

WATERFRONT COMMUNITIES AND CLIMATE CHANGE

LIVING WITH WATER IN FRIHAMNEN, GOTHENBURG, SWEDEN

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ABSTRACT

Sea level is rising and glaciers are shrinking. Some animals have already moved to new homes while others are at the risk of extinction. Many agreed that it is already too late to stop climate change completely. We should accept the fact that our world is changing faster than we expected. It is time to change the way we build our cities as our world is changing.

During the last decade, Gothenburg city has been faced major challenges in development of its waterfront areas. On one hand, there are many abandoned industrial land placed next to the water in central parts of the city which need to be renewed. On the other hand, there is a high risk of flooding in these low-lying areas due to future climate changes. It is highly crucial to manage the future waterfront development in a way that the city and its waterfront are secured from being washed out.

The key question here is how to develop a low-lying site along the water- such as Frihamnen in Gothenburg city- considering the serious risks of sea-level rise and extreme weather events? What is an appropriate urban structure and city-water relationship in this context?

The intention in this project is to find an optimum balance between economic growth and the need to address climate change in the development of Frihamnen- former shipyard area along the Göta River in central Gothenburg. In other word, the purpose is to introduce a new urban waterfront structure which fulfills future economic and environmental needs of the society.

The point of departure in this project was to study global and regional impacts of climate change and to investigate different ways of dealing with

these impacts through planning and design of the built environment. Then a thorough analysis of different climatic and non climatic factors regarding the chosen site was conducted. Based on the results of the earlier investigations and the site analysis, a new urban structure was proposed for the future development of Frihamnen. At the end, the design proposal was discussed and evaluated according to the defined planning objectives and new questions were formulated for further research in this field.

Keywords: Climate change / Climate change adaptation and mitigation / Sustainable development / Living with water / Floating houses

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PREFACE

Redevelopment of former industrial and harbor areas has become one of the most important issues of urban planning in industrialized countries. Revitalization of these areas through an inclusive and collaborative planning process and with respect to cultural and environmental sensitivities plays an important role in creating more sustainable communities. The following points could be discussed under this topic:

Planning process- Dealing with various or even conflicting interests of different actors involved in the process of planning, design and managing urban waterfront development as one of the main challenges in redevelopment of former industrial and harbor areas.

Cultural and historical values- Most of the currently abandoned industrial and harbor areas used to be economic center of cities in industrial era. Therefore it is essential to identify and preserve certain historical and cultural values attached to these areas in order to have a more

sustainable urban development.

Transformation and integration- Converting former industrial and harbor sites into attractive and livable neighborhoods in order to achieve both social and physical integration.

Environmental consideration- Dealing with important environmental issues which appear in the process of revitalization of former industrial and harbor areas such as decontamination of land, purification of polluted water, treatment of waste and rain water, and solid waste management.

Waterfront communities and climate change- How to cope with impacts of climate change such as sea-level rise, extreme weather events, and flooding while building our cities at the water's edge and benefit from the advantages of this adjacency?

The aim of this project was to study one of the above scopes i.e. waterfront communities and

climate change, in planning, design and managing urban development of Frihamnen, former industrial and harbor area along the Göta River banks in Gothenburg, Sweden.

The work procedure took place in autumn semester 2010. It consisted of five phases: set up, collecting data, analyzing, design, and presentation. In the first phase the specific scope of the work was defined based on the relevant literature, previous researches in this field, and discussion with Älvstrandens Utveckling AB. In the next steps, all the relevant data were collected and analyzed. At the end, the design proposal was formulated based on the outcomes of the investigations and analysis.

THEORETICAL BACKGROUND

INTRODUCTION

The main challenge in this project is to find an optimum balance between economic growth and the need to address climate change in planning, design and management of the built environment. In order to find a proper solution for this problem, first it is necessary to understand climate change and its impacts on our life and to explore the best approach to deal with these impacts through urban planning and design. Moreover, it is essential to understand the relationship between sustainable development and climate change adaptation and mitigation and to wave all our knowledge in this field into a comprehensive whole. Only in this way one may be able to manage the complexities and uncertainties in the field of urban planning and design.

In this chapter following issues are discussed:

In which way our climate is changing and how it affects our life in cities (focusing on Swedish context)

Adaptation and mitigation: The best approach to deal with climate change

The relationship between sustainable development and climate change adaptation and mitigation.

IN WHICH WAY OUR CLIMATE IS CHANGING AND HOW IT AFFECTS OUR LIFE IN CITIES

Since the scientists first noticed global warming and its serious impacts on our planet, a lot of efforts have been made to raise the public awareness of the fact that we are negatively affecting our planet and unless we change our lifestyle the consequences will affect us dramatically.

For a long time society resisted to believe this harsh fact and no effective action was taken. Now that we are experiencing the consequences of our interference in the nature we finally came to realize that we need to do something if we want our children and grandchildren to have the same quality of life on this planet. However, recent studies show that our efforts during the past decades have not been enough.

Our world has been warmed up significantly and is still continuing to warm up. The rate of warming has increased over the past 25 years, and 11 out of the 12 warmest years on record have occurred in the past 12 years. Following global temperature increase, global sea level has been rising consistently, widespread melting of snow and ice has been observed, changes have been occurred in the amount, intensity, frequency and type of precipitation, and number of extreme weather events like Heat Waves, Droughts, Floods and Hurricanes has increased (IPCC, 2007).

These changes have had significant effects on our planet and consequently on our life; it has led to severe droughts, heat waves, hurricanes, and floods all over the world. Many species have disappeared and many more are in danger. Natural ecosystems have been disturbed. Food

and fresh water are getting more and more scarce in many parts of the world. A lot of people have been killed, become sick or homeless. Climate change has caused damages to our cities and imposed considerable costs on our societies (See fig. 1).

In Europe, for example, climate change has led to many dramatic changes: retreating glaciers, longer growing seasons, shift of species ranges, and health impacts due to an extraordinary heat wave. Climate change is predicted to increase over time and is expected to negatively affect nearly all European regions; posing challenges to many economic sectors, and magnifying regional

differences in Europe's natural resources and assets (IPCC, 2007).

In Southern Europe specifically, climate change is projected to worsen current conditions i.e. high temperatures and drought- in a region which is already vulnerable to climate variability- and to reduce water availability, hydropower potential, summer tourism and, in general, crop productivity. It is also projected to increase health risks due to heat waves, and the frequency of wildfires. The situation is almost the same in Central and Eastern Europe. Summer precipitation is projected to decrease, causing higher water stress. Health risks due to heat waves are projected to increase.

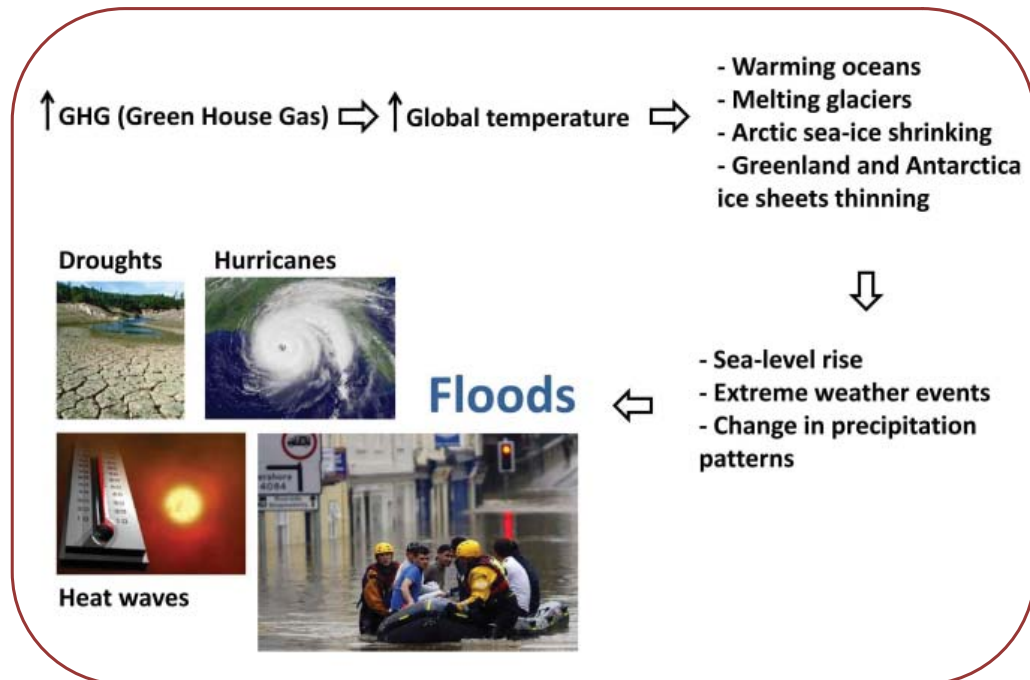


Figure 1: Climate change and its causes and effects

Forest productivity is expected to decline and the frequency of peat land fires to increase. While, in Northern Europe including Sweden, climate change is initially projected to bring mixed effects, including some benefits such as reduced demand for heating, increased crop yields and increased forest growth. However, as climate change continues, its negative impacts including more frequent winter floods, endangered ecosystems, and increasing ground instability, are likely to outweigh its benefits (IPCC, 2007).

In Sweden, climate has always varied, though the rise in temperatures and precipitation over the past 15 years has been unusually large, from a 100-year perspective (Sweden Commission on Climate and Vulnerability, 2007).

Below is the summary of expected climate changes in Sweden (Johansson and Mobjörk, 2009).

Temperature increase 3-5°C by 2080

Increase number of warm days

Increase precipitation in autumn, winter, and spring all over the country

Warmer and drier summers especially in the southern parts

More heavy rainfall events in autumn and winter

Higher water flow and more frequent flooding

Up to 0.8 sea-level rise in southern parts

One of the significant impacts of climate change in Sweden which largely affects human settlements is increased risk of extreme weather events. Some of the recent extreme weather events in Sweden are:

Storm Gudrun, 8 January 2005- The strong winds of storm Gudrun, falling trees and pieces of timber flying around caused major disruption and damage to the infrastructure for electricity, electronic communications, roads and railways. The indirect consequences were serious, due to society's huge dependence on electricity and telecommunications. Various functions were affected, including water supply, care of the elderly, heating and transport (Sweden Commission on Climate and Vulnerability, 2007).

A number of floods have affected many areas of the country since 2000- The road sector has been hit hard in recent years by serious water flows and flooding. Recent flooding has also had negative impacts on dams (Sweden Commission on Climate and Vulnerability, 2007).

Over 55 large landslides, with a spread of at least one hectare, have occurred in Sweden over the past 100 years- The most likely soils to suffer



Figure 2: In summer 2006, a road and rail embankment was washed away at Änn in Jämtland after intensive rain upstream, resulting in a high flow and erosion.

landslides are marine clays which, due to rising land levels, have risen above sea level (quick clay). Particularly vulnerable areas include the Göta Älv valley and other valleys in western Sweden (see fig. 2). The landslides caused immense damage primarily to buildings, but also to infrastructure. In the Göta Älv valley, shipping is often affected by underwater slides (Sweden Commission on Climate and Vulnerability, 2007).

Following table contains examples of major projected impacts of climate change in Sweden divided by sector.

Table 1: projected impacts of climate change in Sweden divided by sector

Sector	Immediate positive affect	Long-term negative impact
Housing industry and services		Increased risk of flooding especially in west and south-west, Increased risk of landslides and erosion, Increase pressure on wastewater systems, Increased risk of overflowing swage, backflows, and flooded basements, Risk of spreading chemical compounds from polluted lands,
Agriculture and forestry	Longer growing period, Higher crop yields, Opportunities to introduce new crops,	Increase problem with pets, New irrigation and drainage systems needed, Increase risk of crop damage due to extreme weather events, Higher forest growth and higher CO2 content, Greater risk of wind felling
Transport and energy	Decreased demand for heating, Better condition for hydropower and wind power production,	Increased precipitation and higher flows led to: Washing away roads, Damage to bridges, Increased risk of landslides and erosion, Stronger winds and increased risk of storm felling for power distribution, Increased demand for cooling, More investment needed for hydroelectric dams due to increase river flows,
Health and water resource	Decreased number of very cold days,	Increased number of very warm days, Increased risk of infections, New disease may enter the country, Decreasing drinking water quality, Increased risk of interruptions to and pollution of water supplies,
Marine and fisheries	Appearance of fish species adapted for warmer temperatures,	Decreasing the salinity of Baltic sea, Disappearance of species,
Ecosystems and biodiversity		Increased loss of biodiversity

ADAPTATION AND MITIGATION: THE BEST APPROACH TO DEAL WITH CLIMATE CHANGE

As described previously, we are already experiencing climate change. Recent studies show that the impacts of climate change will continue for decades and in some cases even for centuries. It is also predicted that the rate of these changes will increase in the future. These studies argue that even if global emission rates are stabilized at the present-day levels, just 20 more years of emissions would give a 25% probability that warming exceeds 2°C, even with zero emissions after 2030, and if global warming exceeds 2°C several vulnerable elements in the climate system, for example continental ice-sheets, Amazon rainforest, West African monsoon and others, could be pushed towards abrupt or irreversible change. In addition, Predictions on future climate changes show that sea level will continue to rise for centuries even after global temperatures have been stabilized, and several meters of sea-level rise must be expected over the next few centuries (the Copenhagen diagnose, 2009).

Therefore, we should not only increase our efforts to reduce GHG emissions by promoting low carbon lifestyle –the mitigation agenda – but also reduce our vulnerability to unavoidable future climate changes and sea-level rise –the adaptation agenda– especially when it comes to coastal and waterfront areas (See fig. 3). In fact, mitigation alone will not stop growth in potential impacts of global warming and climate change such as sea-level rise; it just decreases the rate of future rise and the ultimate rise which eventually is limiting and slowing the need for adaptation (IPCC, 2007).

Identifying the optimal mix of adaptation and mitigation is challenging and needs careful study of capacities, barriers, limits and costs in general and in the specific local areas in which it is going to be implemented. It is also essential to understand the link between adaptation and mitigation carefully in order to prevent negative effects of one on the other.

Mitigation refers to long-term efforts to reduce GHG emissions and stop global warming in order to prevent its fatal effects on human beings. It is a common global concern with measures which can be applied nearly all over the globe. Adaptation, on the other hand, is the attempt to reduce the vulnerability of human societies to

climate change. It is relatively immediate and short-term response to unavoidable impacts of global warming and climate change in a specific local area (IPCC, 2007).

So far mitigation has been the focus in most of the climate change debates. It has been studied and practiced in many parts of the world while the study on climate adaptation has recently been started as a reactive response to unavoidable climate changes, and it is mostly discussed in places which are already facing serious impacts of climate change (IPCC, 2007).

Adaptation which is occurring now, to observed and projected future climate change, is on a

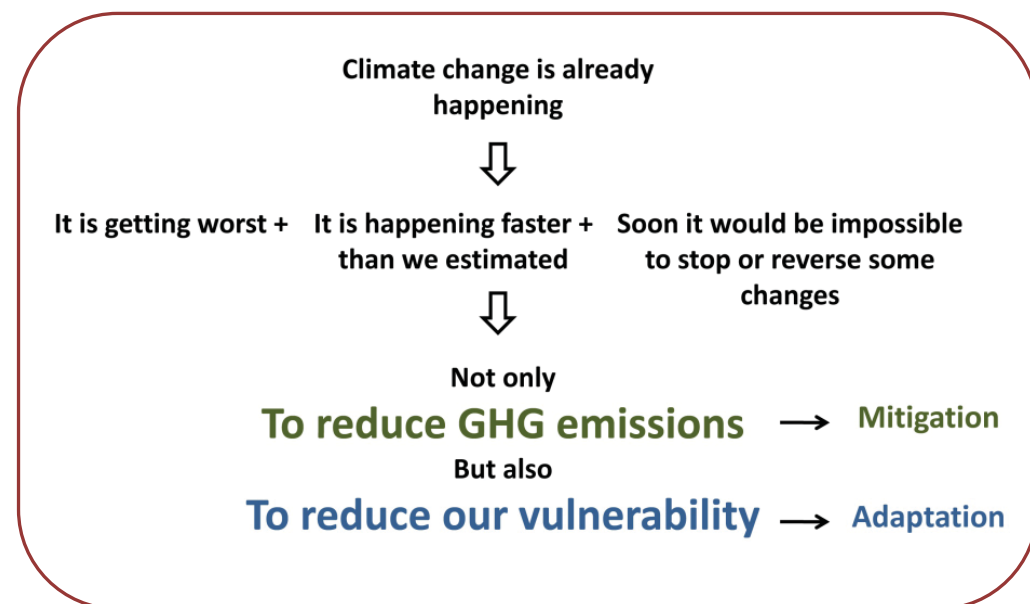


Figure 3: Climate change adaptation and mitigation

limited basis. It is more a reactive response than a proactive encounter, for example consideration of climate change in the design of infrastructure projects such as coastal defense in the Maldives and The Netherlands, prevention of glacial lake outburst flooding in Nepal, water management in Australia, and government responses to heat waves in some European countries. More extensive adaptation is required and not only by technological means (sea defenses) or providing policies (planning regulations) but also by altering lifestyle (changing food and recreational choices) or modifying management systems (sustainable storm water management).

There are also barriers, limits and costs which need to be fully understood. A big barrier is the climate change itself. Increasing climate change reduces society's adaptive capacity. Another obstacle is the uncertain nature of climate change predictions. We still do not know how exactly climate is changing over time, what is the rate of the changes and how the planet will respond to these changes. Therefore, we cannot say for sure how successful our adaptation actions are going to be. There are also non-climatic stresses which limit the adaptive capacity. These includes institutional, political, and financial constraints, poor or no assessment of developed technologies, and challenging environmental, economic, informational, social, attitudinal and behavioral barriers to the implementation of adaptation (IPCC, 2007).

In Sweden, like most parts of the world, mitigation issues have dominated climate policy to date. The work mainly concerns limiting the impact through reducing GHG emissions. Sweden is relatively developed in mitigation policies

and techniques such as using renewable energy sources and building passive houses while climate adaptation is in its infancy here. The issue of climate adaptation has lately risen in Sweden as a response to several extreme weather events during the past decade and it is under development (Johansson and Mobjörk, 2009).

According to a report from Swedish Defense Research Agency (FOI) the general policy for dealing with climate change risks, vulnerabilities and crises is to allocate the various responsibilities to the same actors during crises as under normal conditions. Therefore, much of the responsibility and tools for dealing with climate adaptation

lie at the local level. This means that practical work on climate adaptation will be done by local authorities, businesses, and individuals (Johansson and Mobjörk, 2009).

Central government agencies, on the other hand, have few operational roles with regard to climate adaptation but act rather as a source of information and funding, and as a provider of the regulatory framework. The Swedish Civil Contingencies Agency (MSB), The Swedish Meteorological and Hydrological Institute (SMHI) and The Swedish Geotechnical Institute (SGI) are examples of governmental agencies responsible for producing information on climate change for

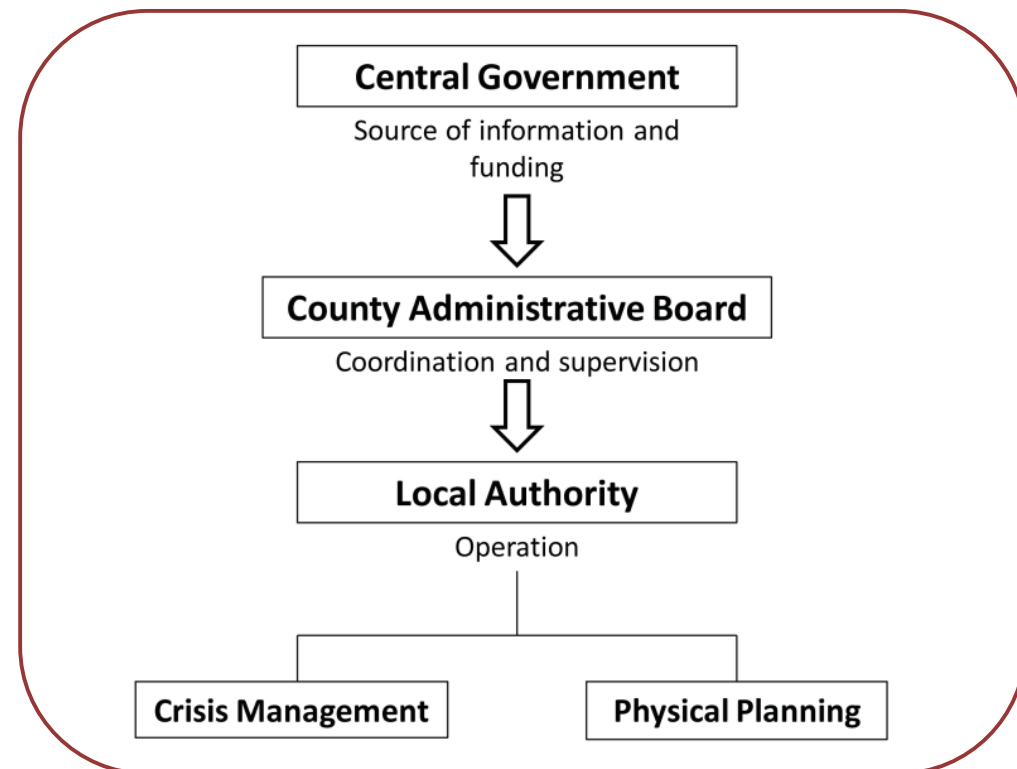


Figure 4: Climate adaptation in Sweden

local authorities (Johansson and Mobjörk, 2009) (See fig. 4).

Since networks and collaboration between different actors appear to be important for society's work on climate change in general and climate adaptation in particular, the commission on climate and vulnerability suggests that county administrative boards should take an overall approach for coordinating the work on a regional level. They should establish a climate delegation in which local authorities, industry, government agencies, organizations and others are invited to participate. Collaborative approach seems to be the best way to deal with complex problems with a lot of uncertainties such as climate change. However, one side-effect is that the responsibility might be diffused and in case of failure there would be no strong leader to take the responsibility (Johansson and Mobjörk, 2009).

The effort in Sweden has been to integrate the organization of adaptation work into existing physical planning and crisis management systems. Major advantage of using existing processes is that the structure is already available and, depending on the experiences, the processes can be altered (Johansson and Mobjörk, 2009).

Implementation of climate adaptation through physical planning has been done in two different ways. The first one is to consider environmental and crisis aspects in all decisions regarding land and water planning. For example, to change prescribed minimum levels for foundation-lying. Second is to reduce vulnerability to extraordinary events such as sea-level rise and flooding by investing on dykes and pumping systems and adapting location and technical design of

buildings and other infrastructure (Johansson and Mobjörk, 2009).

Adaptation measures have been divided into two categories: institutional and specific or local. The experiences concerning institutional measures involve a change in planning and building act while the local measures mostly have dealt with higher water flows. Three major operational actions are to increase minimum level for building foundation, to build dykes around areas vulnerable to flooding or higher sea-level and to invest in new pumping systems (Johansson and Mobjörk, 2009).

Examples of adaptation activities in Sweden

Regulatory activities

To choose location of new buildings with regard to risk of accidents, flooding and erosion (Planning and Building Act)

To take account of a changing climate when specifying the requirements for permitting activities according to the Environmental Code

Direct operational activities

Risk inventory of Sweden's major roads, done by Swedish Road Administration in 2007

Implementation of risk reduction measures (not necessarily for climate change)

Establishment of tree-free zones in railway corridors, done by Swedish Rail Administration

Measures taken against failure in the drainage system, focused on maintenance, monitoring and the use of new materials and equipments

To study impacts of future climate change on technical systems in agriculture, done by Swedish board of agriculture

Formulating a method for risk and vulnerability analysis of drinking water supply, done by national food administration

Updating elevation maps and produce more accurate ones, done by Lantmäteriet (the Swedish mapping, cadastral and land registration authority)

Regulation of Lake Vänern, done by county administrative board of Västra Götland and Vattenfall AB

Development of comprehensive adaptation plan or strategies by municipalities (nothing has been approved yet), Kristianstad, Malmö, Sundsvall, and Göteborg municipalities

Quality evaluation of all authority's steering documents from climate change and adaptation perspective, Ronneby municipality

Mapping of flooding risks

Municipalities have considered following recommendation in their planning activities: "No building should be located below the 100-year flood level; building with great importance for the society should be built even higher than 100-year flood level."

Changing the level of the buildings according to their expected lifetime, design waterproof basements and wastewater system to handle high ground water level, Halmstad municipality

Lomma (one of lowest-laying municipalities in Sweden), Vellinge, and Arvika municipalities have dealt with sea-level rise and flooding in development of their comprehensive plan. They also proposed to build barriers for saving

existing buildings.

Building dykes and pumps, letting the water flow in wetlands outside the city, Kristianstad municipality

temporary, mobile barriers; design areas to be flooded, Falun municipality

Adapting public transport facilities to future water level, done by Stockholm public transport company

To top of the regulated Lake Mälaren to the Baltic Sea integrated with the transformation of Slussen

Adapting water and sewage systems

Testing new and innovative adaptation measures, Malmö municipality

Artificial snow production, done by winter sport companies

To resolve conflict between taking warnings into account and building in attractive areas (by the water), Mariestad municipality

(Johansson and Mobjörk, 2009)

As the above examples show, adaptation measures in Sweden to date mainly oriented towards dealing with extreme weather events such as extreme high water levels, flooding, and hurricanes. The FOI report emphasizes that there is a need to expand the work to other impacts of climate change like new forms of diseases, longer periods of warm weathers, and changing conditions in the Baltic Sea. According to this report it is also important to change the approach from solely reactive response to proactive encounter and include municipalities other than those who are currently facing the problem (Johansson and Mobjörk, 2009).

THE RELATIONSHIP BETWEEN SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE ADAPTATION AND MITIGATION

Achieving sustainability has become central issue in our time. It is a broad concept that covers wide range of issues and has multiple implications depending on the point of view. Yet, the ultimate goal of sustainability and sustainable development, no matter of the point of view, is to sustain human civilization on the planet Earth. This implies that a sustainable community should be capable of withstanding changes without falling apart. In other word sustainable community needs to be resilient.

One of the biggest changes that human civilization faces today, as described in the first part, is climate change. Therefore, to achieve sustainability it is essential to consider this big change in our development processes and build resilient communities. Since increasing climate change reduces our adaptive capacity and consequently our sustainability, it is also essential to mitigate climate change. Accordingly, one realizes how closely climate change adaptation and mitigation is related to sustainable development.

There are various perspectives on the concept of sustainable development. Environmentalists, economists, socialists, spiritual writers, engineers, and politicians have their own definition and implication of sustainable development. Many different criteria with different focuses have been identified based on these various point of views. Yet, the question is “what is sustainable development in the eye of an architect or a city planner?” The answer relies on the nature of architecture and city planning. These are

interdisciplinary professions. It means that an architect or a city planner should know a little bit of all sciences in order to acquire a holistic view on the complex problems of today’s urban environment. Thus, sustainable development for architects and city planners is a mixture of all point of views: environmental, economic, social, and engineering. The result of their work will be in the form of strategies and design codes for planning, design and management of the built environment.

In the following tables, major sustainable development strategies and principles are summarized and adaptive and mitigative outcome of each one of them are presented. Strategies and principles are gathered from sustainable development literature and presented in three scales: city/region, neighborhood, and individual buildings.

Table 2: Planning strategies for a sustainable metropolitan area

Strategies	Mitigative outcomes	Adaptive outcomes
<p>Create dense urban fabric with identifiable centers and edges for all cities and villages in a metropolitan area by:</p> <ul style="list-style-type: none"> - Infill development within existing urban areas (densifying) - Development of brownfields (gentrification) - Development of far reaching suburbs into independent urban centers with balanced job/housing, and defined edges 	<p>Reduction of per-capita resource use and GHG emissions;</p> <p>Dense urban areas contain broad mix of goods and services and generate fewer per-capita trips which results in lesser GHG emissions;</p> <p>preserving nature; absorbing more CO2.</p>	<p>Promoting adaptation to the future with fewer resources: consuming less energy and recourses, living in smaller spaces, sharing common facilities and services, walking or biking rather than driving cars.</p>
<p>Maintain the necessary and fragile relationship between urban areas and their surrounding green lands by:</p> <ul style="list-style-type: none"> - Increased green structure and connected green areas (biodiversity corridors) - Protecting farmlands and green areas from unnecessary developments (preservation) 	<p>Increased green areas increase the absorption of CO2 and reduce the amount of GHG in the atmosphere.</p>	<p>Moderating climate in urban areas;</p> <p>Absorbing water and mitigating impacts of flooding;</p>
<p>Transit oriented development (TOD)</p>	<p>Supporting public transit; decreasing the use of automobile which results in reduction of GHG emissions.</p>	<p>Adapting to the future without oil and automobiles.</p>
<p>Provide Accessible and convenient public transport within the region</p>	<p>Decreasing the use of automobile which results in reduction of GHG emissions.</p>	<p>Adapting to the future without oil and automobiles.</p>
<p>Apply collaborative planning processes</p>	<p>Best approach to overcome complex issues with a lot of uncertainties such as climate mitigation.</p>	<p>Best approach to overcome complex issues with a lot of uncertainties such as climate adaptation.</p>

Table 2 (continue): Planning strategies for a sustainable metropolitan area

Strategies	Mitigative outcomes	Adaptive outcomes
Produce energy locally and from renewable sources	Reducing the need for transporting energy; increasing efficiency of energy distribution systems; reducing energy consumption specially consumption of fossil fuels; reducing GHG emissions.	No need for extensive energy distribution networks; Reducing vulnerability of energy distribution systems to extreme weather events: flooding and storms.
Make space for local food production opportunities	Reducing the need for transportation; reducing consumption of fossil fuels; reducing GHG emissions. Increasing green areas in the region; absorbing more CO ₂ ; reducing the amount of GHG in the atmosphere.	Adapting to the future without fossil fuels and extensive food production industries.
Respect historical and cultural context while developing	Increasing the life time of the built structure; less need for new constructions; reducing the consumption of energy and other resources; reducing GHG emissions.	no particular adaptive outcome, however, one should be careful with the interpretation of this policy in order to prevent negative impacts on adaptation capacity of the community (not all cultures and historical background are good to follow).
Making space for water by: - Integrated Storm water system - Outdoor wastewater treatment - Artificial wetlands	In case of using efficient systems it helps to save energy and produce less GHG. Open water can absorb CO ₂ and reduce the amount of GHG in the atmosphere.	High adaptive outcome for coastal, waterside areas, and regions with wetter climate in the future.

Table 3: Planning and design principles for a sustainable neighborhood

Principles	Mitigative outcomes	Adaptive outcomes
Defined center and edges (limited size)	Reducing the need for motorized modes of travel in the neighborhood; reducing consumption of fossil fuels; reducing GHG emissions.	Preparing for the future without oil and automobile.
Compactness and high densities which supports: - Public transportation - Small/local businesses	Reducing energy consumption and GHG emissions; Preserving nature; absorbing more CO2.	Preparing for the future with fewer resources;
Provide variety of land use, building and dwelling types to meet short- and long-term needs.	Reducing the need for transportation; reducing consumption of fossil fuels; reducing GHG emissions.	Preparing for the future without oil and automobile.
Pedestrian and biking friendly - Proper bike and walk paths	Reducing the need for transportation; reducing consumption of fossil fuels; reducing GHG emissions.	Preparing for the future without oil and automobile. Design of the bike and walk paths should be adapted to future climate changes.
Encouraging sociability by: - providing proper meeting places - Public spaces	Strengthening the sense of community; dealing with complex and multi disciplinary issues such as climate change and climate mitigation with the help of community. Increasing hope for change and improving the quality of life; it would be easier to implement low carbon lifestyle in a stronger community.	Strengthening the sense of community; dealing with complex and multi disciplinary issues such as climate change and climate adaptation with the help of community.
Well integrated in the city context - Connected to city center and other neighborhoods through designed transit and green corridors.	Increasing the life time of the built structure; less need for new constructions; reducing the need for motorized modes of travel in the city; Reducing the consumption of energy and other resources; reducing GHG emissions. Preserving nature; absorbing more CO2.	No particular adaptive outcome unless the designed structure is adapted to future climate change.

Table 4: Design principles for a sustainable building

Principles	Mitigative outcomes	Adaptive outcomes
<p>Reduce building's energy consumption by:</p> <ul style="list-style-type: none"> - Making the building tightly insulated - providing natural lighting as much as possible - using natural ventilations in suitable climates - making mechanical systems more efficient - using heavier materials in the structure 	Reducing GHG emissions to a great extent by saving energy, considering the fact that buildings are the biggest consumers of energy in cities.	Preparing for a future with scarce sources of energy by living in zero-energy buildings. However, the techniques and materials should be chosen with a careful consideration of the place's current and future climate condition specifically in order to have more comfortable indoor environment in a warmer climate.
<p>Reduce the energy needed for making the building by:</p> <ul style="list-style-type: none"> - choosing materials which consume less energy in their manufacture process - making the construction process more energy efficient 	Reducing GHG emissions by saving more and more energy.	Adapting to the future without oil and the industries based on that.
<p>Provide good accessibility and connection to different services in the city such as public transport, shops, restaurants, and cafes.</p>	Reducing GHG emissions by eliminating unnecessary commuting in the city.	Adapting to the future without oil and automobiles.
<p>Use renewable energy sources such as sun, wind, and wave.</p>	Reducing GHG emissions by using clean energy sources instead of fossil fuels.	Reducing the oil dependency and developing resilience for a future without fossil fuels. It is also more convenient to use sun or wind as a source of energy considering future climate changes.
<p>Create the capacity to harvest energy from renewable sources by:</p> <ul style="list-style-type: none"> - Integrating solar panels or silent wind turbines in the design of the building. 	Increasing the efficiency by eliminating the need for transportation of energy which eventually leads to less energy consumption and reduction of GHG emissions.	Producing energy locally; reducing the need for extensive energy distribution networks; reducing vulnerability to the impacts of climate change and extreme weather events.

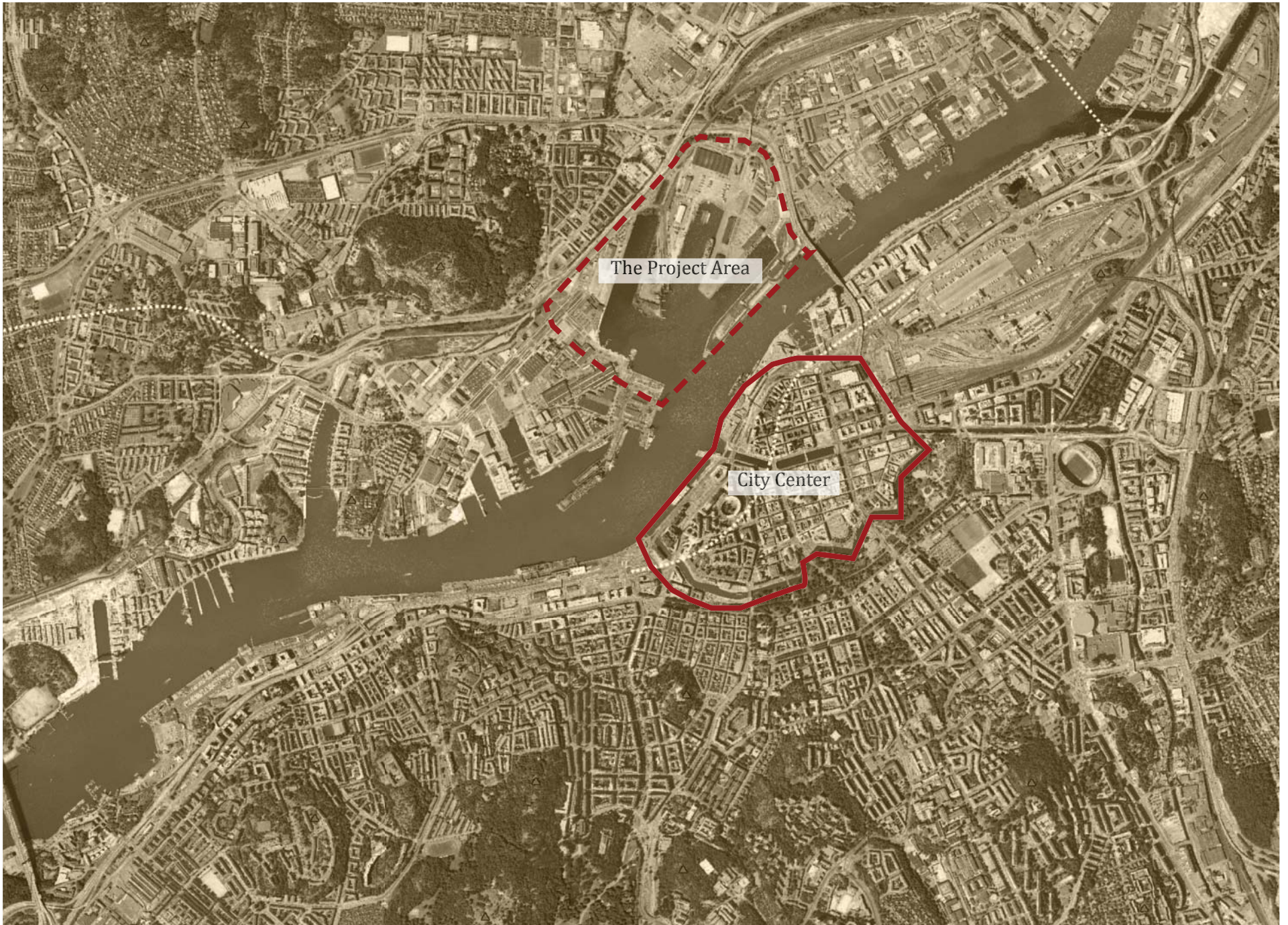
Table 4 (continue): Design principles for a sustainable building

Principles	Mitigative outcomes	Adaptive outcomes
Use materials from non-depletable sources	Smaller ecological footprint, less GHG emissions.	Building up resistance for the future with scarce resources.
Reduce waste and pollution by: <ul style="list-style-type: none"> - Recycling rain and grey water - Recycling waste - Creating capacity to recycle materials used in the building construction 	Reducing consumption of natural resources, saving energy, and eventually reducing GHG emissions.	Adapting to a wetter climate in the future by harnessing and managing rain water. Creating closed urban ecosystems by recycling and reusing garbage and reducing our vulnerability to the future with increased population and urbanization.
Take the long-term view <ul style="list-style-type: none"> - flexible functionality (ability to change its function over time) - Total life cycle costing - Capacity to be restored 	Promoting mitigation by making it economically beneficial. Reducing the need for new constructions; reducing ecological footprint and GHG emissions.	Reducing the need for new construction by increasing buildings' life time and preventing cities from over expansion. This is a smart solution for adapting to increased population and urbanization.
Have minimal negative impact in the surrounding natural and built environment.	Increasing buildings' life time and at the same time reducing the ecological footprint of it just by spending more time on the planning and design process.	Increasing the quality of construction and the building's life time; Adapting the construction processes to the time when there is little land left to build on.
Be integrated in its social and cultural context.	Reducing the need for new construction by increasing buildings' life time. Leading to smaller ecological footprint and less GHG emissions.	No particular adaptive outcome
Promote sustainable lifestyle by: <ul style="list-style-type: none"> - Providing view to outside, Fresh air, and natural light for everyone - Enhancing sense of community - Use architecture as a tool to educate people 	Reminding people the value of nature and helping them protect it. Embedding these values in their everyday life is the most effective climate mitigation action.	No particular adaptive outcome

Conclusion

The concept of sustainable development has been initially formed to preserve the environment, planet and human society. The aim was to generate a development pattern that consumes less energy and resources – mitigation agenda. Later the idea expanded; it was argued that without paying attention to social and economic challenges in cities it is impossible to achieve sustainable development goals. Now after spending years of research and practice people gradually came to realize that political and economic barriers on the way of sustainable development are too strong to overcome and it is already late to stop global warming and climate change. Therefore, it is time to expand the concept of sustainable development one more time and include climate adaptation.

The great challenge here is that the impacts of climate change are so varied across the world. Thus, adaptation policies generated in one place hardly can be implemented elsewhere. This adds to complexity of the problem and emphasizes the need to have local focus in the work on sustainable development including climate adaptation.



CASE STUDY

FRIHAMNEN, FORMER HARBOUR AREA ALONG GÖTA ÄLV, GÖTEBORG, SWEDEN

GENERAL FACTS

Frihamnen is a former harbor area along Göta Älv in central Gothenburg, Sweden. It consists of three piers for loading and unloading of goods. These piers give a unique shape to Frihamnen-looks like a giant fork- and make it distinguished in the satellite photos over Gothenburg city.

The area is defined by Göta Älv in the south, the highway Lundbyleden in the north, Götaälvbron and the highway Hjalmar Brantingsgatan in the east, and Lindholmen area in the west.

The size of Frihamnen is about 1125m x 800m, or 90 hectares, which is equal to 200 football fields. It is almost the same size as the historic core of Gothenburg. Almost one third of the area is covered with water which is another unique quality of the site.

Frihamnen is a flat and low land with a height level between 1.1 m to 2.6 m over normal water level.

HISTORY

Frihamnen used to be a wetland. In 1922 the land was filled in and piers and quays of free port were built. The free port was working until 1996.

From 1980s industries and harbor activities in north side of Göta Älv started to move out. It was then that the planning and development of Norra Älvstranden has begun.

After free port was shot down piers has been used for various purposes. For example since 2000 number of events and festivals have been taking place in southern pier, Bananpiren, in summers.

In 2008 a discussion has started in the municipality of Gothenburg about the future development of this area.

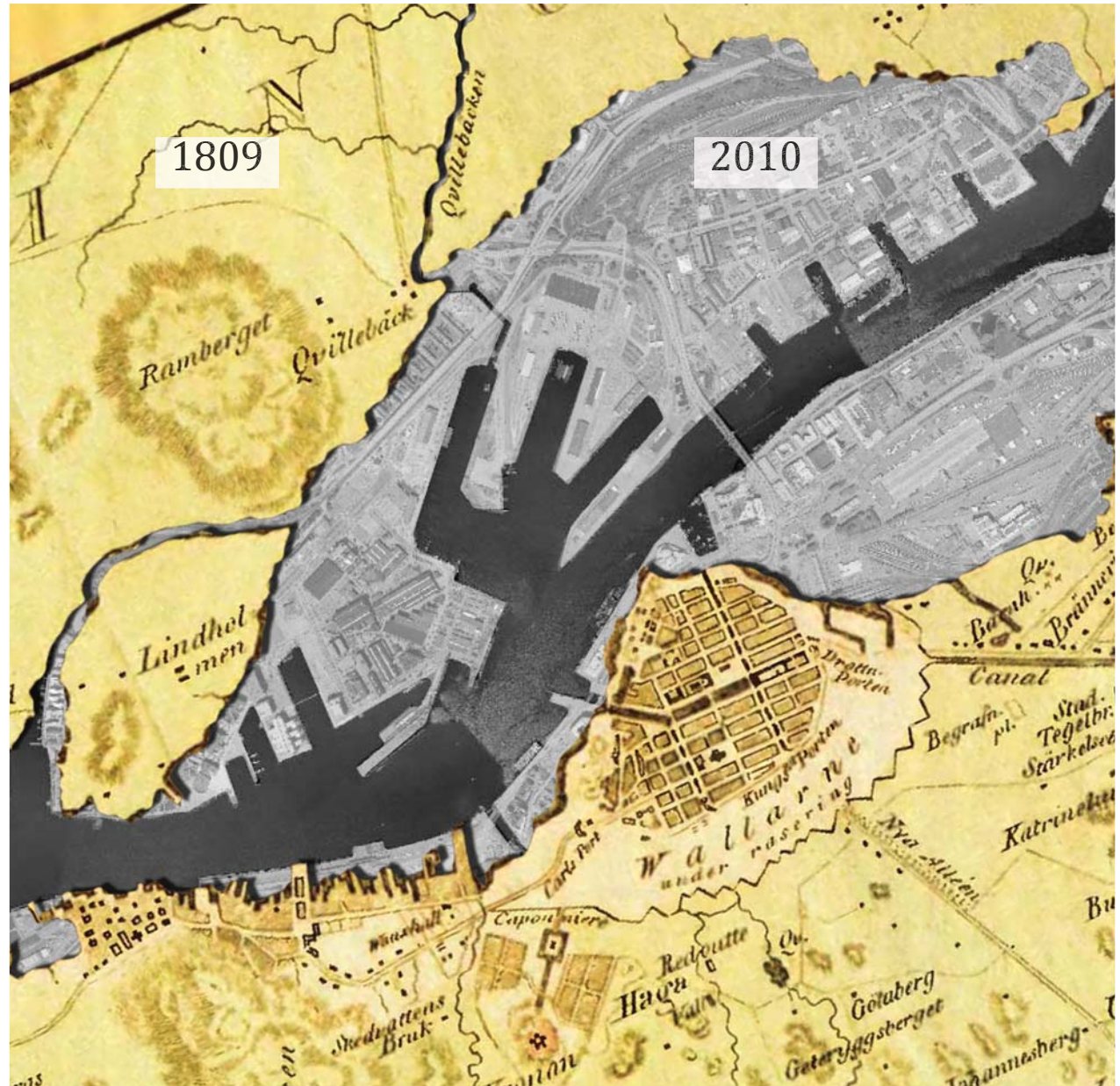


Figure 5: Transformation of waterfront areas over time in central Gothenburg

CURRENT CONDITIONS

Surrounding neighborhoods

Frihamnen is surrounded by six areas. Four of them are former industrial and shipyard sites which have been developed or going to be developed into livable city districts.

Lindholmen

This area used to be an old shipyard site which is located in the west side of Frihamnen. It has been developed since the end of shipbuilding era in Gothenburg and is still expanding. Today mix of businesses, educational institutions and housing exists in the area, and 18000 people are working or studying there.



Figure 7: Lindholmen



Figure 6: Frihamnen and its surrounding neighbourhoods

Ringön and Gullbergsvass

These two areas are also used to be industrial and shipyard sites, but now they are abundant areas which are planned to be developed in the future, probably after development of Frihamnen.



Figure 8: Ringön



Figure 9: Gullbergsvass

Kvillebäcken

This area currently consists of mostly retail and work places. Western-southern part of it is going to be developed soon into a nice mixed-used neighborhood.



Figure 10: Kvillebäcken

Brämaregården

This area like Frihamnen used to be a wetland but was filled in 1870s and since then it has been a housing neighborhood with common inner-city structure.



Figure 11: Brämaregården

Infrastructure and Accessibility

This map illustrates how Frihamnen is connected to different parts of the city through both public transit routes and major car roads. This infrastructure also creates great barriers around Frihamnen especially the port railway (Hamnbanan) and the highway which pass through north part of Frihamnen. These barriers disconnect Frihamnen from its northern neighbor, Brämaregården, which is, by the way, the only housing area around this site.

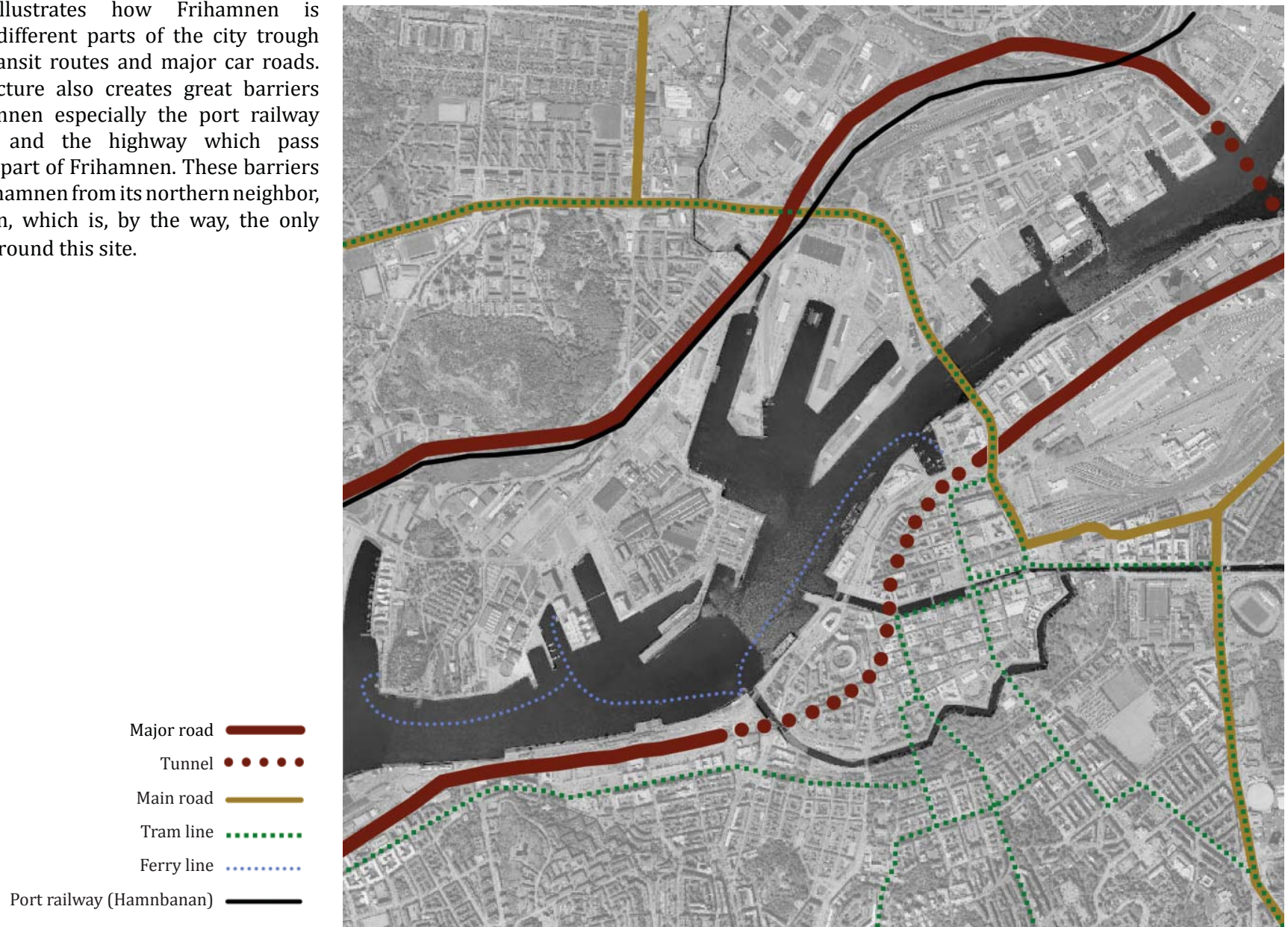


Figure 12: Different means of transport and main transit routes in central Gothenburg

Infrastructure and Accessibility

As it is shown in this illustration Frihamnen is hardly accessible by bicycle or walking although it is so close to city center and number of other public transportation hubs such as Hjalmar Brantingsplatsen.

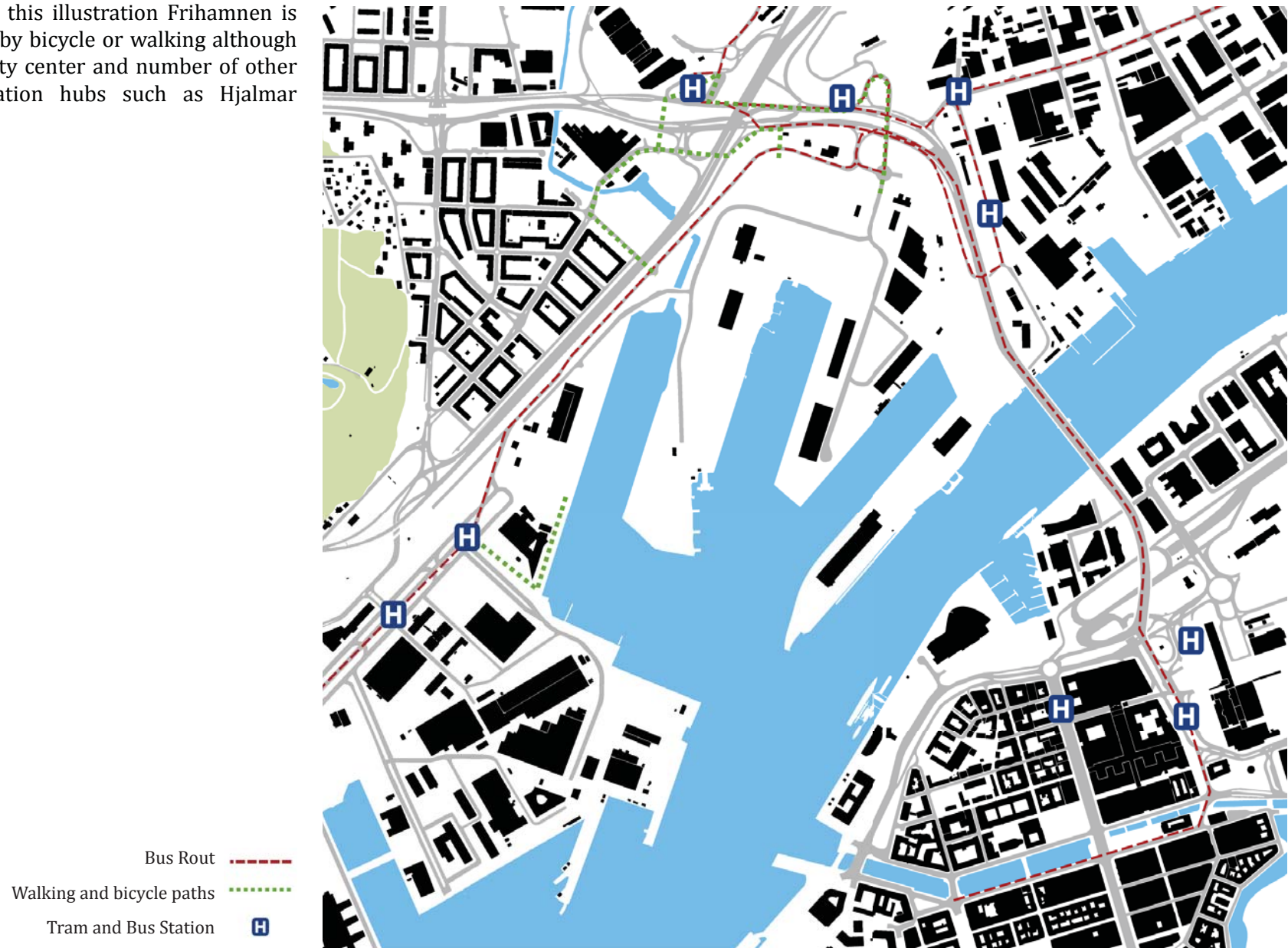


Figure 13: Different ways of accessing Frihamnen

Ground Conditions

As this map shows, most parts of Gothenburg are located on deep clay and almost all waterfront areas- especially in central parts- are artificial land.

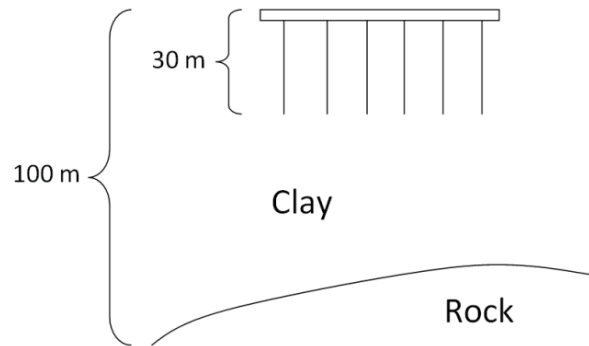


Figure 15: A section showing artificial land built on deep clay

- Clay 
- Infilled land 
- Rock 



Figure 14: Different ways of accessing Frihamnen

Flooding

According to IPCC reports global sea-level will rise by 0.2-0.6 m and Nordic sea level will rise by 1.8-2 m in 100 years.

Currently, water level rises up to 1.8 m in Gothenburg in the case of extreme weather events. Since 2005, extreme weather events have happened 2-3 times in Gothenburg and it is predicted to occur even more frequent in the future.

According to Ulf Moback, from office of city planning in Gothenburg municipality, currently the only precaution measure against flooding in the city is the regulation that says the entrance floors should be located at least 2.8m above normal water level. For important functions like rail stations the limit is 3.8 m above normal water level. This is not enough and more effective actions are needed in order to secure the city against sea-level rise and high water levels.

At the end it is necessary to mention that Gothenburg has a specific height level system. According to this system, normal water level currently is +10.1.

Accompanying map shows how much area is at the risk of flooding in central Gothenburg in the case that water level rises 2.8m.

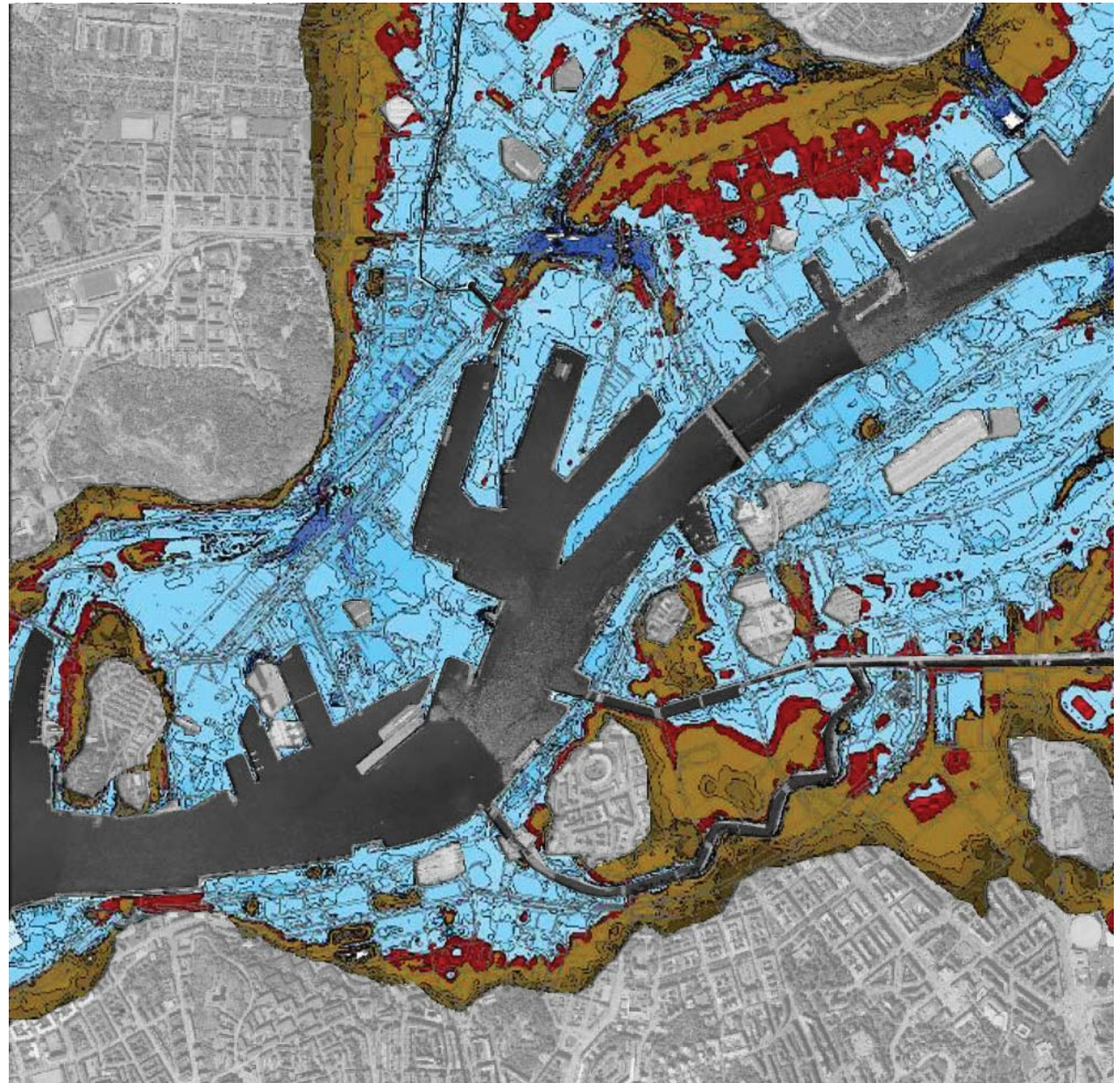


Figure 16: Map produced by the municipality showing the areas at the risk of flooding in central Gthenburg

FUTURE DEVELOPMENTS

The river in Gothenburg seems to be more an obstacle rather than an asset. During the past decade, Älvstranden Utveckling AB in cooperation with the Municipality of Gothenburg has tried to change this. The effort is to develop the city over the river and make the river and water defining feature of the city while creating more integrated and well connected city structure. Accordingly, a project named “Centrala Älvstranden” has been launched recently. The goal in this project is to provide a united vision for the future of Gothenburg city center which is economically, environmentally and socially sustainable.

The most recent development plans around Frihamnen has been illustrated in this map.

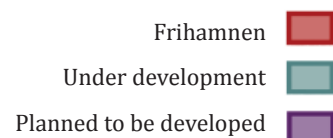


Figure 17: Areas that are under development or planned to be developed in the future

SWOT ANALYSIS

The SWOT analysis has been done based on the feasibility study of Frihamnen conducted by Lena Jacobsson in the planning office, municipality of Gothenburg city.



Figure 18: Bird view over Frihamnen

Large but Disconnected !



Figure 19: View over Hjalmar Brantingsgatan highway

Figure 20: Pedestrian bridge over Lundbyleden highway, the only pedestrian connection.



Strengths	Weaknesses
Extremely central	Surrounded by big roads; accessibility barriers
Large	Poor ground conditions; in-filled land on over 100m clay
Attractive; connection to water	Piers have poor technical conditions
Exposed and flat	Endanger species at the outlet of Kvillebäcken channel; must be protected
Link between the City, Lindholmen and Backaplan	Disturbances such as noise and poor air quality and risks from transporting dangerous goods transport
Close to transportation hub at the landing point of Götaälvbron	Nearby port activities
Owned by the city	Extremely low; high risk of flooding
Mostly undeveloped areas	
Great view over city center	

Opportunities

- Great potential for transformation of land and water with a unique shape and content
- Implementation of climate adaptation through planning and design of urban structure
- Create dense and integrated city center; connecting both sides of the river

Threats

- Climate change and sea-level rise
- Cargo boat traffic on the river
- Economic pressure for development
- Exclusive and expensive development
- Future expansion of “Hamnbanan”



Figure 21: View over city center from Bananpiren

Central but **Low-lying !**

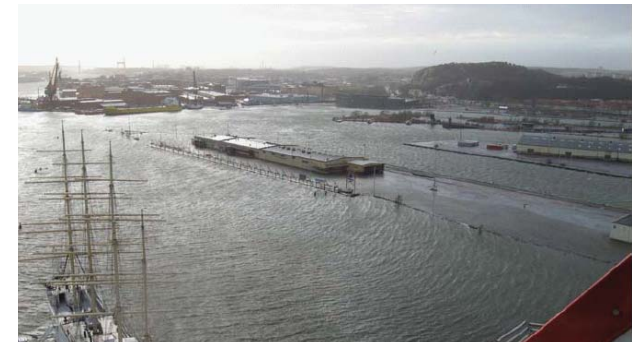


Figure 22: Flooding in Frihamnen due to high water levels and storm in winter

PLANNING OBJECTIVES

Below are proposed goals for the future development of Frihamnen and to create a livable and sustainable neighborhood. These objectives are based on theoretical studies, observations, site analysis, and the discussions among public and local authorities.

Built environment

Dense mixed-used urban structure

Well connected to other parts of the city

Providing all the necessary everyday life services within the neighborhood

Transportation

Efficient public transportation within the neighborhood and to other parts of the city

Pedestrian and bike friendly

Climate change

High water level do not disturb the life in the neighborhood

Water is welcomed and integrated in the urban fabric

Recycling and reusing rain water

Energy efficient and diverse housing

Energy needed for buildings is produced in the area and from renewable sources

There are opportunities for growing food and gardening within the neighborhood

Social issues and identity

Well maintained and efficient (inclusive) meeting places and public spaces

Integrated social context (immigrants/ native, rich/ poor, youth/ elderly)

Landmark of Gothenburg is situated in Frihamnen

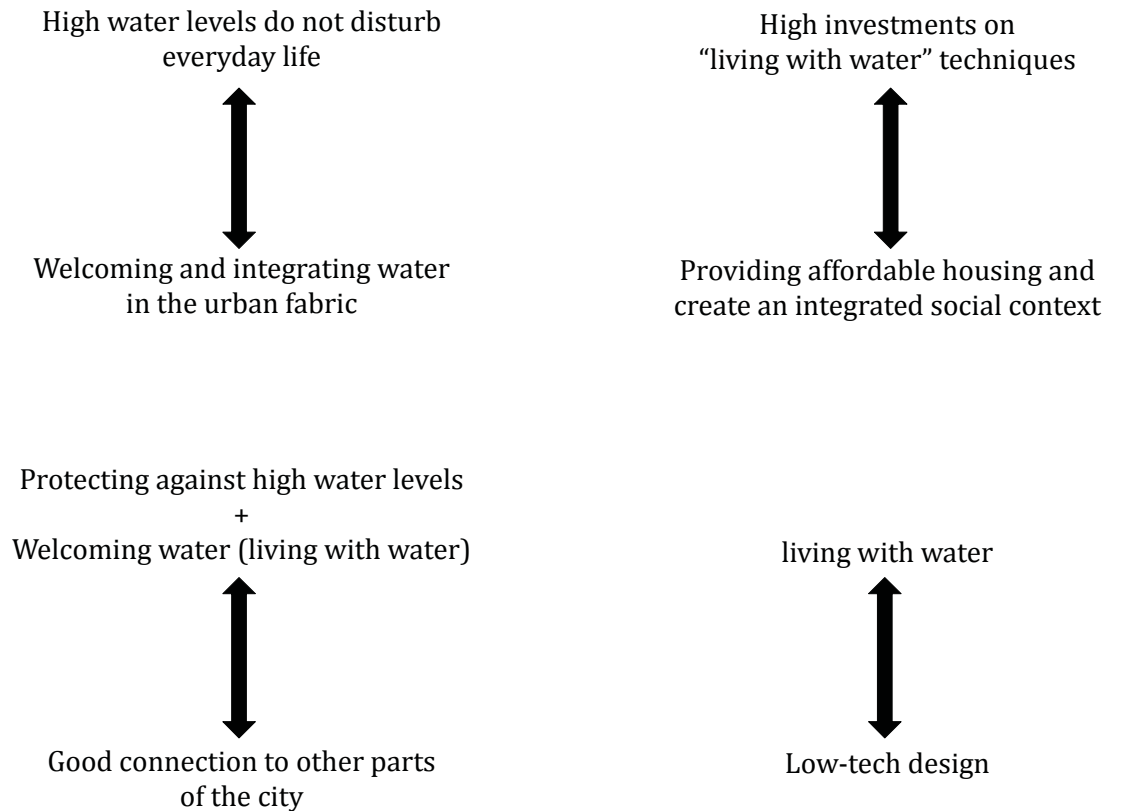
Frihamnen represents contemporary Gothenburg

Tourism

Enough space and convenient services to welcome summer tourists

MAJOR CHALLENGES

Studying the planning objectives, one realizes there are number of significant challenges in the way of developing Frihamnen into a sustainable neighborhood. In Other word there are goals which are difficult to achieve all at the same time. For example:



DESIGN CRITERIA FOR THIS PROJECT

Achieving all the mentioned goals and resolving all the challenges need a lot of time and resources which is out of the scope of this project. Therefore, number of the goals has been chosen as a main focus for this design project.

- Securing the built environment from high water levels by welcoming water in some areas and integrate it in the urban fabric in order to be able to protect other parts.
- Focus on public transit, bicycle, and pedestrian
- Creating connected green areas (green corridors)
- At the same time developing a dense inner-city structure with a good connection to its surroundings
- Representing contemporary Gothenburg

THE PROPOSAL

INTRODUCTION

The effort in this chapter is to propose a viable, yet visionary development of Frihamnen. This proposed design is built upon analysis and investigations in previous sections and in order to provide more clarity, it is presented in two scales. First one is “Frihamnen in Connection with Its Surroundings”. The aim in this part is to establish a set of strategies that form the basis for developing Frihamnen into a sustainable neighborhood. The second one is “Built Structure in Frihamnen” which discusses the proposed urban fabric including street network and the building blocks on the site itself.

FRIHAMNEN IN CONNECTION WITH ITS SURROUNDINGS

In the design of Frihamnen and the way it is connected to its surrounding neighborhoods three considerations have been taken into account:

- Integration within the existing urban structure
- Connection to other parts of the city
- Protection against high water levels

Integration within the existing urban structure

As mentioned in the previous part Frihamnen is surrounded by great barriers such as highways, port railway and the river. In order to develop Frihamnen into a vibrant neighborhood it is important to remove these barriers and improve the pedestrian accessibility to and from the surrounding neighborhoods. For this purpose it is proposed to remove part of the port railway which is located in the north side of Frihamnen (either put it underground or use alternative path) and transform the highway Lundbyleden, another major barrier in the northern side, into a boulevard which carries all means of transport (cars, trams, busses, bicycles and pedestrian). The same concept is proposed for Hjalmar Brantingsgatan (see fig. 23).

Although this transformation requires considerable financial resources which might provoke a lot of discussions among different stakeholders, it provides great possibilities which outweigh its disadvantages. It gives the possibility to design the inner-city street network with integrated traffic system in Frihamnen which enhances the pedestrian accessibility to and from



Figure 23: The proposed street network system for Frihamnen

the site. This is an important factor in creating a lively neighborhood.

Connection to other parts of the city

Public transportation plays an important role in creating a well-connected and integrated city structure. In the accompanying illustration the proposed transportation routes for the time that Frihamnen is completely developed is presented. The blue dashed lines are new tram lines which connect the north and south side of the river as well as the city center to the western Hisingen. The purple lines are the suggested PRT (Private Rapid Transit) network for faster transportation within Frihamnen itself and to the city center.

This concept is derived from the thesis work “Public transport analysis of Frihamnen, Gothenburg” done by Dennis Book and Tobias Lager, Chalmers University, 2009. However it has been modified to fit into the specific design of the street network in this project.

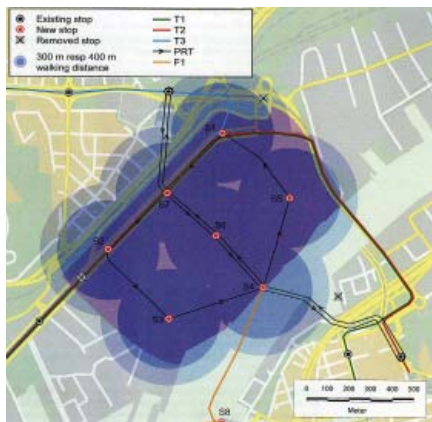


Figure 24: Designed PRT network for Frihamnen by Dennis Book and Tobias Lager, Chalmers University, 2009

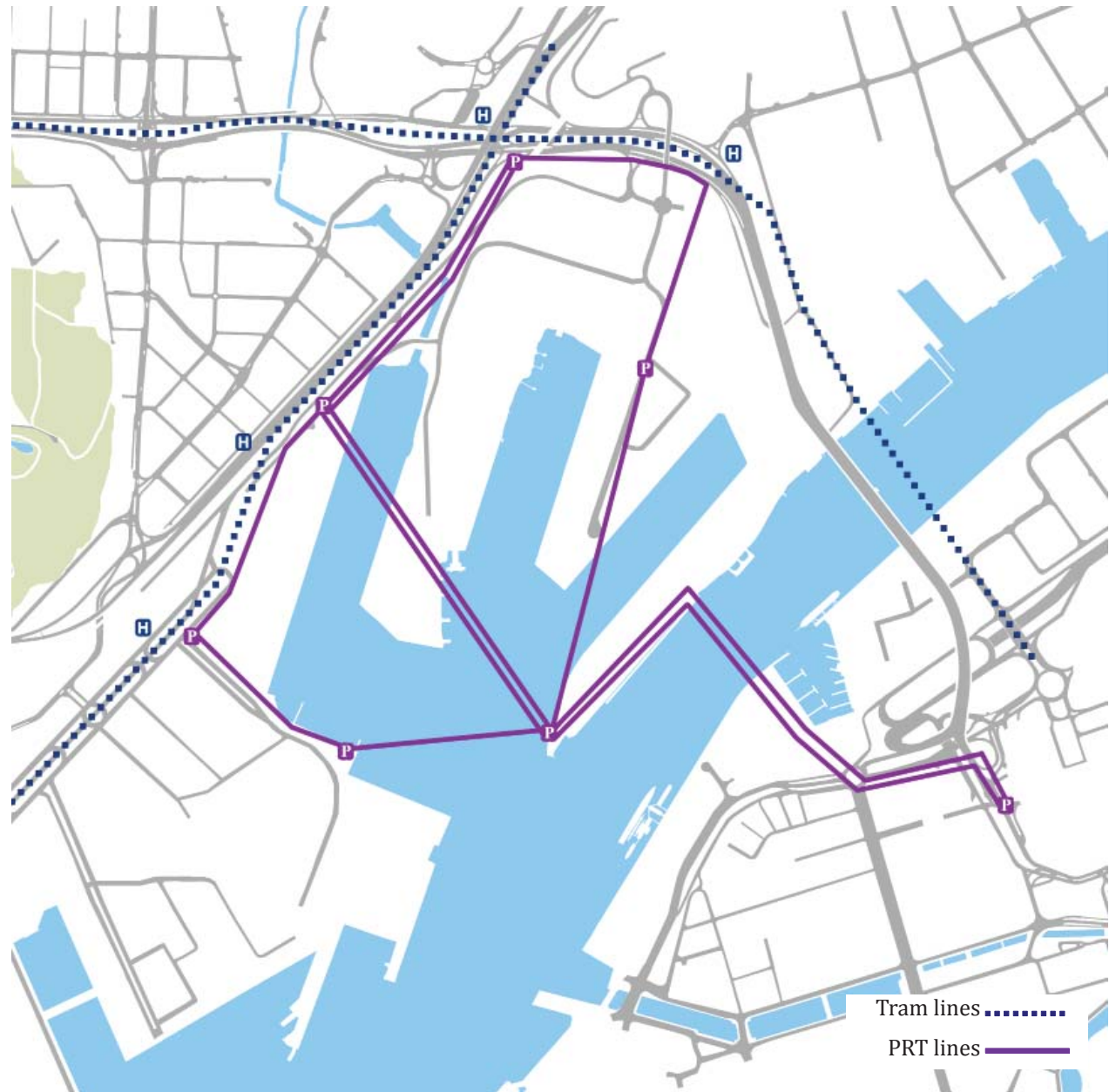


Figure 24: The proposed public transportation system for Frihamnen

Protection against high water levels

In order to protect the settlement against high water levels five different zones has been defined in Frihamnen (see fig. 25). Each zone has specific development strategies to deal with flooding.

- Safe zone; the ground level in this area is raised enough to be safe from both temporary (extreme weather events) and permanent (sea-level rise) flooding.
- Low risk zone; this area is safe from sea-level rise but there is a risk of flooding in the second half of the century due to extreme weather events.
- Medium risk zone; this area most likely will be flooded permanently in 100 years due to sea-level rise, plus there is a risk of temporary floods in the coming 50 years.
- High risk zone; this area is already facing temporary flooding and in the near future will be permanently flooded due to sea-level rise.
- Green zone; Space for water including channels, wetlands, and green areas

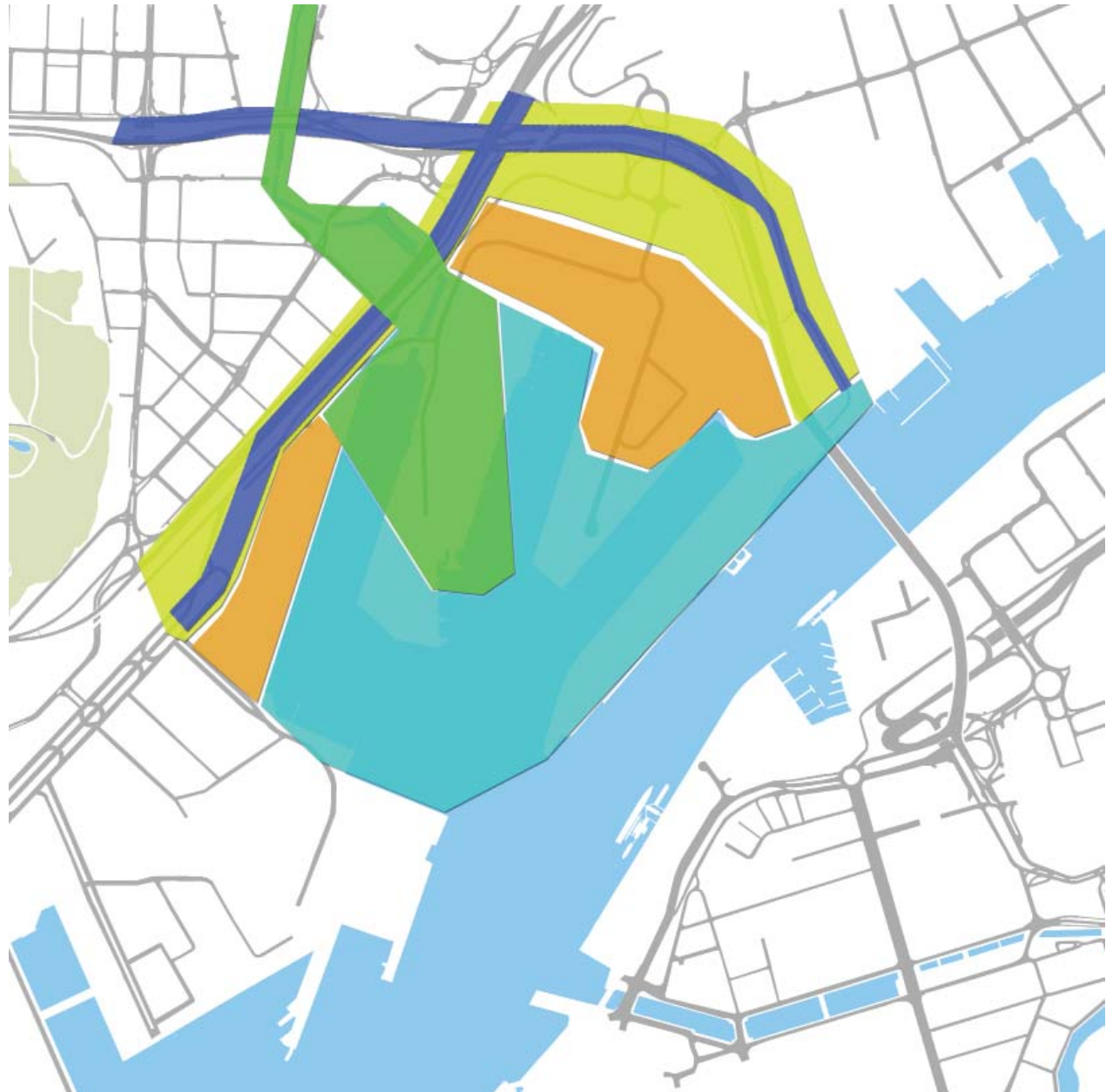


Figure 25: The proposed zoning for protection against high water levels



Figure 26: Turnaround House, Nissen Adams, UK



Figure 27: Building on Stilts, MVRD V, Lower Ninth Ward of New Orleans



Figure 28: Amphibious Houses, Maasbommel, Nederland

As mentioned before, Gothenburg has a specific height level system. According to this system, normal water level in central Gothenburg currently is +10.1. Based on the studies on future extreme weather events and sea-level rise in this city the average height level in each zone in this specific site are:

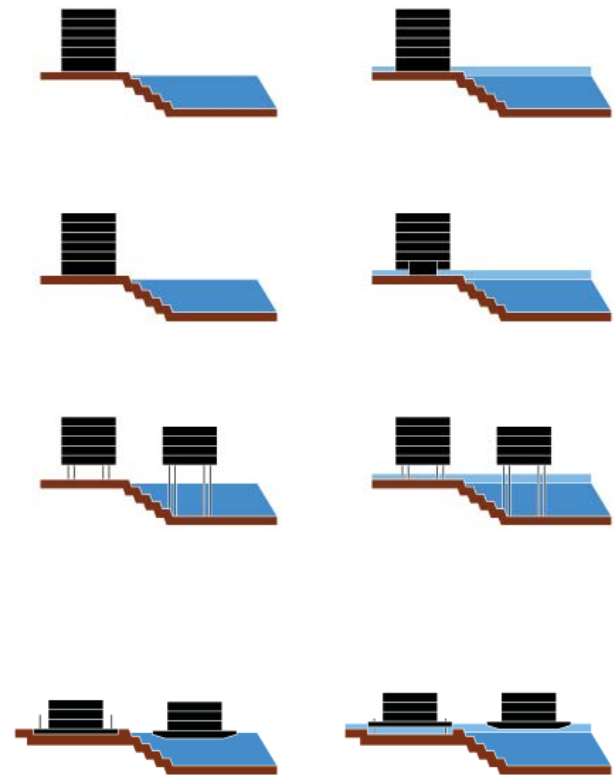
- Green zone < +10.1
- High risk zone +10.1 – +11.1
- Medium risk zone +11.1 – +12.1
- Low risk zone +12.1 – +13.8
- Safe zone > +13.8

Different types of houses in different zones

■ Flood houses; suitable for low risk zone (see fig. 26)

■ Houses on pillars; suitable for low and medium risk zones (see fig. 27)

■ Amphibious and floating houses; suitable for medium and high risk zones (see fig. 28)



BUILT STRUCTURE IN FRIHAMNEN

In order to step forward and provide more detailed design, below factors have been taken into consideration:

Focus on bicycle and pedestrian in the design of the streets and blocks

In order to have a sustainable neighborhood it is crucial to design safe pedestrian and bicycle routes which connects public transportation hubs to all the houses (see fig. 29). For this reason pedestrian, bicycles and the public transport is the first priority in the design of the building blocks and street network. Car streets are the second priority. Another concern is to create an integrated street system where car speed has been reduced and all means of transport exist in the same level (see fig. 30).



Figure 29: Examples of attractive and well-used pedestrian and bicycle paths

Consideration of the local sun and weather conditions in the design

Reducing energy consumption and using renewable energy sources are two important factors in design of a sustainable building. One effective method to achieve these objectives is to design the buildings in accordance with the local sun and weather conditions in order to create pleasant indoor and outdoor environments without consuming so much energy.



Figure 30: A section of a street with an integrated traffic system

Sweden has long and cold winters with heavy frosts and snowfalls. Therefore, sunlight is very appreciated in winter while the winter wind can be so annoying and should be avoided. On the other hand, summers are warm and

pleasant in Sweden. Thus, spaces which can capture the summer breeze are very attractive in summer. Another important point that should be considered is the angle of the sun. Because of Sweden's high latitude, the length of daylight and the sun elevation angles varies greatly throughout the year.

Based on the various sun elevation angles in Gothenburg throughout the year (see fig. 31) and the direction of the wind in summer and winter (see fig. 32), it is concluded that:

Street network grid to be rotated 10-15 degree to the west in order to avoid the winter wind and welcome the summer breeze.

The space between buildings should not be less than 40m in order to prevent buildings from casting shadows over each other. In addition step-shaped rooftop design of the buildings maximizes the capture of solar radiation especially in winter time (see fig. 33).

Introducing new typology of floating buildings

As explained previously, major parts of Frihamnen are at the risk of flooding due to future sea-level rise and extreme weather events. According to a British report prepared by RIBA Building Futures and the Institution of Civil Engineers (ICE), there are three different strategies to deal with flooding in the development of low-lying waterfront areas: Retreat, Defend, and Attack (see fig. 34). To retreat means to step back from the problem and avoid the potential flooding. To defend means to ensure the water does not enter the existing built environment. To attack, on the other hand, means to step forward of the existing water edge and

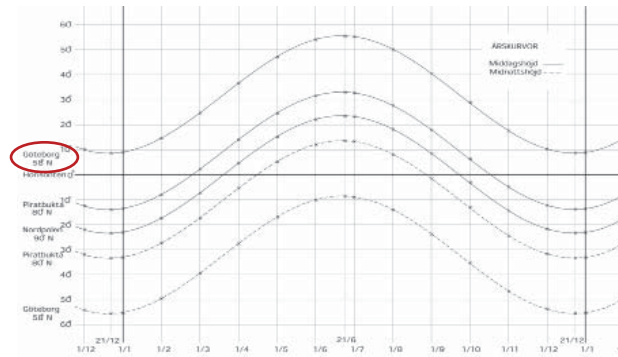


Figure 31: Sun elevation angle during a year in Sweden

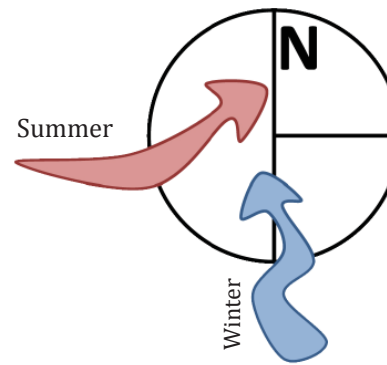


Figure 32: Dominant wind direction in Gothenburg

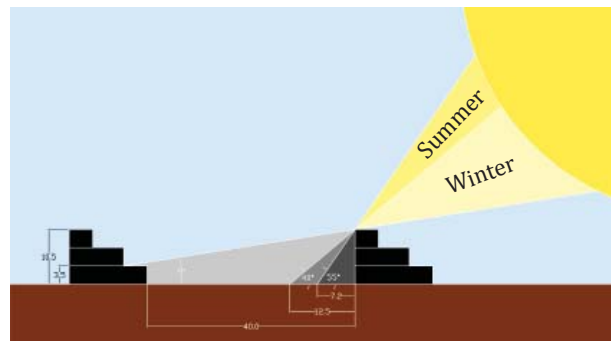


Figure 33: Sun elevation angle in Gothenburg

live with water (RIBA Building Futures and the Institution of Civil Engineers (ICE), 2010).



Figure 34: three scenarios to deal with potential flooding: Retreat, Defend, and Attack.

The focus in this project is to examine and test the attack scenario in the future development of Frihamnen. One of the development strategies within the attack scenario is building floating houses and living on water. Based on this strategy, it is proposed to develop the defined high risk zone in Frihamnen (see fig. 25) into a floating neighborhood.

The concept of living with water is not new; there are various examples around the world (see fig. 35 and 36). Yet, I couldn't find any example of a



Figure 35: Floating villa, Seattle, Washington - USA



Figure 36: Green Housboat, Amsterdam

floating neighborhood which is in accordance with the sustainability guidelines defined in this project. They either consist of single houseboats located in ordinary marinas or floating villas located along the network of dead-end docks and disconnected from surrounding built environment (see fig. 37).

Thus the effort here is to introduce new typology of floating houses that follows the defined objectives in this project. To achieve this purpose, two basic factors have been taken into consideration. First, it is important to have a grid of docks rather than tree-shaped system but at the same time provide access from both land and water for each building. Second, it is essential to produce diverse building types in order to accommodate various functions and land uses. In the following illustrations different alternatives and the final design of this new typology of floating buildings is presented.



Figure 37: View of a Floating Home Community Developed by IMFS (International Marine Floating Structures), USA

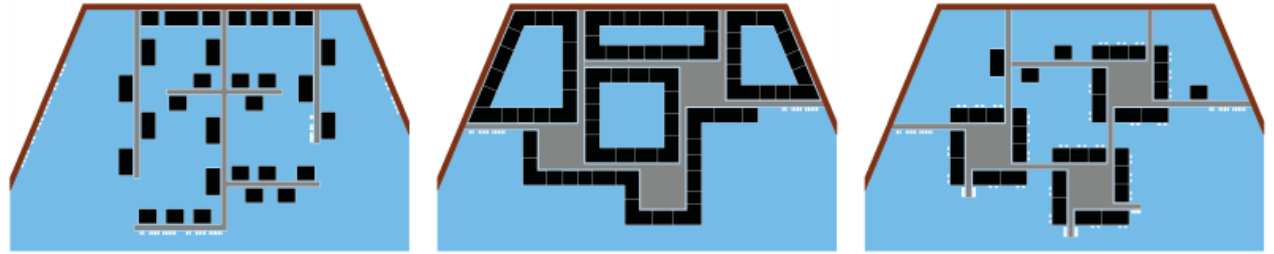


Figure 38: Left- This is the common form of floating home communities but it does not provide proper public spaces and desirable accessibility for pedestrians. Middle- In this alternative water access is not provided for all the building. Right- This alternative provides the desirable land and water access and proper public meeting points but it still lacks the needed diversity.

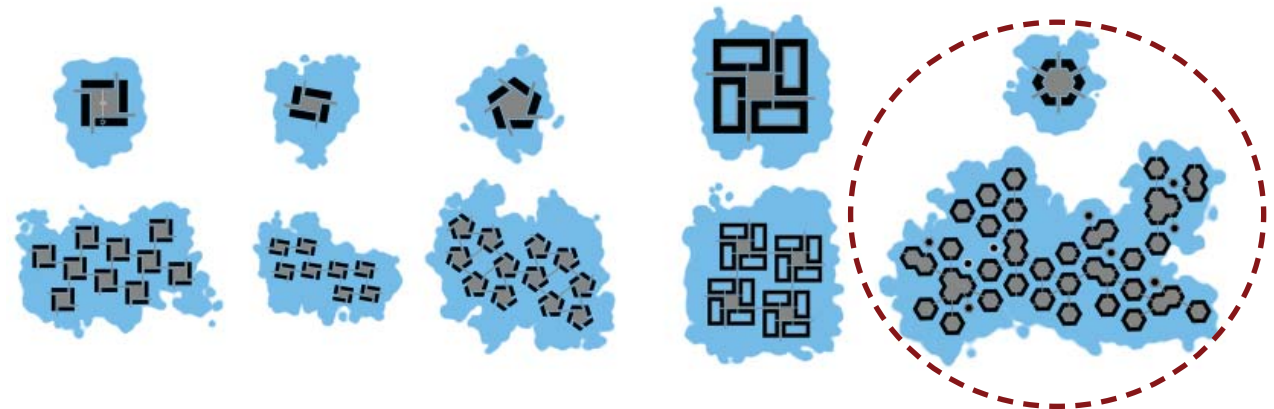
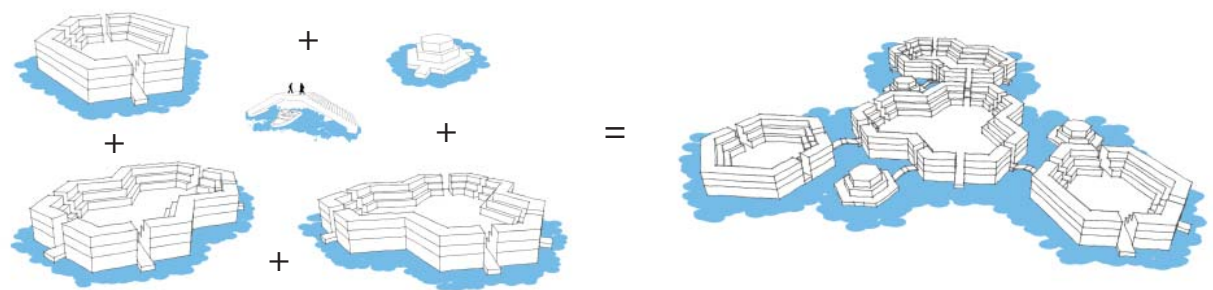







Figure 39: Above- After examining different geometric shapes, the hexagonal is chosen for it fits better into the sites with organic forms. Bottom- Hexagonal form also has a great potential in creating diverse compositions.



MASTER PLAN

Here is the proposed master plan for development of Frihamnen. This plan consists of a big wetland park, new developments along Lundbyleden and Hjalmar Brantingsgatan, floating houses and a culture house.

The wetland park is located along kvillebackskanalen and continues into Göta Älv. New developments are formed along Lundbyleden and Hjalmar Brantingsgatan boulevards. These developments mostly consist of work places especially in the areas which are closer to the main boulevards. Lundbyleden and Hjalmar Brantingsgatan highways form a big barrier around Frihamnen today. Thus in this proposal they are transformed into boulevards with public transport (tram and PRT lines) in the middle and pedestrian and bicycle paths on the sides. It is also recommended to keep some of the structures and reuse them such as the old bridge over Göta Älv and number of the warehouses and buildings which are marked in the map. The idea of keeping old bridge is derived from “Green Link”, a master thesis work at Chalmers University done by Maria Strandberg in 2010. In addition, the concept of culture house (Kulturhuset) is inspired by “Green Viking City”, Håkan Cullberg and it is planned to be the heart of this new neighborhood.

Culture house (kulturhuset)	
Floating houses	
New buildings	
Renovated buildings	
Wetland park	

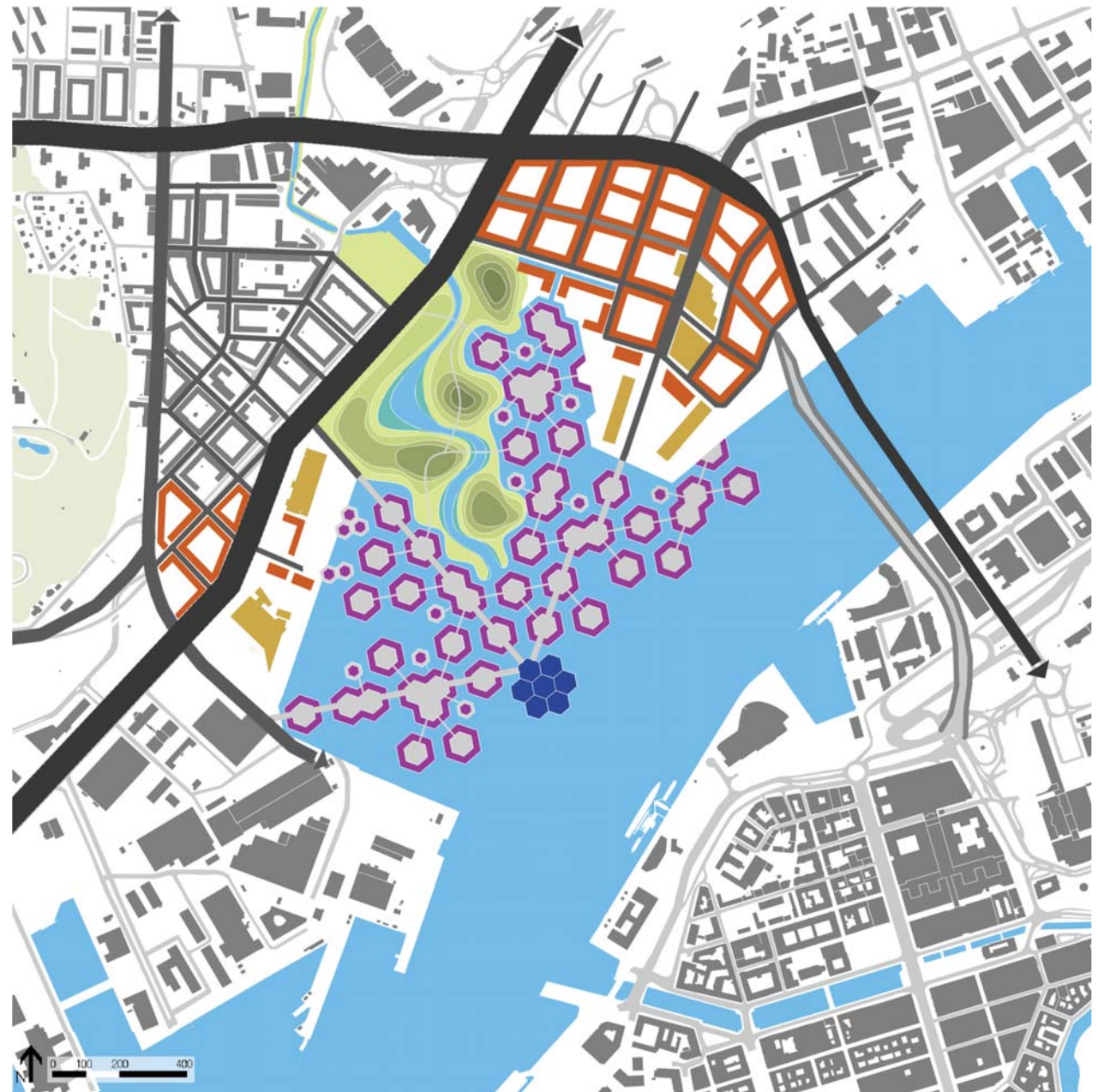


Figure 40: The proposed master plan

Overall sections

Bellow are two sections over Frihamnen and Göta Älv, one shows the current situation while the other one illustrates the situation after development.

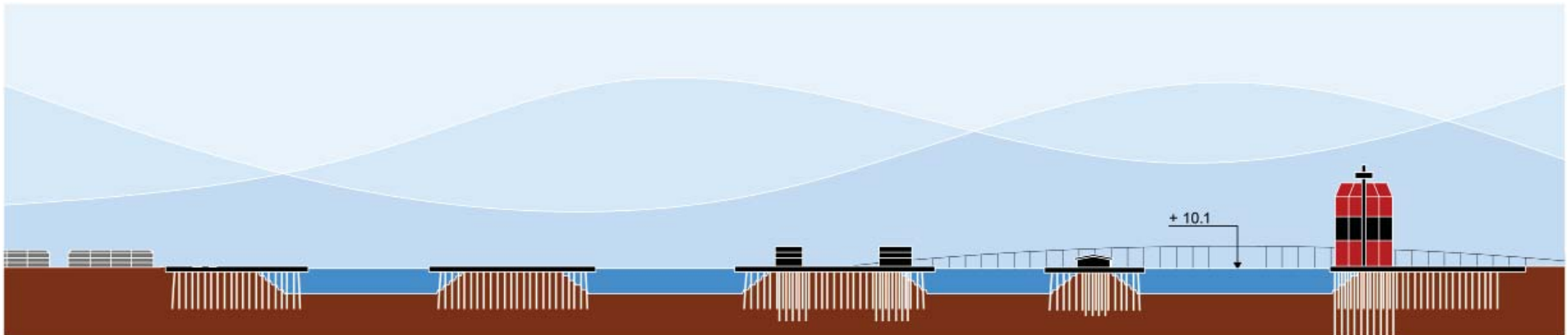


Figure 41: A section over Frihamnen and Göta Älv, current situation

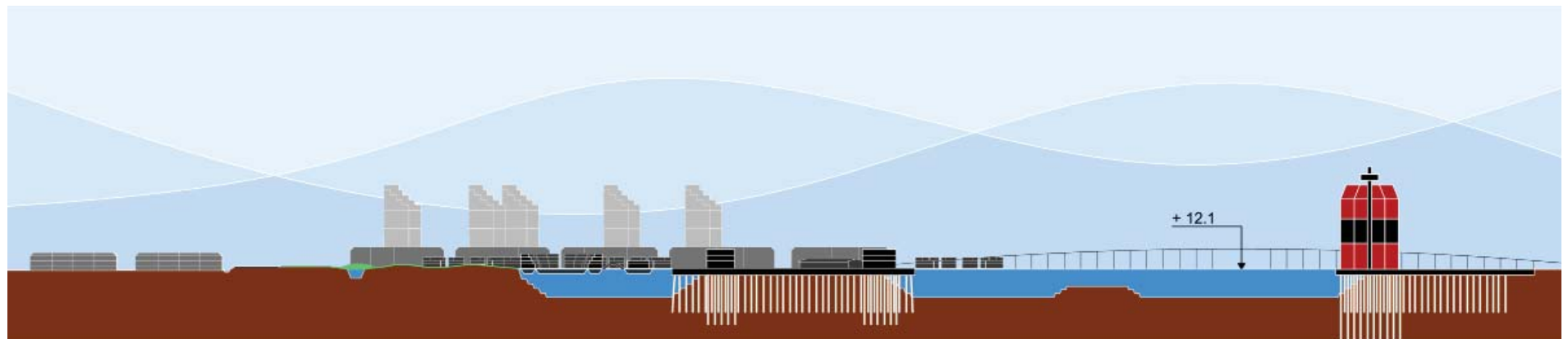


Figure 42: A section over Frihamnen and Göta Älv, after development

Detailed design

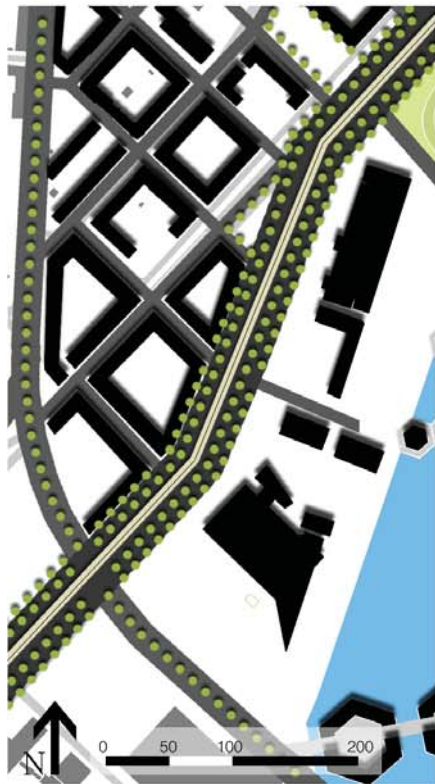


Figure 43: The main boulevard

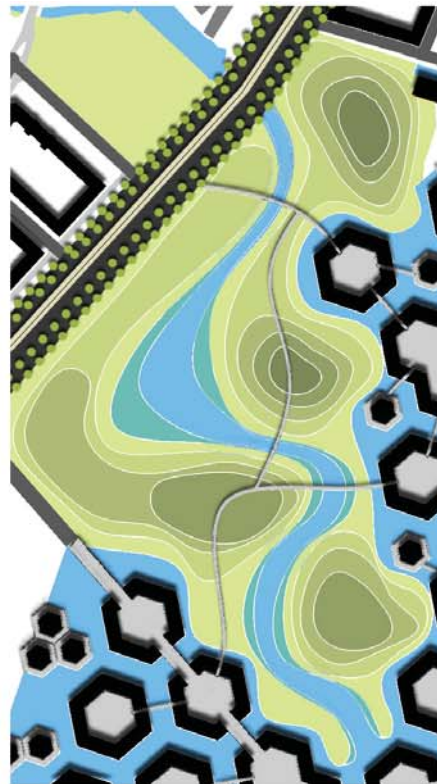


Figure 44: Wetland park

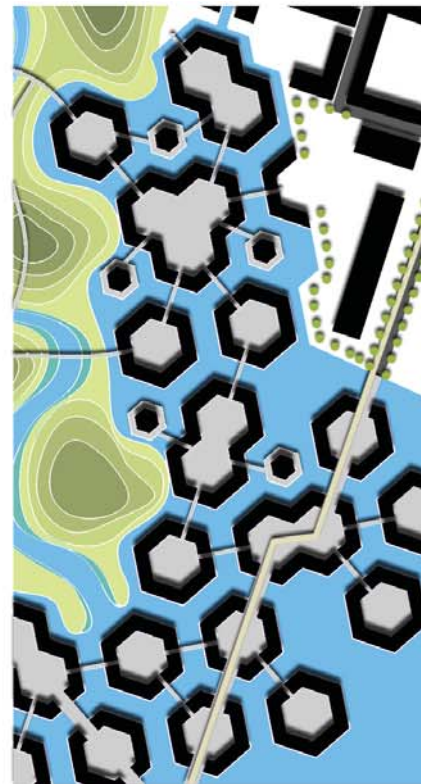


Figure 45: Floating houses community

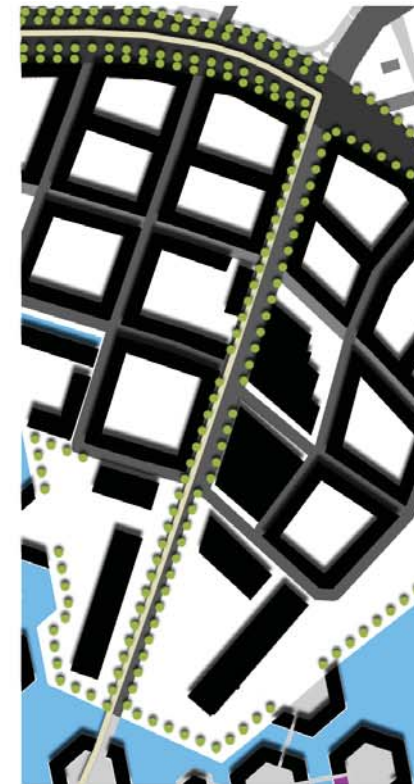


Figure 46: New developments around the existing buildings



Figure 47: Detailed sections over different parts of the proposed master plan

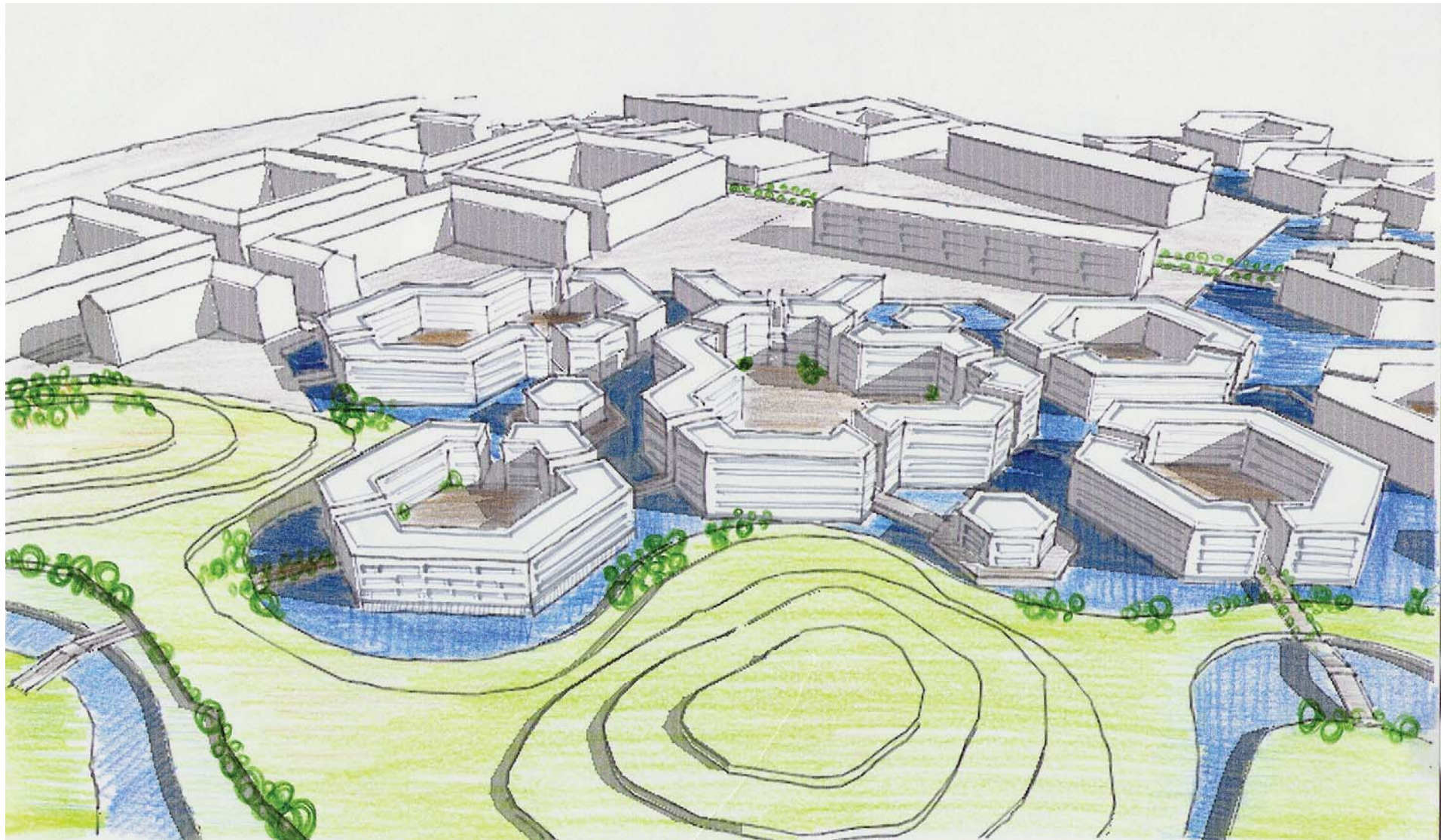


Figure 48: View over Floating houses community

DEVELOPMENT OF FRIHAMNEN OVER TIME

Development of Frihamnen can be done in different stages.



Figure 49: First stage

In the first stage:

The Highways Lundbyleden and Hjalmar Brantingsgatan are transformed into boulevards.

New tram line connects Hjalmar Brantingsplatsen to västra Eriksberg.

New developments are formed along two main boulevards.

Some of the old buildings in Frihamnen are renovated and reused.

The big wetland park is built in the mouth of Kvillebäckskanalen.



Figure 50: Second Stage

In the second stage:

First group of floating houses are built.

New culture house is built where it used to be bananpiren.

More houses and workplaces are built along the main boulevards.

PRT system is established.



Figure 51: Final Stage

In the final stage:

The floating houses community is expanded.

Development of the PRT network is completed and it creates a faster and more attractive connection between Frihamnen and city center.

CRITICAL DISCUSSION

INTRODUCTION

The ultimate goal in this project has been to examine innovative ways of dealing with the impacts of climate change on our cities in general and the urban waterfronts in particular. In this way, architectural tools have been used to analyze where we are standing today and to visualize how far we can go.

The effort, however, has been to test new design ideas on a specific site rather than to offer a definitive plan. To accomplish this mission it is important to finalize the project with a critical discussion and evaluation of the design proposal based on the defined objectives and criteria. It is also essential to discuss the new questions which are raised as the project progress and to explore the possibilities for further research in this field.

EVALUATION OF THE PROPOSAL

As explained in the second chapter, five points has been defined as design criteria for this project. In this part we take a critical look over the proposed plan and see how these criteria have been fulfilled.

The first and most important goal has been to protect the future development in Frihamnen against high water levels. Two main strategies have been used for this purpose. First is to make space for water within the urban areas by building a wetland park. The main advantage of this beside contributing to city's green structure is to reduce and delay the stormwater runoff in the case of extreme weather events and consequently to reduce the risk of flooding in low-lying waterfront

areas. Second main strategy is to define different zones from safe to high risk and develop each zone in accordance with its degree of risk (see fig. 52). For example, it is recommended to develop floating houses in the areas with high risk of flooding. This is one way of reducing vulnerability of the built environment to sea-level rise and flooding.

The second important objective has been creating a dense inner-city structure in Frihamnen while protecting it against flooding. For this purpose, the new typology of floating houses has been designed specifically in accordance with the characteristics of an inner-city structure. These

characteristics are high density, diversity of building types and land uses, and convenient walking and biking paths (see fig. 53).

Focus on public transit, bicycle, and pedestrian has been another objective of this project. To reach this goal the design of pedestrian and bicycle paths has been prioritized over the design of car streets (see fig. 54). Public transport has also been an important element in the design of the master plan. For this reason the development has been oriented along the public transport corridors (see fig. 55)

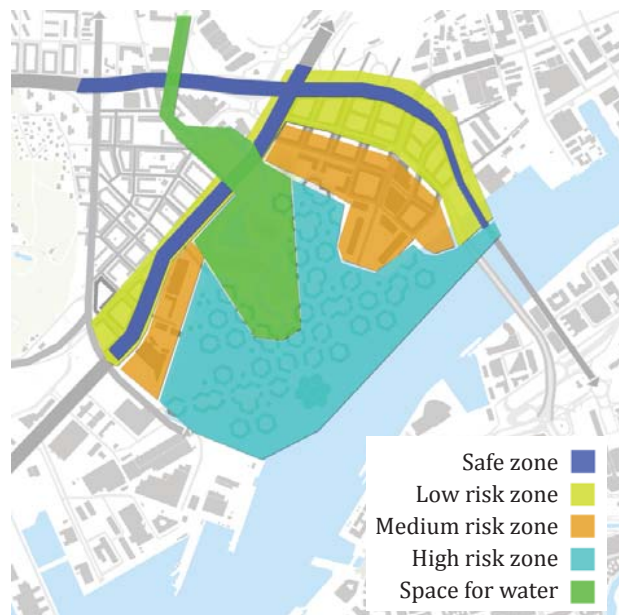


Figure 52: The proposed zoning for protection against high water levels

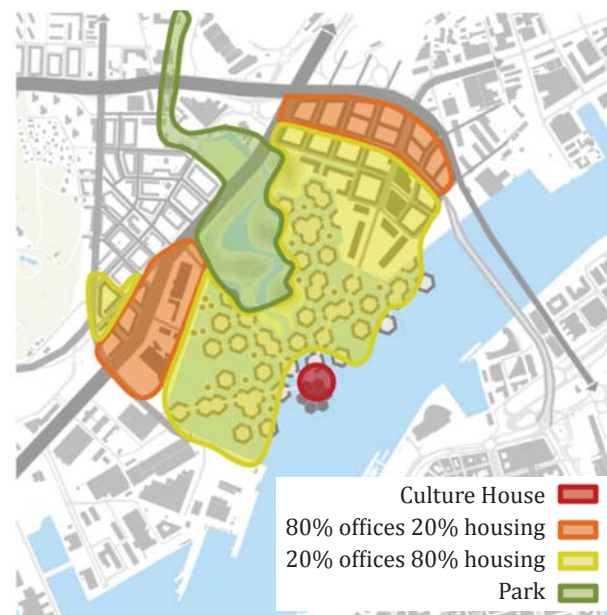


Figure 53: Land use analysis

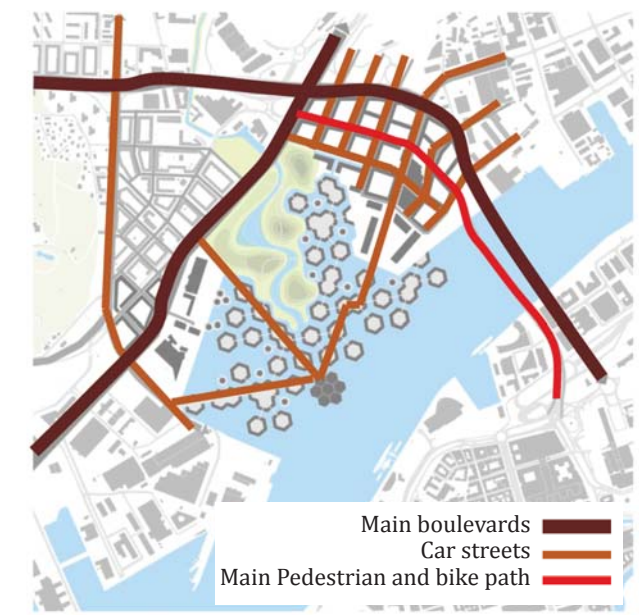


Figure 54: Street network analysis

The fourth objective has been creating connected green areas. This has been fulfilled mostly by the wetland park which connects green areas along the Kvillebackskanalen to Göta Älv.

The last but not the least important aim of this project has been to introduce the new type of city structure which represents the contemporary Gothenburg. This has been achieved by integrating the principles of sustainable development with climate adaptation strategies and introducing an urban structure which is not only sustainable but is resilient. This is how I imagine the future of Gothenburg.

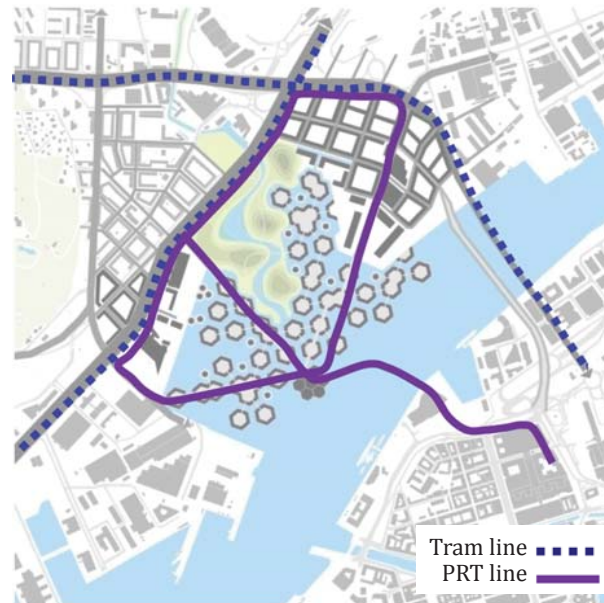


Figure 55: Public transport analysis

WHERE TO GO FROM HERE

The design criteria which discussed above were extracted from a more extensive list of planning objectives (see second chapter). Here we take a closer look over this comprehensive list and discuss the unfulfilled objectives hoping this discussion contributes to future research in this field.

Built environment

Providing all the necessary everyday life services within the neighborhood

A sustainable neighborhood should provide all the basic everyday life services such as food shops, pharmacy, schools, and etc. This is an important factor in reducing the everyday commutes in the city and therefore reducing the energy use in transport sector. By providing divers building types especially among the floating houses, I have tried to provide the basic groundwork for creating this quality. However, more investigation and study is needed in this field which can be a subject of further research.

Climate change

Recycling and reusing rain water

Energy needed for buildings is produced in the area and from renewable sources

There are opportunities for growing food and gardening within the neighborhood

Many studies have been done on the above issues yet what is interesting here is to investigate these topics in the new context of “living with water”.

Social issues and identity

Integrated social context (immigrants/ native, rich/ poor, youth/ elderly)

Social sustainability is one of the main aspects of sustainable development. Many researches and studies have been done in this field yet it is one of the great challenges of our societies. I believe architects and planners play an important role here depending how they see the society and translate it into physical spaces. Unfortunately, giving the time limitations it was not possible to discuss the social aspects of the proposed plan and answer the questioned rose as the project progressed. Number of these questions are:

What is the relationship between climate adaptation and social sustainability?

How to build our cities to be both socially and physically resilient to future climate changes?

How to develop “living with water” techniques and at the same time provide affordable housing and create an integrated social context?

Tourism

Enough space and convenient services to welcome summer tourists

With global warming and heat waves attacking southern Europe, summer tourism becomes more and more important in Scandinavia and Sweden. It brings opportunities and threats with itself and I believe it is time to include this issue, as one of the main factors, into the field of urban planning and design.

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