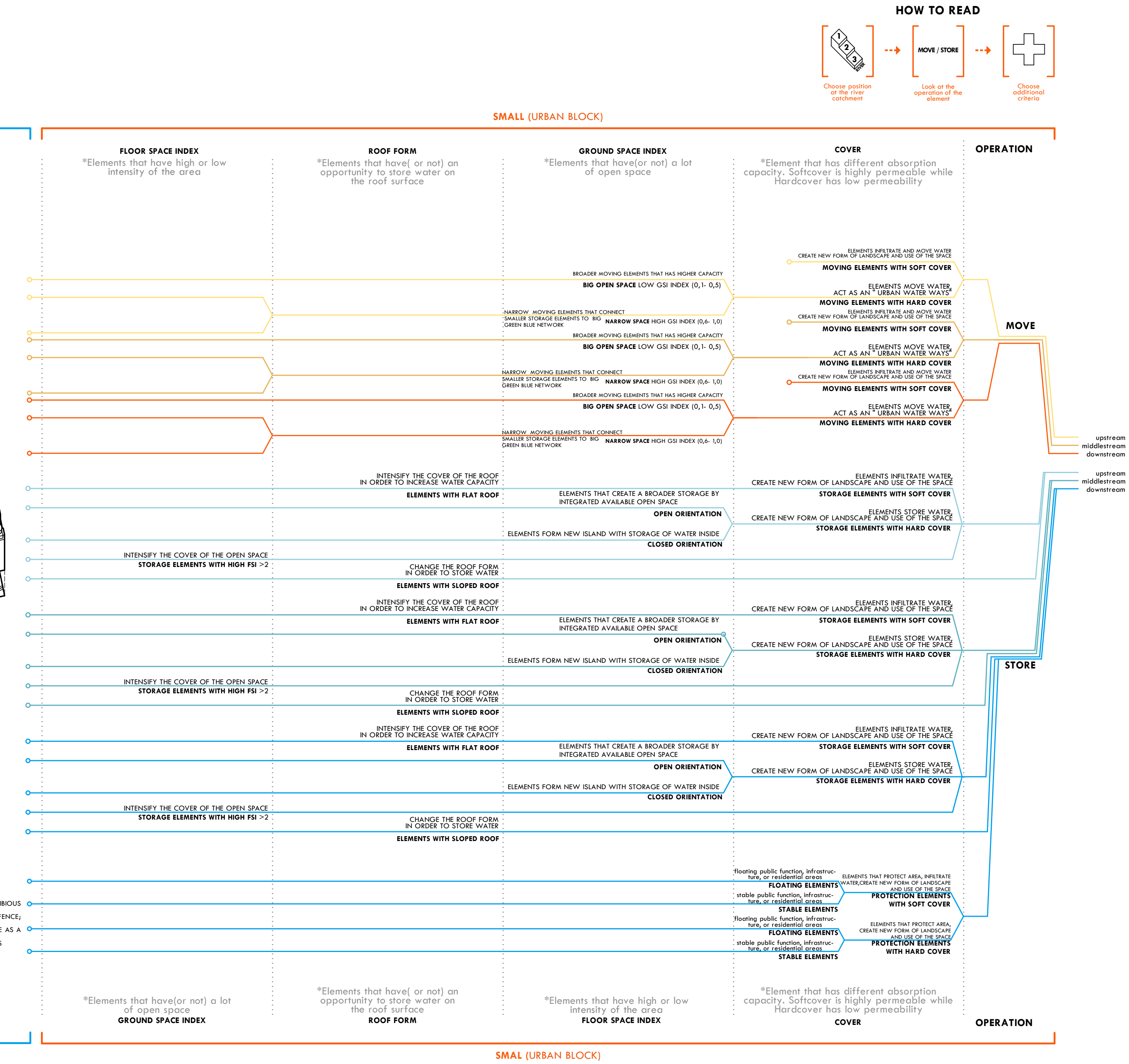
INSIDE GARDENS



BIG CANYON ; GREEN GRAIN STREET GRIDS; BIG OPEN WATER CANALS; WATER SCAPES; HOLLOW ROADS; OPEN; STEEN DRAINAGE SYSTEM; SMALL INSIDE GARDENS; COMMUNITY GARDENS; PLAYGROUNDS; WETLANDS IN FRON OF RIVERBANKS; CASCADING LANDSCAPE; DIKE; WATERSCAPES; GREEN SHORES; FLOATING ARTIFICIAL ISLANDS; URBAN SWIMMING POOL; FLOATING INFRASTRUCTURE; TEMPORARY LANDSCAPE; FLOATING ARTIFICIAL ISLANDS;; URBAN SWIMMING POOL; FLOATING PUBLIC SPACES (parks, recreation zones); TEMPORARY LANDSCAPE; CITY LEVEL; OPEN SPACE; URBAN FORESTS; ART SCAPES; URBAN MEDOW; EVENT LANDSCAPES; SPORT FIELDS; WATERSCAPES

INTENSIVE GREEN ROOF; GREEN FACADES; AMPH BUILDINGS; USE OF BUILDING AS FLOOD DEF TEMPORARY FLOOD PROTECTION; FLOOD WALL; DIKE BUILDING; WET PROOFING; BUILDING ON THE PILLARS

MEDIUM (SQUARE 500 * 500 m)

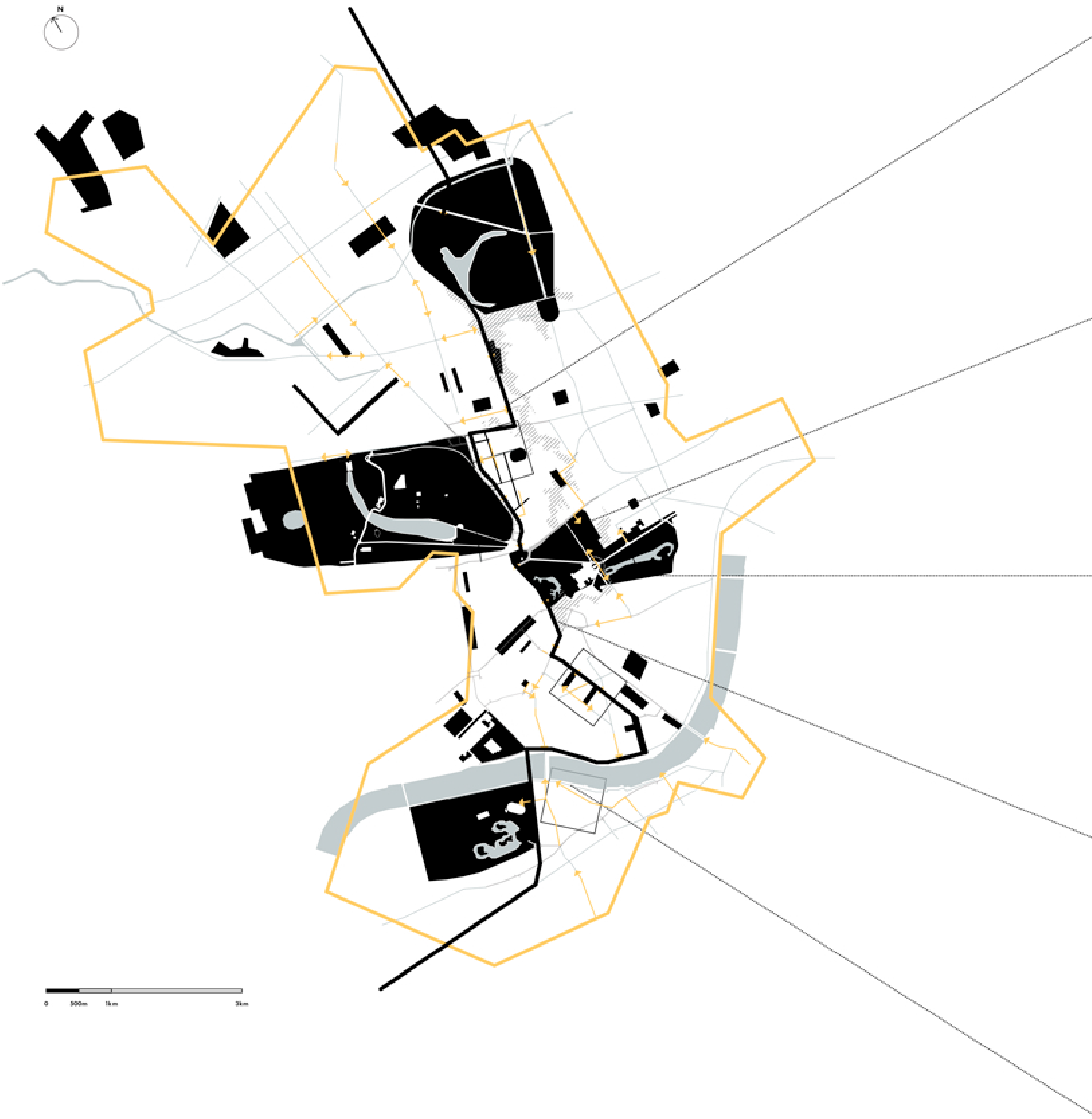

HOW TO READ
MOVE / STORE
Choose position at the river catchment
Look at the operation of the element
Choose additional criteria
SMALL (URBAN BLOCK)
FLOOR SPACE INDEX
*Elements that have high or low intensity of the area
ROOF FORM
*Elements that have(or not) an opportunity to store water on the roof surface
GROUND SPACE INDEX
*Elements that have(or not) a lot of open space
COVER
*Element that has different absorption capacity. Softcover is highly permeable while Hardcover has low permeability
OPERATION
ELEMENTS INFILTRATE AND MOVE WATER CREATE NEW FORM OF LANDSCAPE AND USE OF THE SPACE
MOVING ELEMENTS WITH SOFT COVER
BROADER MOVING ELEMENTS THAT HAS HIGHER CAPACITY
BIG OPEN SPACE LOW GSI INDEX (0,1- 0,5)
ELEMENTS MOVE WATER, ACT AS AN " URBAN WATER WAYS"
MOVING ELEMENTS WITH HARD COVER
NARROW MOVING ELEMENTS THAT CONNECT SMALLER STORAGE ELEMENTS TO BIG GREEN BLUE NETWORK
NARROW SPACE HIGH GSI INDEX (0,6- 1,0)
MOVE
upstream
middlestream
downstream
INTENSIFY THE COVER OF THE ROOF IN ORDER TO INCREASE WATER CAPACITY
ELEMENTS WITH FLAT ROOF
ELEMENTS THAT CREATE A BROADER STORAGE BY INTEGRATED AVAILABLE OPEN SPACE
OPEN ORIENTATION
ELEMENTS FORM NEW ISLAND WITH STORAGE OF WATER INSIDE
CLOSED ORIENTATION
ELEMENTS INFILTRATE WATER, CREATE NEW FORM OF LANDSCAPE AND USE OF THE SPACE
STORAGE ELEMENTS WITH SOFT COVER
ELEMENTS STORE WATER, CREATE NEW FORM OF LANDSCAPE AND USE OF THE SPACE
STORAGE ELEMENTS WITH HARD COVER
INTENSIFY THE COVER OF THE OPEN SPACE
STORAGE ELEMENTS WITH HIGH FSI >2
CHANGE THE ROOF FORM IN ORDER TO STORE WATER
ELEMENTS WITH SLOPED ROOF
STORE
floating public function, infrastructure, or residential areas
FLOATING ELEMENTS
stable public function, infrastructure, or residential areas
STABLE ELEMENTS
ELEMENTS THAT PROTECT AREA, INFILTRATE WATER,CREATE NEW FORM OF LANDSCAPE AND USE OF THE SPACE
PROTECTION ELEMENTS WITH SOFT COVER
ELEMENTS THAT PROTECT AREA, CREATE NEW FORM OF LANDSCAPE AND USE OF THE SPACE
PROTECTION ELEMENTS WITH HARD COVER
*Elements that have(or not) a lot of open space
GROUND SPACE INDEX
*Elements that have(or not) an opportunity to store water on the roof surface
ROOF FORM
*Elements that have high or low intensity of the area
FLOOR SPACE INDEX
*Element that has different absorption capacity. Softcover is highly permeable while Hardcover has low permeability
COVER
OPERATION
SMAL (URBAN BLOCK)

London bird eye view. 2014. Source:https://thebrokelondoner.files.wordpress.com/2010/09/p9060801.jpg

DESIGN PROPOSAL S, M, L, XL/ EVALUATION/ **RECOMMENDATION**

STRATEGY AND MAIN COMPONENTS

HOW TO READ



Strategy of the project is organised in 3 scales and 5 components, which are working as one system. Canyons and waterfronts are linear elements of the system that transfer water from higher to lower areas and eventually move it from the site. In addition, storage areas and connecting spots react on incoming water at the local scale and ensure the effectiveness of larger system. In result, urban fabric is capable to respond to occurring rainfalls effectively by means of landscape architecture and urban design.

source: archinect.com/news/tag/214565

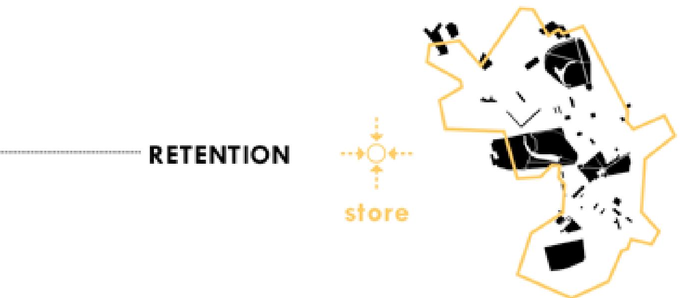
HARD CANYON

This element is designer for safe transfer of the water from upstream area to downstream. Besides of this it is connected to the largest green bodies of the city that can easily store considerable amount of rainwater. This «hard canyon» is transforming along its way according to the characteristics of each particular site. It can be an open waterway, a hollow road or really deep paved canyon, which can be used as public space with open slopes in dry and normal periods and as «city river» during heavy rainfalls.

source: allday2.com/index.php?newsid=540450

SOFT CANYON

This element is functioning in the hybrid between hard cover that moves water and soft cover that stores water, which are basically the elements that act as buffering zones. Soft canyon can partly infiltrate the rainwater, but it moves surplus water towards downstream areas. It is called soft canyon because it is not limited by street form but consists of spaces inside the blocks and streets network. This method allows to create bigger and more integrated spatial system, reacting on water volumes in the same way and at the same time performing in accordance with its urban surroundings.



source: http://koozarch.com

STORAGE AREAS

Storage areas serve as a retention zone for the rainwater running from the surrounding streets. It is used mainly during heavy rains and cooling the overall area in dry periods. Designed as network of pocket parks, this storage system has also public function and can contribute to overall quality of urban environment, apart from its main function of water storage.

source: http://koozarch.com

CONNECTING SPOTS

These components of the strategic plan are located in intersections of other types. They connect two or three intersecting elements, transferring water towards the downstream, and redirect the aggregate flow. These intersections are also used as public spaces where connection of different water flows provides new identity and bring new narratives into land use patterns.

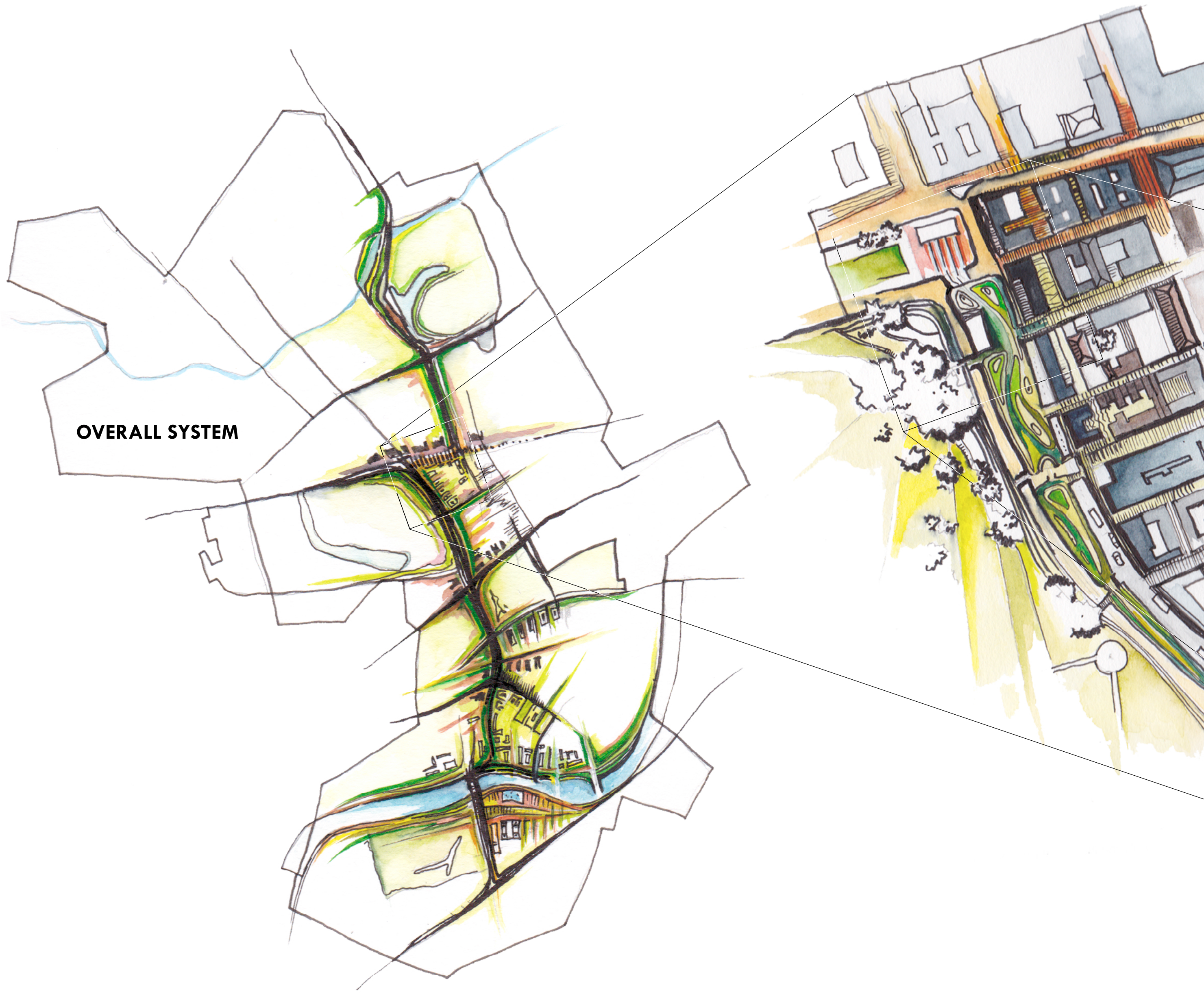
source:https://www.pinterest.com

MULTILEVEL WATERFRONT

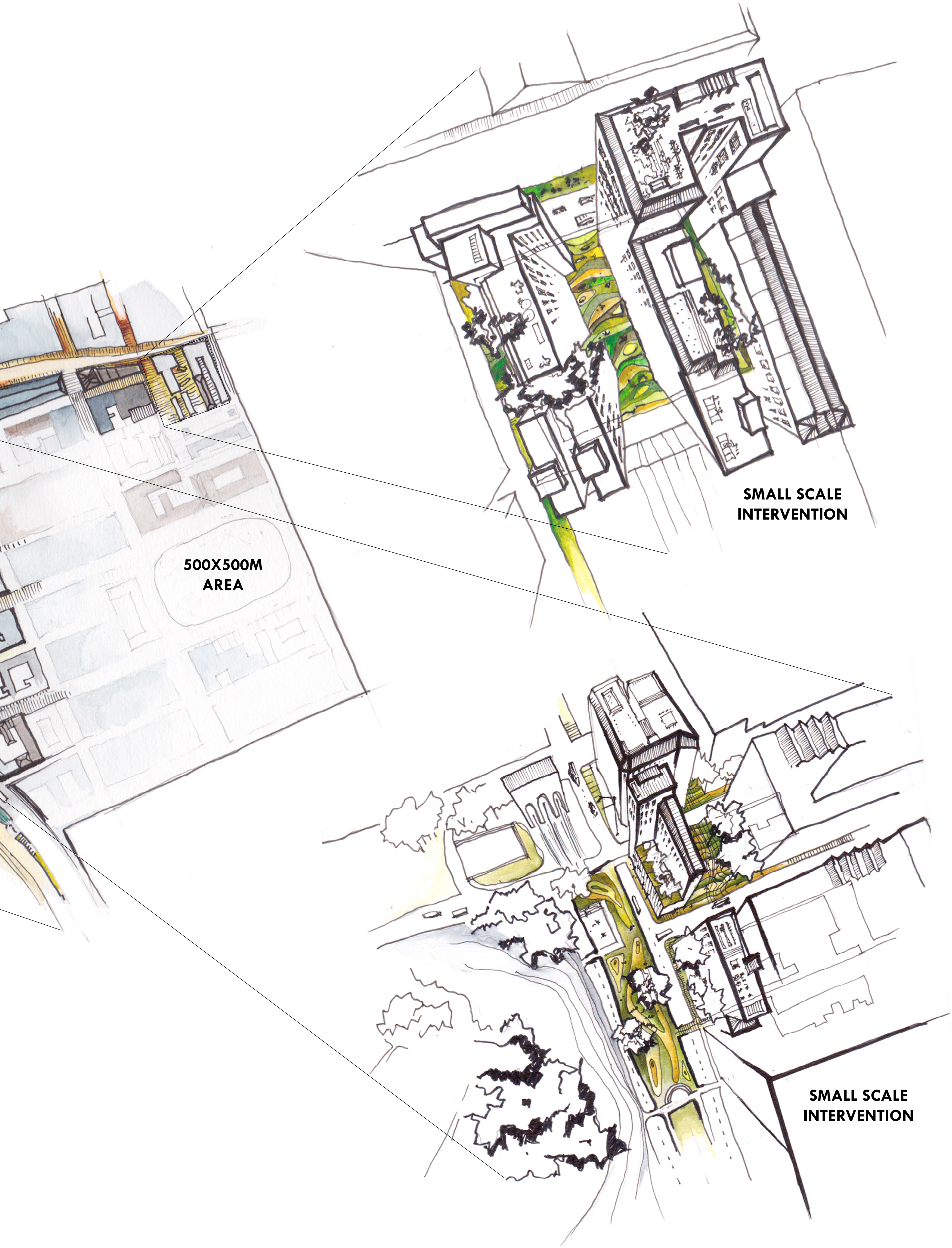
This strategic element of 50 hectares is situated at the downstream area and representing the realistic flood risk (+ 1.8 m to current water level is expected in 2050). Consequently, the decision was made to design a system of multiple flood-adaptive zones, composed of infrastructural and recreational components. Design proposal combines floating components, containing not only buildings but also open platforms and cascade landscape with integrated recreational facilities. Main principle for this system is to ensure that design is adaptable to the rise of water level.

STRATEGIC SCENARIO

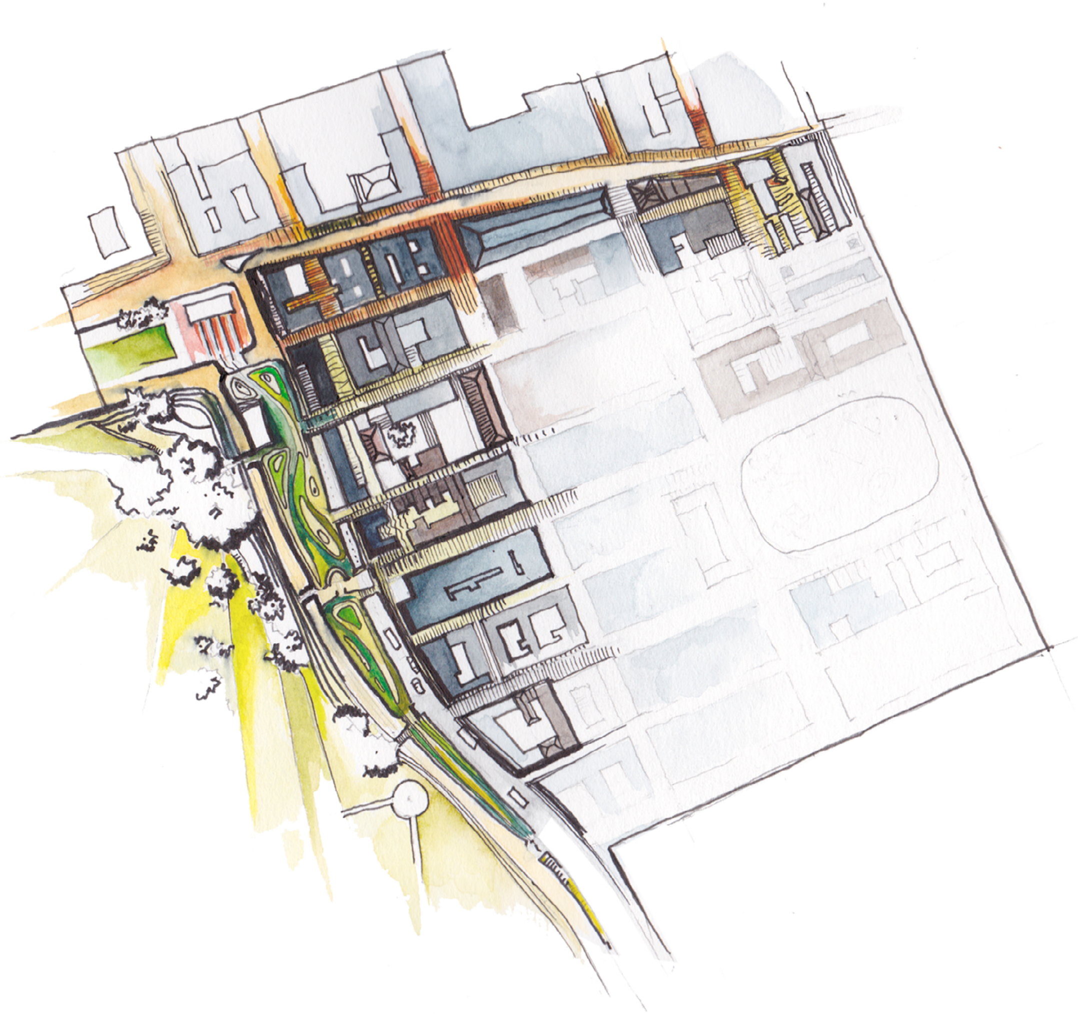
APPLICATION OF THE APPROACH TO THE UPSTREAM PROJECT SITE

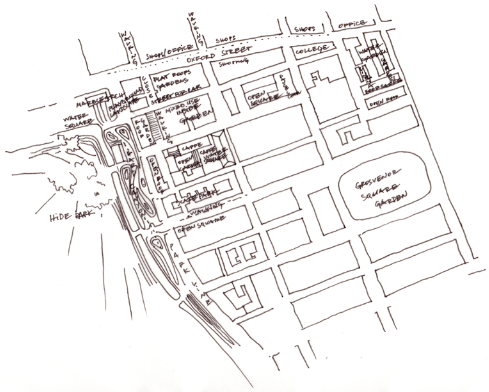


The following scenario, made for the upstream area of the project shows how the proposed system works between different scales and how small improvements within urban fabric increase resilience of the city. Small scale interventions like pocket parks and special types of pavements, focused on better perception of water volumes, collect the coming water and transport it to the canyons. For transportation of surplus water the system is using natural differences in relief, which is determining the locations of water collectors.


SMALL SCALE
INTERVENTION
500X500M
AREA
SMALL SCALE
INTERVENTION

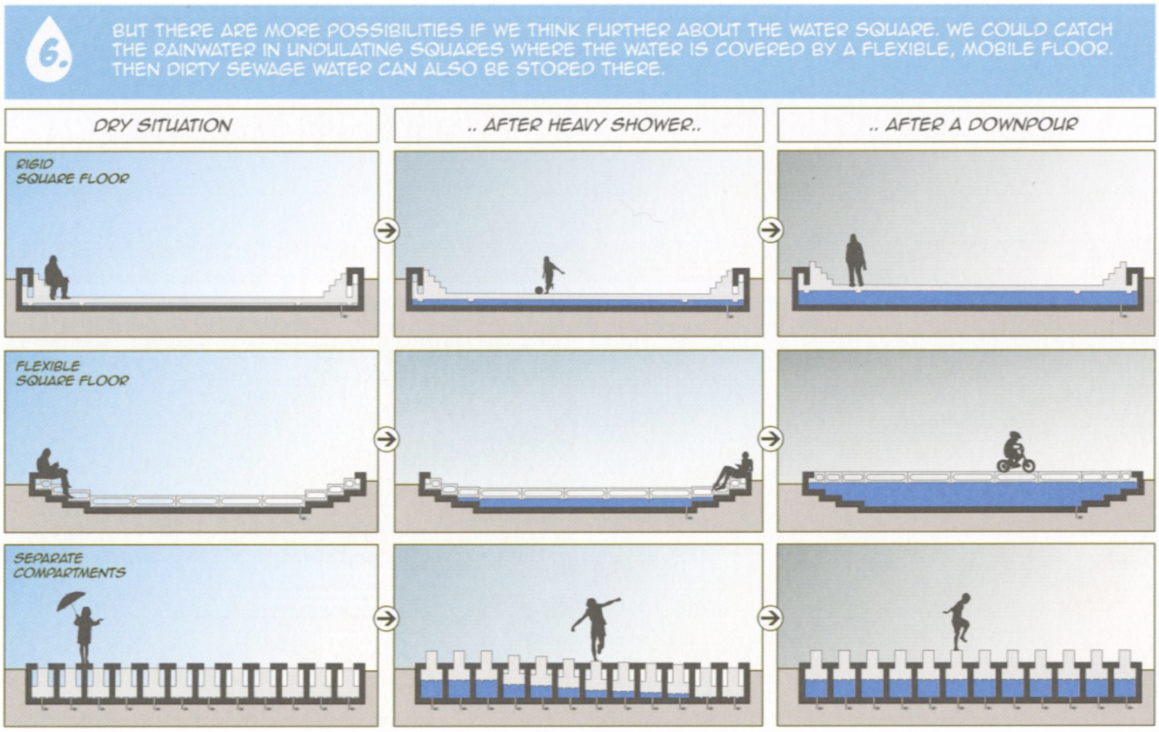
MEDIUM SCALE
DESIGN PROPOSAL





Interventions should be made in places that are the most vulnerable in case of flooding and that are the most actively used, because it allows to keep city going. In case of this project site these areas are Park line and Oxford street, which are part of the network of main streets. Interventions in Park line are aimed at transforming these streets from fully urban to half natural, what requires better integration with adjacent Hyde park. Oxford street is very busy street so it cannot become more green, but surrounding blocks can perceive the water flows from it and leveled pavements can highlight drier zones of public space. These interventions affect functional program of the area, because green zones can function as parks in dry periods and as water storage in wet periods.

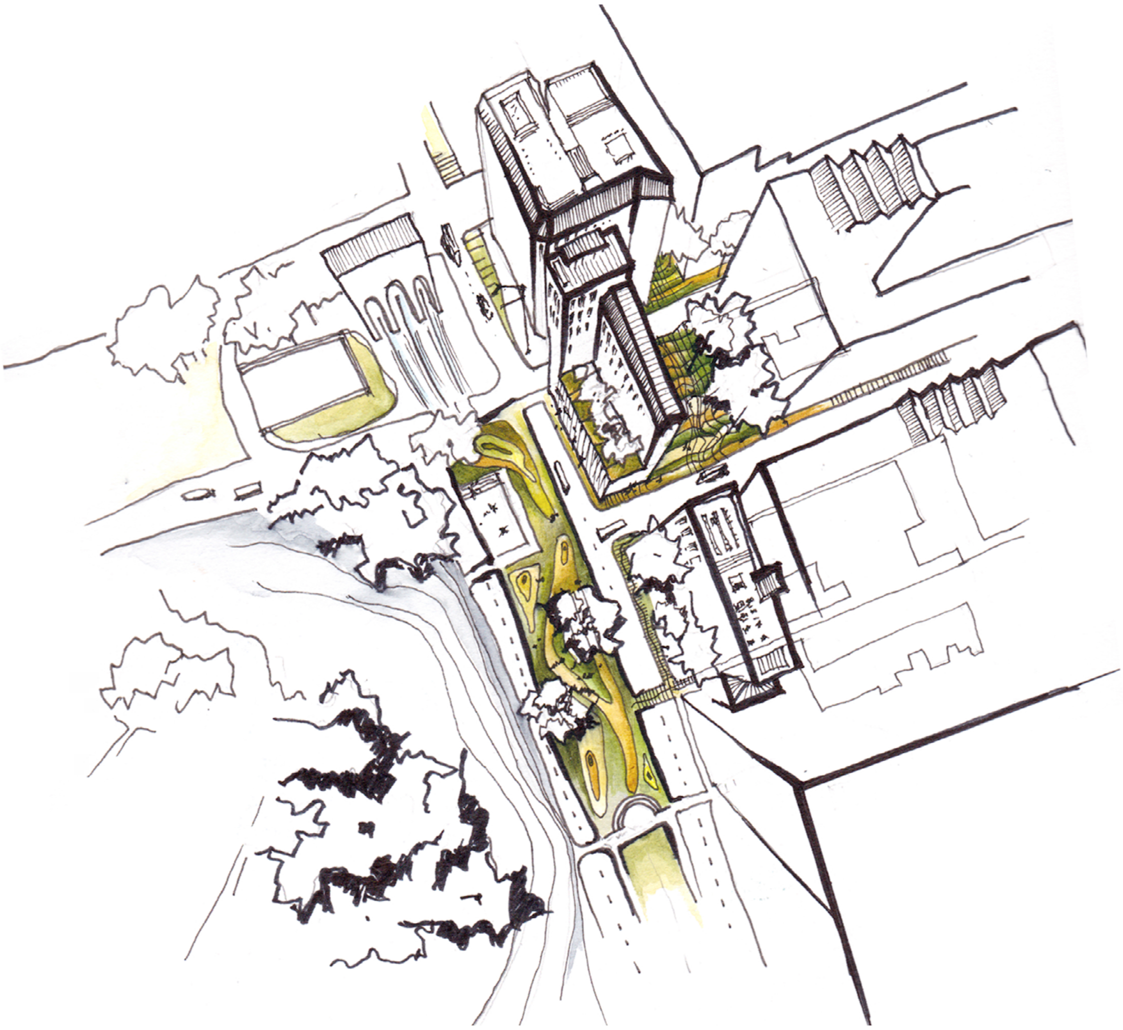
ADAPTIVE PUBLIC SPACE



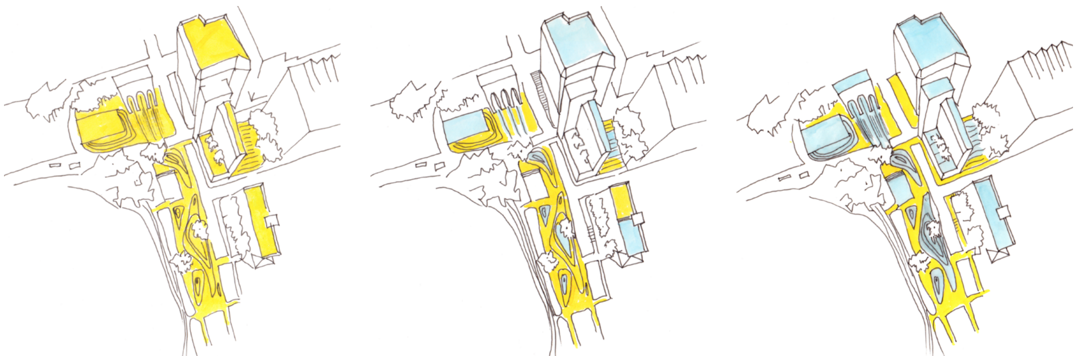
The most important parameter of middle scale design is adaptive capacity of public space in order to allow public space to function in all periods - dry and wet. Landscapes unify groups of functions and forms islands, therefore complementarity of functions within one island and between different islands determines their performance as elements of public space.

Adaptivity of space can also add playfulness into scenarios, programmed in urban system and create new narratives and ways of experiencing the city. Playfulness can contribute to healthy lifestyles, as excercies can become part of commuting or recreation.

DESIGN PROPOSAL FOR PUBLIC SPACE

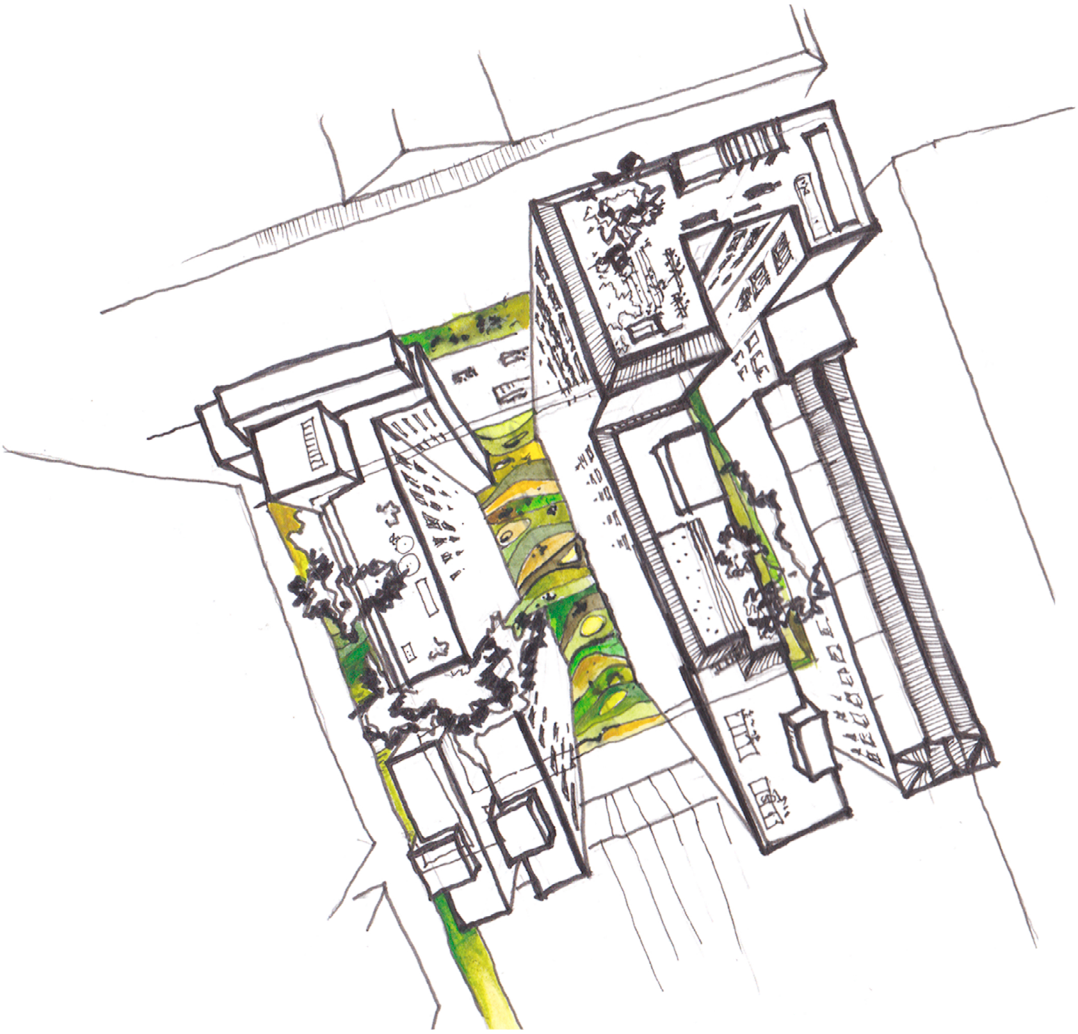


Park line is located on the edge of Hyde park and is partially using park's capacity to store water. In addition, this street is important transportation artery, so water flows have to be very focused and compact. Therefore, main intervention concerns the greenery in the middle of the street, which turns into layered landscape park with various zones for water storage, at the same time designed to fasten water flows in case of extreme rainstorms. The line, functioning as urban waterway, is connected to storage area and infiltration zone inside the adjacent block, which acts as a buffer for surplus water.

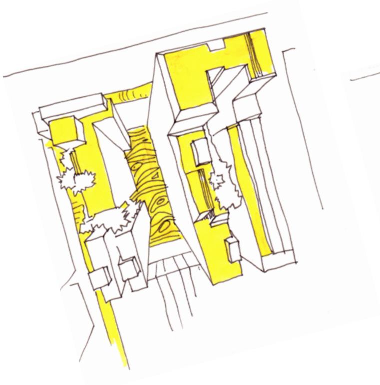


Diagrams show the surfaces that perceive water and process it further along the system. Apart from ground level interventions, roofs of surrounding buildings participate in collection and temporary water storage in order to transport it more gradually and avoid flooding.

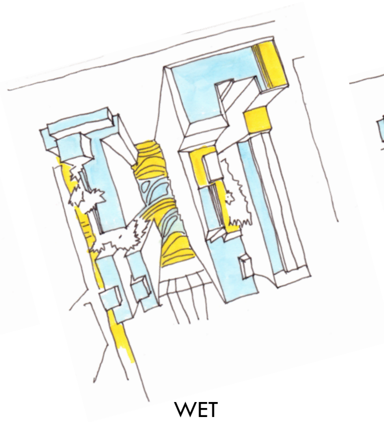
DESIGN PROPOSAL FOR URBAN BLOCK



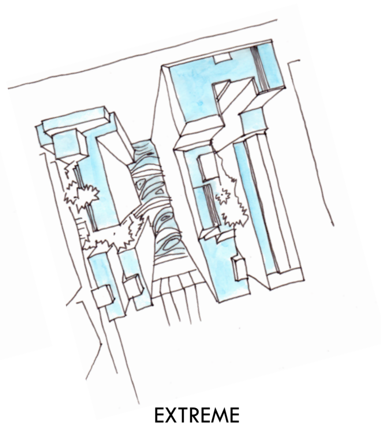
Inner space of urban block, considered in this design intervention, differs from Park line in character of its land use and its distance from major green zone of the city. This site acts as more local water storage, but it can store considerable amount of water because of its non-transit location - the whole surface of the inner courtyard can store surplus water. Located in the lowest point of relief, such site can collect water from the surroundings, infiltrate it and transfer to the corridor hard canyon.



DRY



WET

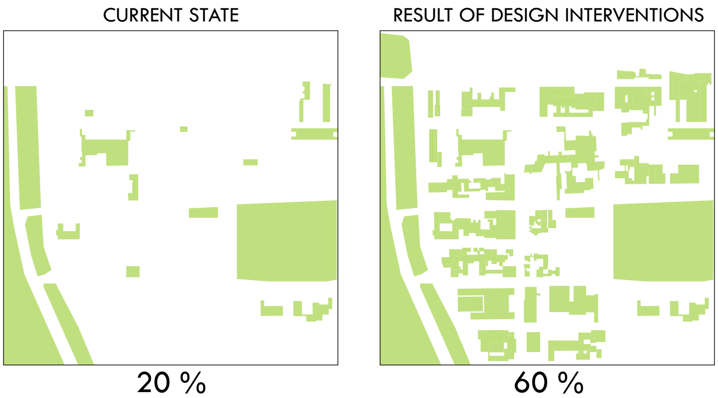


EXTREME

Diagrams show that roofs also participate in water storage in the same way as near the Park line, while the ground level can also be entirely occupied by surplus water in times of extreme rainfalls. In dry periods layered landscape acts as local sports and recreational facility, accessible for public and introducing more social life in the area.

EVALUATION

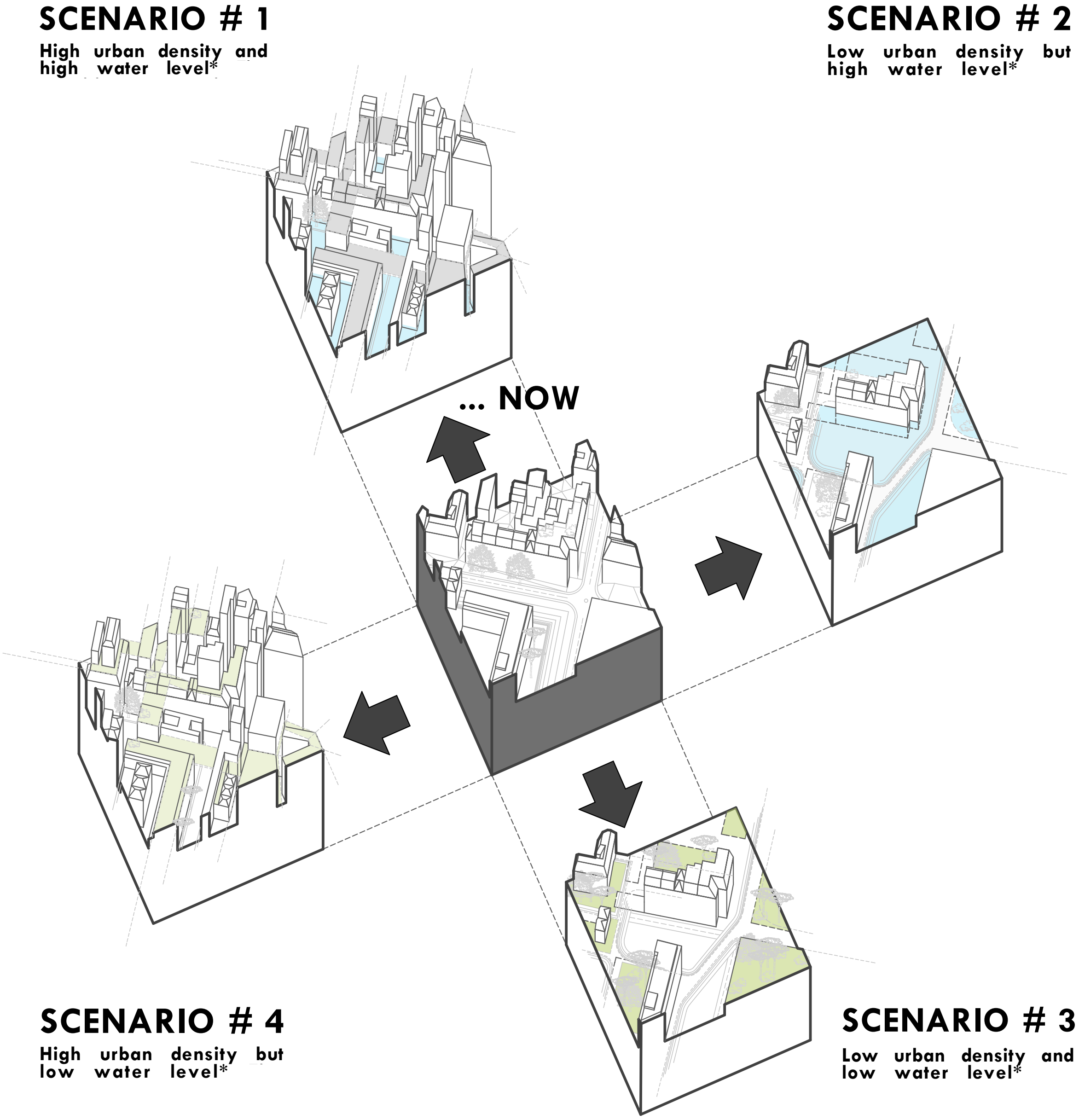
WATER STORAGE CAPACITY



In result of design interventions capacity of water storage can be increased from 20% to 60% of total area of project sites. This allows to dramatically improve the resilience of urban environment to extreme rainfalls. In addition, this adaptive urban fabric contributes to more attractive and vibrant street life, therefore project makes the city not only resilient but also interesting place.

Adaptive character of urban environment can be best compared with water park - some elements are used to transport water, others are used to store water, but the work as one system and increase social and cultural life in the area.

FUTURE SCENARIOS



The aim of the final stage of the project is to test developed approach in several future scenarios: for extremely abundant or lacking water volumes and for extreme changes in urban density. Especially important is the scenario when rainfalls exceed the considered volume and the system can not cope with amount of incoming water. The most important question then is how the system can develop when the maximum capacity of water that it can process is already achieved. Further stages of adaptiveness of urban space should be investigated.

In addition, design proposals should be elaborated further in terms of their functionality and capacity to store water. Each plan needs complementary 'user guide', exploring the ways in which landscape can be used during different stages. Performance of design interventions as elements of water system needs the quantitative research and comparison with natural systems.

Source of chosen scenarios: http://www.ambiental.co.uk/products/ukfloodmap4/

Battersea area reconstruction project. Source: https://metrouk2.files.wordpress.com/2014/10/battersea-thames-pic.jpg

SOCIETAL AND SCIENTIFIC RELEVANCE / ETHICAL DIMENSION / **EXPECTED DELIVERABLES** / TIME-SCHEDULE / **BIBLIOGRAPHY**

9. SOCIETAL AND SCIENTIFIC RELEVANCE

Due to climate change both the chance and consequence of flooding are increasing. 1.5 million people live in the floodplain of the River Thames and its tributaries. Many more people work, visit or travel through these potentially vulnerable areas. The damage and environmental issues that can potentially be causes of climate change effects make this issue very relevant nowadays.

8.1 SOCIETAL RELEVANCE

In this particular project the environmental issue and societal relevance are very related. One depends on another. The effects of climate change, spatially in densely populated areas, can affect a living condition we used to. About half a million properties at risk of tidal flooding in London, with 16% (approximately 80,000) of properties considered to be at moderate or significant risk. (London Sustainability Exschange, 2012). In addition, the essential civil infrastructure is in a threat – including hospitals, fire, police and ambulance stations, and etc. Because a vast territory of the city is a floodplain, this problem can affect a lot of people living and using this territory. Moreover, as it was mentioned before, waterfront is crucial part of the city. It means that lack of this space or accessibility of public domain can influence social life of the city. It also necessary to note, that climate change affects on environment, especially on «health» of the city.

8.2 SCIENTIFIC RELEVANCE

One of the key emphases and contributions of environmental directed research has been to examine and evaluate patterns in the spatiality or geography of risk or potential harm (Walker 2009). The risk of flooding is focused primarily on particular spaces in proximity to rivers, coastlines

Fig. 8.1 Campaign against Climate Change. Protest in London. 2011. Source: www.telegraph.co.uk

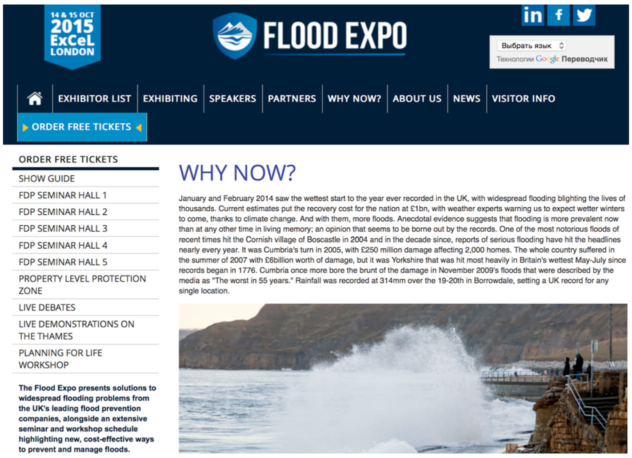


Fig. 8.2 The Flood Expo 2015. Solutions to widespread flooding problems in UK. Source: http://www.flooddefenceexpo.co.uk

and other water bodies. Recently several studies of patterns of risk areas from coastal and river flooding in England, Wales and Scotland have recently been completed (Fielding and Burningham 2005; Walker et al. 2007; Walker et al. 2003; Werrity et al. 2007). However those studies were mainly focus on who is living within such 'at risk' spaces. Owing to urgency of the problem there is a large quantity of current studies in this field.

However this particular project can be an edition to existing knowledge body. It will offer: a toolbox of intervention that could be done along the riverfront, according to findings made by research and theoretical framework and several design solutions as an illustration of investigation, based on developed scenarios. All this will strengthen an idea that protection can be an attractive, resilience and vibrant urban space.

10. ETHICAL DIMENSION

The aim of this chapter is to disclose the appropriate concern for the values regarding the natural world. The main object of discussion will be Environmental Ethics - the value and moral status of our impact on the environment, and our position as urbanists in this field.

Nature was the focus of many nineteenth and twentieth century philosophers. Contemporary Environmental Ethics only emerged as an academic discipline in the 1970s. The questioning and rethinking of the relationship of human beings with the natural environment over the last thirty years reflected an already widespread perception in the 1960s (Rachel Carson, 1963). Land Ethics attempting to extend moral concern to cover the natural environment and its nonhuman contents, was drawn on explicitly by the Australian philosopher Richard Routley (1973, 1980). Nowadays, Environmental Ethics is already a part of Urbanism (Hanna, Folke, & Mäler, 1996; Kates et al., 2001; Rosan, 2012)

Environmental Ethics, by this account, is founded on what we call a human right to nature. The World Commission on Environment and Development claims: “All human beings have the fundamental right to an environment adequate for their health and well-being” (1987b: 9). This includes the basic natural elements as air, soil, water, func- tioning ecosystems, hydrologic cycles and so on. These used to be previously taken for granted. But now, this right is made explicit and strongly defended. Note that it is not any claim against nature, or for nature itself; but rather a claim made against other humans who might deprive others of such nature. (Nicholas Bunnin & E. P. Tsui-James, 2003)

However, not only this right can be a part of the ethical dimension of this project, but also responsibilities. We should keep in mind that everything we do with nature could have a nonreversible effect. Once changed, our environment can no longer be the same- attributes and functions alike, just as urban areas as a representation of «human made nature». First of all, being an urban designer, I would like to think that every city is another form of the natural system. For this kind of system, we can create different working patterns. This means that any space could develop in one way given one condition, and another given other conditions. In such a way these will improve space quality because it will make it flexible, open to changes, and become more sustainable. Urban designers should be able to come up with effective plans that have the least negative impact on the environment. It is our role to ensure that our works are environment-friendly, not only in terms of contemporary energy consumption and space development, but as well as its possible impacts on our future generations.

12. REFLECTION

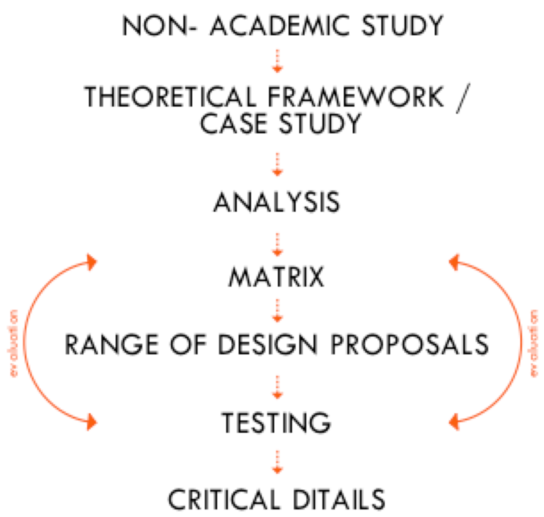
The aim of the reflection is to look back and see if the chosen approach worked, to understand the "how and why", and subsequently to learn from this.

1. The relationship between research and design

Water management is a very complex technology and at the same time it is usually difficult to integrate in dense urban context, so one has to ensure that supportive system works well. Current systems manage incoming rainwater by means of engineering communications, but this technology is not sufficiently resilient to the extreme rainfalls of changing climate.

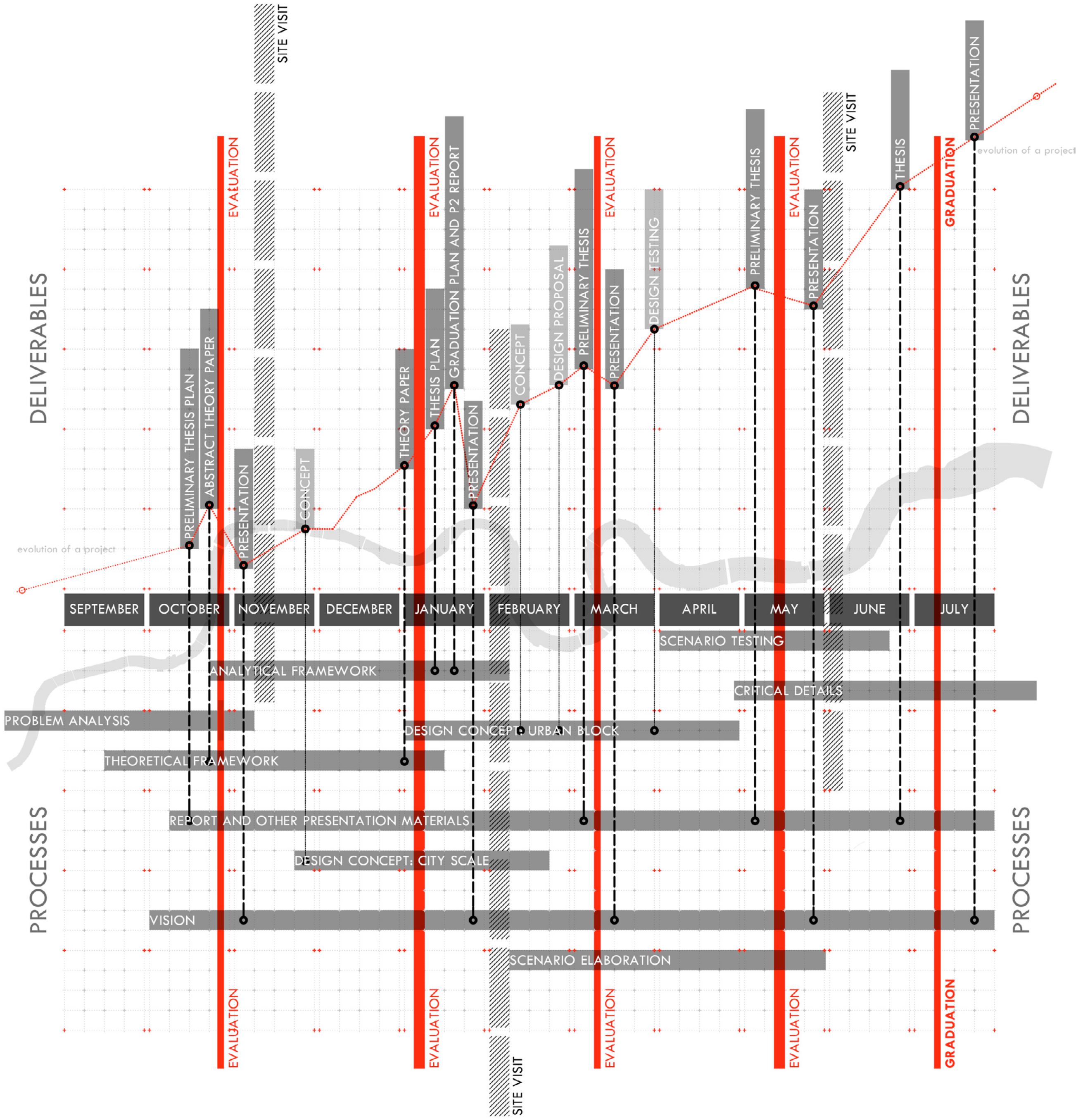
In case of urban or metropolitan context, issues have to be managed within the whole catchment are in order to be dealt with effectively and systematically. The approach contains two essential aspects: storage and transfer of surplus water. This leads to necessity to define suitability of various parts of urban system in regard to these aspects. In addition, every aspect can be addressed in different scales from the whole river catchment to distinctive area in the city or small urban block. Outcome of this research is the matrix, organising the range of design solutions, based on problems scales and character. In addition, solutions are placed in order of their application along the water system, depending on elevation level, what dictates respective scenarios of their development.

Research determines settings for the matrix, which provides set of designs in relation to urban context and location. As a result, diversity of designs contributes to aesthetic quality of urban environment simultaneously with systematic water management and adaptation to climate change.



2. The relationship between the theme of the graduation lab and the subject/case study chosen by the student within this framework (location/object)

The main focus of the studio is the design of public space, and the water is playing more and more important role in the course of climate change. Consequently, issue of integrating water management into design of urban fabric and public space can contribute to its better performance in extreme natural conditions. Water is also an extraordinary element in the city, introducing greater changeability into public space, so its better integration into urban fabric can improve its aesthetics and climate resilience.



3. The relationship between the methodical line of approach of the graduation lab and the method chosen by the student in this framework

The studio of design of urban fabric motivates students to research urban patterns in order to find intelligent solutions to complex problems of contemporary cities. In this project this pattern research intersects with system of scalar classification, because the posed problem of climate resilience cannot be resolved within one scale of intervention. Thus, studio methodology is adopted to purposes of the research and considered in relation to natural and climate conditions. In addition, project is based on method of scenarios, which allow to test which solutions are more effective.

4. The relationship between the project and the wider social context

The project contributes to wider social context, because it provides the alternative solutions to water management. In contrast to current plans of London City Council, planning huge infrastructural interventions and requiring considerable financial investments, the project proposes the set of lighter and smaller interventions that are performing not only engineering function but also adding natural dimension to performance of public spaces. This solution allows to decentralise water management without losing its efficiency, what also opens opportunities for more stakeholders. Developed approach can be applied to other cities with problems of water management.

N
[PROJECT 6]
OXFORD STREET
[PROJECT 5]
GREEN PARK
[PROJECT 4]
[PROJECT 3]
[PROJECT 2]
[PROJECT 1]
0
1 km

[PROJECT 1]
[PROJECT 2]
[PROJECT 3]
[PROJECT 4]
[PROJECT 5]
[PROJECT 6]

13. CONCLUSIONS

1. The relationship between problem statement and design

The main goal of this graduation project - based on the desire to create a resilient urban environment -is to prevent the city of London from flooding, retrench the pressure in existing areas and to reduce the need for the «super sewer». Moreover the phases of transformation from existing space to a new form, function, or facilities are investigated. In this case the aim is to illustrate how adaptable existing urban fabric can be. This adaptive urban fabric contributes to more attractive and vibrant street life, therefore the project makes the city not only resilient, but also an even more interesting place. The adaptive character of urban environment can be best compared with a water park - some elements are used to transport water, others are used to store water, but they work as one system.The use of hard protection in London has been useful in flood prevention; however, it can be argued that the current system does not fully maximise the functions of open space. The design does not cater to the recreational requirements of city life and is also considerably costly.

This project aims to develop a plan that will enable several spots to work as one collaborative system. A new design is proposed that will function two-way: as water storage during rainy days, and an offering of a vibrant city atmosphere on days when not. Through this initiative, any city will become flexible and resilient to various environmental impacts.

2. Answer to the main Research Question

Main Research Question: How can spatial interventions within one river catchment of the river Thames help to make London more resilient to flooding?

An efficient flooding system is needed in order to make London resilient to flooding. Flood water collected that come from upstream, middle, and downhill areas are all released back to the ground. This floodwater is then moved from one point to another for excretion.

How can we deal with processes that are limited in predictability?

Due to the limited predictability of Climate Change, contemporary urban designs need new adaptable and flexible approaches that would make cities resilient against flooding. This project makes use of various metrics and schemes designed to provide solutions based on the location. It allows change in the urban fabric and water capacity in smaller areas which provides room to work on unpredictable circumstances.

13. BIBLIOGRAPHY

This chapter provides a list of literature review, which are using for the theoretical framework. For more convenient navigation through literature I combine them with the main research question and subquestions.

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