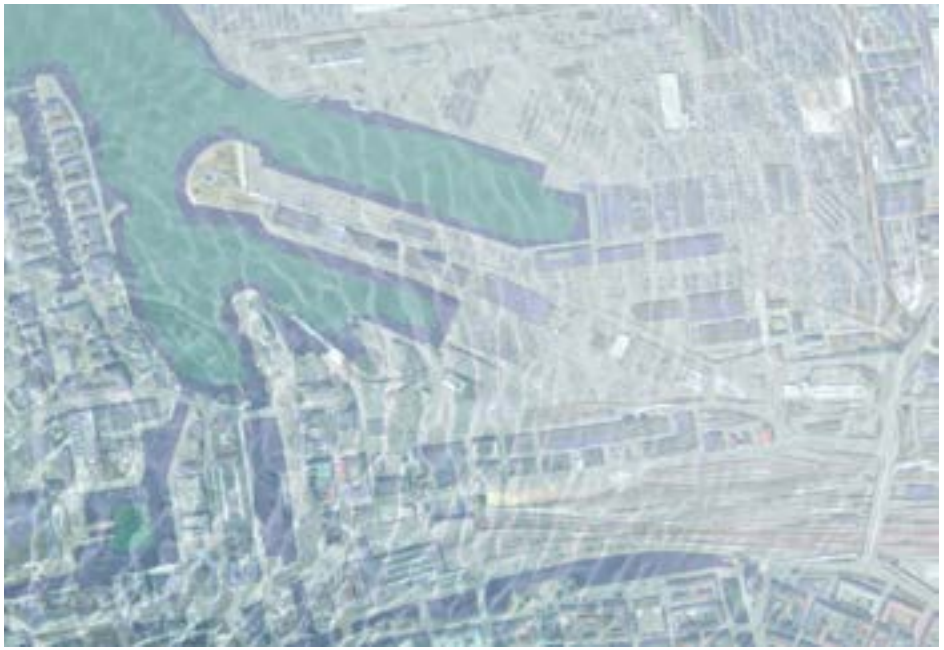

Nyhamnen, climate adaptation regarding sea level rise and flood

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Supervisor: Teresa Arana Aristi
Examiner: Lars-Henrik Ståhl

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All images and illustrations presented in this report are done by

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Content

Abstract

During the last decades, climate change has been one of the most major issues for human beings. Global warming causes ice melting and sea level rise that besides the torrential rains increase risk of floods in different parts of the word especially along the coastal areas. Since population growth intensifies the necessity of home developments in many countries, use of lands near seas is inevitable. By this way, prevention of flooding and protection in these areas are essential in many cities.

In the thesis project, one of these areas in Sweden is under investigation to find practical solutions for coastal areas development. The area is located in the north part of Malmö, Nyhamnen which is assumed to be a vibrant area in future.

During the design process it is attempted to make a combination of urban design principles and climate adaptation to experience sustainability both socially and environmentally in the area.

Since Nyhamnen has been isolated and used for industrial activities from the first day, making connections with its surrounding and central part of Malmö is another goal in the project. To strengthen the connection and inviting people to the area every part has its unique protection based on its potentials and character. Also, to benefit the maximum potential of physical measures and to make functional urban spaces, every measure has an urban role to enhance social sustainability besides climate adaptation. Implementation of multi functions is considered as a response to the need of keeping the area both protected and alive in different circumstances.

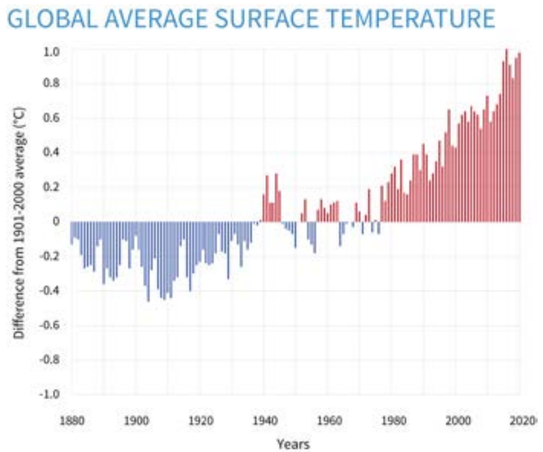
01
CLIMATE CHANGE

Climate change

After 1800s human activities caused long-term shifts in temperatures and weather patterns which is known as climate change. The main dominant factors have been burning fossil fuels that cause greenhouse gas emissions. (1)

Around 1.0°C of global warming have caused by human activities and global warming is estimated to overtake 1.5°C between 2030 and 2052 if the rising temperature rate will not change. Now in many parts of the world and in different seasons higher temperature than the global average is observed. (2)

Earth's temperature has risen by 0.14° F (0.08° C) per decade since 1880, and the rate of warming over the past 40 years is more than twice that is 0.32° F (0.18° C) per decade since 1981. (3)



Source:
https://www.climate.gov/news-features/understanding-climate/climate-change-global-tempera-

Main Drivers

Human activities have made sever changes in land cover which have had significant impact on the climate change acceleration. Urbanization and agriculture have led to changes in land use and land cover which result in changes in albedo, urban heat island effects, emissions from burning forests and changes in natural water cycle. Also, the combustion of fossil fuels is the main driver of altering the climate system among all human activities. (4)

Source:
https://cdn.sei.org/wp-content/uploads/2019/03/gettyimages-115949132crop-1488x889.jpg

Source:
https://www.euractiv.com/section/agriculture-food/news/eu-parliament-unwilling-to-reject-com-

Source:
https://wsimag.com/architecture-and-design/32403-planetary-urbanization

Source:
https://www.pbs.org/wgbh/nova/article/climate-change-acceptance/

Consequences

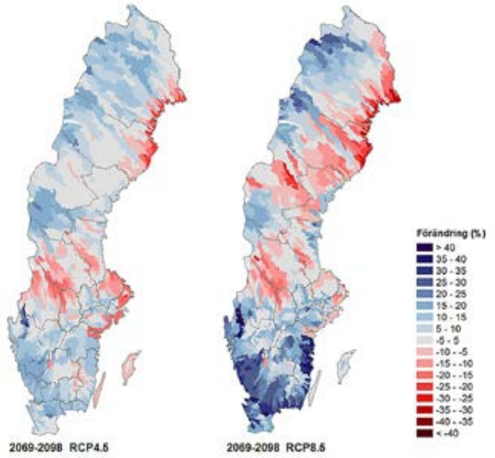
Although the known feature of climate change is global warming and warmer temperature, it is just the start of more serious problem. Since the planet works as a system, every single change in one area can affect the other part. Intense droughts, water scarcity, severe fires, rising sea levels, flooding, melting polar ice, catastrophic storms and declining biodiversity are some of the climate change consequences. (1)

It is most likely that the past emission causes profound alternations to human and natural systems like further sea level rise than resulting in raising global-mean temperature to 1.5°C above pre-industrial levels which put small islands, megacities, coastal regions, and high mountain ranges among the most affected areas. (2)

Source:
https://weather.com/news/climate/news/skinny-polar-bear-photo

Climate change in Sweden

To estimate climate change in future there are different scenarios depends on how strong the climate policy is to reduce emissions. In Sweden the average temperature will rise by 2-6 degrees by the turn of the century. Also, the average precipitation increases by more than 50%. Both factors will be higher in northern parts of country, but the very highest flows will increase in southern Sweden rather than northern part which can cause flooding. By the next century the number of days with snow cover reduces in whole country by 40-80 days. (5)



The maps show changes in centenary inflow, to the left with the scenario limited greenhouse gas emissions (RCP4.5), and to the right with the scenario high emissions (RCP8.5). (5)

Source:
https://www.thelocal.se/20180522/in-pictures-thawing-snow-causes-floods-in-northern-sweden/

02
SEA LEVEL RISE & FLOOD

Sea level rise

Sea level rise means an increase in the water level of oceans around the world which is stem from climate change and global warming. In fact, by absorbing the heat the temperature of water rises so it expands and contribute to sea level rise which has consequences especially for coastal life such as increased intensity of storm surges, flooding, and damage to coastal areas. (6)

The main cause of sea level rise since 1970 have been human activity. Based on recent observation expansion due to ocean warming and melting of glaciers and ice sheets are components that results in sea level rise. (7)

Global mean sea level (GMSL) rise estimated reach 2m by 2100 and 5m until 2150 under a very high GHG emissions scenario. (7)

“The report [AR6 Interim Report 1 - The Scientific Basis] released by the IPCC in August 2021 compiles data on global sea level rise. Regardless of which emission scenario society will follow in the future, sea levels will continue to rise for hundreds to thousands of years. By the middle of the next century (year 2150), the global mean water level at a very low emission scenario (SSP1-1.9) is estimated to rise 37–86 cm compared with the reference period and at a very high emission scenario (SSP5-8.5) with 98–188 cm (probably). If societal developments were to follow the very high emission scenario, it cannot be ruled out that the sea could rise 5 meters by the year 2150 (less likely).” (8)

Estimated future rise of the global mean water level (probable interval)		
Scenario	Until the year 2100	Until the year 2150
Very low (SSP1-1.9)	28 – 55 cm	37 – 86 cm
Low (SSP1-2.6)	32 -62 cm	46 – 99 cm
Medium (SSP2-4.5)	44 – 76 cm	66 – 133 cm
High (SSP3-7.0)	55 – 90 cm	89 – 165 cm
Very high (SSP5-8.5)	63 – 101 cm	98 – 188 cm

(8)

Sea level rise in Skåne and Malmö

The amount of sea level rise is not same in different parts of Sweden due to the variation in the speed of the land uplift in different areas as the land uplift is the compensator of sea level rise. For example, in coastal area of southern Sweden the average water level rises along the coast since the land uplift is slower than sea level rise. (8)

Temporary floods happen in coastal area today and the increase of the average water level make higher the starting level of floods and high-water events which result in more common and worse floods in future. (8)

Increasing erosion in coastline, changing the quality of drinking water due to the higher level of salinity in water sources, changing ground water level, damaging agricultural land, biodiversity are some consequences of sea level rise. (8)

Swedish Meteorological and Hydrological Institute (SMHI) released a report on November of 2020 based on IPCC report which show the average mean water level in different area of Sweden and estimated how high it will be in future. For example, in Malmö Municipality the average water level was 13 cm in RH 2000 for 1995-2014 years and the total land uplift for this area was 0.092 cm / year (of which the elastic component is 0.064 cm / year). The following table shows the average mean water level of same area in 2050 and 2100 based on five scenario of IPCC report. (9)

Estimated average mean water level in Malmö			
Scenario	Year 2050 Median (Probable interval)	Year 2100 Median (Probable interval)	Year 2150 Median (Probable interval)
Very low (SSP1-1.9)	33 (23 to 45)	52 (30 to 77)	69 (34 to 110)
Low (SSP1-2.6)	35 (27 to 45)	57 (39 to 78)	73 (44 to 110)
Medium (SSP2-4.5)	37 (29 to 47)	70 (53 to 93)	101 (69 to 145)
High (SSP3-7.0)	37 (28 to 47)	79 (58 to 106)	121 (81 to 173)
Very High (SSP5-8.5)	39 (29 to 50)	91 (67 to 121)	139 (94 to 201)

(9)

For Malmö, high sea levels mean a risk of flooding in low-lying coastal sections and parts of the central city with a direct connection to the sea, namely harbor basins and canals. Malmö’s 43-kilometer coastline will be affected by high sea levels. In addition, a large low-lying area along Segeås lower course is affected, which is of great importance for the city’s communications and supply. It is crossed by railways and roads, power lines and major water mains. (10) (Student translation)

1 m sea level rise in Malmö (11)

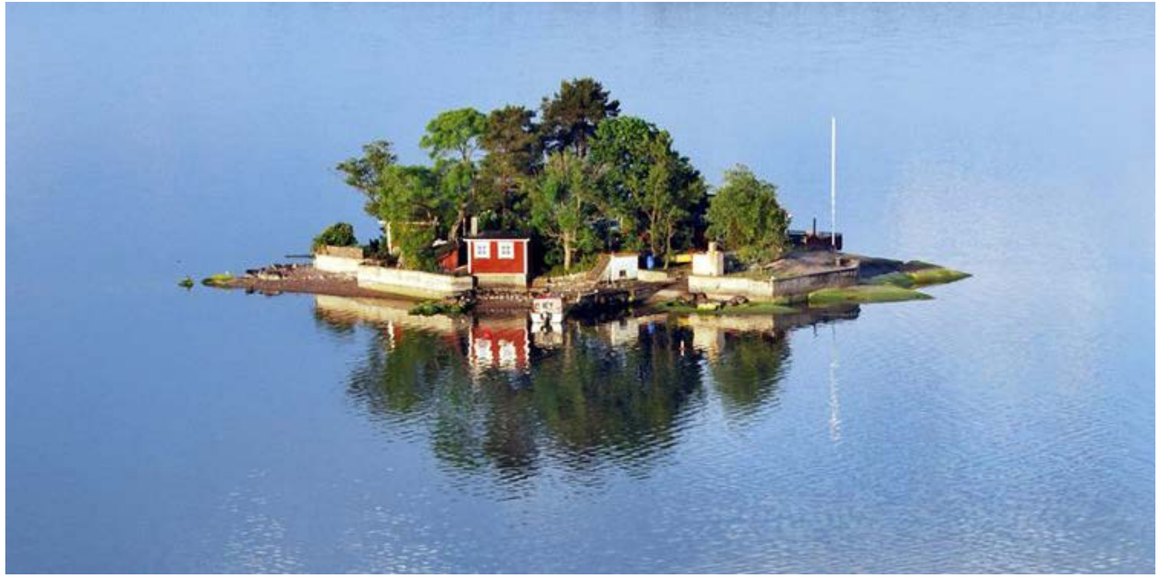
2 m sea level rise in Malmö (11)

3 m sea level rise in Malmö (11)

High sea levels have various meteorological causes where the most important factors are air pressure, wind and tides. In Öresund, the tide varies only by about 5–15 cm. When several factors interact, extremely low or high-water levels can occur. The duration of a storm, wind speed and direction, the strength of a low pressure and the depth conditions of the sea affect the sea level. Simplified, it can be said that low pressure and onshore winds give high levels, while high pressure and offshore winds lead to lower sea levels. Problematic high-water levels are often relatively short-lived. The situation in Öresund is complex due to the topography. The water levels are often higher in the northern parts than the southern ones, but also very locally, the variation at one and the same time can be large. (10)

Rising sea levels are generally an effect of rising global temperatures. The UN's climate panel IPCC's latest report (2013) shows that the average level of the sea may rise by about 1 m until 2100. Temporary levels can in addition amount to an additional 2.5 m due to storms and other hydrological phenomena. This scenario means that temporary high sea water levels may amount to +3.5 m in 2100, which in turn means that very large values in Malmö are in the danger zone. (10)

High sea levels and rising average levels affect a wide range of aspects. Property values and opportunities for urban development close to the sea, business, ecology, groundwater, saltwater intrusion, recreation and so on. (10)



Source:
https://www.klimatanpassning.se/en/climate-change-in-sweden/climate-effects/water-level-1.98613

Floods

Submerging dry land by water overflow is considered as flood which is the most frequent type of natural disaster so that it, along with drought and sever storm, account 80 – 90 % of disaster in last decade. The intensity and frequency of floods are increasing. (12)

“Causes of flooding can be, for example:

• Heavy rain for a short period

• A lot of rain for a long period

• Large snowmelt

• Strong wind that pushes up sea water towards the coast” (13)

Source:
https://www.businessinsider.co.za/flooding-uppsala-sweden-train-station-floating-photos-2018-7

Different type of flood

Floods at lakes and streams

Increasing the watercourses flows by consistent rainfall or snow melts can cause flooding around lake and stream. Strong winds or impeding the water flow by something exacerbate the flood. While in the southern Sweden floods can occur at lake and watercourses any time during the year, in the northern part, spring flood mostly is the main cause of this type of overflows. (13)

Source:
https://www.krisinformation.se/faktasidor-till-apparna/forbered-dig-for-oversvamning

Floods caused by heavy rain

Rapid and excessive rainfall can result in urban area flooding. Impermeable ground material can make the water bodies, forced the sewerage system to exceed capacity, flooded basement and roads. This type of flood usually occurs for short period of a few hours up to a few days. In Sweden this type of flood commonly happens during summer, and it can arise everywhere in the country. (13)

Source:
https://baravanligtvatten.com/2015/02/10/floods-in-malmo-sweden/

Floods caused by high sea levels

Strong onshore winds raise water towards the coast that mostly results in coastal floods. Also in this condition, low air pressure increase the water level elevation. Regarding large local variations the water level can rise further in a narrow bay. This type of flood mainly occurs in winter for short hours. (13)

Since the global warming leads to sea level rise which raise the baseline level of water, the temporary high tide events will be more common, and they will reach further up on land in the same area in future. (13)

Combinations

Coincidence of high sea level rise and a watercourse high flow in an area make water flow more difficult towards the sea resulted in worse flood especially in the estuary and upstream in water-course. (13)

Source:
https://baravanligtvatten.com/2015/02/10/floods-in-malmo-sweden/

Floods in Malmö

Skåne and Malmö geographical features

The southernmost part of Sweden is Skåne, surrounded by the sea on three sides, involves different types of climates such as boreal to more temperate and locally maritime climate in the west coast. The dominant wind mostly comes from west and southwest to the area. (14)

The Skåne mainly is flat with less than 100 meters height above sea level (m.a.s.l.) Including Malmö with the highest elevation of 37 m.a.s.l. The city has approximately 340,000 population and its area is 7,700 ha which around half of that is impermeable. (14)

To calculate the risk of flooding along the coast of Sweden, the land uplift must be taken into account. Sweden has a land uplift from close to 0 in Skåne to about 1 centimeter per year in Västerbotten. In northern Sweden, the land uplift thus takes out approximately the estimated sea level rise until the end of the century, but in Skåne the sea rises about as much as the global average. (15) (Student Translation)

Floods along the seacoast today often occur with a combination of high waves and wind gusts. SMHI has performed calculations of such an event for Malmö, which is called “estimated maximum sea level”, at the end of the century. (15)

Areas around central Malmö that are at risk of flooding are indicated in the figure below. Here it can be seen that large parts of Malmö’s port area are in risk of being under water, as well as important infrastructure such as the station area and several major roads. The seawater also finds its way up the Sege river. (15)

Note that this is an extreme case that combines continued accelerating discharges with the worst possible weather situation. (15)

Estimated highest sea level at the end of the century; sea level rise according to RCP8.5 as well as high waves and stagnation (2.91 m in RH2000). (15)

Precipitation amounts have already begun to increase. By the middle of the century, a 100-year rainfall contains 17% and 26% more precipitation, respectively, depending on the RCP scenario. By the end of the century, a 100-year event could contain 50% more precipitation if emissions continue to accelerate (RCP8.5). A rain that today has a return time of 100 years will thus become more common in the future; the same amount of precipitation will have a shorter return time at the end of the century. (15)

	RCP4.5	RCP8.5
2011-2040	+12 %	+17 %
2041-2070	+17 %	+26 %
2071-2100	+20 %	+52 %

Change in precipitation amount for an event of 1 hour with the return period 100 years relative to the period 1971-2000. Applies to southwest Sweden. (15)

Increasing rainfall means an increased risk of flooding, especially in densely populated areas with paved surfaces. The City of Malmö has carried out a rainfall mapping where areas that risk accumulating water during a rainfall, so-called low points, have been identified. Areas are also being rebuilt to prevent floods. (15)

While torrential rains can affect all cities, coastal cities are by definition particularly vulnerable to rising sea levels. Areas that are not flooded today risk doing so in the future at temporarily high sea levels. Parts of the city that are rarely flooded will be flooded more often. (15)

As for Malmö’s residential areas, such as the central parts of the city, Limhamn harbor and Västra hamnen, they are low and are particularly vulnerable to rising sea levels. Rail traffic on the Södra stambanan and Öresundsbanan, which connect Denmark and Sweden, risks being interrupted by floods. Larger port and operating areas in Malmö, such as Norra hamnen, Industrihamnen and Frihamnen, risk being submerged at permanently or temporarily higher sea levels. When industrial areas and landfills are flooded, there is a risk that pollutants will spread over large areas. (15)

Source: https://www.dn.se/debatt/bara-tre-procent-av-kommunerna-har-tillrackligt-skydd-mot-oversvamningar/

Rainfall and flood history

I collected infomation of the date and location of historical floods based on SMHI reports which is shown in the following table: (16)

Sweden Floods History					
Date	Location	Date	Location	Date	Location
2021	Eastern Götaland and Svealand	2002	Orust	1951	Southwest Sweden and Götaland
	Gävle		Southern Götaland		
2020	Southern Sweden	2001	Eastern Svealan and Southern Norrland	1938	Vindelälven
			Sundsvall		
2018	Northern Sweden	2000	Vänern	1924	In many parts of the country
			Glafsfjorden		
			Värmland and Dalarna		
			Southern Norrland		
2017	Söderhamn and Karlskoga	1999	Vättern	1922	Luleälven and Piteälven
2016	Svealand	1997	Sysslebäck	1919	Southern and central Norrland
			Fulufjället		
			Pitetrakten		
2015	Hallsberg	1996	Östergötland and Northeastern Småland	1916	Dalälven (Worst flood of the 20th century)
2014	Bohuslän	1995	Northern Sweden	1905	Arpujärvi in Kiruna
	Malmö		Southern Sweden		
	Klarälven				
2013	Norrland	1993	Norrland rivers	1904	Mälaren
	Uppland				
2012	Silverån	1989	Lule River	1900	Fyrisån
2011	Västra Götaland	1986	Dalarna and Hälsingland	1879	Ljusnan
2010	Götaland and Southern Svealand	1985	Dalarna and Hälsingland	1861	Vuontisjärvi
	Norrland and Northern Svealand		Småland coast		
2008	Northern Norrland	1984	Torne River	1860	Dalälven (Worst flood of the 19th century)
2007	Götaland	1980	Northern Skåne	1796	Ragundasjön in Indalsälven
	Outside of Northeastern Norrland				
	Southwest Sweden				
2006	Western Götaland	1977	Bergslagen	1677	Torneälven
	Ånn				
	Northern Sweden				
	Southern Sweden				
2005	Mountains	1973	Sysslebäck	1649	Östergötland
	Torneälven				
	Western Götaland				
2004	North and South	1968	Torneälven	1617	Övertorneå
	Kebnekaise to the Gulf of Bothnia				
	Värmland				
2003	Småland	1966	Southern Sweden and Dalälven river	1596	Örslösa in Kållandsö

Between 2007 and 2014, Malmö was hit by three torrential rains that caused serious consequences for buildings and infrastructure as well as major traffic disruptions.

2007-07-05: 100 mm rain in 24 hours over eastern Malmö

2010-08-14: 60 mm rain in 6 hours over western and central Malmö

2014-08-31: 120 mm rain in 6 hours over central Malmö. The rain event is the single largest rainfall event in Malmö since the measurements started at the end of the 19th century. (17)

Flood 2014

One of the examples of flood cause by heavy rain is that happened on 31 August in Malmö. (13)

The rainfall caused a flood which is considered as the worst urban flooding in Sweden. The flood also damaged the areas around the Malmö and even Copenhagen. The maximum rainfall was recorded in 10 Km south of Malmö with more than 150 mm. (14)

While all parts of city were affected by the cloudburst, the highest amount of rain was in central Malmö and the lowest was in eastern and western parts. The rainfall caused basement flooding, cutting of roads in the whole city and in central parts they were along with combined sewer systems. The flood caused damages around 60 MEUR. (14)

Base on SMHI's precipitation station 100 mm fell for 24 hours was measured while some municipality stations measured more amount of rainfall. Other consequences of the flood were power outage of households, traffic stuck and cancelation of trains trips. (18)

The City of Malmö has calculated the return time for the event in 2014 to be over 360 years based on local meters. So, it was a very unusual event. (15)

Source:
https://www.lucsus.lu.se/article/swedish-citizens-need-more-support-handle-effects-climate-change

03
SEA LEVEL RISE & FLOOD PROTECTION

Flood Protection By Malmö Municipality

The consequences of torrential rain will never be fully prevented by increased capacity in the pipeline networks. It would in most cases be practically impossible and unreasonably expensive. The key to a rain-resistant city is instead to create areas where a flood can occur without serious consequences and that everyone takes their responsibility. In Malmö, the municipality, together with the VA organization VASYD, has produced a rainfall plan. The downpour plan is a long-term and concrete action plan for how the municipality should prepare for downpours. The biggest challenge is to secure existing buildings and infrastructure as the elevation is already given. There are greater opportunities for new buildings. (15)

With the help of physical barriers, the water can be prevented from reaching vulnerable areas. Some roads can be set aside as runoff roads without conflicts with important transports. Another approach is to let the water take place by directing it to areas where it can stand for a while without doing damage, such as green areas, football pitches and playgrounds. With good planning, it is possible to achieve synergy effects such as increased ecosystem services and new recreational areas. (15)

Rising sea levels can be managed in several ways, including by embankments along the coast and by permanently raising the ground along the coast. Port entrances can be protected with gates that can be closed at high tide and thus protect internal parts of the port. (15)

Rainfall solutions differ depending on where in the system they are installed and what their purpose is. To handle rainfall in Malmö, a combination of several different solutions is needed, both large-scale facilities and smaller local solutions. They can to some extent be carried out on public land, on streets, squares and in parks. It is important that property owners also take measures on their plot for Malmö to reach the goal of being able to handle a 100-year rain. The measures include local disposal on plots of land, local flow paths and delay areas near the source, flood surfaces and rainfall roads as well as pipe network solutions. (17)

• Local disposal is measures on neighbourhood land to delay water before it ends up in the public pipe network. This includes small-scale solutions on residential plots or slightly larger solutions on large properties for businesses or multi-family houses.

• Local flow paths and delay surfaces are medium-sized measures on public site land that locally relieve the pipeline network. This includes solutions such as delaying / handling water along streets, on green areas / neighbourhood parks, parking lots, etc.

• Flood surfaces and rainfall roads are large-scale solutions dimensioned to be able to collect and handle large volumes of water.

•Pipeline network solutions include both targeted rainfall measures and planned measures under the auspices of VA SYD. (17)

"Danish rainforest" Tåsinge Plads in Copenhagen has been rebuilt to be able to store larger amounts of rainfall as part of Copenhagen's cloudburst plan. (17)

The picture shows the proposed rainfall road at Dalgas Boulevard, in Copenhagen during normal conditions and during rainfall. (17)

Responses to Sea Level Rise

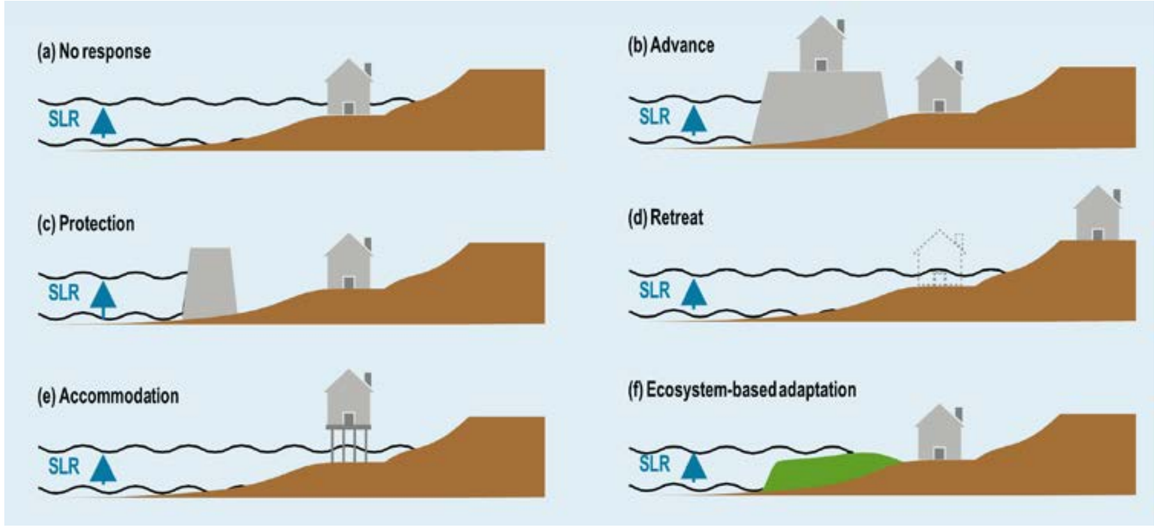
"**Protection** reduces coastal risk and impacts by blocking the inland propagation and other effects of mean or extreme sea levels (ESL). This includes: i) hard protection such as dikes, seawalls, breakwaters, barriers and barrages to protect against flooding, erosion and salt water intrusion, ii) sediment-based protection such as beach and shore nourishment, dunes (also referred to as soft structures), and iii) ecosystem-based adaptation (EbA). The three subcategories are often applied in combination as so-called hybrid measures. Examples are a marsh green-belt in front of a sea wall, or a sea wall especially designed to include niches for habitat formation.

Accommodation includes diverse biophysical and institutional responses that mitigate coastal risk and impacts by reducing the vulnerability of coastal residents, human activities, ecosystems and the built environment, thus enabling the habitability of coastal zones despite increasing levels of hazard occurrence. Accommodation measures for erosion and flooding include building codes, raising house elevation (e.g., on stilts), lifting valuables to higher floors and floating houses and gardens. Accommodation measures for salinity intrusion include changes in land use (e.g., rice to brackish/salt shrimp aquaculture) or changes to salt tolerant crop varieties. Institutional accommodation responses include EWS, emergency planning, insurance schemes and setback zones.

Advance creates new land by building seaward, reducing coastal risks for the hinterland and the newly elevated land. This includes land reclamation above sea levels by land filling with pumped sand or other fill material, planting vegetation with the specific intention to support natural accretion of land and surrounding low areas with dikes, termed polderisation, which also requires drainage and often pumping systems.

Retreat reduces coastal risk by moving exposed people, assets and human activities out of the coastal hazard zone. This includes the following three forms: i) Migration, which is the voluntary permanent or semi-permanent movement by a person at least for one year. ii) Displacement, which refers to the involuntary and unforeseen movement of people due to environment-related impacts or political or military unrest. iii) Relocation, also termed resettlement, managed retreat or managed realignment, which is typically initiated, supervised and implemented by governments from national to local levels and usually involves small sites and/or communities. Managed realignment may also be conducted for the purpose of creating new habitat. These three sub-categories are not neatly separable– any household's decision to retreat may be 'voluntary' in theory, but in practice, may result from very limited choices. Displacement certainly occurs in response to extreme events but some of those retreating may have other options. The need for retreat and other response measures can be reduced by avoiding new development commitments in areas prone to severe SLR hazards.

Ecosystem-based adaptation (EbA) responses provide a combination of protect and advance benefits based on the sustainable management, conservation and restoration of ecosystems. Examples include the conservation or restoration of coastal ecosystems such as wetlands and reefs. EbA measures protect the coastline by (i) attenuating waves, and, in the case of wetlands storm surge flows, by acting as obstacles and providing retention space; and (ii) by raising elevation and reducing rates of erosion through trapping and stabilising coastal sediments, as well as building-up of organic matter and detritus. EbA is also referred to by various other names, including Natural and Nature-based Features, Nature-based Solutions, Ecological Engineering, Ecosystem-based Disaster Risk Reduction or Green Infrastructure." (19)



(19)

04
LOCAL CONTEXT

Malmö

Malmö is situated in the southwestern part of Sweden. It is a port city and capital of Skåne (Scania) County and the third largest city of the country (after Stockholm and Göteborg) according to population number. (20)

On 31 December 2021 there were 351,749 residents in Malmö, and it rose by 3,800 in the same year which showed the rate of 1.1% and made Malmö as the fastest growing large city in Sweden. Also, it is predicted that the annual increase will be 4,000 yearly in this city. (21)

Malmö has good connections in national and international scale with Copenhagen, Hamburg, Oslo, and Gothenburg as a part of string megaregion (Southwestern Baltic Sea Transnational area Implementing New Geography). (22)

Malmö Climate

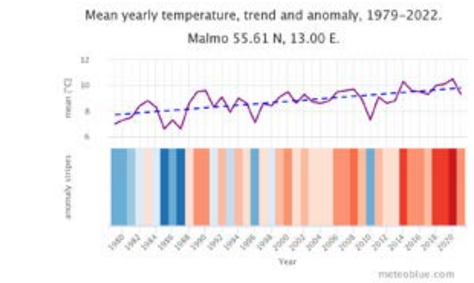
Malmö has an oceanic climate with the average maximum temperature of 21°C during July and August and average minimum temperature of -2°C in February. There is high precipitation even during April as the driest month of city.

Due to its northern latitude the length of day has a wide variation. The shortest day is around seven hours in last days of December and the longest happens in mid of June with 17 hours 31 minutes.

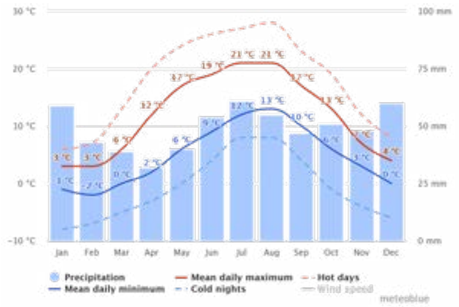
It is mainly overcast and partly cloudy and the sunniest days is experience during May. Also, the highest precipitation is during December and January that is more than 15 days per month.

The dominant wind blows from west and south-west and the highest speed is more than 61 km/h during winter.

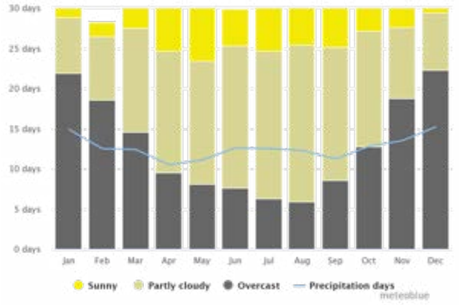
As a result of the climate change the mainly temperature of Malmö has gradually risen from 7°C mean yearly temperature in 1979 to 9.3°C in 2021. (23)



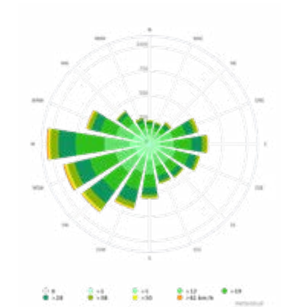
Average temperatures and precipitation (23)



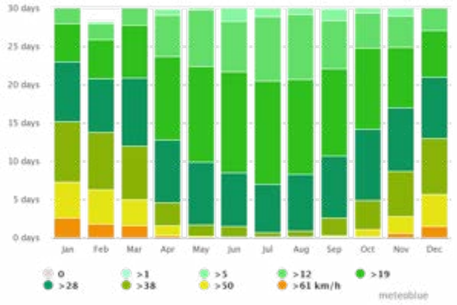
Cloudy, sunny, and precipitation days (23)



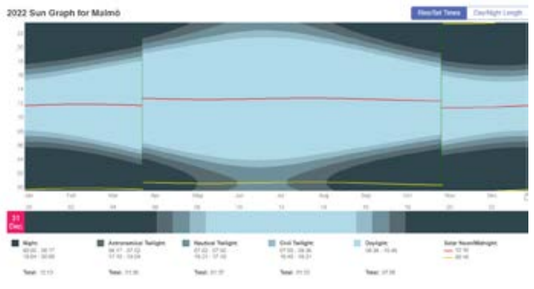
Wind rose (23)



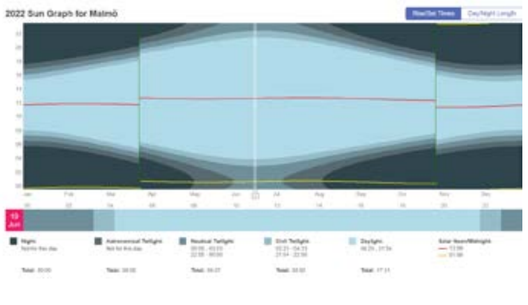
Wind speed (23)



Shortest daylight for Malmö (24)



Longest daylight for Malmö (24)



Malmö History

The Sweden made the Skåne region and Malmö part of its soil in 17th century. While Malmö population was about 2,300 in the beginning of 18th century, wars and plague epidemics reduced the population to 1,500. In 1775, appearance of the modern harbour led to an expansion and a growth of inhabitant's number. (20)

The city developed during the Middle Ages through the rich fishing in Öresund. During the industrial era, Kockum's shipyard was a driving force in Malmö's development and port operations were significant. (10)

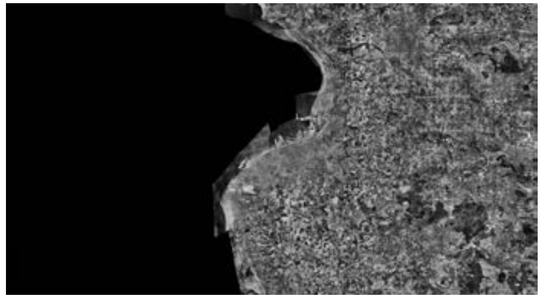
In 1840 the shipyard was stablished and became one of the most popular in the world. Appearance of the Southern Main Line railroad made the world market more accessible and resulted in the expansion of industries and manufacturing. (25)

Through the early of 20th century Malmö grew and the population reached to 200,000 by 1952. The recession in the mid-1970s caused the high unemployment in Skåne area and the second financial crise during 1990s worsened the unstable economic condition. (20)

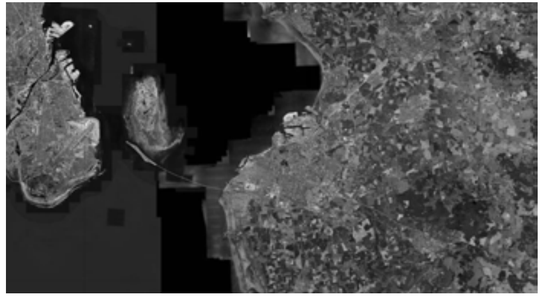
Today Malmö is the most cosmopolitan city of Sweden and based on the population it is the third large city of the country which about 1/3 of its population are internationals. (26)

Malmö's history is characterized by its proximity to the sea. Gradually, several of the industries that had the sea as a base, such as fishing and shipping in the form of passenger traffic, decreased. Port operations gradually moved to the northeast. Previous port environments have thus been able to provide space for new mixed urban development. (10)

In recent decades, with a focus on sustainable urban development in a coastal location, Västra Hamnen has functioned as an engine for Malmö's transformation from an industrial city in decline to a young modern and forward-looking metropolis. (10)



Malmö Map 1955 - 1967



Malmö Map 2018 - 2020

Source:
https://kartor.eniro.se/?c=55.590375,13.0036938&z=11&l=historic&fs=true

Malmö Historical Expansion

Malmö Map-1850 (27)

Malmö Map-2002 (27)

Malmö Map-1947 (27)

Malmö Map-2013 (28)

Nyhamnen

Nymhamnen is an old industrial area located in north centre of Malmö which is connected to central station from the south and Västra Hamnen from the west.

Nyhamnen will be developed from an old industrial and port area. On the old padding of Öresund from the late 19th century, the city makes room for the homes of the future, workplaces and inclusive, public environments with blue and green values. When fully developed, Nyhamnen is estimated to accommodate up to 9,000 homes and 21,000 new and old workplaces. (29)

Most industrial activities in Nyhamnen were related to shipping and trad. By filling and quays extensions the area has been expanded further into the water since then the merchant Frans Suell started port construction in 1775. (29)

Nyhamnen is a relatively old name, which is included on maps from the early 20th century. The Nyhamn basin was created when Nyhamnspiren and Hullkajen were expanded in 1903. From the beginning, it stretched all the way down to Jörgen Kocksgatan. In the early 1990s, the innermost part of the harbor basin was refilled and became a parking lot for cars to be transported to Germany. (29)

The railway between Malmö and Lund was the first railway section in Malmö which was inaugurated in 1856 and the entire southern main line was completed by 1864. During 19th and 20th, the railway operations were linked to the port operations and some of these tracks even are preserved in Nyhamnen today. (29)

Most part of city's food handling was located in Nyhamnen due to accessibility entailed by railway and the industrialization at the latter part of 19th century. (29)

Source:
https://www.google.com/imgres?imgurl=https%3A%2F%2Fmalmo.se

Source:
https://www.thelocal.se/20190116/twenty-images-that-show-malmo-through-the-ages/

To facilitate the meat trade from the port the city's public slaughterhouse was inaugurated in Nyhamnen In 1904. A control station for eggs and dairy products, so-called Smörkontrollen, was stablished on the Ångbåtsbron During the 1930s. Both aforementioned buildings have been preserved and gained new character today. (29)

Nyhamnen has been main part of ferry traffic. A steam ferry terminal was constructed at the end of 19th century in Nyhamnen and a train ferry station for ferries commute to Copenhagen was built by SJ which was replaced by a ferry service to Travemünde in Germany in 1986. Today the ferry traffic has moved to Norra Hamnen and cruise ships are docking along the north side of Grimsbygatan. (29)

In 1965, the Flygbåtarna operation was started on the strait and accelerated traveling between Malmö and Copenhagen. The boats commuted to and from Skeppsbron in Malmö. Flygbåtarna had more than one million passengers annually during last years of the 1980s. (29)

Between 1984 and 1994, the noisy but fast hovercraft started flying in the Malmö – Kastrup route operated by the SAS airline. And the last aircraft fly across the Öresund in the autumn of 2000 due to inauguration of Öresund Bridge. (29)

Both hat and cold bath building have been in Nyhamnen which divided to separate departments for both genders. Malmö Badhusaktiebolag stablished the first cold bath building of the area in 1867 that located on pillars a bit out in the water next to the Hans Michelsensgatan today location. (29)

To initiate the Nyhamnen construction at the early of 20th century the cold bath building was needed to be relocated. The new bath building was stablished on an artificial island outside the harbor entrance in 1897. Consistent with the new bath building a new Beach Pavilion with a restaurant was also built. The bath house was used until the start of war in 1939 and in 1946 the building was demolished after a severe winter storm. (29)

Merchant Frans Suell

Source:
https://sv.wikipedia.org/wiki/Frans_Suell

Slaughterhus

Source:
https://bildarkivet.malmo.se/asset-bank/action/browseItems?categoryId=12491&categoryTypeId=2&cachedCriteria=1

Malmö-Lund Railway

Source:
https://blogs.lse.ac.uk/businessreview/2019/05/14/how-railways-aided-early-democratic-social-movements/

Smörkontrollen

Source:
https://historiskbildbyra.imagedesk.se/viewpic.htm?ID=1500634

Site Boundry

Site Pictures





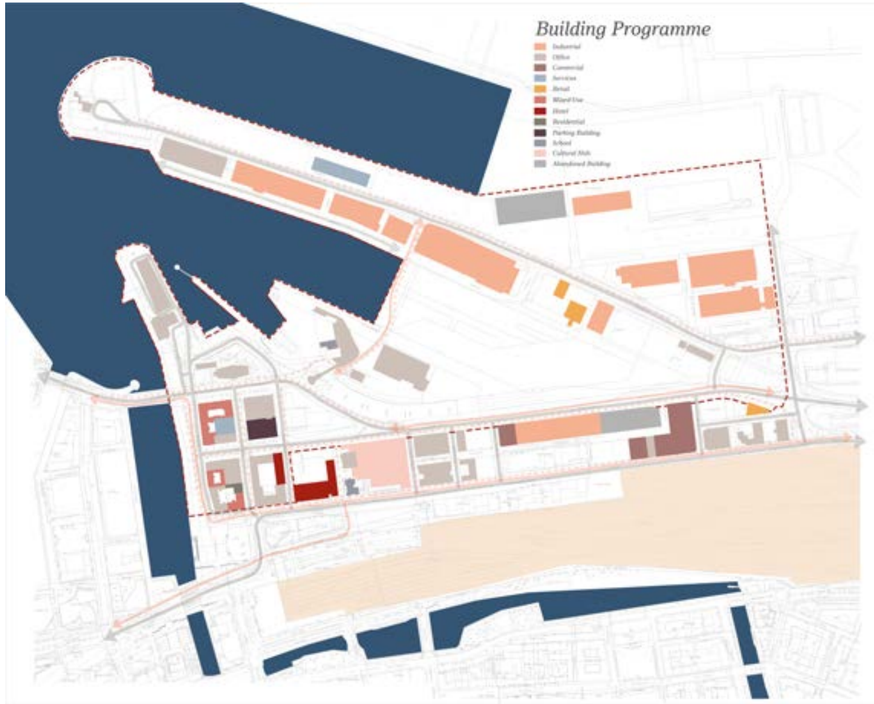




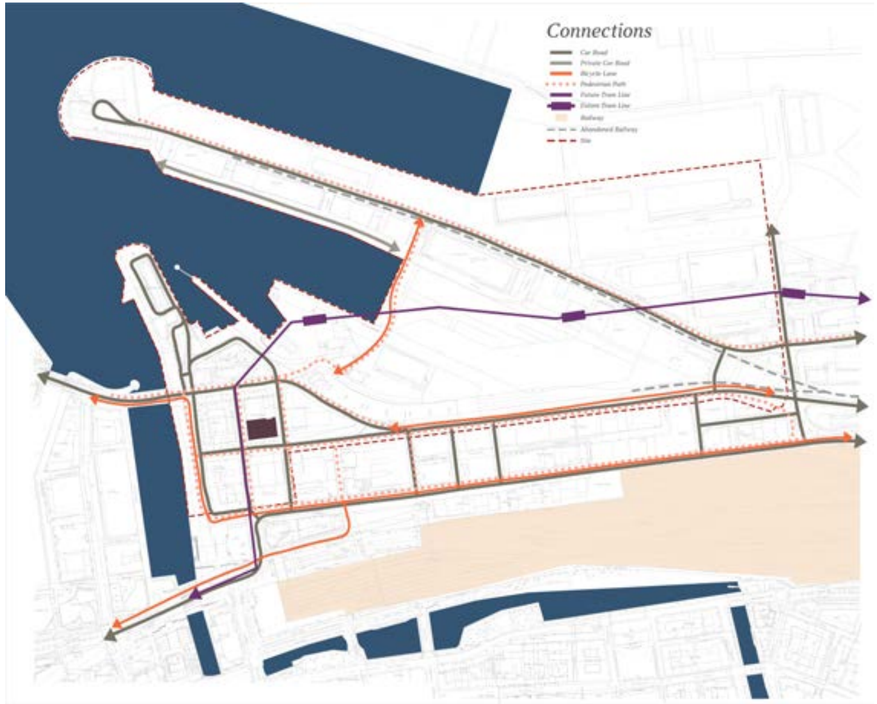


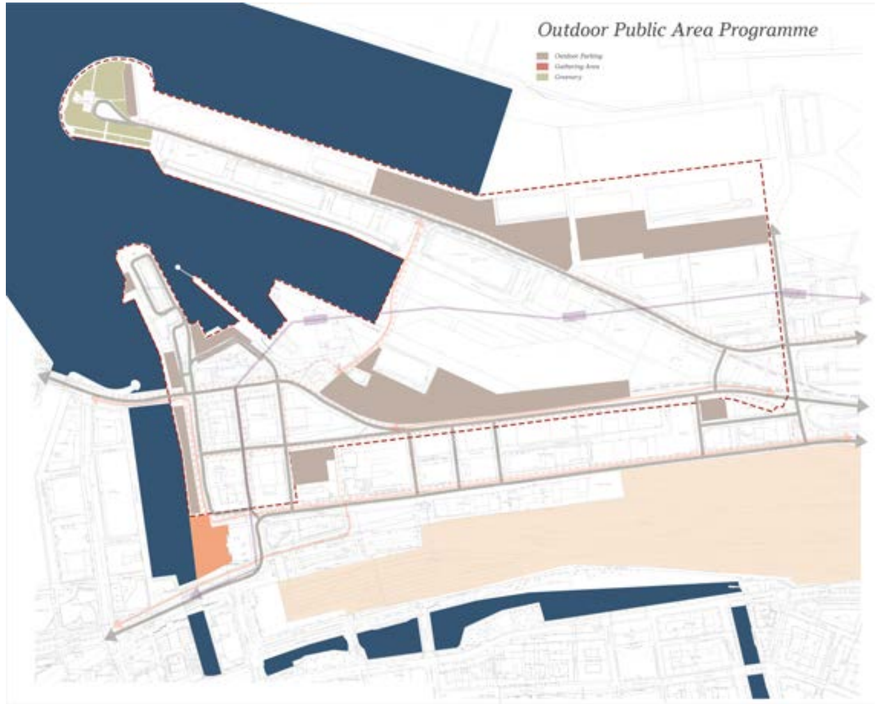

SWOT Analysis of Current Situation of the site

Current Situation			
S	*W*	*O*	*T*
The proximity to Water	*Car dominance*	*High accessibility in regionally, nationally, and internationally scales*	*Sea level rise and flooding*
Good Connection regarding Central Station & Roads	*Västkustvägen bridge act as barrier in east part*	*Stronger international connection in future regarding Fehmarn Belt and Öresund metro station*	*Impermeable ground material*
Historical buildings	*Lack of residential area*	*Large empty areas for new development*	*Lack of night life*
New character of Slagthuset as a Cultural hub	*Lack of hierarchy*	*Increasing commercial activities*	*Feeling low security especially during evening*
	Lack of public places		*Scarcity of pedestrian and bicycle lanes*
	Deficit of community services		*Large parking spaces*
	Large abandoned areas		*Mono functional district as ferry terminal and port operations*
	Lack of Greenery		


Building Programme


Historical Building


Connections
Car Road
Private Car Road
Bicycle Lane
Pedestrian Path
Future Tram Line
Future Tram Line
Railway
Abandoned Railway
Site


Outdoor Public Area Programme
Outdoor Parking
Gathering Area
Greenery

05
DESIGN PROPOSAL

Vision

The main challenge of the project is protecting the Nyhamnen area from sea-level rise and flood and transforming this threat into an opportunity that creates dynamic urban spaces. Also, creating a safe and flexible district is considered to raise social efficiency. In fact, the future vision of the area is:

Combination of climate protection and social sustainability in a resilient area

Master Plan

Proposed Building

Existing Building

Municipality Proposed Block

Municipality Proposed Bridge

Site Strategies

Protecting sea level rise prone shoreline

Providing water collectors in inner parts

Implementation of active Squares

Making green connection with surroundings

Using abandoned old railway

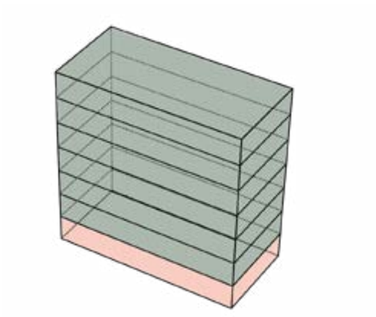
Building Typology

In terms of building typology, there are two types of buildings:

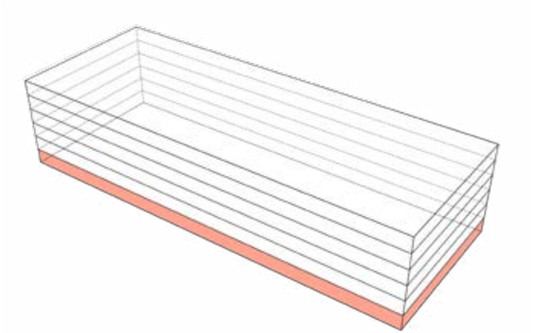
- Mixed-use Buildings consist of commercial and offices on the ground and first floors and residential on the upper floors.

- Residential Buildings consist of common areas on the ground floor and home apartments on the upper floors.

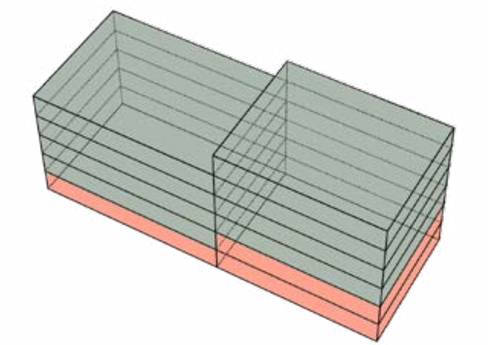
- Parking Buildings consist of commercials on the ground floor and parking areas on the upper floors.



Residential Building (common area on the ground floor)



Parking Building (commercial on the ground floor)



Mixed-Use Building (commercial and offices on the ground and first floors)

Block Typology

The combination of Mixed-use and Residential buildings makes two types of blocks:

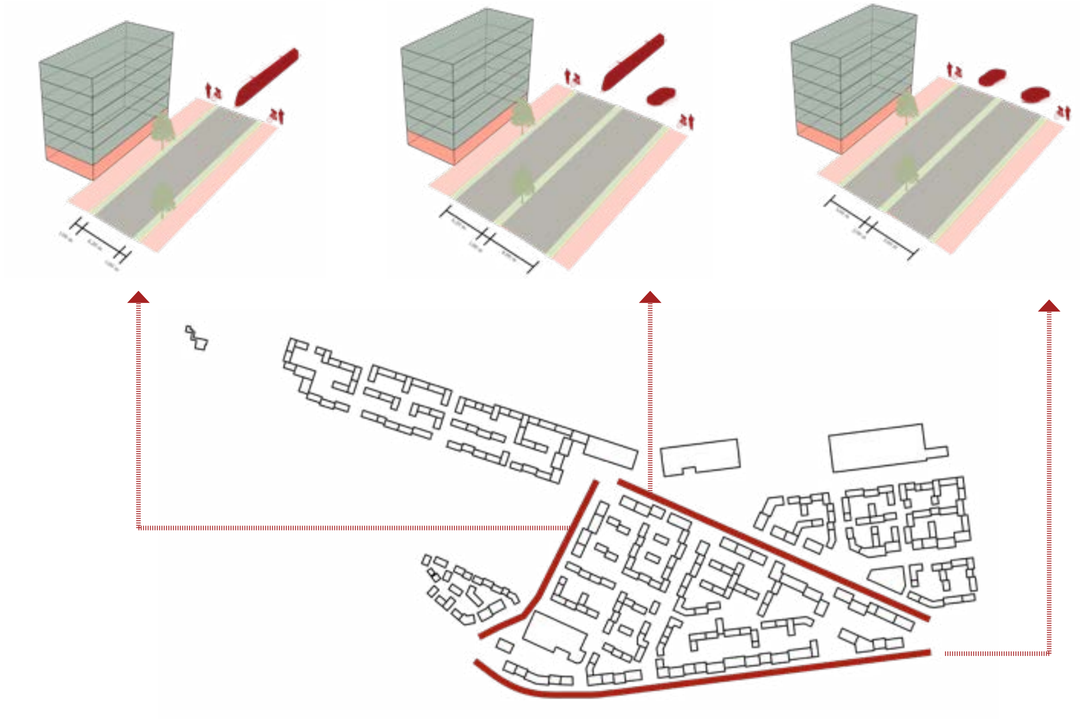
- The block with mixed-use buildings on the street edge and residential buildings in the inner part.

- the block consists of residential buildings.

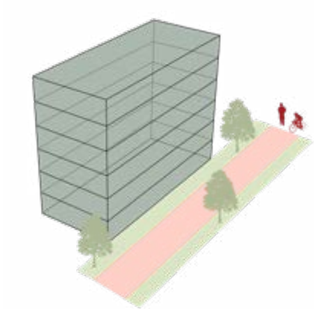
Residential Buildings Block

Residential & Mixed-use Buildings Block

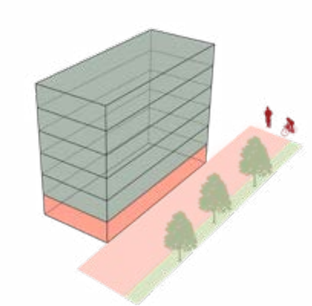
Street Type



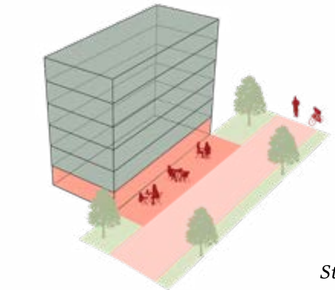
Street Edges

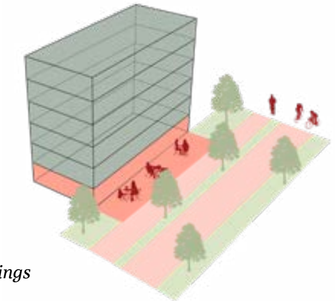


Street Edge along Residential Buildings



Street Edge along Mixed-use Buildings





Street Edge along Mixed-use Buildings with Sitting area

Zoom In Plan


Mixed-use Building
Mixed-use Building
Mixed-use Building
Mixed-use Building
Mixed-use Building
Mixed-use Building
Parking Building
Mixed-use Building
Mixed-use Building
Mixed-use Building
Mixed-use Building
Mixed-use Building
Mixed-use Building
Mixed-use Building
Mixed-use Building
Mixed-use Building

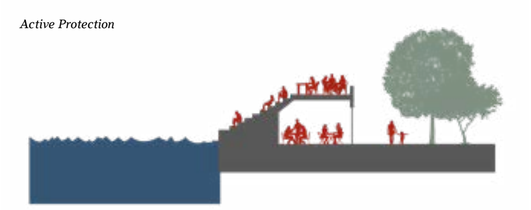
Sea Level Rise and Flood Protection Strategies

Edge Protection

Active Protection

This strategy is implemented along streets through shorelines to optimize the spaces and make a lively urban environment.

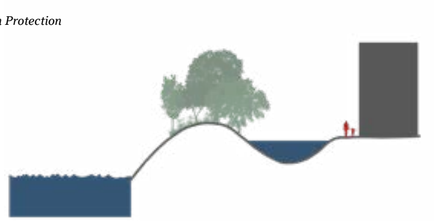
Active Protection



Green Protection

This protection strategy enhances biodiversity along the shoreline by increasing greenery and wetlands and providing calmer places in areas that are needed.

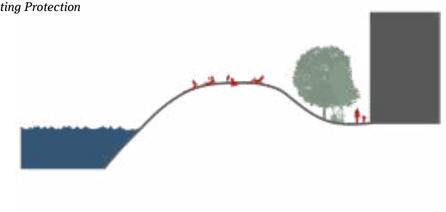
Green Protection



Resting Protection

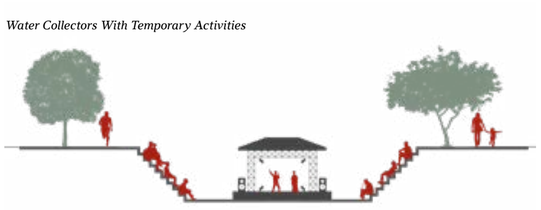
This strategy besides the protection will provide places for recreational activities and make public spaces where people can gather together and enjoy the proximity of water.

Resting Protection

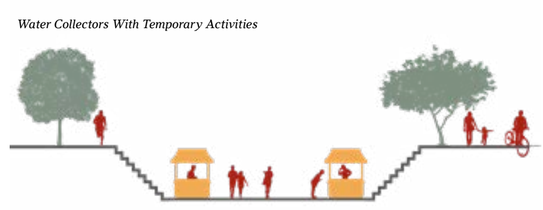


Inner Protection

Water Collectors With Temporary Activities



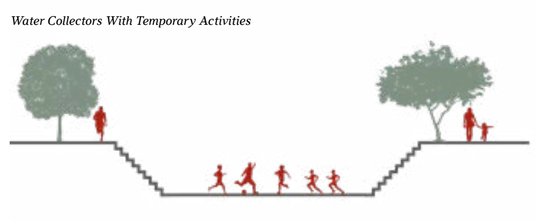
Water Collectors With Temporary Activities



Water Collectors With Temporary Activities

These water collectors are located on crowded public areas to provide spaces for temporary activities during dry days as well as collecting water during rainy days.

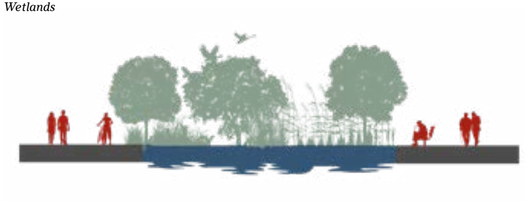
Water Collectors With Temporary Activities



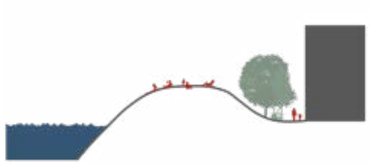
Wetlands

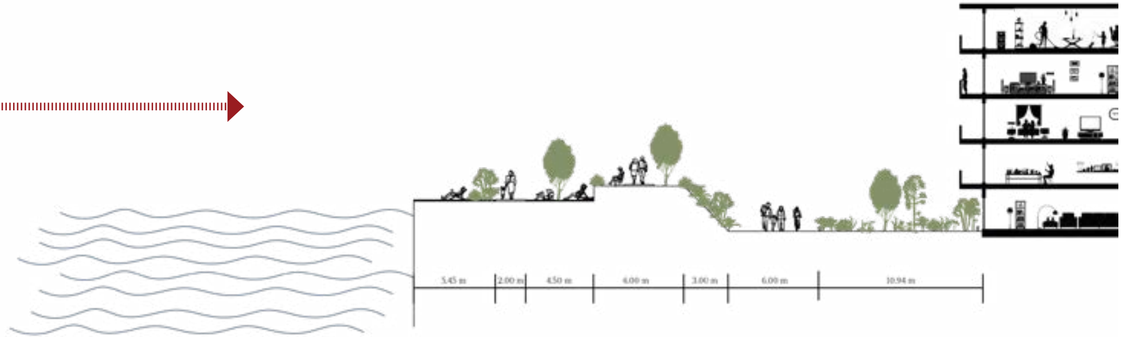
Wetlands will help to enhance biodiversity in inner parts of the site and they contribute to better water management in case of precipitations.

Wetlands



Resting Protection



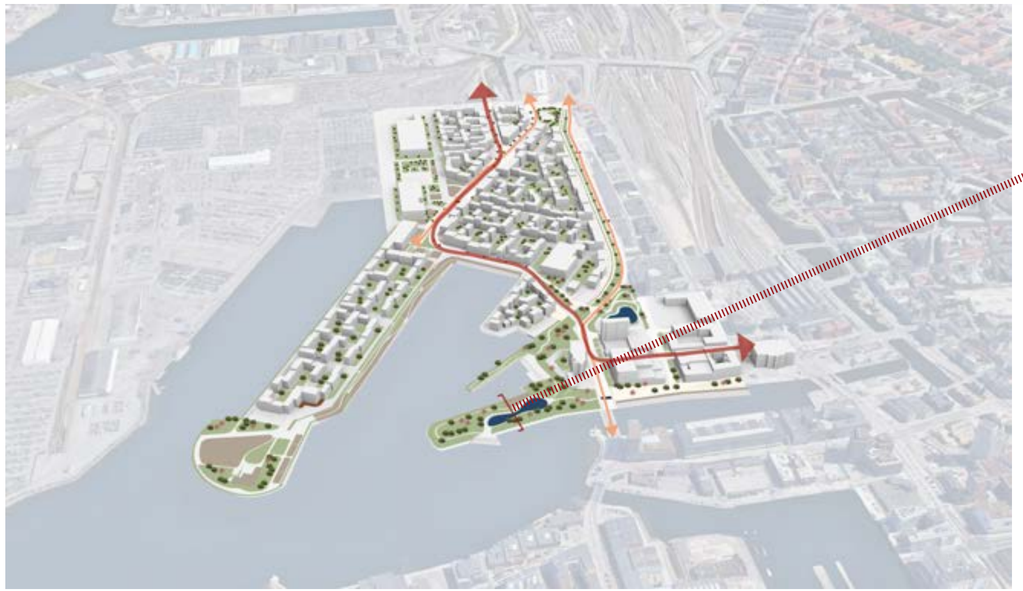


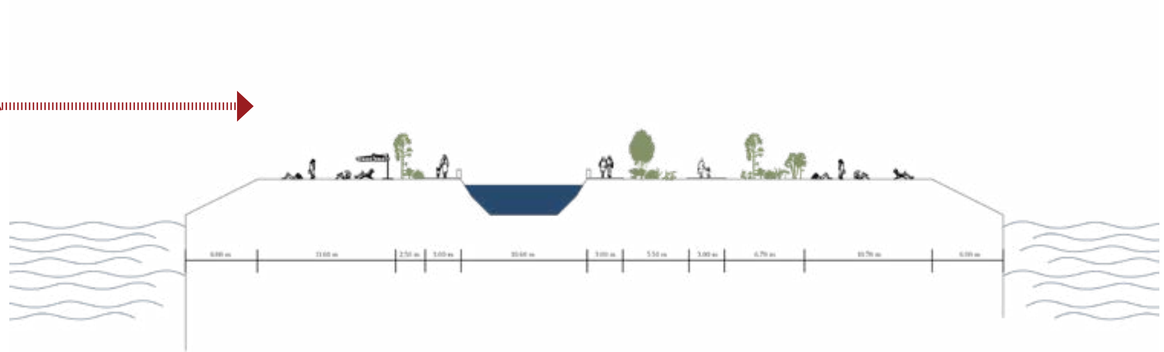
Long-stepped terraces and high paths protect the residential area in the north and northwest from rising sea levels. It also bridges the inner part to the lush coastline in the northwest.

These terraces provide spaces for various activities such as gathering, swimming, and sunbathing. In addition, there is a pedestrian path and seating areas with benches on the highest level with a great view of the sea.

Moreover, this high guard can protect the pedestrian and bicycle paths on the ground level against the wind, especially in winter.

Green Protection



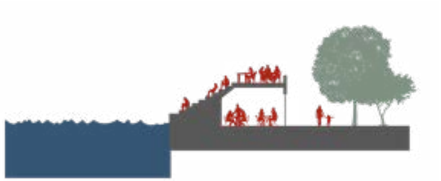


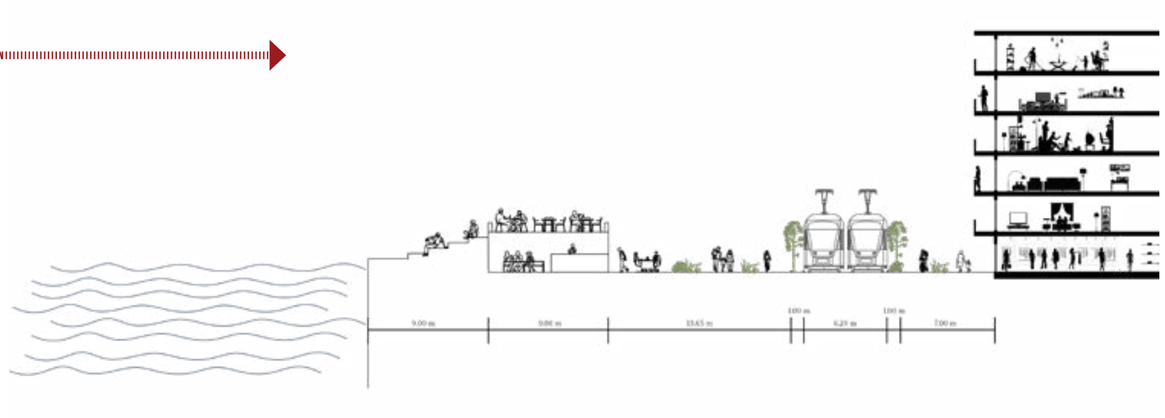
Thanks to the large green elevated zone in the west that protects the area from sea-level rise and enhances biodiversity. Also, a pond in the center will collect the rainfall during heavy rains.

This green protection has a view of the sea and the whole area. It makes a strong interaction with the water. There are stairs south of this part to access the water directly.

Also, it provides meeting places and a natural environment to attract people to the Nyhamnen.

Active Protection

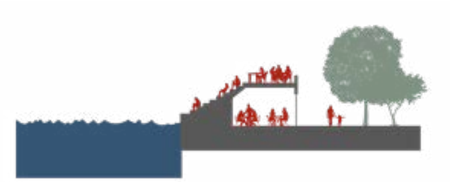


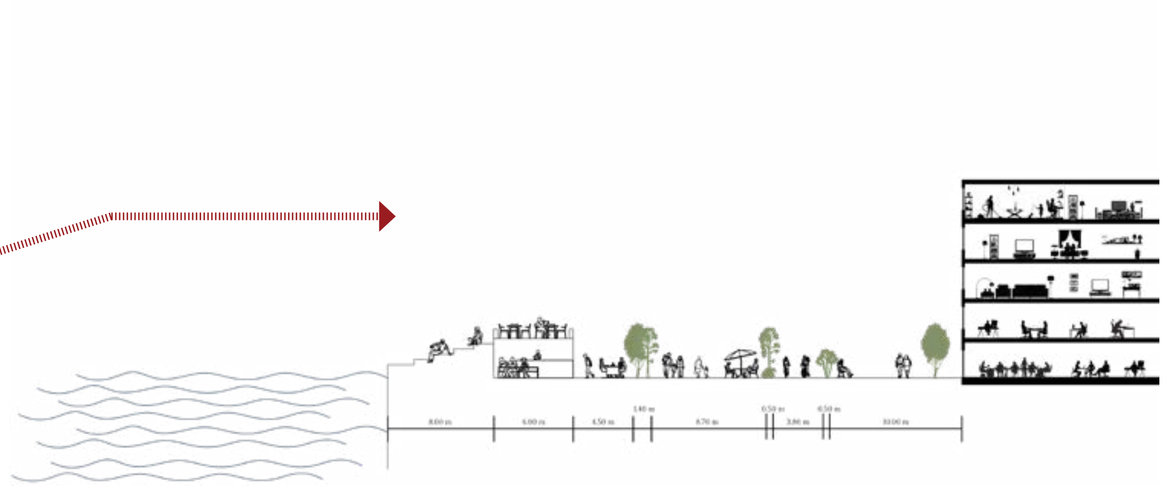


Along the active protection, the space underneath the stairs can be used for commercial activities, making a livelier environment throughout the street. The roofs of these places will also be the living quarters of cafes and restaurants to serve the people.

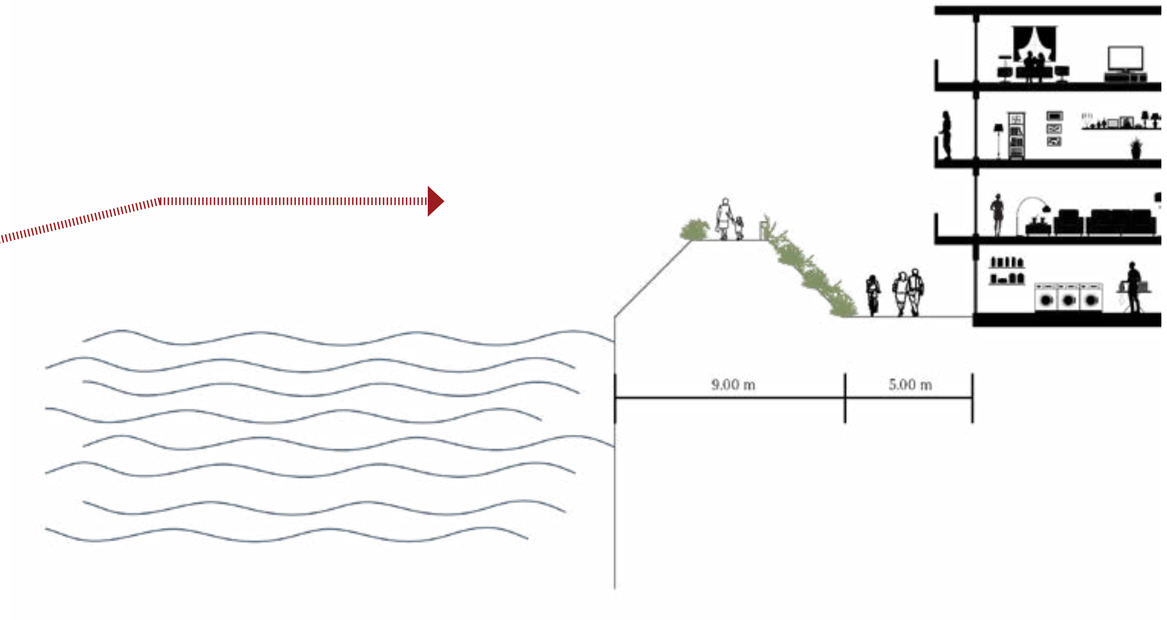
Since there are just a tramline, pedestrian, and bicycle lanes in the street, it provides an active edge and will be a safe promenade for visitors.

Active Protection

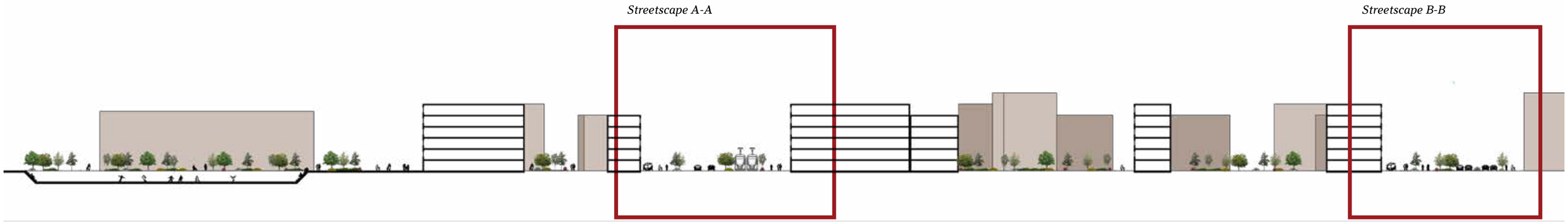




Protection & Green path Next to Residentials

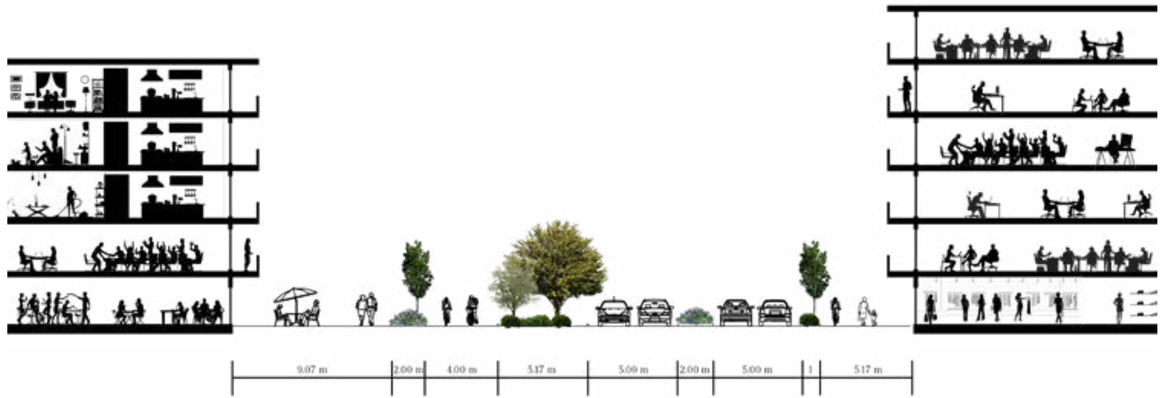


Section C-C



Streetscape A-A

Streetscape B-B



Master Plan Phase 1

In phase one, which lasts between 10 and 15 years, protection strategies against sea-level rise will implement. As these protection measures create green spaces, meeting places, and communications along the coastline, they draw people to the Nyhamnen area.

The Jörgen Kocksgatan street is also being refurbished with a wide green path and mixed-use buildings in this phase to provide a convenient east-west connection for pedestrians and cyclists.

Master Plan Phase 2

Phase two is estimated to last around 20 years. In this stage, the mixed-use buildings and residential blocks will add to the north and center parts to provide places for people to settle permanently in the Nyhamnen.

It is tried to make a strong connection between the municipality's proposed bridges and the north part of the area by the south-north pedestrian paths and squares between buildings.

Master Plan Phase 3

In the final phase, predicted to take 20 years, the north part of the site will accomplish. The historical buildings will be renovated and reused for social purposes. Also, a water collector with a large park will place between them.

The path along historical buildings makes another east-west connection for pedestrians.

Also, more residential buildings will be added in the north part to provide more places to live in Nyhamnen.

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ANNEX

Municipality Proposal

New sustainable district is emerging with a mix of housing and businesses, trade and services.

Accessibility to quays and the sea is a key element in Nyhamnen. New urban environments with housing are emerging directly by the water, through fills of the inner part of the Nyhamn Basin, new canals and two new islands at Nyhamnspiren and along the quayside towards the Dockan area in Västra Hamnen.

The islands are car-free above ground, but it must be possible to get to and from the islands by car through a tunnel. Pedestrian and bicycle bridges become a link between the islands and the rest of the city, other bridges over the railway yard at the central station connect Nyhamnen with the oldest parts of the city. (30)

Source:
https://malmo.se/Welcome-to-Malmo/Sustainable-Malmo/Sustainable-Urban-Development/Nyhamnen.html

SWOT Analysis of Municipality Proposal

S	W	O	T
Sea level rise protection by barriers and gates	New fillings and artificial island	More spaces for new buildings	more environmental issue by new islands construction
Terminal for cruise ships to enter Nyhamnen	disturbance from ships and port operations for homes	stormwater management	Water pollution due to cruise ships commuting
sight lines	Straight main streets	Visual connection	Wind corridor
More connection by adding north – south lane and strengthen of east – west streets	Lack of balance in distribution of different activities like commercial services concentration on western part	More connection with its vicinity and being more accessible	Flooding in case of heavy rain due to artificial topography on east part of area
A new public transport node		more intimate interaction between the sea and buildings	
New pedestrian and bicycle paths		strengthen the place's marine character	
green and blue loop		a wide range of culture and leisure activities	
Making room for boat-borne public transport		Reclaiming abandonet historical buildings	
public functions in the ground floors of the houses		various water-related functions will be provided by The Nyhamn basin	
Different types of transportation		Space for new business	
attractive promenade by transformation of Skeppsbron street		Social diversity	
Footbridge over the railway		Community services / Amenities	
different forms of home tenancy		Organized parking area	
Housing for elderly, disabled people, and social housing			
Different buildings and neighbourhoods' typology			
A parking garage along Carlsgatan and curbside parking			
Increasing permeable land			

New fillings

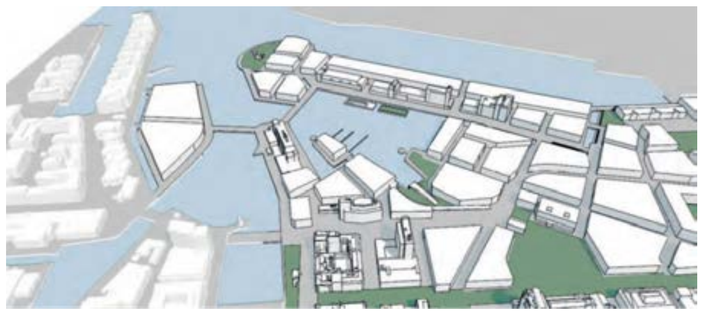
Based on overview plan for Nyhamnen, through fillings in the harbor basins, new built-around water spaces are created that give Malmö a new type of urban environment. It provides a smaller large-scale water space and more quay, which increases water contact and at the same time there is a more intimate interaction between the sea and buildings. Two new islands are being built for mixed urban development. This creates new channels that contribute to an attractive urban environment. (31)

Although new fills provide the opportunity to build around more intimate water spaces and two new islands will provide space for new buildings and greater proximity between Västra Hamnen and Nyhamnen, this long-term construction activities in the water cause more water pollution and more unnecessary advance to natural sea.

Cruise Ships Commuting

Opportunities for cruise ships to enter Nyhamnen is proposed to be developed. Terminal functions can be integrated into new buildings at Södra Frihamnskajen. (31)

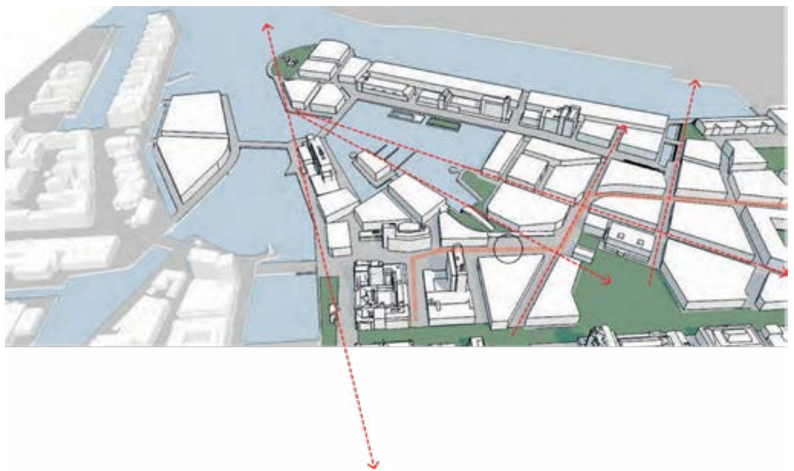
Although it is recommended that the buildings there should also designed to protect homes from any disturbance from ships and port operations, the outdoor spaces, specifically near the sea, will not be calm and pleasant due to noisy environment.



Visual Connection

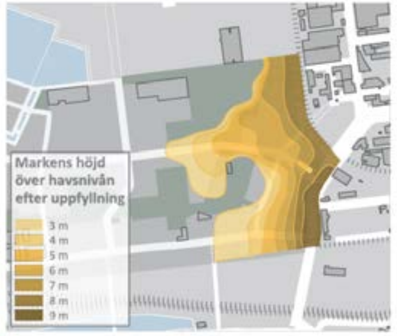
Long unbroken lines of sight provide views of the sea from Nyhamen's interior and north-south lines of sight create visual contact with the harbor. Through sight lines into and out of Nyhamnen, visual connections are achieved that provide visibility and connection. (31)

However, these long straight streets in north-south direction will act as wind corridors during windy days.



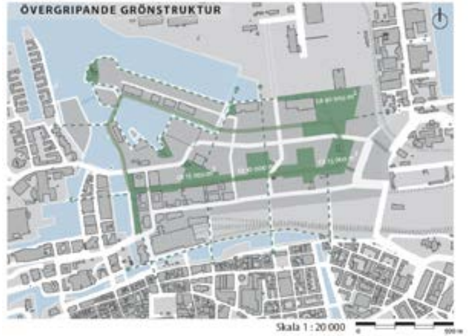
Artificial Topography

The level difference towards Frihamnsviadukten provides the opportunity to create a slope that provides a new visual experience of Nyhamnen with views of the entire district and the sea. The height difference can also give the place its own identity. Also, the ground level is raised by a slope up to the level of Västkustvägens. Towards the freight track to Mellersta hamnen, the new, higher ground level ends with a retaining wall, which means that new buildings will be approximately 6 m above the level of the track. As the design of Nyhamnen will enable a low car ownership so that the need for parking will also be low and one of the areas recognized for parking garages is under the elevated ground level adjacent to Västkustvägen. (31)



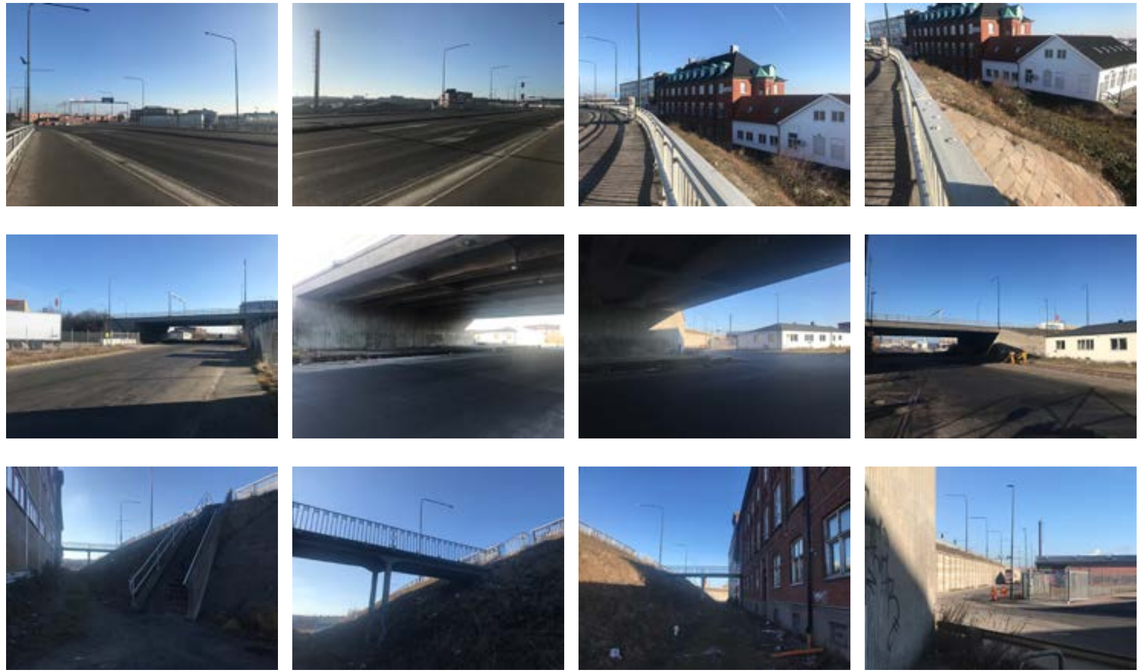
By raising the ground level to the same level as Västkustvägen, a topography is created that provides views at the same time as an urban meeting can take place with Västkustvägen.

Although a large green park is proposed on part of this elevated area, this topography will deteriorate the barrier character of Västkustvägens bridge in ground level. Today, there are many abandoned areas underneath and around the bridge that cause feeling unsafe for pedestrians and bicycle riders. Also in ground level, areas around historical building adjacent to east part of Västkustvägens bridge seems derelict, polluted, and unsecure for people. So, if the development will just continue on the elevated terrains, this circumstance can intensify on underneath level. In addition, this artificial topography would cause accumulation of water during rainy days in downhill which needs more strategies to prevent from flood.



Overall green structure

Current Condition of Västkustvägens Bridge Underneath



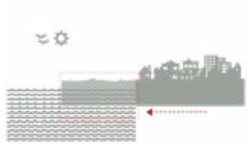
Imbalance Distribution of Activities

Nyhamnen will be developed into a destination that attracts local and regional visitors and help to profile Malmö as an event and place to visit. An innovative, small-scale, and niche restaurant and retail offering in a multifunctional and waterfront urban environment will create attractions that take advantage of Nyhamnen's specific character. Commercial service must be made possible in ground floors and corner locations in many places, but mainly in the western parts of the area and in connection with existing trade, according to the principle "trade breeds trade". (31)

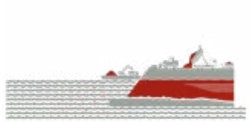
According to trad and hospitality location map, the concentration of these activities is on west part of site mainly in connection with existing activities and to enhance relation with Västra hamnen. So, this imbalance distribution makes isolated area in east part of site which will not be as lively as west part.

Primary trading modes	
Primary locations for the hospitality industry	

Municipality Proposal's Weaknesses & Treats



New fillings and artificial island



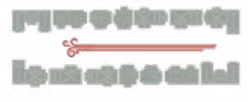
More environmental issue by new islands construction

Water pollution due to cruise ships commuting

Disturbance from ships and port operations for homes

Flooding in case of heavy rain due to artificial topography on east part of area

Lack of balance in distribution of different activities like commercial services concentration on western part



Straight main streets act as Wind corridor

Conclusion

Although there are many strengths and opportunities in the municipality proposal, the threats and weaknesses are investigated to gain more lessons to start the design process in this thesis project.

So, it is being tried to prevent advances to the water and to make the project more sustainable and reduce the cost of construction, the artificial topography and elevated area is just implemented along the shoreline to protect from sea level rise, and it is not drawn to the inner spaces.

In addition, it is considered to make a balance of activities in the whole area to make all parts lively and enhance public activities.