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Development

# A Resilient Design Approach to Climate Adaptation of Coastal Landscape

Exploring Design Principles in Facing Flood Risk and Rising Sea Levels

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# ABSTRACT

In the footsteps of human society global warming have caused the world's oceans to expand due to increased average temperature and further created sea level rise and flooding. Today the most frequent natural disasters are water related which comes with great challenges in designing and planning for coastal protection. This master thesis is an independent work within landscape architecture with the focus on designing in relation to sea level rise and flooding. Through the understanding of climate change adaptation and resilience concepts, this thesis aims to identify design principles to resist extreme weather events and flood risk. The principles derived from resilience theory will further be applied on a case study in order to test and explore what kind of tactics that foregrounds in addressing flood risk and sea level rise. While discussing the most fundamental design processes about coastal landscape and its water related problems, the design principles will work as an inspirational guide for architects, designers, planners and other people interested in the subject. The design principles are based on and inspired by human relationship with water, projects from all over the world and well-known principles as methods in dealing with flood risk and rising sea levels. The principle *integrate* aims to see the coastal landscape as an opportunity, instead of a constraint, and further on adapt into living with water. *Protect* aims to managing water and to sheltering certain interests and further shut the water out in order not to interrupt the life within the protected area. Finally, *separate* aims to distance the water by temporary or permanent relocation but could however also mean to create restrictions where or where not to exploit. The design proposal, *Archi-Pelago*, are applied on Falsterbo peninsula in Sweden. It aims to test the principles and together with a series of tactics answer how the principles will practically be achieved. Archi-Pelago aims to enlighten a landscape architect's perspective on flooding and sea level rise in relation to resilience. The outcome of the project creates several opportunities to not only protecting us from the water but to see new ways to actually live with water or to use the water as a possibility.



# SAMMANFATTNING

Denna masteruppsats är ett självständigt arbete inom landskapsarkitektur med fokus på gestaltning i relation till havsnivåhöjning och översvämningar. Uppsatsen lyfter de mest grundläggande tankarna gällande kustlandskapet och resilient gestaltning vilket ligger till grund för tre gestaltungsprinciper i att hantera extrema klimatförändringar. Gestaltungsprinciperna appliceras vidare på en fallstudie med syfte i att undersöka och utforska vilken typ av taktik som är relevant för det valda området, Falsterbohalvön.

## PROBLEMATISERING

Följderna av den globala uppvärmningen och framtida klimathot ställer kustlandskapet i ett sårbart tillstånd inför framtida utmaningar såsom översvämning och höjda havsnivåer. Forskning visar på olika inriktningar, teorier och tillvägagångssätt i att hantera dessa kustrelaterade problem. Utfallet har haft både positiva och negativa effekter men vidare skapat oväntade följder. Syftet med uppsatsen är att introducera ett resilient perspektiv i landskapsarkitektur gällande kustlandskap vilka är sårbara för översvämningar.

### SYFTE

Genom förståelsen av klimatanpassning och resilienta koncept ämnar denna uppsats till att identifiera gestaltungsprinciper i att hantera extrema väderförutsättningar och översvämningrisk. Principerna, härledda från resilienta teorier, kommer vidare tillämpas på en fallstudie för att undersöka och utforska vilken typ av taktik som ligger till grund i hanteringar av översvämningrisk. Genom att föra en diskussion beträffande de mest grundläggande koncepten om kustlandskapet och dess vattenrelaterade problem ska gestaltungsprinciperna fungera som en inspirerande guide för arkitekter, designers, planerare och övriga intresserade i ämnet.

### FRÅGESTÄLLNINGAR

*Vad kan landskapsarkitektens disciplin praktisk lära av och bidra till den pågående klimatanpassningen och resilienta koncept?*

*Vilka gestaltungsprinciper kan identifieras i resilienta teorier och hur kan dessa användas för att hantera översvämningrisk i ett empiriskt fall på Falsterbohalvön i Sverige?*

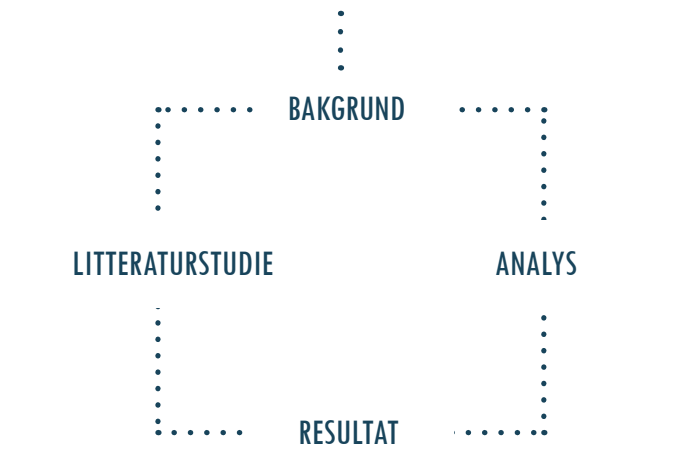
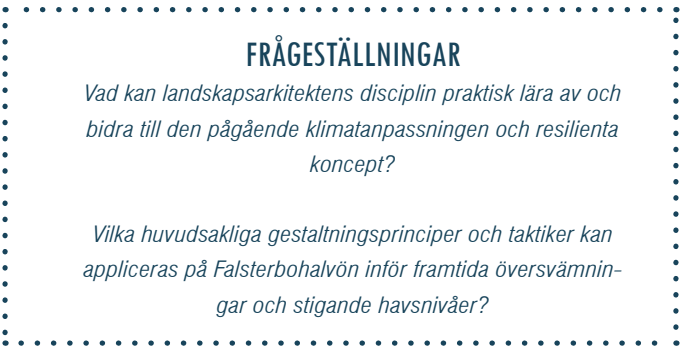
## BAKGRUND - UNDERSÖKA RESILIENS SOM ETT VERKTYG FÖR KLIMATANPASSNING

Trenden visar att den globala uppvärmningen högst troligen kommer att fortskrida och orsaka vattenrelaterade problem världen över i en betydande skala. Idag är 90% av alla naturkatastrofer vattenrelaterade. Samtidigt lever cirka 40% av världens befolkning inom en 100 kilometers radie från kusten vilket betyder att en stor del av världsbefolkningen påverkas av dess följder. Trots detta är kusten en attraktiv plats att exploatera och bo på på grund av dess vackra vyer över vattnet, turism, fiskemöjligheter samt närheten till rekreation.

Historiskt sett är den moderna människan välbekant med kustlandskapet då vi levt och verkat av den gradient hav och land skapar. Senare, mer exakt under den förhistoriska agrara revolutionen, får människan en annan relation till kustlandskapet då vi går från ett flexibel och anpassat synsätt till kontrollerande av naturen. Vi frågar oss hur framtiden kommer att se ut och hur kommer synen på kustlandskapet kan komma att tolkas i framtiden. I takt med den globala uppvärmningen präglas dagens samhälle av ett mer resilient perspektiv. Resiliens definieras som motståndskraften av ett systems förmåga att svara på förändringar eller störningar utan att ändra sin grundläggande funktion eller struktur. En resilient tankegång föreslår ett alternativt synsätt av användandet av vår jords resurser och vidare skapar möjligheter snarare än att begränsningar.

Med historien i baktanke och framtiden i förbehåll krävs ett resilient sätt att hantera kustlandskapet. Inom landskapsarkitektur och planering syftar en resilient gestaltning till att anpassa sig inför oförutsedda förändringar i en ständigt förändrande värld.

## SYFTE



## DESIGNPRINCIPER OCH TAKTIKER

FLÖDESSCHEMA ÖVER PROCESSEN.

## METOD

Uppsatsens process började med en inledande fas där vi diskuterade International Federation of Landscape Architects (IFLA) designtävling för studenter vi deltog i. Tävligen introducerade oss till uppsatsens ämne och vidare styrde projektet i hur vi skulle adressera problematiseringen. I syfte om att erhålla kunskap om ämnet gjordes en omfattande litteraturstudie. Gestaltungsprinciperna utformades från litteraturstudien och den genomgående processen som vidare testades på en fallstudie.

Nedan följer en beskrivning av de valda metoderna.

### LITTERATURSTUDIE

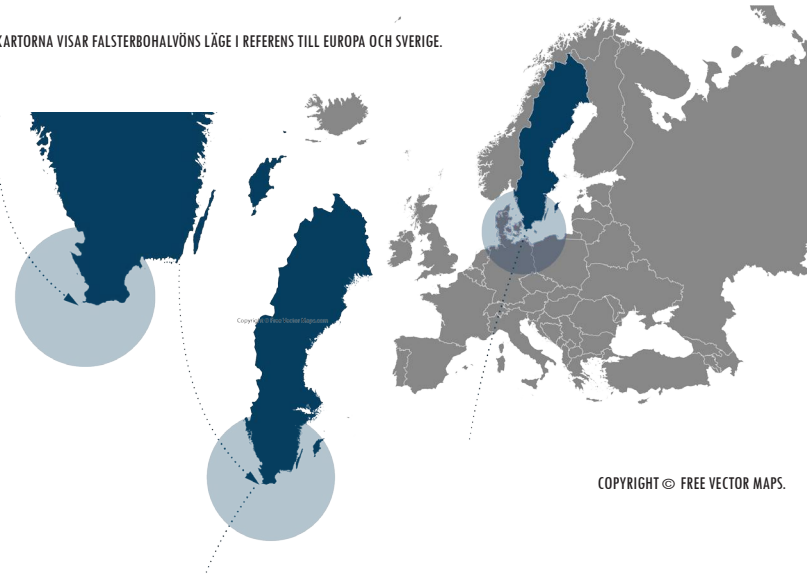
Litteraturstudien syftar till att erhålla kunskap om den globala uppvärmningen och problematiken med klimatförändringar. Litteraturstudien ämnar vidare till att undersöka översvämningar och havsnivåhöjningar där flera olika perspektiv diskuteras och tas i åtanke. Vidare undersöks konceptet resiliens samt samspelet mellan kustlandskapet och samhället. Som en del av litteraturstudien gjordes även en referensprojektstudie av valda projekt. Syftet var att undersöka vilka utmaningar som är vanligt förekommande världen över och vilka lösningar som svarar på dessa problem.

### FALLSTUDIE

Fallstudien syftar till att förstå och utreda nyckelkaraktärerna av det valda området. Falsterbohalvön valdes som utredningsområde utefter sin sårbarhet gällande framtida klimatförändringar. Kriterierna för den valda platsen var; ett område sårbar för framtida översvämningar och höjda havsnivåer, beläget i Skåne (på grund av den icke existerande landhöjningen) samt ett landskap med byggd miljö.

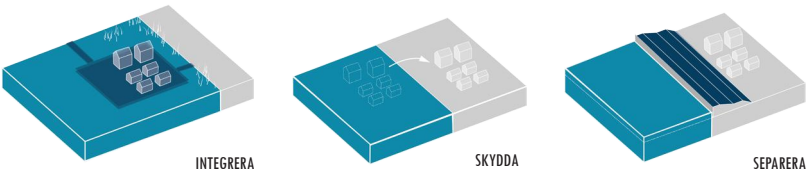
### ANALYS AV MÖJLIGHETER OCH BEGRÄNSNINGAR

Analysens syftar till att sammanfatta och analysera platsen förutsättningar med information erhållen från litteraturstudien och fallstudien. Både ekologiska, ekonomiska och sociala aspekter tas i beaktande för att ligga till grund för gestaltungsförslaget.



# GESTALTNINGSPRINCIPER I ATT TÄNKA RESILIENT

Tre gestaltungsprinciper har identifierade utifrån den kunskap som fått från litteraturstudie, referensprojekt samt platsanalys. De tre utarbetade principerna består av integrera, skydda och separera vilket baserats och inspirerats av människans historia med att leva med vatten, projekt världen över samt kända principer och metoder för att hantera höjda havsnivåer och översvämningar. Varje princip är uppdelat i en serie av taktiker, vilka agerar som olika medel i klimatanpassning och resiliens samt vidare visar på hur principerna praktiskt skulle uppnås. Designtaktikerna är presenterade som en del av fallstudien över Falsterbohalvön.



## INTEGRERA

Principen *integrera* handlar om att anpassa sig till och leva där kustlandskapet uppfattas som en möjlighet snarare än ett problem. Denna princip refererar till lösningar som sakteligen integreras till ett samhälle som “lever med vatten” och anpassas efter det ständigt föränderliga landskapet. Utvalda gestaltningstaktiker för denna princip är följande;

**FLYTANDE STRUKTURER**  
Ämnar till att anpassas när vattnet stiger och sjunker såväl för översvämningsskydd. Flytande strukturer syftar till att göra det möjligt att “leva med vattnet”.

**SÄLFLOTTAR**  
Med anledning av att Möklåpen är den enda uppehållsplatser för grå- och knubbsalar i södra Östersjön, syftar sälflottarna till att säkra det behovet som vidare kan anpassas efter stigande såväl som sjunkande vattennivåer.

**FÖRFLYTTNING AV SAND/ RESTAURERING AV SANDDYNER**  
Genom att förflytta sand och restaurera stranden stärks därmed kustlandskapet med sina attraktiva vyer och funktioner.

**LEVANDE KUSTREMSA**  
Den levande kustremsan integrerar ekologiska funktioner som vidare reducerar risken för kusterosion. Den växtbeklädda kustremsan fungerar på ett integrerande sätt i att sudda ut den distinkta linjen mellan land och vatten.

**NYA TRANSPORTMÖJLIGHETER**  
Taktiken ämnar till att säkra transportmöjligheter med att introducera nya alternativ såsom utökade vattentransporter och linbanor. Transportmöjligheter som syftar till ett mer integrerat sätt att leva genom att använda vattnets möjligheter precis som i Venedig, där hela transportsystemet är baserat på vatten.

**BRYGGESTRUKTUR**  
Bryggstrukturerna utgörs av ett system som kan användas vare sig om vattennivåerna är höga eller låga. Bryggstrukturerna har multifunktionella funktioner och kan användas till offentliga rum när vattennivåerna är låga och som promenadstråk när de är höga.

**ÖVERSVÄMNINGSPARK**  
Områden, gjorda för att hantera stora mängder vatten, kan buffra och skydda vid översvämning och kan resilient fungera genom att återhämta sig snabbt efter stormar.

**KONSTGJORDA ÖAR**  
Konstgjorda öar är strukturer som syftar till att skapa ekologiska funktioner och biologisk mångfald. På dessa kan nya habitat skapas.

## SKYDDA

Principen *skydda* syftar till att skydda valda värden och intressen från vattnet genom att stänga det ute. Skyddade intressen till exempel kan vara av ekonomiska, ekologiska eller kulturella skäl eller värnande om den byggda miljön. Genom detta kan samhället leva ostört inom det skyddade området. Utvalda gestaltningstaktiker för denna princip är följande;

**VÄGBRYTARE**  
Vägbrytare skyddar kustlinjen från vågor och strömmar genom en hård struktur av stenar och murar. Vägbrytare kan även implementeras i andra strukturer såsom bryggstrukturer eller artificiella öar som skyddar mot vind.

**UPPHÖJDA EXISTERANDE BYGGNADER OCH INFRASTRUKTUR**  
I syfte att leva nära vatten måste vissa intressen, såsom byggnader och infrastruktur sårbara mot översvämningar, bli säkrade. Taktiken syftar till höja byggnader och infrastruktur, där infrastruktur kan bli säkrad genom flytande eller upphöjda vägar.

**ÖVERSVÄMNINGSBARRIÄRER**  
Översvämningsskärmar utgör ett skydd som motverkar översvämningar och stormar och därmed skyddar byggd miljö och infrastruktur. Barriären består av portar som stängs när vattennivåerna höjs.

**LEVEE**  
Levees är jordvallar som fungerar som ett skydd mot översvämning genom att kontrollera vattnets flöden. Konstruktionen ämnar till att hålla undan vattnet i floder och motverka vågar.

**KUSTSKYDD**  
Består att ett kustskydd som skyddar mot vågor och strömmar. Kustskyddet ämnar till att både skydda kustlinjen men även motverka klippor från att erodera.

## SEPARERA

Principen *separera* menar på att ta avstånd från vattnet genom att flytta, temporärt eller permanent, till säkra områden. Det kan innebära att byggnader eller till och med att naturen måste flyttas dit vattnet inte når. Vidare kan principen även betyda att skapa restriktioner om vart bebyggelse får och inte får byggas, med fokus på att bevara kustlinjen. Detta för att göra strandlinjen tillgängliga för allmänheten och säkerställa en god miljö.

Att vara tvungen att förflytta bebyggelse på grund av sårbarhet för vattenrelaterade problem kan uppfattas som kontroversiellt, speciellt när det rör bostadsbebyggelse. Enligt United Nations (UN) gynnar vissa parametrar den separerande principen att lyckas. En av parametrarna för att lyckas med principen separera är det faktum att en liten population är lättare att förflytta. I dessa områden är det möjligt att kostnaden blir lägre genom att flytta än jämfört med att stanna och skydda område. En annan faktor är att planeras förflyttningen i tidigt skede då de boende tenderar att vara mer öppna om det planeras tidigt.

**FÖRFLYTTA**  
Denna taktik ämnar till att flytta byggnader till en annan plats på grund av hög sårbarhet för översvämning och stigande havsnivåer. Detta kan vara permanenta eller tillfälliga lösningar beroende på om läget på den ursprungliga platsen är stabilt. Skillnaden mellan reträtt och förflytta är att förflytta syftar till att flytta en del av det samhälle som påverkas allra mest medan reträtt är komplett förflyttning. Taktiken kan ske i etapper och förflyttningarna kan innebära att hela samhället flyttar på sikt.

**BEGRÄNSAD EXPLOATERING**  
Att begränsa exploatering menas med att skapa restriktioner om vart det får bebyggas. Denna taktik fungerar i förebyggande syfte för att säkra bebyggelsen och undvika den eventuella risken i att behöva dra sig tillbaka om det skulle ske översvämningar, höga havsnivåer eller erosion. Detta skapar också att allmänheten får tillgång till kusten samt att kustens växt- och djurliv kan skonas.

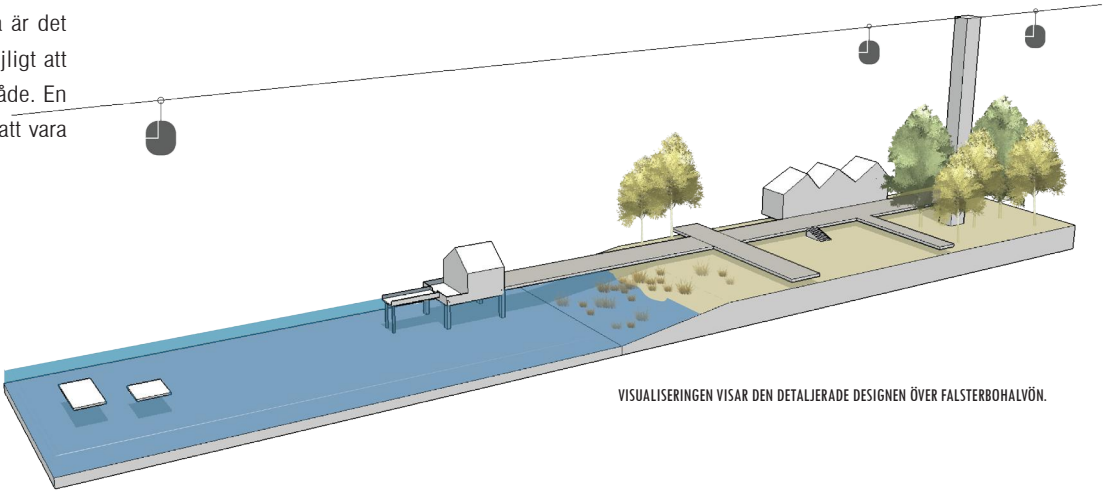
**RETRÄTT**  
På grund av akut eller mycket hög sårbarhet för översvämning och stigande havsnivåer kan reträtt vara det bästa och ibland enda alternativet. Denna taktik syftar till att förflytta bebyggelse, infrastruktur och viktiga intressen till säkrare områden. Denna ingång till vattenrelaterade problem passar när förlusterna för skadorna på samhället är mycket hög och inte värd att riskeras. Denna princip har applicerats på det lilla samhället på ön Isle de Jean Charles i Louisiana. Där var klimatnoten så pass höga att det ansågs vara ett högriskområde, vilket lämnade om med få alternativ än att flytta till säkrare områden.

# ARCHI-PELAGO

## UNDERSÖKANDE AV GESTALTNINGSPRINCIPERNA OCH TAKTIKERNÄ PÅ FALSTERBOHALVÖN

Archi står för arkitekt, i detta förslag landskapsarkitekt. Pelago kommer från latin och betyder hav. Archi-Pelago syftar till att upplysa en landskapsarkitekts perspektiv på översvämning och stigande havsnivåer i relation till resiliens. Vidare står Archi-Pelago för en arkitekts sätt att binda samman öar, eller i detta fall en serie av taktiker för resilient kustskydd. Projektets resultat skapar flera möjligheter i att inte bara skydda oss från vatten, utan att se det med nya ögon och faktiskt leva med vatten.

Gestaltungsförslaget av Falsterbohalvön är ett verktyg i att testa gestaltungsprinciperna och utforska taktikerna som ligger till grund till principerna. Designen är specifik för den byggda och naturliga miljön på Falsterbohalvön men ämnar till att fungera som en inspirerande guide inför framtida planering och projekt tack vare sin teoretiska och filosofiska bakgrund (Se bilaga för förslaget och bidraget till studenttävlingen).



VISUALISERINGEN VISAR DEN DETALJERADE DESIGNEN ÖVER FALSTERBOHALVÖN.

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# INTRODUCTION

## EXPLORING RESILIENCE AS A TOOL FOR CLIMATE ADAPTATION

The consequences of climate change have become the 21st century's greatest threats to our planet (WHO 2018) and dealing with water related problems has globally becoming a challenge in an unprecedented scale (UN 2011). Climate change is causing rising sea levels, coastal flooding, ice mass loss and extreme weather events (NASA 2018) and 90% of the most frequent natural disaster are water related (UNISDR 2018).

The concept of coastal landscape are highly romanticized where land meets the sea, with its great vistas, the sound of the waves and the mysterious depths of the ocean. Urban development along the coastline are today one of the most attractive areas to exploit because of its high market value (Rouwendal & Van Marwijk 2017). By using hard surfaces and built structures human society have tried to manage and harness the coastal landscape creating this notion of a perfect line between land and sea (Mathur & Da Cunha 2018). It is often forgotten that it is also an ecotone, a transition zone between land and sea that creates its own unique and dynamic environment (Kark 2013). With the contrasts between the romanticised view of the coastal landscape and the vulnerability due to water related events, how can we live with water? Or reverse, can we live with water?

This master thesis investigates climate change adaptation and explores resilience concepts. The thesis further focus on identifying design principles derived from resilience theory and exploring these principles as a tool in addressing flood risk in an empirical case study.

## SCOPE

Dealing with challenges of global warming and future climate threats, the coastal landscape is at a vulnerable state facing future extremes like flooding and sea level rise. Research shows different approaches, theories and methods that have been successfully, and unsuccessfully used, dealing with coastal flooding and sea levels rise, but creating unexpected effects. The scope of the thesis is to introduce resilience thinking in landscape architecture and design process of coastal landscape that is vulnerable to flood events.

## AIM AND OBJECTIVE

Through the understanding of climate change adaptation and resilience concepts, this thesis aims to identify design principles to resist extreme weather events and flood risk. The principles derived from resilience theory will further be applied on a case study in order to test and explore what kind of tactics that foregrounds in addressing flood risk and sea level rise. While discussing the most fundamental design processes of coastal landscape and its water related problems, the design principles will work as an inspirational guide for architects, designers, planners and other people interested in the subject.

## RESEARCH QUESTIONS

*What can landscape architect's discipline learn practically from; and contribute to; the ongoing climate change adaptation and resilience concepts?*

*Which design principles could be identified in resilience theory and how could these be used in addressing flood risk in an empirical case of Falsterbo peninsula, Sweden?*





## BACKGROUND

The background section provides the reader with an overview of the subject's context and the concepts. Initially, the underlying causes; global warming and natural cycles of nature are introducing the core of the subject; coastal flood and rising sea level. The history of waters impacts on human society are broadly described to provide a historical background and as an introduction to the concept of coastal landscape. Finally, a description of resilience and its relationship to landscape architecture is presented.

### GLOBAL WARMING AND NATURAL CYCLES OF NATURE

In order to bring a holistic view to the debate about flooding and sea level rise it is important to understand the underlying causes. Therefore, to understand flooding and sea level rise, we have to understand global warming and natural cycles to estimate the extent of the consequences. It is also fundamental to understand the definitions and differences of concepts used in the debate about the changing climate.

First of all, climate is defined as the average weather of one place and climate change is considered as a change in the frequency of numerous of weather events. For example one year of high temperature cannot tell if the average temperature is changing but years of high temperatures could indicate that the global temperature is rising (NOAA 2013). According to *National Aeronautics and Space Administration's* (NASA) research, 97 % of climate scientific research reinforces that the trends of global warming are linked to human activities. Several science institutions including NASA, NOAA and Japanese Meteorological Agency show similar changes in the data for the global temperature between 1880 and today. The data reveals that the temperature have rapidly risen in the past decades and the last decade has been the warmest on record (NASA 2018).

Global warming refers to the climate change of rising temperature on Earth as a whole. The temperature of the Earth has fluctuated naturally throughout its history and goes through periods of ice ages and interglacials, natural cycles that spans across 100.000-years. However, the footprint of human society on the Earth face rising temperatures regardless of that natural factors would have led to a slightly cooler climate (NOAA 2015).

*The Intergovernmental Panel of Climate Change* (IPCC) research shows that the glaciers are melting more rapidly than expected, where one of the causes is that glaciers are losing mass and melting. Over the period 1992 to 2011, prognosis shows that ice sheets of Greenland and Antarctic have been losing mass and will likely rapidly continue to do so over 2002 to 2011. IPCC are highly confident that the glaciers will continue to shrink almost worldwide (IPCC 2014). As a matter of fact, there has been significant improvement to understanding and projection of the sea level change since the *Fourth Assessment Report* which was released in 2007. The latest prognosis from the *Fifth Assessments Report* in 2014, predicts that the borderline of the global glaciers of Antarctica (not including the Greenland and Antarctica ice sheets), will decrease by 15% to 55% in the lowest likely event and by 35% to 85% in the worst likely event of average surface temperature and precipitation (IPCC 2014).

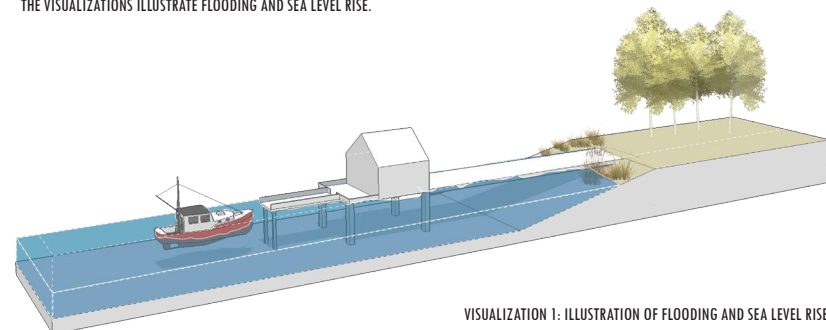
Concentrating on Sweden, the effects of a changing climate predicts to be a warmer and wetter weather (Swedish Civil Contingencies Agency 2016). *The Swedish Commission on Climate and Vulnerability* reports in 2007 that the surface temperature

in Sweden, as well as Scandinavia in general, will likely rise more than worldwide. The sea level is predicted to rise by 0.2-0.6 metres globally over the next hundred years, excluding the fact of the ice mass loss (The Swedish Commission on Climate Change 2007).

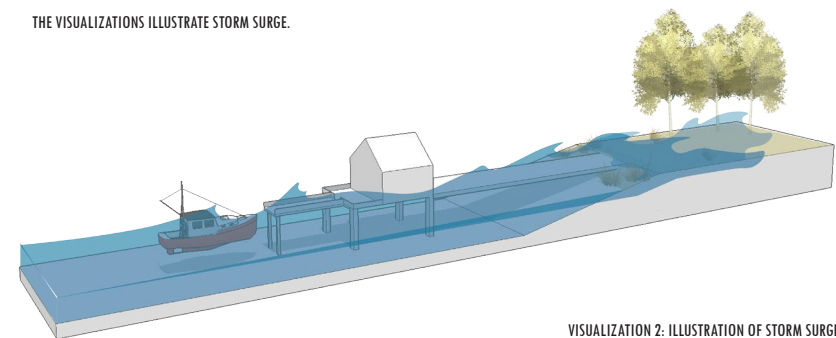
Furthermore, prognosis shows that intensive cloudbursts will increase significant and occur more frequently as well as the risk for flooding, putting built construction and infrastructure at risk (The Swedish Commission on Climate Change 2007).

However, stated in the report of The Swedish Meteorological and Hydrological Institute (SMHI) in 2011, further impacts of climate change is the loss of sea habitat due to sea level rise and an increased mortality because ocean acidity, and therefore a crucial threat to global biodiversity (Maclean & Wilson 211).

THE VISUALIZATIONS ILLUSTRATE FLOODING AND SEA LEVEL RISE.



THE VISUALIZATIONS ILLUSTRATE STORM SURGE.



## HISTORY OF THE COASTAL LANDSCAPE'S IMPACT ON THE HUMAN SOCIETY

Waters' impact on human life is a hot topic in political debate; its consequences extends to both political, social, cultural, economical and ecological concerns. Historically, there is no doubt that water had a crucial and positive impact on human society and development. Water has been essential for human survival and been a source for food and enabled transportation leading to trading of goods (Gillis 2016).

164,000 years ago the modern humans, homo sapiens, lived as coastal dwellers with the constantly changing landscape in the shores of the South African coast. They had a flexible and adaptive approach to the changing landscape, taking advantage of the rich environment that the transition between land and water provided (Gillis 2016). Later the human relationships to nature started to change, and we went from an adaptive to controlling approach to nature. This change in thinking happened around 12,000 years ago under the prehistoric agricultural revolution (Barker 2009). The view of the landscape come to be the springboard to much broader concerns.

The concept of urban living collide with the constantly changing nature, which makes it difficult for these two worlds to act in harmony. Today we face flooding and sea level rise in many urban areas along the coasts (Climate Central 2018). This creates further investigation about the concept of coastal landscape and what approach we should consider to deal with these processes of nature. Can we find a key in our history and can we learn from our ancestors?

### UNDERSTANDING COASTAL FLOOD AND SEA LEVEL RISE

Today lives according to United Nation approximately 40% of the world's population in cities within 100 kilometres of the coast (UN n.d.). Taking cities near deltas and lakes into consideration the percent will be higher which means more people are vulnerable to flooding and sea level rise.

As stated before the coastal landscape was beneficial for our ancestors development and survival but the coastal landscape is still attractive for today's society. Settlement along the coast is beneficial because of attractive vistas towards the sea, fisheries, tourism and recreation. But as much as the coast is an attractive area for development, it can be a threat to coastal ecosystems and our own society (UN 2007).

*The report Cities and Flooding - A Guide to Integrated Urban Flood Risk Management for the 21st Century by World Bank*, shows that the number and frequency of flooding events has increased significantly over the past 40 years. Among all types of natural disasters flooding events are the most frequent. However reported numbers between 1950 to 2010 shows that immediate loss of life related to flooding decreases while economic losses increases. This might indicate that water management can improve people's life on a large scale. Rural settlements in developing countries are the most vulnerable to flooding and sea level rise while urban settlements in wealthier countries are better to handle water related events. However damage on urban settlements are more costly, strikes more intense and affects more people. The numbers of death might decrease but the aftermath reveals side effects like the spread of diseases, loss of livelihoods and reduced opportunities of education (World Bank 2012).



## WHAT IS RESILIENCE?

Below Walker and Salt defines resilience as:

“*Resilience is the capacity of a system to absorb disturbance and still retain its basic function and structure*”  
(Walker and Salt 2006 p. xiii).

It was first introduced in terms of psychology and psychiatry with an interest in the mental health of human individuals (Fleming & Ledogar 2010). Later on, together with the rise of system thinking (Davoudi et al. 2012) resilience became common in terms of ecology. In ecology it was defined as the persistence of relationships within a system, measured in ability to absorb changes and still preserve (Holling 1973).

In terms of landscape and urban planning, resilient systems depends on being able to adapt to unprecedented and unforeseen changes in a constantly changing world (Ahern 2010). Resilience thinking proposes a different way of looking and managing our planet's natural resources, and furthermore offers a constructive alternative that creates options rather than limits them (Walker & Salt 2006). It addresses an approach to managing natural resources that embraces socio-ecological systems that is continually adapting through change (Walker & Salt 2006).

## RESILIENCE AND LANDSCAPE ARCHITECTURE

As stated above resilience thinking is about understanding the complexity of a constantly changing world. Walker and Salt argues that by understanding that we are more equipped to work alongside change, instead of being its victim (Walker & Salt 2006 p.14). During the last decades interdisciplinary interest in sustainability and resilience of cities has increased as well as a wider understanding for resilience and its implications for urban sustainability (Ahern 2012). It happens that the concepts are mistaken for the same meaning. Sustainability is about how to increase the quality of life while respecting environmental, social and economic systems. While resilience is focused on the response of these systems (Dayton et al. 2017).

In landscape planning and design, resilient thinking offers a way of using multifunctional systems for protection and to fail safer in the likely event of a crisis or natural disaster. Resilient landscape architecture and planning is designed to both buffer, recover more quickly from extreme events as well as strengthen biodiversity and creating opportunities for recreation, where these systems are often the most cost-effective. *American Society of Landscape Architects* (ASLA) is arguing that the best defenses are to mimic nature and strive to create adaptive solutions (ASLA 2018).

## LIMITATIONS

Below are the limitations of the thesis listed.

### IFLA 2018 STUDENT LANDSCAPE ARCHITECTURE DESIGN COMPETITION

As a part of this master thesis, we chose to enter an annual international student design competition. The competition is sponsored by *International Federation of Landscape Architects* (IFLA) and organised by *Singapore Institute of Landscape Architects* (SILA) and this years theme is *Resilient Landscape*. The objective of the competition, which were open for all student world wide to enter, were to make a thoughtful and innovative environmental design. Any landscape sites and challenges could be applied and furthermore also the context, site and scale of the project were optional (IFLA 2018).

Apart from the fact that it was the design competition that introduced us to the subject of the thesis, the purpose of participating was to use the competition as a tool in exploring the subject with a design approach from a landscape architect student point of view. To encourage us to investigate and interpret the specific site and implement our reflection and thoughts into specific design principles for Falsterbo peninsula. Furthermore, the design competition was used to limit our project by making the framework for the thesis.

The competition have led us in a more design oriented direction and have been the main reason why we did a design proposal. It has restricted us to do a proposal and it has been a challenge to do so regarding the many aspects to consider when implementing and design a large scale site. On the other hand this have later helped us in testing our design tactics and further been beneficial in the discussion about what problems we encountered in the implementation of the tactics.

### CHOICE OF CLIMATE SCENARIO

Discussing the future climate we had to make a statement regarding which climate scenario we would base the thesis on. We decided to use the *Intergovernmental Panel on Climate Change* (IPCC) climate scenarios called *Representative Concentration Pathways* (RCP), which underlies by four future climate scenarios. Each scenario represent different future anthropogenic greenhouse gas concentrations (IPPC 2014).

In this thesis we are going to use the worst scenario, RCP8,5 which means that the emissions continue to rise which leading greenhouse gases to generate 8,5 W/m<sup>2</sup> radiative forcing. The decision is based on that we cannot be certain about the future climate and politics and therefore we adopt to a “better be safe than sorry” approach and use the scenario with the highest greenhouse gas concentration. There is also uncertainty about the consequences and extent of the melting glaciers which means that there is a risk that they affect us in a much greater extent than predicted.

## SITE SELECTION OF CASE STUDY

Due to the fact that the competition allowed the design to be implemented anywhere in the world, we chose a site situated in Sweden. The site was chosen in Sweden because of our knowledge about the Swedish landscape context as well as the public access to documents and maps regarding sea level rise and flooding.

The area of investigation in the thesis is named *Falsterbo peninsula* but however does not include the whole peninsula. Regarding our choice to limit the site boundaries we decided to focus on the most vulnerable built environment situated furthest from the mainland. The built environment of Höllviken and Ljunghusen were therefore excluded because of its distance to open water and not vulnerable in the same extent as the chosen site. We decided that taking more of the built environment in consideration was not necessarily due to the beliefs that it would not make a different outcome in the result.

### LIMITED EXPERTISE KNOWLEDGE OF THE LANDSCAPE ARCHITECT

Due to the fact that landscape architects lack expertise knowledge in ecology and engineering, we choose to use the case study as a tool to test and explore our design principles. Falsterbo peninsula is a large scale site and needs to be looked into as a whole but also in specific areas within the site. To understand a site fully the site have to be divided into small character areas that has to be analysed individually and in the context of one another. This would help to understand how to implement each tactic but also understand the further impact of them.

In this thesis we choose to test our principles in a overview perspective with the focus on the selection of tactics based on the lens of a landscape architect. We want to point out that further investigation and a more detailed study of the area would be needed to identify tactics that are appropriate to the landscape context. Our interest lies in analysing what types of tactics that foreground resilience thinking. The purpose of implement the tactics on Falsterbo peninsula are to explore and discuss the challenge of looking into the different aspects of designing in a resilient way.



# METHODS

## GRASPING THE SUBJECT OF CLIMATE ADAPTIVE DESIGN

The working process started with a preface, discussing the International Federation of Landscape Architects (IFLA) annual student design competition we entered. The competition brought us on the subject of the thesis and further on directed the project in how we would address our scope. In order to get a comprehensive knowledge of the subject a literature review were made. The design principles were constructed from the literature review and the all through process and further tested and explored on a case study.

Below a flowchart over the process and the different working methods are described.

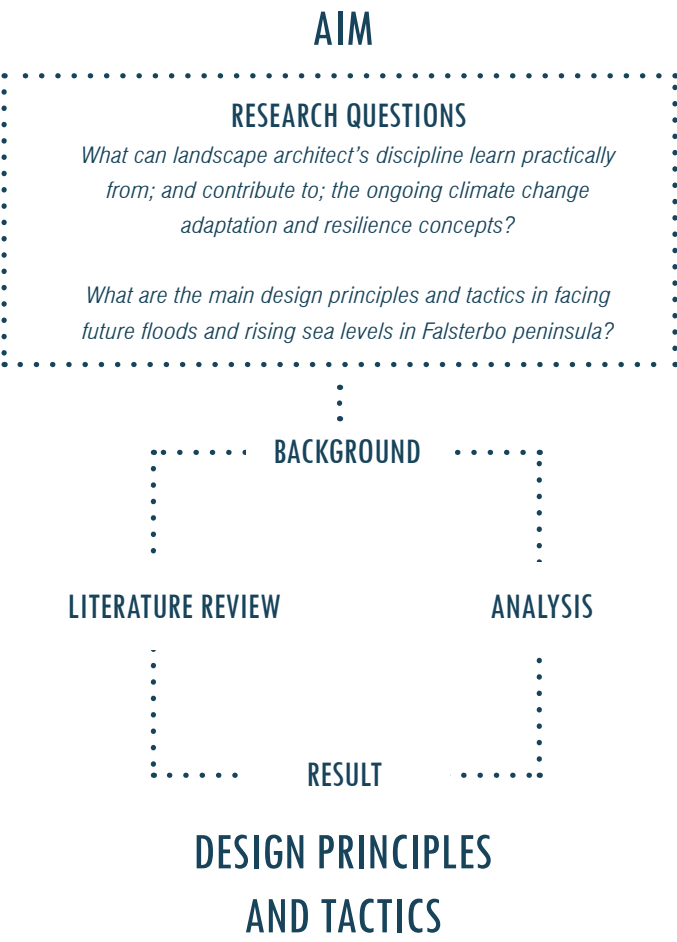


TABLE 1: FLOWCHART OVER THE PROCESS



THE PICTURE SHOWS BIRD WATCHING AT MÅKLÄPPEN ON FALSTERBO PENINSULA.

PICTURE 2: SKADARE MÅKLÄPPEN BY ANNIKA LUNDB. (CC BY 2.0)



LITERATURE REVIEW

In order to get knowledge about climate change adaptation and resilience concepts, a literature review were made. The purpose of the literature review were to explore the fundamental understanding of flooding and sea level rise and have been the most important part of our choice of methods. The literature review have been the base for our design principles, where focus lied in going back to the most fundamental thoughts about the coastal landscape and challenge conventional ways of thinking resilience. There is lot written in the subject which have favour our research. We have carefully selected the literature in order to bring diversity to the research and therefore we have been interested in literature from different parts of the world. We studied bold, innovative and unconventional perspectives and methods in the literature review as a tool to challenge the way of discuss flooding and sea level rise in today’s debate in Sweden. The literature included books, journals, scientific reports, planning documents and articles which together created a rich foundation of knowledge. We used the library’s search tool Primo, with search words like; “resilience”, “resilient+design”, “resilient+landscape+architecture”, “system+thinking”, “sustainability+resilience”, “rising+sea+levels”, “global+warming”, “climate+change”, “climate+adaptation”, “climate+adaptation+design”.

As a part of the literature review a study of five reference project were made. The purpose of the study were to investigate which challenges are commonly occurring worldwide and what solutions answer to those problems. We choose to investigate and analyse project located by the coast similar to our area of investigation. The reference study played an important role in anchor the result in real life with projects chosen to explain our design principles and tactics.

CASE STUDY

The purpose of the case study was to test and explore what kind of tactics that foregrounds in addressing flood risk and sea level rise. In order to achieve this we had to gain knowledge and understand the key attributes of the chosen site and its surroundings. More precise to gain knowledge regarding the existing natural and built environment as well as the cultural aspects of the site. Further to understand what challenges they are facing in the future. In order to get a grip of the area itself, a site visit were made. We did not intended to make a full site inventory (see limitations) but rather to get to know the place and see which characters the site holds.

The landscape site was chosen after studying planning documents and investigating future risks regarding climate change. Main focus were in investigating sea level rise and flooding caused by the global warming’s progression. Criteria for choosing our location were; a site facing future risks in sea level rise, located in Skåne County (due to the non-existing post glacial land raise), and a landscape with built environment.

OPPORTUNITIES AND CONSTRAINTS ANALYSIS

An opportunities and constraints analysis, so called “ops and cons”-analysis´, is based on the Auckland Design Manual from Auckland Council. The opportunities and constraints is concluded in a diagram which aims to outline and summarise the result from the case study. The knowledge gained from the study will set out the design framework for the final proposal (Auckland Design Manual 2018). We felt that an constraints and opportunities diagram were more suitable than for example an SWOT-analysis (short for Strengths, Weaknesses, Threats and Opportunities). A SWOT analysis would give a more subjective outcome, where equal value is given to each part of the investigation. A weakness today can be a threat in the future and therefore we decided to do a more clean analysis that would give more space for our own inputs.

The “ops and cons” analysis is a tool to analyse the information gained from the case study. Both social, cultural, economical and ecological aspects, seen from the lens of a landscape architect, are included in order to give a comprehensive analysis of the place. The conclusion of the analysis can later on be used as foundation for the testing the design principles and tactics on Falsterbo peninsula. The features of the site are not valued as “good” or “bad” because of the strive to limit our own subjective thoughts as much as possible. A constraint should be seen as something that limit our choices rather than being a negative feature for the site.

THE DEVELOPMENT OF THE DESIGN PRINCIPLES

The design principles were created from knowledge and inspiration from the literature review, the reference projects and their way of approach water. The literature review changed our way of understanding the coastal landscape and the freedom in the competition brief gave room for our own analysis. This made us interested to investigate a more philosophical approach. During the process of this master thesis, the aim changed and the project took another direction to than initially intended. The project took a more reflective path where a philosophical discussion about strategies is presented. We went from planning to do a pure design proposal to a thesis that explored and developed design principles in resilience thinking. We then wanted to further explore and test them on a case study to get an understanding of the implementation of them.

While digging deeper into resilience thinking we began to reflect over the concept of resilience and our own understanding of it. We started to look into projects and research about coastal resilience in the context of flooding and sea level rise. From the research we extracted methods and approaches in thinking resilience that we later had to distinguish and then define and categorise. By categorise the tactics and principles into groups that shared similarities in approaching coastal landscape we had it easier to put them together, like in a scheme. This was the most important step in our process in order make sure the principles and tactics correspond to each other.

The final step was then to name them by using a terminology we found neutral and correct to each definition of the principles. Like stated earlier, the process were of the looping type were we had to process the tactics and principles while we were exploring them.

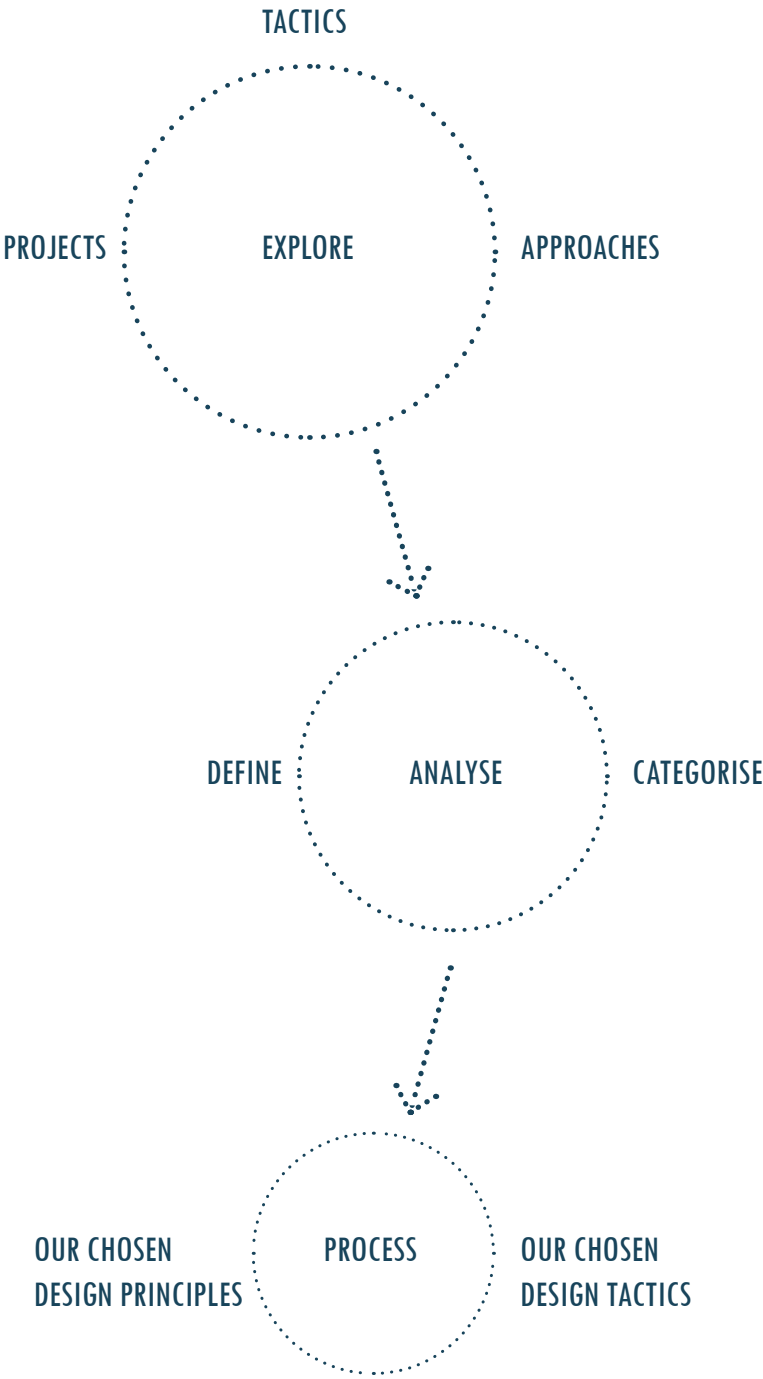


TABLE 2: FLOWCHART OVER THE DEVELOPMENT OF THE DESIGN PRINCIPLES AND TACTICS



# CLIMATE CHANGE AND RESILIENCE

## LEARNING FROM THEORY AND PRACTISE

Following chapter contains first reflections over the literature review where sources are critically placed against each other. Second, a presentation of the reference projects and which different characters and approaches they are taking. Finally, the case study of Falsterbo peninsula is presented.

### FUNDAMENTAL THOUGHTS AND REFLECTIONS OF THINKING RESILIENCE

According to Jack Ahern, professor of landscape architecture, resilience demands a new way of thinking about sustainability (Ahern 2011). Climate change, and the global warming is shifting the condition for landscape and urban planning (Ahern 2010), and to ignore or resist this change only increases vulnerability in social, economic and environmental systems. Furthermore relinquish emerging opportunities and thereby limit our options (Walker and Salt 2006). Walker and Salt argues that resilience thinking offers a different way of facing climate problems and creates options rather than limits them (Walker & Salt 2006).

Michael D Murphy writes in "*Landscape Architecture Theory - An Ecological Approach*" as we gain increasing power to change the landscape, we are obligated take care of it wisely. To value our valuable and irreplaceable resources (Murphy 2016). Supporting this, Walker and Salt also argues that ignorance and misunderstanding plays a central role in the fact that our resources are diminishing. Instead than being victimized by it, to work side by side with the change, understanding the complexity of a constantly changing world. And resilience thinking is the way to do it (Walker & Salt 2006).

Netherlands has, as widely known, been dealing with water management through all times, due to the fact that large areas of their country is under the sea level. In an interview with professor Chris Zevenbergen, he says that "In the Netherlands, we are not responding to flood disaster, we are anticipating a flood disaster" (Living on Earth 2017). This way of looking at water as a possibility instead of a threat is also the case in Mathur and da Cunha's work. They argue for not separating water, urban and rural environments (Mathur & Da Cunha 2018).

However climate change and the frequency of recent event of natural disasters, such as Hurricane Sandy sweeping through the United State's east coast leaving death and devastation behind (Live Science 2012), reminds us the vulnerability in human settlements as well as the vital importance of resilience in planning for the future (Sharifi & Yamagata 2014). Resilience is about the past, present and future. Learn from the past and prepare for the future. Because if the Earth's resources disappear, so do we.





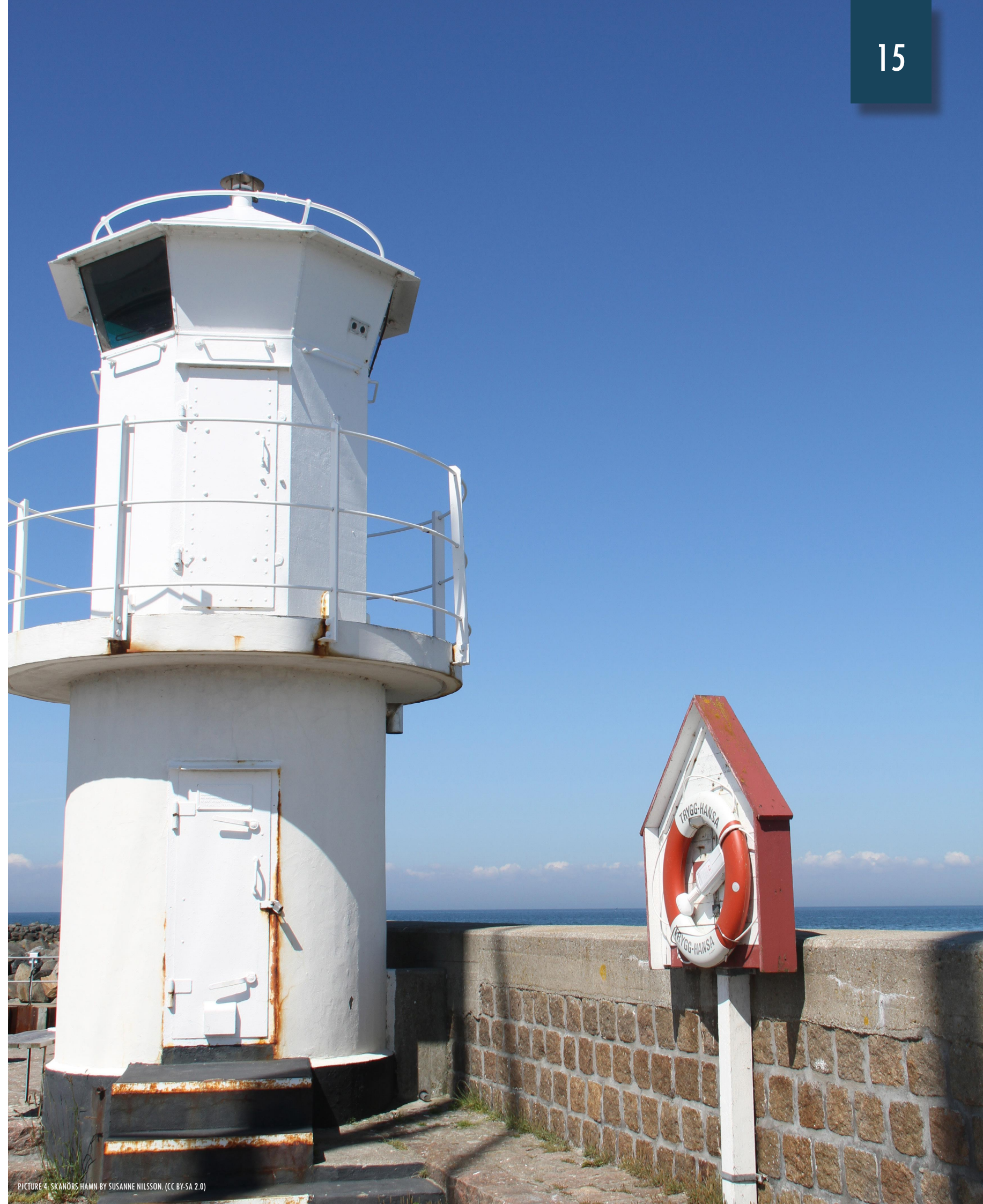
## THE CONCEPT OF COASTAL LANDSCAPE THROUGH HISTORY

Our connection to the coastal landscape dates back to our ancestors and this is described in *Coastal Change, Ocean conservation and Resilient Communities* by professor John R Gillis. Gillis point out that modern humans, *homo sapiens*, are in recent finding to be coastal dwellers originally living on the shores of South Africa approximately 164,000 years ago. Gillis explain the reason behind the coastal living seems to be caused by drought in the inland areas and therefore humans seeking richer environments. The development of the human brain, tool and language inventions gave them the abilities to take advantage of the assets from both land and water, and the unique environment the coastal landscape consist of (Gillis 2016). In *Ecotones and ecological Gradients* professor Salit Kark describes the transition the shoreline creates as an ecotone. Kark defines the ecotone as an area which creates a gradient between two biomes, characterized by its rich diversity (Kark 2013).

Later on, the human society spread along the coasts from Africa to Asia, Australia, Europe and America. Scientist believed at first that humans came to America from inland, this theory is called the Clovis-first model but later archaeological evidence shows that human came to America much earlier than thought by traveling along the shorelines (Gillis 2016). The new theory *Kelp highway*, that humans spread along the shorelines, gained a foothold among the scientist and when evidence of settlement from at least 14,500 years ago was found the Clovis-first theory collapsed (Science 2017). Foragers had strategies like moving inland when the water was threatening in this way the people were flexible and adaptable to the landscape. The concept of harbours arrived first in the nineteenth century and small fishing villages came between seventeenth and eighteenth century (Gillis 2016). Barker describe the foragers as having a great understanding for the coastal landscape they inhabited and by collecting and hunting food they stayed self sustaining by living together with nature with a adapting and flexible approach (Barker 2009).

A great milestone in the human history with water is the prehistoric agricultural revolution, also known as Neolithic Revolution, about 12,000 years ago. This is when our relationship with nature changed and we went through a transition from the moving hunting gathering lifestyle along the shore to one of agriculture and settlement. This was a profound change in humans relationship to the landscape. We started to domesticate nature rather than adapt to it which led us to increase in number (Barker 2009). This new approach come to influence us even today, especially our view on the coastal landscape.

THE PICTURE SHOWS A LIGHTHOUSE AT THE PORT OF SKANÖR.



PICTURE 4: SKANÖRS HAMN BY SUSANNE NILSSON. (CC BY-SA 2.0)



## LIVING WITH WATER

Can we find a key in coastal living in how communities around the world live? The coastal landscape comes with economic benefits and therefore are human settlements often more concentrated in the coastal zone than elsewhere (UN 2018). The activity of humans around the coast put great pressure on the ecosystem that can be found near the coast. However, even if flooding and sea level rise is threatening, people have learned to live with water and taken advantages of the assets the coastal landscape offers (UN 2018).

One example are Bangladesh extremely vulnerable (World Ocean Review 2018) because the majority of the population are settled in the lowest riparian region (GIAHS 2018). Bangladesh have suffered from extremely low agricultural production because of cyclones, rainfall, salt damage and of crops sweeping away because of flooding. The consequences have made farmers of Bangladesh to be inventive and adaptive to the environmental conditions and changes. Therefore, they have developed floating gardens where they can grow crops without soil (GIAHS 2018). This adaptive approach aimed to integrate with water to find new opportunities for the coastal living people of Bangladesh.

Undeveloped and poorer coastal communities have often the option to either adapt or retreat confronting flooding and sea level rise because of the lack of financial possibilities. While wealthier communities are often in the position to have the possibilities to protect themselves from these problems (World Ocean Review 2018). What approach a community can take to handle water related problems seem to be linked to what financial conditions a country has, which in turn are related of the size of the population. By this it can be assumed that by looking at the economic structure of a community it can be possible to see what approach they are able to adopt.

## RISK TAKING IN CLIMATE ADAPTATION

According to *United Nations International Strategy for Disaster Reduction*, how vulnerable or resilient we are against natural hazards depends on how we cultivate our food, where and how we shape our built environment, what kind of government we have and how our financial system works (UNISDR 2018). The economist and academic researcher Stéphane Hallegatte presents in *Natural Disasters and Climate Change – An Economic Perspective* an interesting approach in dealing with “good” risk-taking and “bad risk-taking”. “Bad” risk-taking is in for example political economy obstacle, where decision-makers are reluctant to invest in risk management due to the high cost of immediate risk management while the profits often are long-term and less visible (Hallegatte 2014). Hallegatte argues that sometimes, instead of building flood protections, a more efficient approach in risk management could be to secure connections for work by resistant infrastructure, in safe housing areas (Hallegatte 2014).

Reading about different ways to solve (or reduce) the risks when it comes to natural hazards, different approaches and ways on how we look at the problem comes up. Should our built infrastructure prepare for the worst but hope for the best? Accordingly to sources, and mostly the strategy the Netherlands have had, we do believe that we need to prepare for the worst but hope for the best when it comes to disaster risk reduction.

Nevertheless when it comes politics, the economic perspective always plays a vital role, it cannot be emphasized.

## THE ONGOING DEBATE - LONG TERM AND SHORT TERM STRATEGIE

What can we do to reduce the risk of water related disasters to occur? Across the world different strategies and tactics have been used to adapt to rising sea-levels and prevent flooding, but which strategy is the best can be discussed. In *Coastal change, ocean conservation and resilient communities* are ideas about the coastal landscape explored and discussed by professionals. In the book, landscape architect Marcha Johnson lifts the problem with the disconnect between those who see the benefits as well as the damage of trying to control coastal landscape, and those who are supporting built structures like sea gates and wave breakers to reduce storm surge but would do less to act against the damage of rising sea-levels (Johnson 2016). Indeed, the attitudes differ in what approach to consider. In the publication *Facing up to rising sea levels: Retreat? Defend? Attack?* by Institution of Civil Engineers (ICE) they look into three main approaches. The publication aims to create awareness and communicate a long term thinking in water management (ICE 2007).

Should we retreat, defend or attack? In facing up to rising sea-levels ICE distinguished three strategies to water related problems of the coastal landscape. The first one is (1) retreat which means relocate buildings to safer grounds and allow the water to flood former built areas. The second approach is (2) defend which is meant by protecting the built environment from the water to enter. The last approach is (3) attack which is to step out from the inland areas and create urban sprawl into the sea (ICE 2016). These strategies have influenced the discussion about rising sea levels and flooding as well as being criticised. Tomas Germundsson, professor in human geography, and Carola Wingren, professor in landscape architecture, argue that the terminology are more or less a hierarchy and that the retreat approach can come across as a defeat. They explain that many strategies for coastal protection often apply a military approach and terminology, for example the one in ICEs publication (ICE 2007), which have contributed to increased negativity towards the ocean (Germundsson & Wingren 2017).

## REFERENCE PROJECTS

To practically gain knowledge about climate change adaptation, five reference projects have been chosen to inspire us in the development of the design principles and further contribute to the discussion about resilience. Projects with different challenges and design approaches were chosen, in order to provide a broad range of strategies to discuss. The criteria for choosing the reference projects are; (1) Large scale projects, (2) Projects dealing with at least one water related problem, (3) Different approaches in dealing with resilience and (4) Project from different parts of the world and preferably different landscape offices.

Large scale projects were chosen in order to strive for similarities with our

own large scale case study. Projects dealing with at least one water related problem were chosen due to the relevance to the subject of the thesis. Different approaches in ways of dealing with resilience and coastal protection were chosen in order to gain knowledge of different coastal protections and further contribute to the debate about resilience. Finally we choose projects from all over the world in order to gain knowledge and inspiration on how climate change adaptation and resilience are dealt with in an international perspective.

The reference projects on the next page are presented with a description of the main challenges of the project and which characteristics and tactics they implemented in the project.





PICTURE 5: ZANDMOTOR BY RIJKSWATERSTAAT/ JOOP VAN HOUDT ( CC0)

THE PICTURE SHOWS THE SAND MOTOR PROJECT ON THE DELFLAND COAST IN THE NETHERLANDS.



PICTURE 6: MAESLANT KERING BY BERKNOT, (CC BY-SA 2.0).

THE PICTURE SHOW THE MAESLANT BARRIER.



PICTURE 7: ISLE DE JEAN CHARLES BY KAREN APRICOT (CC BY-SA 2.0).

THE PICTURE SHOW DAMAGE ON ISLE DE JEAN CHARLES, CAUSED BY ENVIRONMENTAL PROBLEMS.

## REFERENCE PROJECT 1: THE SAND MOTOR

**NAME:** Sand Motor Delfland Coast

**LOCATION:** Delfland Coast, the Netherlands

**BEHIND THE PROJECT:** Building with Nature, a pilot project involving public authorities, private companies and research institutes

The west part of the Netherlands is located below sea level with a shoreline which is suffering from coastal erosion (De Zandmotor 2018). The Sand Motor aims to form a nature based flood defence for protecting the coastal landscape by using natural processes (Eco Shape 2018). The design strategy aims to channel the force of winds, waves and currents in placing 21.5 million square meters of sand on the coastline, leaving the wind and currents to gradually redistributing the sand along the shoreface, beach and dunes. Furthermore encouraging the development of new dunes, minimise the disturbance of local ecosystems, while additionally providing new areas for nature and recreation (Eco Shape 2018). Since the construction in 2011, results have shows that the project is progressing as planned. Sand is indeed spreading along the shoreline, creating new dunes, seals have been spotted and rare species have been found. However the site have also become a popular recreation area for surfers (Eco Shape 2018).

### CHARACTERISTICS:

- Valuable species, habitats and nature are threatened (Eco Shape 2018)
- Recreation spot (Eco Shape 2018)
- Natural landscape (Eco Shape 2018)

### DESIGN TACTICS:

- Relocation of sand (Eco Shape 2018)
- Living shoreline (Eco Shape 2018)

## REFERENCE PROJECT 2: MAESLANT BARRIER

**NAME:** Maeslant Barrier

**LOCATION:** Rotterdam, the Netherlands

**BEHIND THE PROJECT:** An independent committee in collaboration with Ministry of Infrastructure and Water Management, the municipality of Rotterdam and the Dutch Waterboard

The Delta Works is a serie of dams, floodgates and storm barriers aimed at protecting the port of Rotterdam from flooding. It originally started as a consequence of the North Sea flooding that occurred in 1953 and took the lives of 1,800 people. The Maeslant Barrier finalised the Delta Works and port of Rotterdam's flood protection (Schuler 2008).

The Measlant works as a flood surge barrier, closes off the New Waterway when water levels are too high and thereby protecting Rotterdam and its surrounding from flooding (Deltawerken 2004). The construction, which is movable, consists of two large steel gates that operates completely automatically (Ministry of Infrastructure and Water Management n.d).

The Maeslant, with a width of 210 meters on each door, were finished in 1997 and was used for the first time in 2007. With the global change and rising sea levels, the Dutch Government predicts that the Maeslant barrier will be more frequently used in the future (Schuler 2008).

### CHARACTERISTICS:

- Extreme vulnerability to flooding and sea level rise (Ministry of Infrastructure and Water Management n.d)
- Located near economic interests (Rotterdam Climate Initiative 2013)

### DESIGN TACTICS:

- Sea gate (Deltawerken 2004)
- Storm surge barrier (Ministry of Infrastructure and Water Management n.d)

## REFERENCE PROJECT 3: ISLE DE JEAN CHARLES

**NAME:** Isle de Jean Charles

**LOCATION:** Louisiana, US

**BEHIND THE OFFICE:** The state of Louisiana's Office of Community Development-Disaster Recovery Unit (OCD-DRU)

On Isle de Jean Charles local website they describe their island as a narrow island and the home for the tribe Biloxi-Chitimacha-Choctaw. Isle de Jean Charles is located in Terrebonne Parish, Louisiana US, and have numerous of environmental problems causing people to move away and relocate their homes to safer areas. The problems are explained as oil and gas companies have exploited the surroundings causing consequences like salt water intrusion and erosion. Furthermore, actions against the sea level rise and flooding have been taken, in this case using levees, but later created land sinking because of the lack of soil renewal. These changes in the environment have affected the island's biodiversity negative because of changed environmental conditions of the island (Isle de Jean Charles 2018).

In 2016 Isle de Jean Charles was the first community in US that received federal assistance to retreat to safer areas because of the untenable situation of climate threats. Around 80 full time residents are supposed to be relocated to the new home that are about nine feet above sea level. The relocation site will make the access easier to services, jobs and schools and furthermore protect the community from the environmental problems (NOLA 2017).

### CHARACTERISTICS:

- Low density population (NOLA 2017)
- Rural area (NOLA 2017)
- Due to coastal protection requirements the islands struggles with maintaining a good economy (GSN 2016)
- Extreme environmental conditions (Isle de Jean Charles n.d)
- Unique community (Isle de Jean Charles n.d)

### DESIGN TACTICS:

- Relocation (NOLA 2017)
- Levee (Isle de Jean Charles n.d)
- Elevated roads (Isle de Jean Charles n.d)
- Transportation by boat (Isle de Jean Charles n.d)



REFERENCE PROJECT 4: BLUE DUNES

NAME: Blue Dunes: The Future of Coastal Protection

LOCATION: Offshore New York and New Jersey, US

BEHIND THE PROJECT: WXY architecture + urban design, West 8 Urban Design & Landscape Architecture, AIR Worldwide, ARCAIDS, BJH Planning & Design, Stevens Institute of Technology, and Varisk Analytics

As a result of Hurricane Sandy’s devastated impact on the Northeastern coast of the United States in 2012, causing a significant number of lost lives and billions of dollars in damage, Hurricane Sandy Rebuilding Task Force in partner with the U.S Department of Housing and Urban Development proclaimed a innovative design competition, Rebuild by Design (Rebuild by Design n.d). One of the finalist in the competition was the proposal The Blue Dunes: The Future of Coastal Protection, which aimed to address and mitigate the damage of future storms in a changing climate (WXY n.d.) in a new form of designed coastal protection (Rebuild by Design n.d.).

The project, based on a system of artificial barrier islands centered in the New York/ New Jersey harbor, aims to protect the Mid-Atlantic Coast (Weisz 2018). The project worked with understanding the natural processes of nature in creating a multi-functional system that could change over time and evolve along with nature (Rebuild by Design n.d.). This approach offers an effective line of defense for a wide variety of storm types, furthermore would provide an unique ecosystem with rich biodiversity, providing habitats for numerous coastal species and opportunities for education and recreation (WXY n.d.). The proposal brought together a wide spread of professions such as designers, climate scientists, financial advisors, risk management and was competed in 2014 (WXY n.d.).

CHARACTERISTICS:

- High density population (World Population Review 2018)
- Enhance and restore valuable nature (Rebuild by Design n.d.)
- Protect from storm surge (Rebuild by Design n.d.)

DESIGN TACTICS:

- Artificial islands (Rebuild by Design n.d.)
- Living shoreline (Rebuild by Design n.d.)
- Relocation of sand (Rebuild by Design n.d.)
- Boardwalk (Rebuild by Design n.d.)
- Breakwaters (Rebuild by Design n.d.)

REFERENCE PROJECT 5: SHANGHAI HOUTAN PARK

NAME: Shanghai Houtan Park

LOCATION: Shanghai, China

BEHIND THE PROJECT: Turenscape Landscape Architects

The former brownfield site has been designed into a constructed wetland with the purpose of improving flood control. Located by the Huangpu river the site had problems with both land and water pollution making it important to first restore the polluted site. The design framework was to create an alternative flood control instead of the existing floodwall. The existing strategy with the floodwall was effective yet unsightly due to the muddy shoreline that came with the 2.1 metres tidal fluctuation.(Archdaily 2011).

This project focused on the ecological assets to deal with the difficulties of the site. The creation of a living landscape with various ecological services made a innovative design with multifunctional purpose. Shanghai Houtan Park offers several ecological services such as urban farming, flood control, enhanced biodiversity and improved water quality. Samples show that the water quality improved from the lowest

grade V to grade III which shows the power of ecological infrastructure (Archdaily 2011).

The design enable people to come closer to the river and creates a recreational and ecological space for the citizen. The footpaths follows the contours of the landscape creating several thresholds among the fields of plants, crops and flowers, inspired by the Chinese agricultural landscape. By this the park will function as a educational link between the people and nature creating a demonstration of the ecological culture (Archdaily 2011).

CHARACTERISTICS:

- Areas vulnerable to flooding (ASLA 2010)
- Polluted water (ASLA 2010)
- Demonstrative ecologic culture (ASLA 2010)
- Former brownfield (ASLA 2010)

DESIGN TACTICS:

- Floodable wetland (Landscaped Performance Series 2018)
- Living shoreline (Landscaped Performance Series 2018)
- Boardwalks (Landscaped Performance Series 2018)
- Floating structures (Floating landscaped dock) (Landscaped Performance Series 2018)
- Rip rap floodwall (Landscaped Performance Series 2018)
- Cargo pier (ASLA 2010)

THE PICTURE SHOWS THE DEVASTATED IMPACT IN NEW JERSEY AFTER HURRICAN SANDY.



PICTURE 8: 121103-F-ZZ999-391 BY JOINT-BASE MCGUIRE-DIX-LAKEHURST

THE PICTURE SHOWS THE SHANGHAI HOUTAN PARK.

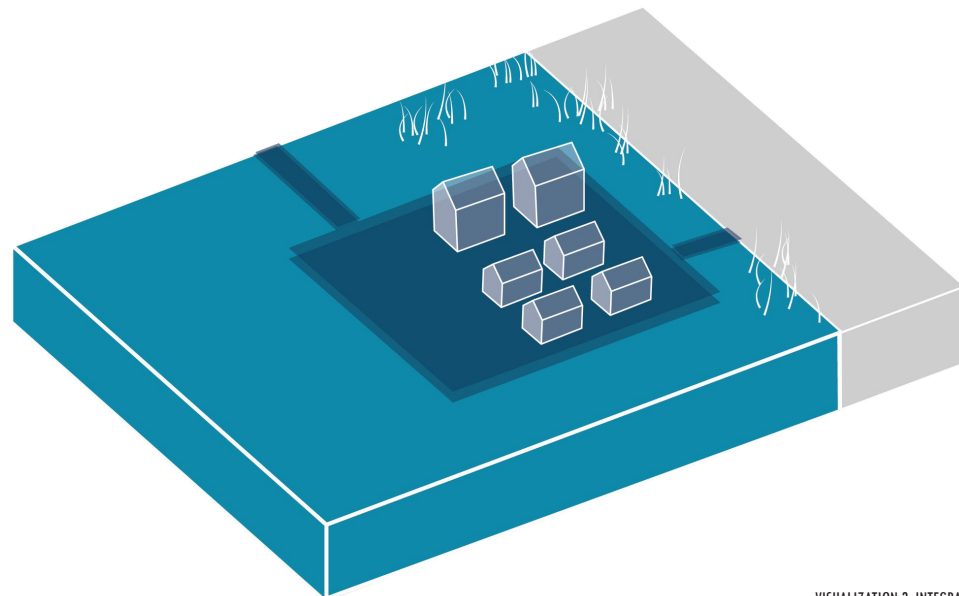


PICTURE 9: 403\_1070445 BY BRICOLEURBANISM. (CC BY-NC 2.0).



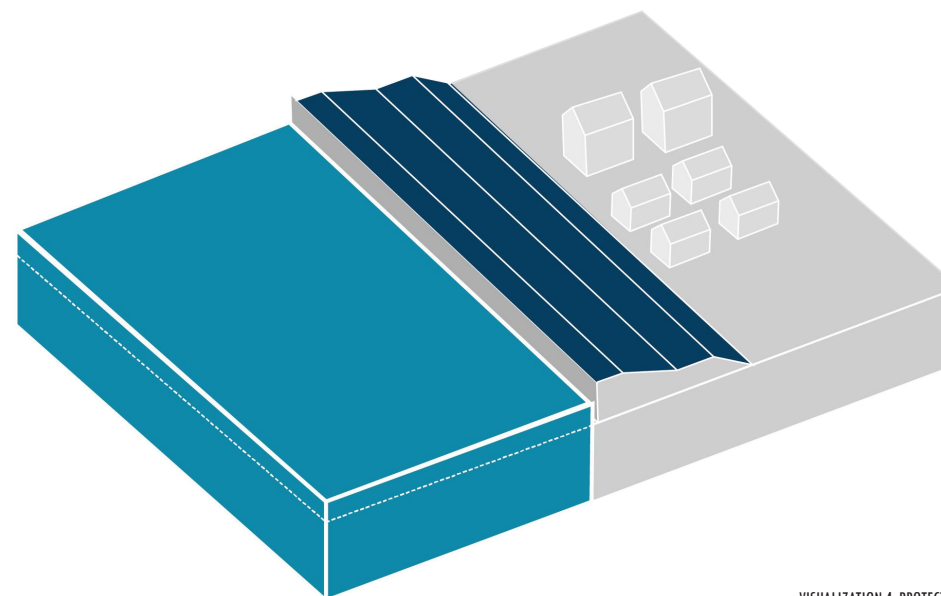
# DESIGN PRINCIPLES

## IN CLIMATE ADAPTATION AND RESILIENCE



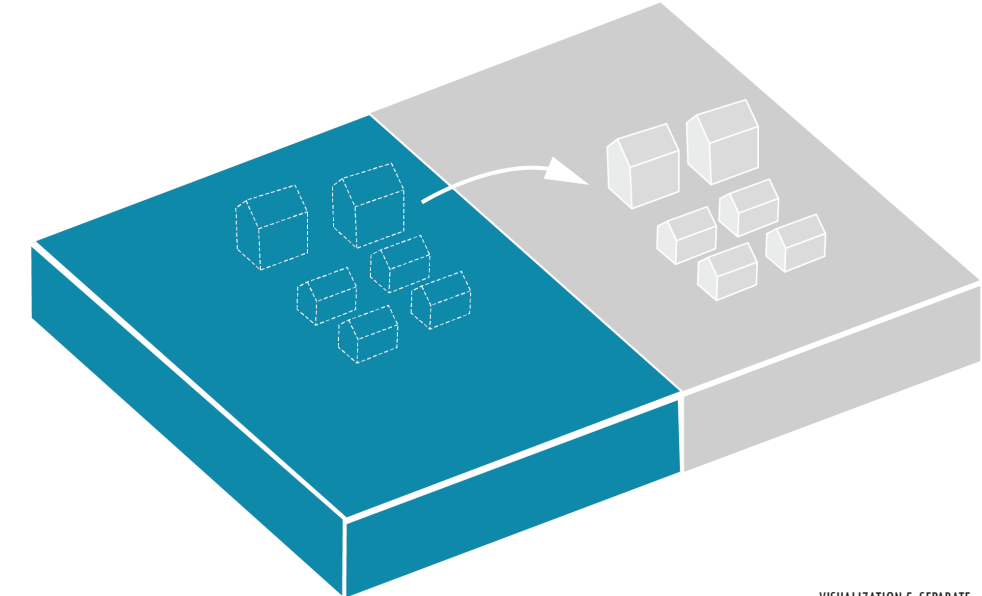
VISUALIZATION 3: INTEGRATE

### INTEGRATE



VISUALIZATION 4: PROTECT

### PROTECT



VISUALIZATION 5: SEPARATE

### SEPARATE

Three principles can be distinguished based on the knowledge gained from the literature review; (1) *The integrating principle*, (2) *the protective principle* and (3) *the separating principle*. Similar to the Building Futures and Institutions of Civil Engineer's (ICEs) three strategies *Defend*, *Retreat*, *Attack* and Donald Watson's and Michele Adam's *design responses retreat, accommodation and protection* we have distinguished three principles but used a different terminology. Our developed principles (integrate, protect and separate) can be described as different ways in how to approach the call for coastal protection. Each principle is narrowed down to a series of design tactics, which acts as different means of climate adaptation and resilience and shows further how the principles would practically be achieved. The design principles are presented later in the thesis, as a part of the case study of Falsterbo peninsula. The tactics have mainly been inspired and based on the knowledge from United Nation and our chosen reference projects.



# INTEGRATE

## THE WAY OF LIVING WITH WATER

The *integrate* principle aims to integrate a life where the water is seen as a possibility rather than an problem or obstacle. The principle refers to solutions where you slowly adapt society by *living with water* and integrate with the changing coastal landscape as in the reference project *Blue Dunes* (Rebuild by Design) and in tactics adopted by living shorelines where the natural environment can integrate into the built environment (NYC Planning 2013).

This principle takes inspiration and support in Anuradha Mathur and Dilip da Cunha's, research discussing why we draw a distinctive line to separate land and water. They question how we look at it, not about the right technology, and questioning the most fundamental thoughts about the coastal landscape. They ask themselves why flooding is criticized when it is a natural event. Flooding as something wrong is, according to Mathur and da Cunha, a product of human beliefs since it is a part of natural processes (Mathur & da Cunha 2018).

There are several examples of integrating design where buildings, nature and infrastructure have been built upon the water. It is important to understand that the integrating approach can both use tactics that are man-made, using hard structures, likewise it can be exemplified with green infrastructure. In Bangladesh for example farmers are using floating gardens, similar to hydroponic agriculture, to cultivate the water (MOA 2018).

The principle *integrate* share similarities to the definition of ICE's strategy *attack* which describe attack as "*To attack is to advance and step seaward of the existing coastline*" (ICE 2016). To step seaward is one of many tactics *integrate* include but does not necessarily have to be to built upon the water. To have an integrating approach means that the water can flood and the society adapts to it which, for example, could be to relocate new sand (Germundsson & Wingren 2017) and soften the coastal edges with green infrastructure to buffer against flooding (NYC Planning 2013)

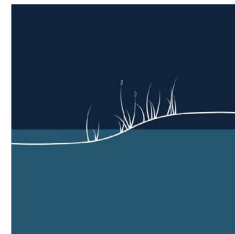
It can be discussed whether each tactic are in line with the resilience thinking. Elevated buildings for exemple protect the buildings but does not necessarily have to buffer against sea level rise and flooding. While there are buildings that are able to adapt to sea level change, so called amphibious housing, and are also effectively dealing with floods. These structures are partly floating and partly fastened in mooring posts. In this way they are able to rise because of the pressure of water, when the sea levels are high (UN, 2015).



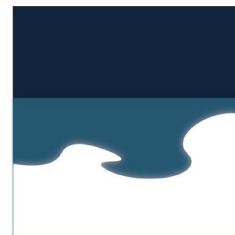
VISUALIZATION 6: FLOATING STRUCTURES



VISUALIZATION 8: SEAL RAFTS



VISUALIZATION 10: LIVING SHORELINE



VISUALIZATION 12: RELOCATE SAND/ DUNE RESTORATION

### FLOATING STRUCTURES

Floating structures aims to adapt to rising and falling water levels as well as coastal flooding (ECAP 2015). This tactic makes it possible to integrate and live near the attractive coastal landscape without the risk of be affected of sea level rise and recurring coastal floods.

### SEAL RAFTS

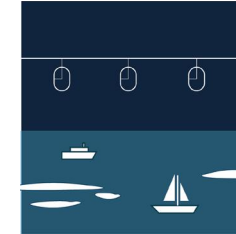
Due to the fact that Måkläppen is the only site provider in South of the Baltic Sea for seals (County Administrative Board of Skåne) the seal rafts consist of new sites provided which can furthermore to be integrated regardless the water level.

### LIVING SHORELINE

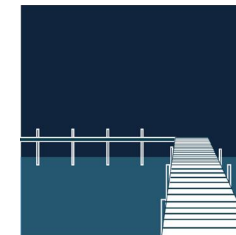
Living shoreline incorporate ecological functions with reducing the risk for coastal erosion (NYC Planning 2013). Additionally, living shoreline works in a integrating way to soften the distinction line between water and land.

### RELOCATE SAND/ DUNE RESTORATION

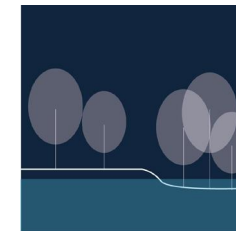
In order to strengthen the coastal landscape and its attractive attribution, making sure the features is integrated with the landscape and not disappeared in the future. Furthermore, protecting the shoreline of coastal erosion. By relocating sand and restore dunes, made in the Sandmotor project, in protecting the shoreline of coastal erosion an furthermore aim to protect the ecological features and biodiversity.



VISUALIZATION 7: NEW TYPES OF TRANSPORTATION



VISUALIZATION 9: BOARDWALK



VISUALIZATION 11: FLOODABLE PARK



VISUALIZATION 13: ARTIFICIAL ISLANDS

### NEW TYPES OF TRANSPORTATION

New types of transportation such as extended water transportation and cable cars as a alternative way of transportation. A transportation that is more adapted in living with water, using the water like Venice in Italy and its transport system fully on water - with boats, gondole and water taxis.

### BOARDWALK

The boardwalks constitutes of a structure which could be used whether the water levels are high or low. It serves multifunctional purposes in creating public places when the water levels are low and further consist of transportation when water levels are high.

### FLOODABLE PARK

Floodable areas can protect in case of coastal flooding and can work in a resilient way to recover quickly in storm events (NYC Planning 2013).

### ARTIFICIAL ISLANDS

Artificial island are floating structures that aims to create ecological functions and biodiversity (NSTA n.d) It have been successful in for example creating the artificial island Pepparholmen were a rich biodiversity has been created on the former steril island (Radio Sweden 2013).

# PROTECT

## TO MANAGE THE WATER

The *protective* principle aims to sheltering interests, for example economic interests, built environment, ecological aspects and cultural heritage etcetera. By this the urban life can go on uninterrupted within the protected site. In *Design for Flooding* by Donald Watson and Michele Adams are protection as a solution described as using sea walls, sea gates and levees but could also be protective walls of vegetation that stops water from flooding (Watson & Adams 2011). Unlike Watson and Adams we do not take soft green infrastructure, for example dunes, marsh land and living shorelines, as a protective approach. Instead we classify these solution as integrating tactics because of their purpose to engage with water like a sponge. While sea walls creating a distinctive line between land and sea.

This approach share similarities with the strategy defend in the publication *Facing up to rising sea-levels* (ICE 2007) but our principle *protect* are more focused on the aim to protect certain interest because we believe; if there is nothing to protect there is nothing to defend.

*Protect* has also taken inspiration from the approach *fortification* described in Rising tides Boston which is explained as a solution to sea level rise and flooding, typically in the form of hard infrastructures. As we also can see in the reference project *Measland Barrier's* (Reference project 2) protective flood defence, so called fortification, are these solutions often seen in cities where most economic loss can take place and are placed where they can be most effective (Rising tides Boston 2018).

While looking into a resilient way of thinking the protective principle can be discussed whether its in line with resilience. We want to point out that the protective principle are the least resilient approach of our principles but can buffer against flooding and sea level rise to some extent. Green sea walls can buffer in a small scale but are depending on how well the plants can respond to the rising tides and waves. However these green sea walls are in the grey zone between integrate and protect which makes it difficult to categorise.



VISUALIZATION 14: BREAKWATERS



VISUALIZATION 16: FLOOD BARRIERS



VISUALIZATION 18: SEA WALLS

### BREAKWATERS

Breakwaters aims to protect the coastline from waves and currents by hard structures of rocks and rubble which can be located both offshore and at the shoreline (ECAP 2015). Breakwaters could also be implemented in other structures for example boardwalks or artificial island with a protection against wind.

### FLOOD BARRIERS

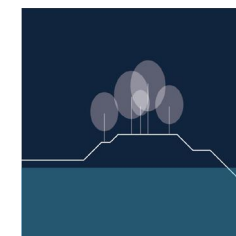
Flood barriers is a flood protection which prevent flooding and storm surges, and thereby secures settlements and infrastructure. Flood barriers as sea gates are able to close when the water level are too high (ECAP 2015).

### SEA WALLS

Sea walls is a coastline protection that protects from waves and currents (NYC Planning 2013). Sea walls are used in both the purpose to protect the coastline as well as prevent cliffs from eroding (ECAP 2015).



VISUALIZATION 15: ELAVATE EXISTING BUILDINGS AND INFRASTRUCTURE



VISUALIZATION 17: LEVEE

### ELAVATE EXISTING BUILDINGS AND INFRASTRUCTURE

In order to live near water, certain interest such as infrastructure and buildings need to be secured and protected against flood events. Infrastructure could either be constructed as floating or elevated in order to protect them (ECAP 2015).

### LEVEE

Levees works as a defense in preventing flooding (NYC Planning 2013). Levees are embankments, constructed with the purpose to control the water in preventing ocean waves to flood and keep the water out. Levees require high maintenance and regularly control. (Infrastructure Report Card 2017). The Netherlands is an example of a frequent user of levees and dikes in order to control the water levels.

# SEPARATE

## TAKE DISTANCE FROM WATER

The *separative* principle aims to separate and move away from the water with the purpose to protect certain interests. This could mean that buildings or even nature have to be relocated to safer grounds where the water can not reach (ICE 2007). This include both permanent relocation, as what happen for the community of Isle de Jean Charles (See reference project 1), and temporary relocation which partly is what happened when hurricane Katrina swept over New Orleans (NOLA 2015). However, the separating approach can be seen in planning too, in Sweden for example there is restrictions about how close you can build from the shoreline. The aim is to make the water available to the public and to ensure good environmental standards (Boverket 2018).

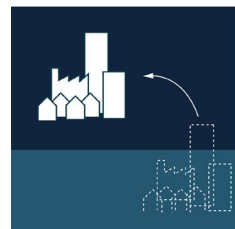
To retreat from areas which are exceptionally vulnerable can be very controversial, especially when there are residential settlement. According to UN certain parameters makes the separating approach more likely to succeed. One parameter for success is to relocate areas with low density population. The costs are possible to be less than to invest in coastal protection. If the plans of retreat are in a long term perspective people are more likely to accept to relocate to safer grounds (UN 2018).



VISUALIZATION 19: RELOCATE



VISUALIZATION 20: RESTRICTED EXPLOITATION



VISUALIZATION 21: RETREAT

### RELOCATE

Due to high risk vulnerability of flooding and rising sea level, this tactic aims move buildings to another location (ECAP 2015). To move houses when it is more suitable and the risk for either flooding or coastal erosion is less.

### RESTRICTED EXPLOITATION

To restrict exploitation means to establish areas where construction is not allowed (ECAP 2015). This works preventative in securing the coastal areas and postponing the eventual risk of retreat fully (see next description).

### RETREAT

Due to high risk or acute vulnerability of flooding and rising sea level, this tactic aims move settlement, infrastructure and all other productive activity to another location (ECAP 2015). This approach is suitable when the risk for natural disasters to occur are too high and the loss of such an event would cause huge damage and not worth risking (Watson & Adams 2011). Retreat as a solution has been taken on Isle de Jean Charles, where the climate threats were too high and constituted as a high-risk area, leaving no other option than to retreat to safer areas (Isle de Jean Charles n.d.).



# CASE STUDY OF FALSTERBO PENINSULA

## TESTING THE DESIGN PRINCIPLES AND TACTICS ON AN EMPIRICAL CASE

In order to test the design principles on a area, a case study investigating the areas challenges were made. Below the case study of Falsterbo peninsula is presented. First a description of the local extremes, second a description of the areas conditions and surrounding and finally an analysis of the opportunities and constraints of the area.

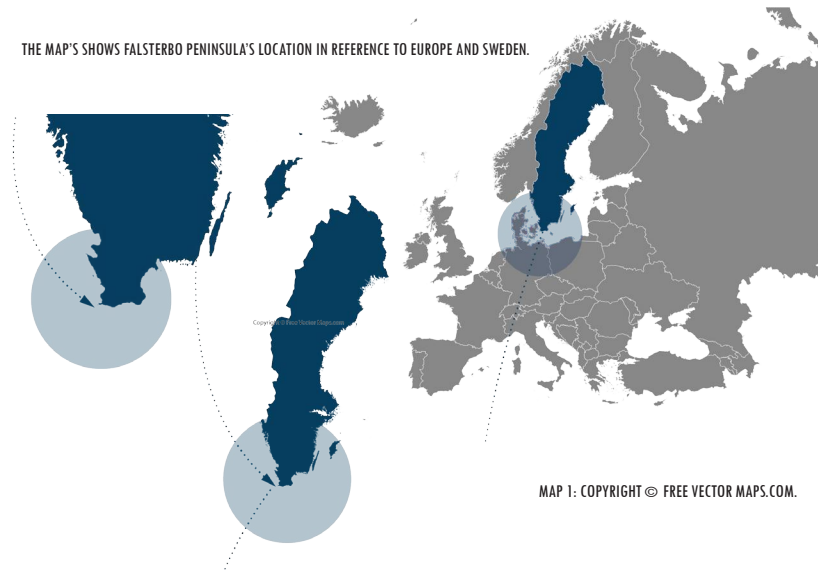
### FALSTERBO PENINSULA

Falsterbo peninsula (in Swedish *Falsterbohalvön*) is located in the south west of Sweden in Skåne County. Furthest south west on the peninsula two towns, Skanör and Falsterbo, are situated (Nationalencyklopedin 2018). Falsterbo canal is separating Skanör and Falsterbo from the mainland and the neighbouring towns Höllviken and Ljunghusen.

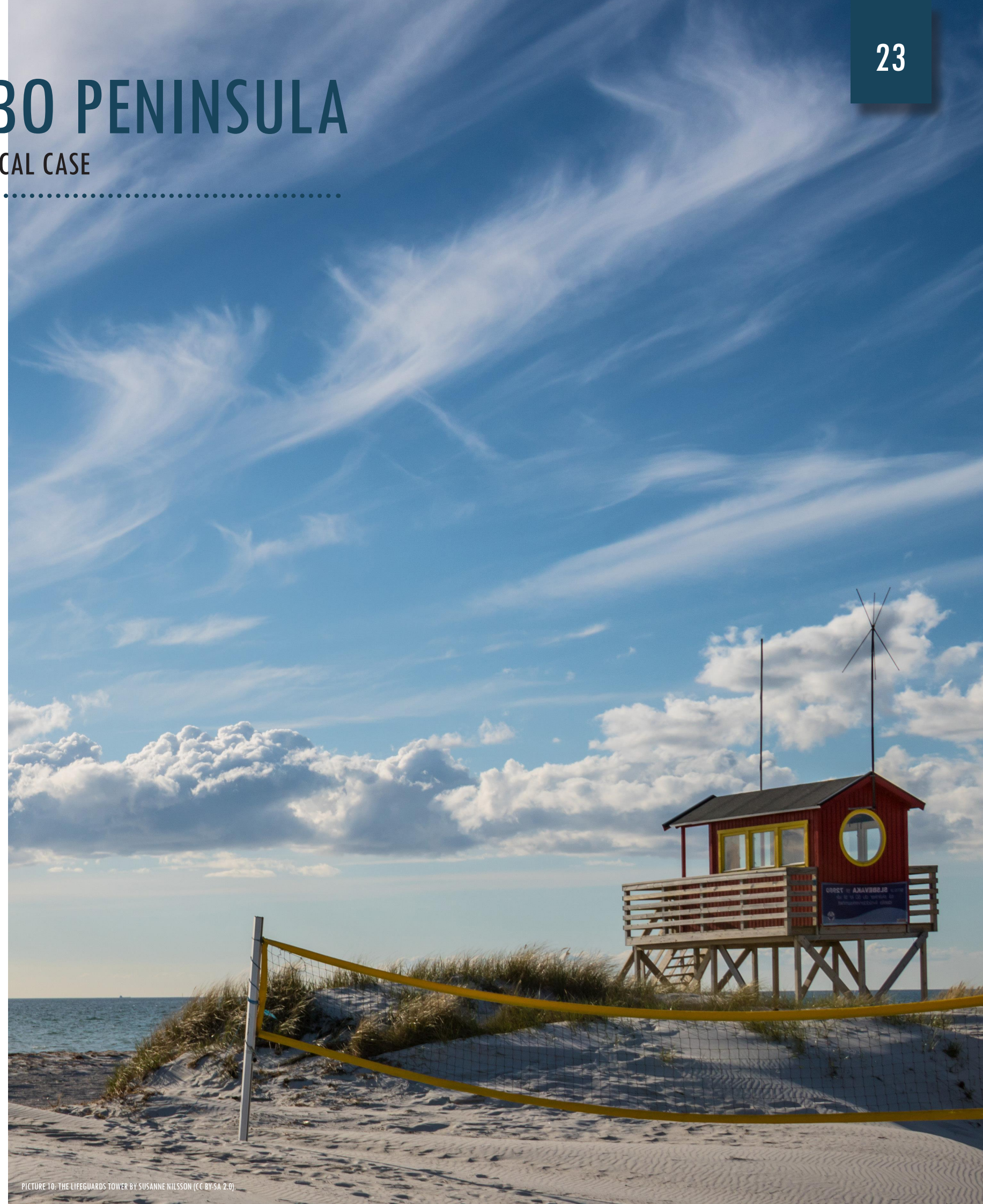
The landscape of Falsterbo peninsula was formed, less than 400 years ago, when sand and gravel were deposited around moraine that rose from the sea (The Municipality of Wellinge n.d). Falsterbo peninsula dominates with carbonates sedimentary bedrock with outer small parts of quartz-field sedimentary bedrock (SGU 2018). The soil depth is mainly between 30 and 50 meter to the bedrock with small parts of the Falsterbo peninsula with less than 50 meter. Furthermore, the area of Knävsången and Knösen measures in between 10 to 20 meter to the bedrock (SGU 2018).

The coastal areas in south of Sweden belongs to the warm temperate zone where deciduous forest dominates the local nature (SMHI 2017). The climate in Skåne County is characterized with warm and wet weather with a average temperature at zero degrees in January and 17 degrees in July. The average annual percentage rate is around 500 mm (SMHI 2016). Skåne County is characterised with its open landscape which causes frequent wind turbulence with occasionally occurring hurricanes (SMHI 2016).

Falsterbo peninsula is of great importance for recreation and outdoor life and likewise the biological values are of great value (County Administrative Board of Skåne 2018).



THE PICTURE SHOWS THE LIFEGUARDS TOWER IN SKANÖR.



PICTURE 10: THE LIFEGUARDS TOWER BY SUSANNE NILSSON (CC BY-SA 2.0).

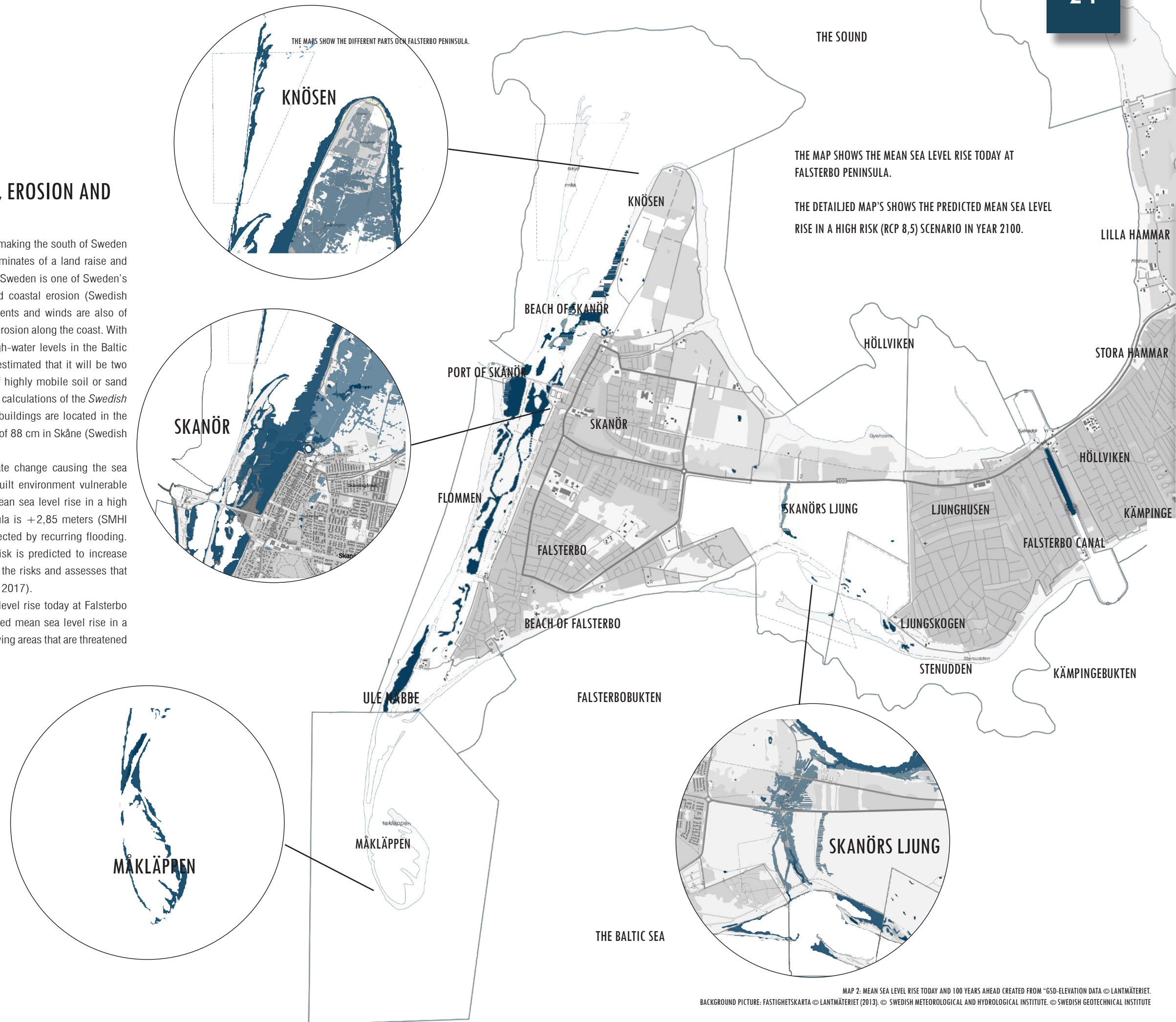


## LOCAL EXTREMES: RISING SEA LEVEL, EROSION AND FLOODING

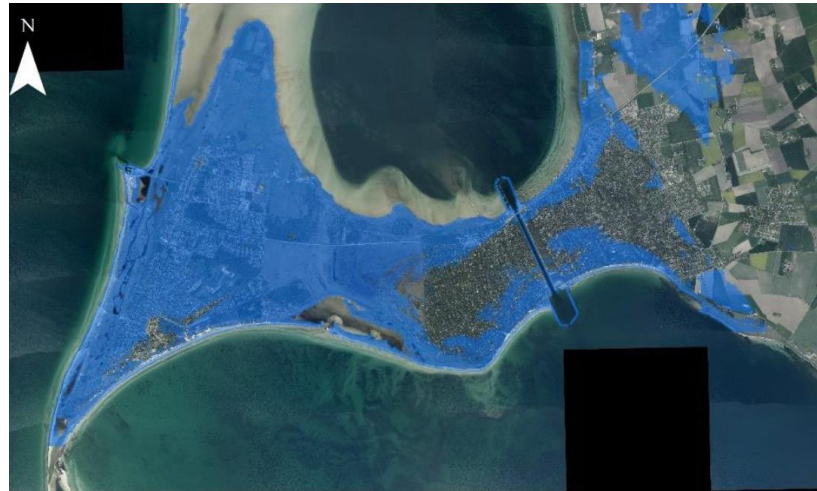
The south of Sweden is lacking the post glacial land raise, making the south of Sweden vulnerable. Skåne While the north parts of the country dominates of a land raise and therefore compensating for the sea level rise. The south of Sweden is one of Sweden's most vulnerable and exposed areas for sea level rise and coastal erosion (Swedish Government Official Reports 2007). Low-pressure movements and winds are also of great significance to sea levels and the risk of flooding and erosion along the coast. With increased dominance of westerly winds, the maximum high-water levels in the Baltic Sea will rise substantially. At the end of the century it is estimated that it will be two metres higher. Coastal erosion affects areas that consist of highly mobile soil or sand (Swedish Government Official Reports 2007). According to calculations of the *Swedish Commission of Climate and Vulnerability* (2007) 150.000 buildings are located in the area susceptible to erosion in the case of a rise in sea level of 88 cm in Skåne (Swedish Government Official Reports 2007).

For Falsterbo peninsula there is a risk of climate change causing the sea level to rise. Such change will make the coastline and built environment vulnerable for flooding and coastal erosion. The highest predicted mean sea level rise in a high risk scenario (rcp 8,5) in year 2100 for Falsterbo peninsula is +2,85 meters (SMHI 2018). Falsterbo peninsula is described as a low area affected by recurring flooding. The damage on built environment is today rare, but the risk is predicted to increase in the future. The municipality of Vellinge looks serious at the risks and assesses that precaution of physical flood protection is required (SWECO 2017).

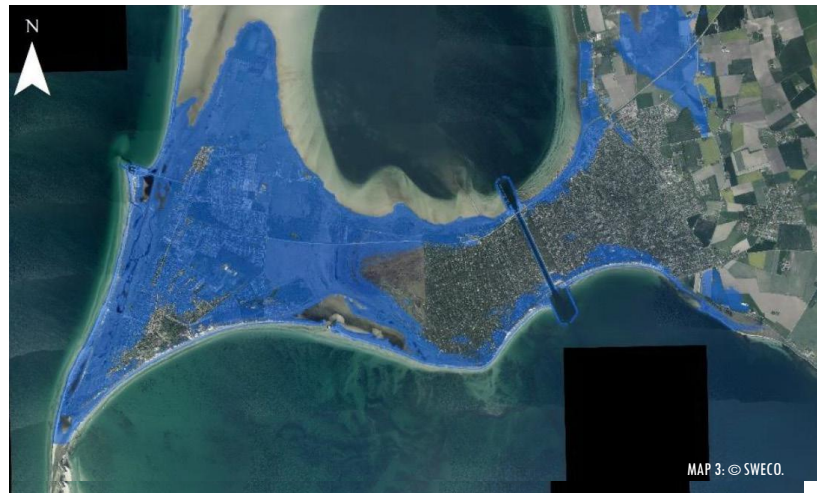
To the right the large map shows the mean sea level rise today at Falsterbo peninsula and the detailed maps shows further the predicted mean sea level rise in a high risk scenario in year 2100. On the next page maps showing areas that are threatened by flooding from the sea are presented.







MAP 3: AREAS THREATENED BY FLOODING BY BACKFLODEN IN TODAY'S CLIMATE



MAP 4: AREAS THREATENED BY FLOODING BY BACKFLODEN IN YEAR

## SITE CONTEXT - EXISTING ENVIRONMENT

Falsterbo peninsula contains of three types Nature 2000 sites; *Skanörs Ljung with bird protected area Ängsnäset*, *Flommen's protected area* and *Måkläppens animal protected area*. Furthermore, the peninsula is divided by several unique landscape sites; *the coastal landscape*, *Knäsvången* and *Knösen*, *Falsterbo vång* and *Måkläppen*.

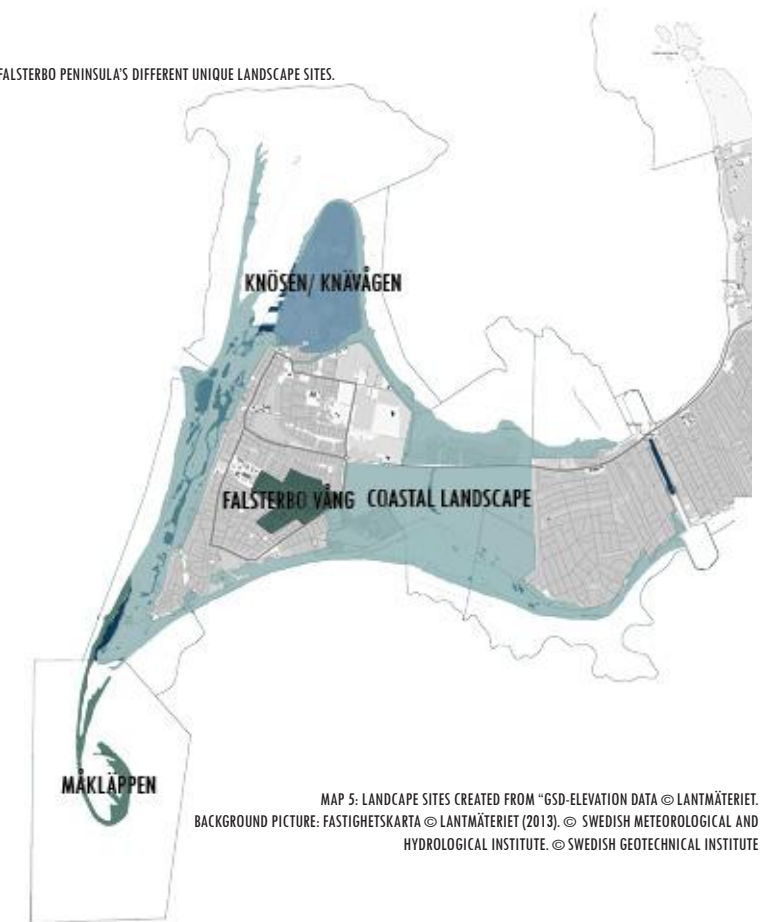
The *coastal landscape* of Falsterbo's peninsula contains of unique natural environment, which cannot be found anywhere else in Sweden (Sweden's Environmental Protection Agency 2017). It is constantly changing due to wind, waves and currents (County Administrative Board of Skåne 2018). The shorelines, especially the beach of Falsterbo, are characterised with sand dunes, covered with fine-grained sand of quartz. The area has an exceptional high recreation value and together with the forest areas constitutes of great value to the resident's outdoor life (County Administrative Board of Skåne 2018). Due to its geographical location and outline the coastal landscape, the area is one of the country's most important resting places for migratory birds. The area *Flommen*, located in the west part of the peninsula, also constitutes of one of Sweden's best habitat of different kind of toads. Furthermore, the vegetation and flora constitutes of several unusual species of plants (County Administrative Board of Skåne 2018). The marine areas with surrounding coastline beaches creates extraordinary habitats for flora and fauna. It is the sandy seabed, the short water depth and the strong currents that creates a productive and enriched environment for nature and wildlife as well as an important area for breeding. Furthermore offers the marine area's the most profitable reproductive site in Sweden for turbot (County Administrative Board of Skåne 2018).

*Knäsvången* and *Knösen* contains primary of well-maintained pasture land and are of great biological and geoscientific value. The area are of important value for nesting and staging birds. The pasture land is also of great importance for several species of amphibians. The area consist the are of many protection system for the shoreline (County Administrative Board of Skåne 2018).

*Falsterbo vång* consist of an old agricultural land. Today the area is of great of recreational where parts of the site's used for horse riding (County Administrative Board of Skåne 2018).

*Måkläppen* is a sandy, low peninsula, located on the outermost part of Falsterbo peninsula (Nationalencyklopedin). The size and form of the peninsula are constantly changing. Måkläppen is of great value for many nesting seabirds and as well an important living area for anseriformes. South of the Baltic Sea, Måkläppen is the only site provided for the grey and harbour seal. Together with the processes of geological and the biological values, the overall natural value of Måkläppen is very high (County Administrative Board of Skåne 2018).

THE MAP SHOWS FALSTERBO PENINSULA'S DIFFERENT UNIQUE LANDSCAPE SITES.



MAP 5: LANDSCAPE SITES CREATED FROM "GSD-ELEVATION DATA © LANTMÄTERIET. BACKGROUND PICTURE: FASTIGHETSKARTA © LANTMÄTERIET (2013). © SWEDISH METEOROLOGICAL AND HYDROLOGICAL INSTITUTE. © SWEDISH GEOTECHNICAL INSTITUTE

## OPPORTUNITIES AND CONSTRAINTS ANALYSIS

The opportunities and constraints analysis is made to understand and outline the possibilities and limitations of the site, summarized from the site analysis and literature study. Economical, social, ecological and cultural aspects are taken into consideration to provide a comprehensive analysis to underlie the design principles. The analysis should be read as possibilities and limitations rather than positive and negative features of the site.

The diagram presented on the next page is structured accordingly after topics which are described in more detail in the right column. The right column explain how the different aspects affects Falsterbo peninsula. The knowledge is drawn from both the literature review, reference projects and our own analysis. References from the United Nations (UN) Sustainable Development goals will be brought up in the scheme.

OPPORTUNITIES	SCIENTIFIC FOUNDATION	REFERENCE OBJECT	OWN ANALYTICAL CONTRIBUTION
ECONOMIC ASCEPCTS	Good economic conditions based on Statistics Sweden. The households in municipality of Vellinge have the highest disposable income in the Lund-Malmö region. Vellinge is also a popular area and the population have increased since 1981 (Municipality of Vellinge 2016).	An example of a city that takes economical benefits mainly of its attractive location by the coast is Venice in Italy.	Good economic conditions thanks to the tourism. Economical, as well as social, benefits comes with an attractive location by the coast.
ECOLOGICAL ASCEPCTS	The area consist of a unique natural environment that cannot be found anywhere else in Sweden (Sweden's Environmental Protection Agency 2017). The marine areas with surrounding coastline beaches contains of productive and enriched environments, which creates extraordinary habitats which work as important areas for breeding (County Administrative Board of Skåne).	Example of an project that valued the ecological aspect and the preservation of habitats is the Sandmotor project.	
CULTURAL ASCEPCTS	The area have an exceptional high recreation value and outdoor life (County Administrative Board of Skåne).	Example of an project which took an approach to strengthen the cultural identity and connect people in the city is Yanweizhou park in China, which is an floodable park.	From our site analysis we perceived the area as having a strong identity with a great recreational value especially during summer.
LANDSCAPE AND CHARACTER	The shorelines, especially the beach of Falsterbo, are characterised with sand dunes, covered with fine-grained sand of quartz (County Administrative Board of Skåne).		The peninsula consist of large nature areas that can work as a buffer during intense cloudbursts.
OTHER FACTORS			After studying the effects of global warming, the size of the problem and what it will cause in the future we perceive that it is wide known by the municipality and government, which both is working actively against it.
CONSTRAINTS	SCIENTIFIC FOUNDATION	REFERENCE OBJECT	OWN ANALYTICAL CONTRIBUTION
ECONOMIC ASCEPCTS	Economical vulnerability comes with an attractive location by the coast, due to the fact that exclusive areas is located near the coast (Aerts et al. 2014)	Hurricane Sandy is an example on an huge economic loss regarding human settlements near the coast. Also the Maeslant Barrier is an example of a barrier to protect Rotterdam.	Conclusions after reading the literature is that the peninsula depends on tourism and its attractive location close to the coast. It would be a big economic loss if the landscape would disappear. Could also cause insurance complications.
ECOLOGICAL ASCEPCTS	One of the sustainable development goals is Life below water (Goal 14). It aims to "Conserve and sustainably use the oceans, seas and marine resources" (UN 2018). Another goals is Life on land (Goal 15). Aims to "Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss" (UN 2018).	The projects Shanghai Houtan Park, Blue Dunes and Sandmotor takes all an ecological approach. Either in preserving unique ecosystems or creating new ones.	It is important, which is stated in the sustainable development goals, to preserve the natural environment on land as well as in the ocean. It is vital to secure the ecological factors.
CULTURAL ASCEPCTS			Outread from the literature and site analysis, our oppintion is that the area has a strong identity with a great recreational value during summer. We believe that it is important to keep this identity!
CLIMATE	The area is located low and is affected of recurring flooding (SWECO 2017), coastal erosion (Swedish Government Official Reports 2007) and a rise in sea level (The Swedish Commision on Climate Change 2007). One of the sustainable development goals is Climate action (Goal 13). It aims to "Take urgent action to combat climate change and its impacts" (UN 2018). The municipality of Vellinge assesses that precaution of physical flood protection is required (SWECO 2017).	The projects Shanghai Houtan Park, Blue Dunes and Sandmotor takes all an ecological approach. Either in preserving unique ecosystems or creating new ones.	Stated in the sustainable development to take urgent actions to climate change. Gained in the literature review as well as the site analysis is that Falsterbo peninsula is vulnerable in the future due to the changing climate. And we believe that precaution against it is needed.
LANDSCAPE	The coastal landscape is constantly changing due to wind, waves and currents (County Administrative Board of Skåne).		We believe it is an vulnerability in built areas/ settlements located as close to the coast, both social and economic
OTHER ASPECTS	<i>Peace, justice and strong institutions</i> (Goal 16). Aims to " <i>Promote just, peaceful and inclusive societies</i> " (UN 2018). Partnership for the goals (Goal 17). " <i>Revitalize the global partnership for sustainable development</i> " (UN 2018).		A never-ending discussion on how to approach these kinds of problems and its impacts. The municipal-ities is pressured in building new housing in today's housing shortage and the government's interest in creating new job-opportunities. Also the landlords interest in building houses in attractive locations near the coast.

TABLE 3: DIAGRAM OVER OPPORTUNITIES AND CONSTRAINTS



# ARCHI-PELAGO

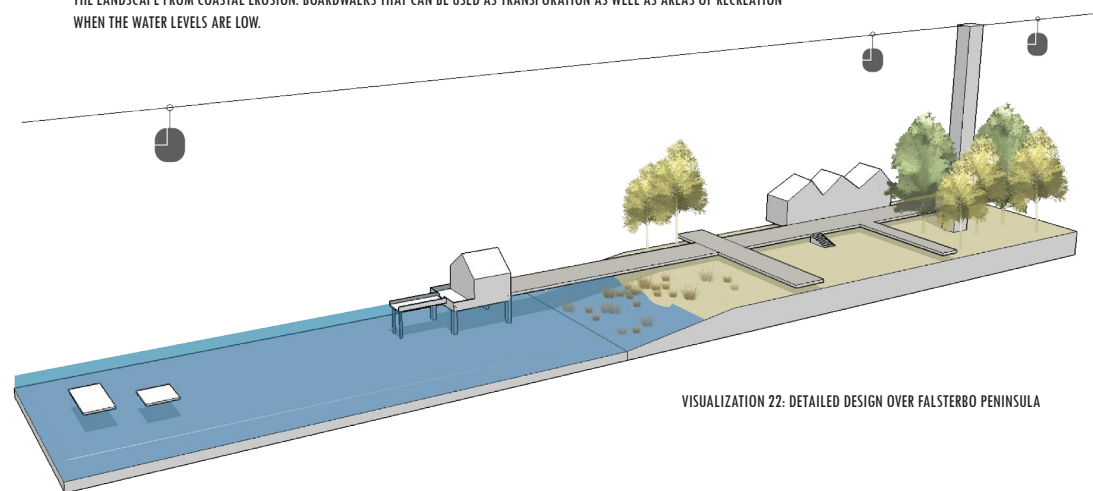
## TESTING THE DESIGN PRINCIPLES AND TACTICS ON FALSTERBO PENINSULA

**ARCHI** stands for the architect, in this proposal landscape architect.

While **PELAGO** comes from latins pelagus and means ocean. Archi-Pelago aims to enlighten a landscape architect's perspective on flooding and sea level rise in relation to resilience. Archi-Pelago describes further on an architect's way of connecting islands, or in this case a series of tactics for coastal protections. The outcome of the project creates several opportunities to not only protecting us from the water but to see new ways to actually live with water or to use the water as a possibility.

The design proposal of Falsterbo peninsula is a tool for testing the design principles and exploring what tactics the principles foreground. It is a part of the design framework and will act as a guide for policymakers, planners and designers. The design proposal are specific to the built and natural environment of Falsterbo but can become a inspiration for other projects because of its theoretical and philosophical background (See appendix for the design proposal and contribution to the IFLA 2018 student landscape architecture design competition).

THE VISUALIZATION SHOWS THE DETAILED DESIGN OVER FALSTERBO PENINSULA. RAFTS THAT SECURE LIVING AREAS FOR THE SEALS. BUILT STRUCTURE ON POLES THAT SECURES THE BUILDINGS FROM SEA LEVEL RISE AND FLOODING. LIVING SHORELINE THAT PROTECTS THE LANDSCAPE FROM COASTAL EROSION. BOARDWALKS THAT CAN BE USED AS TRANSPORTATION AS WELL AS AREAS OF RECREATION WHEN THE WATER LEVELS ARE LOW.

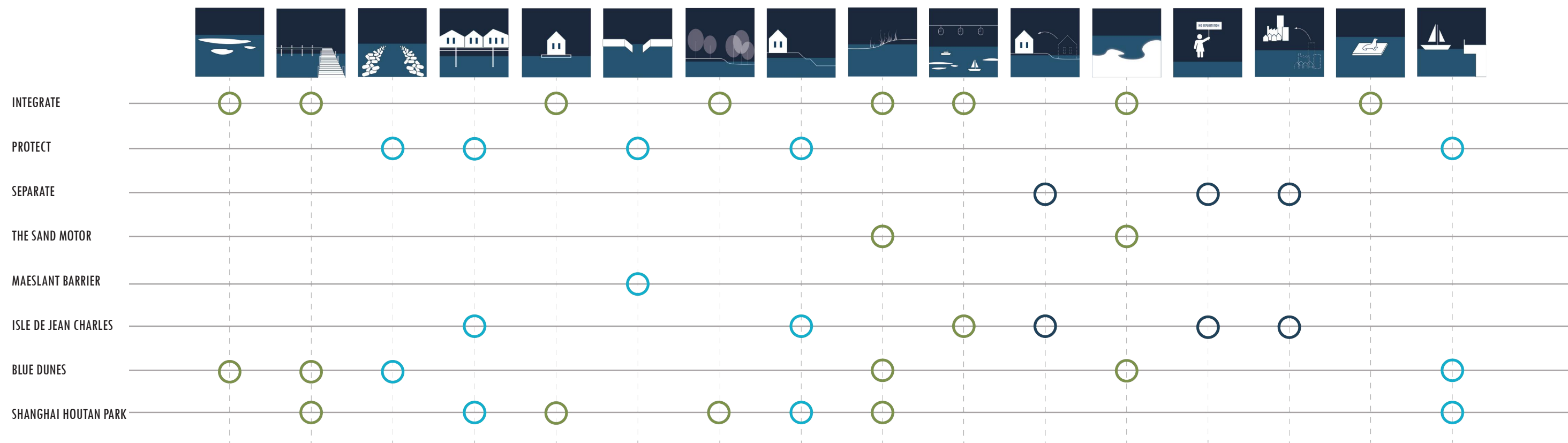


VISUALIZATION 22: DETAILED DESIGN OVER FALSTERBO PENINSULA

*The visualization shows the seal rafts with the seals enjoying themselves.*



VISUALIZATION 23: ILLUSTRATION OVER ARCHI-PELAGO

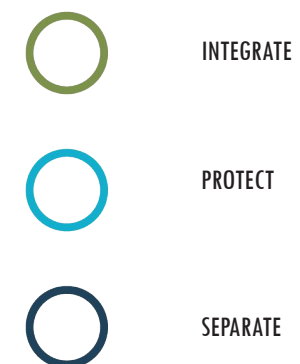


DESIGN TACTICS IN RELATION TO DESIGN PRINCIPLES AND REFERENCE PROJECTS

Above, a diagram is showing the summary of which tactics the design principles and reference project is taking. In order to get an overview over the result, this diagram aims to link the reference projects to the design principles and identify further which approaches the different projects is taking. According to our diagram, Sandmotor relates to the integrating principle and Isle De Jean Charles to the separating principle.

- Sandmotor identifies with the integrating principle
- Maeslant Barrier identifies with the protective principle
- Isle De Jean Charles identifies with the separating principle but holds protective tactics
- Blue Dunes identifies with the integrating principle but holds one protective tactic
- Shanghai Houtan Park identifies with both the integrating and protective principle

TABLE 4: DIAGRAM OVER TACTICS IN RELATION TO PRINCIPLES AND REFERENCE PROJECTS





# DISCUSSION

## CLIMATE AND RESILIENCE IN RELATION TO LANDSCAPE ARCHITECTURE



PICTURE 11: BATHING CABIN BY SUSANNE NILSSON (CC BY-SA 2.0).

THE PICTURE SHOWS A BATHING CABIN AT SKANÖR.

In this section we will review the result in the context of the literature and our own thoughts and knowledge of the subject. The discussion is also including the limitation of the research as well as the implications of the findings.

*What can landscape architect's discipline learn practically from; and contribute to; the ongoing climate change adaptation and resilience concepts?*

The landscape architect's discipline can learn a lot from looking into the resilience thinking in the aspects of climate change. Climate change call for dynamic solutions that can adapt to environmental change, while we often tend to design static solutions that have to be rebuilt in a couple of years after. With this in mind we also have to gain knowledge of design in a long term perspective in order to manage the effects of global warming such as flooding and rising sea levels.

The landscape discipline can contribute with a different perspective of using resilience in climate change adaptation. As the landscape architect profession often work interdisciplinary we are able to combine principles and tactics in order to create a multifunctional design. Working across disciplines can make a place more dynamic, lively and functional, for example can coastal protection be combined with leisure and ecological functions. These designed environments can further on work in an educational purpose to create awareness about climate change and resilience.

Large scale projects as Falsterbo peninsula can benefit from working collaborations that work across disciplines. We derived this insight from our case study and realised that landscape architects are limited in expertise knowledge to analyse the

complex nature of the ecological dimension a large scale project comes with. Further lack of engineering expertise of coastal protection limited our work. We conclude that expertise needs to be taken in from other professions in order to get a profound analysis over the site as a whole and its different areas within.

Falsterbo peninsula contains of unique nature with complex ecological systems and protected natural environments that will need the knowledge from biologists and ecologists. Because of the nature reserves on the site the design is restricted in what is possible to do and one of the main challenges is to look into and take the aspects of the protection of species and habitats into account.

We want to emphasise the importance of working interdisciplinary when it comes to striving for resilience. The concept of resilience can be applied in a wide spectrum, from resilience in the aspects of ecology to the financial issues of implementing the design. Applying resilience through the whole design process can be difficult. The Municipality of Vellinge face pressure in building more residential housing to accommodate the growing population. At the same time we asking ourselves, is protecting existing settlement and build more housing consistent with the concept of resilience?

While exploring the concept of resilience we found that there is ethical issues in protecting Falsterbo peninsula. To protect the existing built environment we might have to exploit the environment to make it liveable. New types of infrastructures and elevated buildings will disturb the natural environment affecting the habitats and ecosystems. At the same time, to relocate buildings or force people to live elsewhere will exploit land at a different place that might cause problems on the new site. Further when the sea

levels rises we have to carefully consider what land to exploit and how we exploit it. Relocating settlement to safer grounds can be controversial in the aspects of cultural heritage and peoples connection the landscape. For example, exploit agricultural land are often controversial because of its importance for the economy of a country but also crucial if a crisis occur, for example in times of war.

One of the most common tasks a landscape architect has to manage is to improve the environments for humans, to provide safe and attractive spaces. Falsterbo have a unique and vulnerable landscape due to flooding and sea level rise which makes exploitations of the landscape complicated. Can we be resilient in all aspects of managing coastal flood and sea level rise? To reconnect to what we wrote earlier, resilience is focused on the response of a system to manage change while sustainability is to increase quality of life while taken environmental, social and economical systems in consideration. This means that in terms of resilient design, the design aims to being able to manage change but to realise the project in real life the concept of sustainability have to be taken in consideration. A project could be resilient in one aspect, for example in the aspect of manage sea level rise, but would consider the economical aspect less. Landscape architects often work with sustainability but in order to make a resilient design, the design has to work over time and buffer against change.

In the large scale, global warming are rising rapidly but for the society it can be difficult to understand that change is happen and first realise it when a natural disaster happen. Landscape architects as a profession are able to visualise and communicate the scenarios of extreme events and the potential of resilient design to the public. By using the tool to visualise these extreme event action can be taken to prevent and reduce the



damage.

We see our result as a inspiration for architects, designers, planners and highly relevant for people interested in the subject. The thesis leaning against a theoretical and philosophical background together with more practical principles and tactics, bridging theory with practice together. We believe it is important to challenge traditional ways of thinking and investigate which alternatives there are in approaching the coastal landscape in planning and design. The importance of coastal water management in a early stage is crucial in order to avoid taking rushed decisions when a crisis occurs.

*Which design principles could be identified in resilience theory and how could these be used in addressing flood risk in an empirical case of Falsterbo peninsula, Sweden?*

This thesis identifies three design principles for approaching coastal flood and sea level rise and are a result of the literature review, site- and reference study. The three principles have been extracted and processed during our working process and consist of integrate (1), protect (2) and separate (3). These are mainly inspired and based on ICEs strategies (ICE 2018) , UNs research about adaptation option (UN 2018) and Design for Flooding by Watson and Adams (2011). We also found the initial theoretical sections to be useful to investigate the concept of coastal landscape and resilience to get a rich foundation to further identify the principles. Our principles are similar to many known strategies, principles and approaches but are slightly different in some aspect and uses a different, and according to us a more neutral, terminology. We believe that the terminology often reveals the intentions for targeting the coastal landscape and we try to be as neutral as possible.

The design proposal, Archi-Pelago, are specific to Falsterbo peninsula but the principles can stand for themselves. We want to be clear that our proposal *Archi-Pelago* is one way to approach flooding and rising sea levels that Falsterbo peninsula face in the future and are meant to show a design proposal that can work over time, and buffer against climate change. We decided that we wanted to combine the three principles because of the many characters of the site which required us to think differently about each character. After studying risk-taking in planning and design, we decided to use several types of tactics to reduce the risk and not trusting one method to manage flood and sea level rise. In this way, if one system fail another one can step in and buffer.

The tactics are the answer to *how* the principles can be achieved. The ones we chosen for Falsterbo are our way, of the lens of an landscape architect, to deal with the water related challenges Falsterbo peninsula is facing today and in the future. During the process we realised that the tactics are many and they are possible to combine in many ways. We also noticed that it is complicated to categorise them into the principles because the tactics float into each principle depending on how they are combined and the purpose of them. For example, elevated building belongs to the protective principle if they are elevated in the purpose to protect from the water while new elevated buildings belongs to the integrating principle because their purpose is to integrate with the water.

In a wider perspective, the design principles are suppose to act as an tool-kit in thinking resilience and can be applied to any site and project. Depending on the features and context, one principle can be better than another and the outcome might

be different from another site with the same principle. However, we want to be clear with the fact that we can not say which principle that are the best for a certain site but there is characteristics that make one principle more likely to be adopted than another.

## REFLECTING OVER THE WORKING PROCESS AND METHODS

Our working process have been of the looping type where we worked with different processes parallel to each other. The literature review and the result have especially been important and processed along our work with the thesis. However, the literature review made us rethink our own thoughts and beliefs which further changed our view of the coastal landscape and how we approach it through design. We realised the power of soft infrastructure and that public space are important in many more ways than being for recreational value. We know now that there is no “best” solution and we changed our direction by starting to research different tactics and identify what sort of approach they had to the coastal landscape. By that knowledge we could identify the principles and study how they were defined in other reports and documents.

Parallel to the thesis we worked with the student competition which have been a inspirational and challenging way to work with resilient design. The student competition had a more crucial part in a early stage of the thesis and was the main reason why we chose this subject. Later on we started to go away from a more design oriented aim to a more theoretical and philosophical oriented one. Instead of a pure design proposal we developed principles and further tested these on a case study. This new aim was something that we felt was a subject for the future and got us interested to investigate more. On the other hand, the student competition consume a lot of time and effort which might have taken focus from the thesis even if the student competition also had an overall positive impact. However, the thesis’s heart lies in the principles and the design proposal was a way to grasp the aim in a more practical way.

## FINAL CONCLUSION - WHAT WE LEARNED AND FURTHER QUESTIONS FOR THE FUTURE

Bringing the concept of resilience into the debate about climate adaptation provides new ways of thinking. This thesis outlines principles for approaching the coastal landscape in facing climate change while it contributes to the identification and categorisation of climate adaptation options. We also wants to uplift landscape architecture as a discipline and how important it is to work across disciplines with other professionals in order to achieve resilience. While uplifting the landscape architect role we also want to point out the importance of knowledge from other professionals. The expertise from other disciplines are crucial to analyse an area in-depth in order to make a design that manage all the layers of a landscape, all from technical solutions to social and ecological dimensions.

It would be interesting in a wider perspective to study how we can integrate urban living with water in order to avoid exploit agricultural land and other valuable

landscapes. We suggest further evaluation of the qualities of the implemented principles and tactics. What are the aftermath for implement chosen principles and tactics, and how does each principle correspond to their environment? It would be interesting to see if one principle can have a different outcome on two different sites and by that investigate what factors causing it to differ from place to place. To further explore this relation, a comprehensive reference study would be appropriate to see how the approach have affect the environment and community.

Our principles offers a way of approaching coastal problems as well as opening up for the debate about resilience. The design proposal allowed us to test the principles and made us realise how complex a coastal landscape is. Our conclusion is that resilient design is a great way to handle the coastal landscape due to fact that it is constantly changing. But it is still very complex to approach due to the many aspects that has to be taken in consideration to make a site sustainable.

We believe that this thesis enlighten the role of the landscape architect as well as to work together with other professionals in climate adaptation to further inspire in the strive for a resilient future in coastal design and planning.



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MASTERPLAN ARCHI-PELAGO



# ARCHI-PELAGO

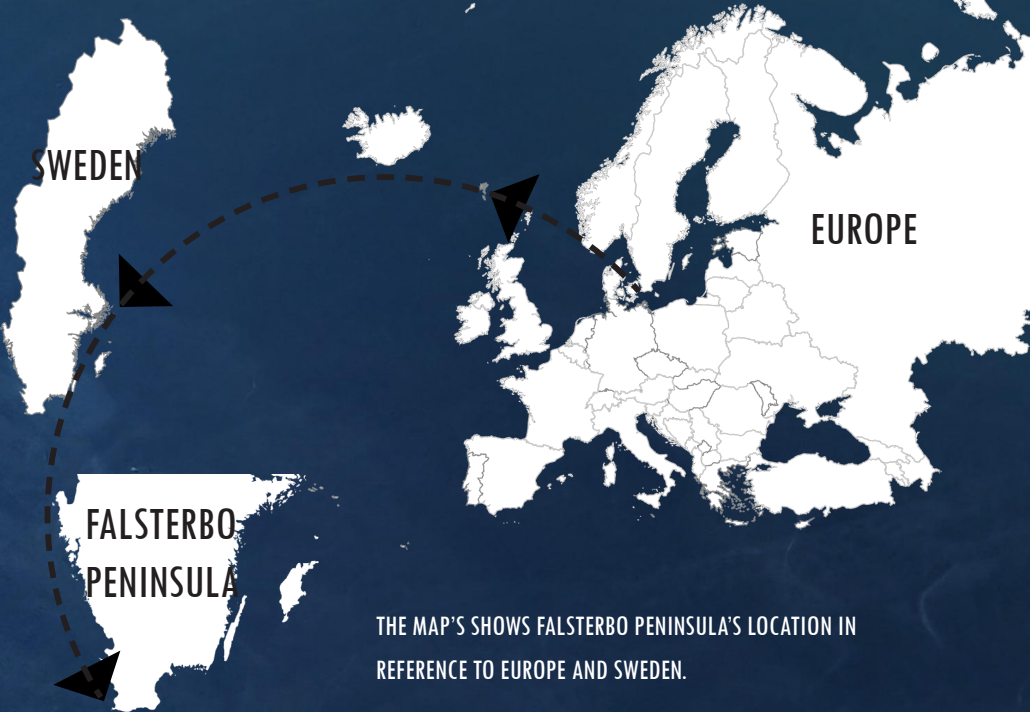
## CHALLENGE

Dealing with challenges of global warming and future climate threats, the coastal landscape is at a vulnerable state facing future extremes like flooding and sea level rise. With the contrasts between the romanticised view on the coastal landscape and the vulnerability due to water related events, how can we live with water? Or reverse, can we live with water? Falsterbo peninsula, located in south of Sweden, is at a vulnerable state facing sea level rise, flooding, and coastal erosion in the future. What is the most resilient approach in a long-term perspective? Should we integrate, protect or separate ourselves from the water?

## OUR ANSWER IS ARCHI-PELAGO

Archi-pelago describes an architect's way of connecting islands, or in this case a series of tactics for coastal protections. The outcome of the project creates several opportunities to not only protecting us from the water, to see new possibilities to actually live with water or to use the water as a possibility.

## LOCATION OF THE SITE



**ABOUT FALSTERBO PENINSULA**  
Falsterbo peninsula is located in south of Sweden, in Skåne County. The site is characterised by its unique natural environment which consist of many protected areas, high values of biodiversity and a wide spread of flora and fauna. The coastal landscape, which are of great recreational value, is characterised with sand dunes, covered with fine-grained sand of quartz. The built environment, centered in the twin-towns Skanör and Falsterbo, consist of mainly residential areas.

## FLOODING PROJECTIONS



FLOODING/ SEA LEVEL RISE

STORM SURGE

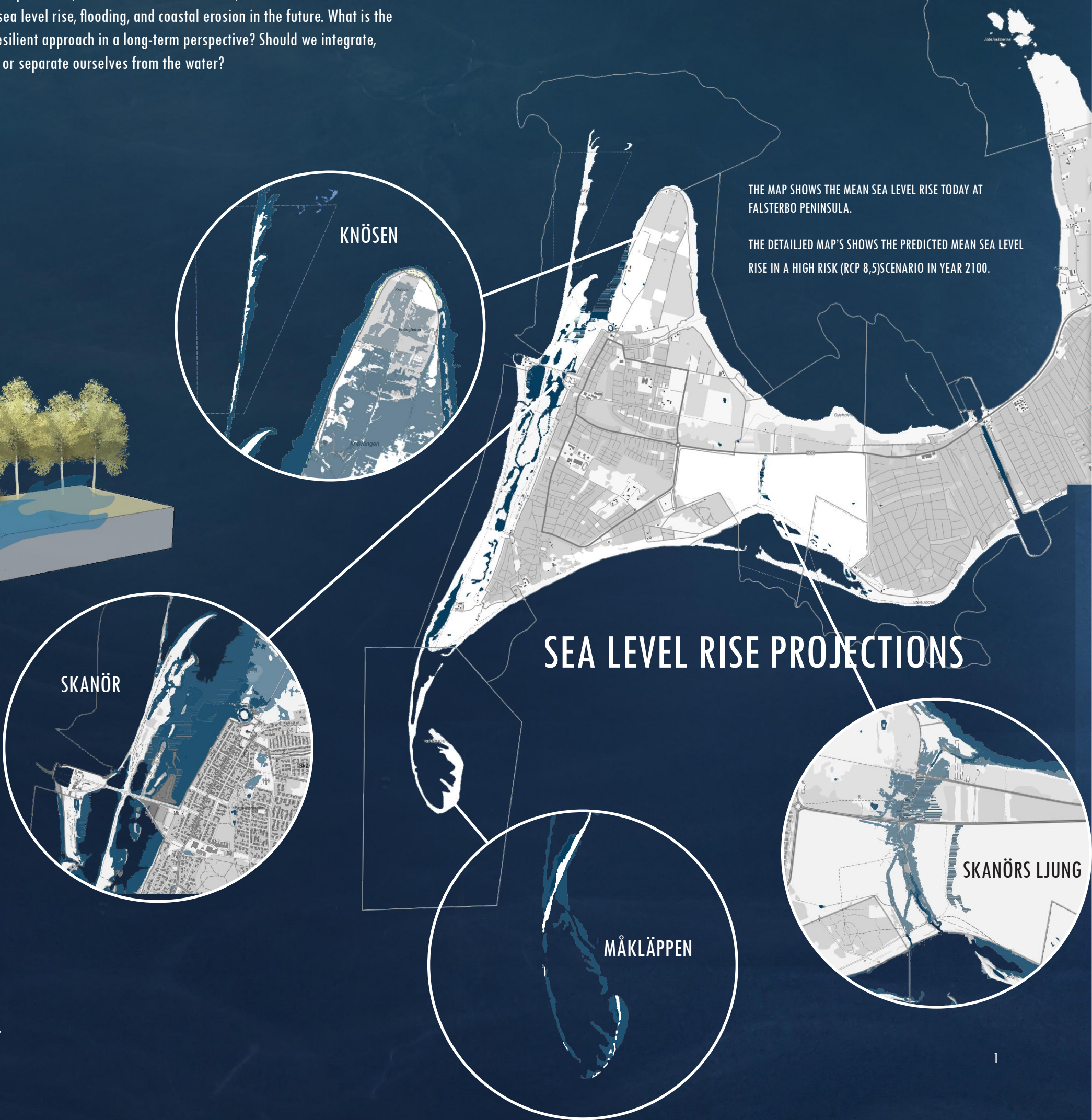
THE FIGURES ILLUSTRATE FLOODING AND STORM SURGE.

MAP 1. AREAS THREATENED BY FLOODING BY BACKFLOW IN TODAY'S CLIMATE  
MAP 2. AREAS THREATENED BY FLOODING BY BACKFLOW IN YEAR 2065

# +2,85

HIGHEST PREDICTED MEAN SEA LEVEL RISE (HIGH RISK RCP 8,5) SCENARIO IN YEAR 2100 IS +2,85.

## SEA LEVEL RISE PROJECTIONS



THE MAP SHOWS THE MEAN SEA LEVEL RISE TODAY AT FALSTERBO PENINSULA.

THE DETAILED MAP'S SHOWS THE PREDICTED MEAN SEA LEVEL RISE IN A HIGH RISK (RCP 8,5) SCENARIO IN YEAR 2100.

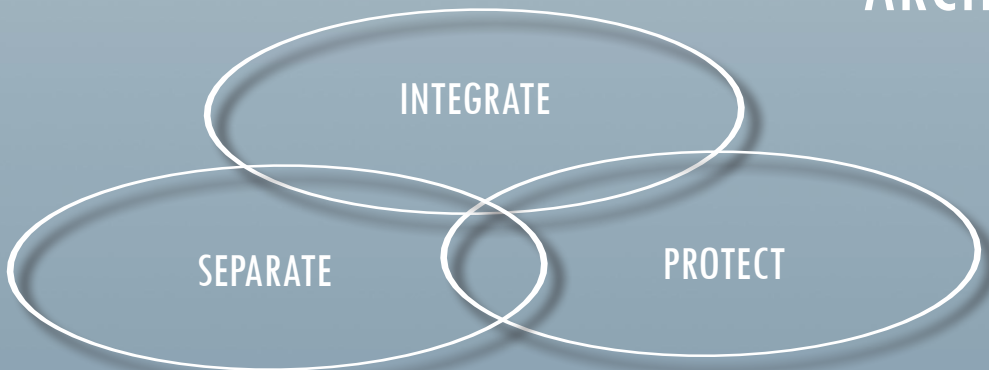


# DESIGN PROPOSAL

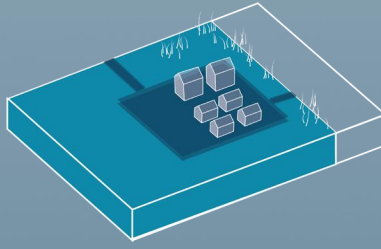
## DETAILED DESIGN

THE ILLUSTRATION SHOWS THE RESULT OF HOW THE PRINCIPLES AND TACTICS FORM A PROTECTION AND A WAY OF LIVING WITH WATER.

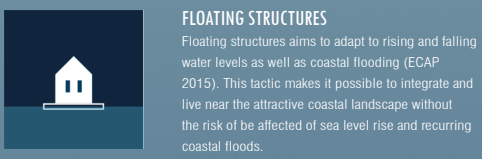
## DESIGN PRINCIPLES



### DESIGN PRINCIPLE: INTEGRATE



### DESIGN TACTICS: INTEGRATE



**FLOATING STRUCTURES**  
Floating structures aim to adapt to rising and falling water levels as well as coastal flooding (ICAP 2015). This tactic makes it possible to integrate and live near the attractive coastal landscape without the risk of being affected of sea level rise and recurring coastal floods.



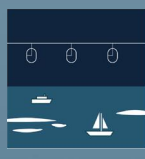
**SEAL RAFTS**  
Due to the fact that Malmågen is the only site protected in Sweden for seals, the seal rafts consist of new also provided which can furthermore be integrated regardless the water level.



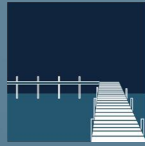
**LIVING SHORELINE**  
Living shoreline incorporate ecological functions with reducing the risk for coastal erosion (NVC Planning 2013). Additionally, living shoreline works in a integrating way to soften the distinction line between water and land.



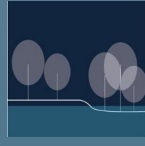
**RELOCATE SAND/ DUNE RESTORATION**  
In order to strengthen the coastal landscape and its attractive attributes, making sure the features is integrated with the landscape and not disappeared in the future. Furthermore, providing the initiative of coastal erosion, by relocating sand and restore dunes, made in the Svanen project, in protecting the shoreline of coastal erosion as furthermore aim to protect the ecological features and biodiversity.



**BOARDWALKS**  
The boardwalks consists of a structure which could be used whether the water levels are high or low. It serves multifunctional purposes in creating public spaces when the water levels are low and further canal of transportation when water levels are high.



**FLOODABLE PARK**  
Floodable areas can protect in case of coastal flooding and can work in a resistant way to recover quickly in storm events (NVC Planning 2013).



**ARTIFICIAL ISLANDS**  
Artificial island are floating structures that aims to create ecological functions and biodiversity (ICAP 2015). It have been successful in for example creating the artificial island Freppelsholmen were it rich biodiversity has been created on the former steel island (Radio Sweden 2013).



**BREAKWATERS**  
Breakwaters aims to protect the coastline from waves and storms by hard structures of rocks and rubble which can be located both offshore and at the shoreline (ICAP 2015). Breakwaters could also be implemented in other structures for example boardwalks or artificial island with a protection against wind.



**FLOOD BARRIERS**  
Flood barriers is a fixed protection which prevent flooding and storm surges, and thereby secures settlements and infrastructure. Flood barriers as sea gates are able to close when the water level are too high (ICAP 2015).



**SEA WALLS**  
Sea walls is a coastline protection that protects from waves and storms (NVC Planning 2013). Sea walls are used in both the purpose to protect the coastline as well as prevent cliffs from eroding (ICAP 2015).



**LEVEES/ DIKES**  
Levees works as a defense in preventing flooding (NVC Planning 2013). Levees are embankments, constructed with the purpose to control the water in preventing ocean waves to flood and keep the water out. Levees require high maintenance and regularly control. (Infrastruktur Report Card 2017). Netherlands is an example of a frequent user of levees and dikes in order to control the water levels. Netherlands is an example of a frequent user of levees and dikes in order to control the water levels.



**ELEVATE EXISTING BUILDINGS AND INFRA-STRUCTURE**  
In order to live near water, certain interest such as recreation and buildings need to be secured and protected against flood events. Infrastructure could either be constructed as floating or elevated in order to protect from (ICAP 2015).



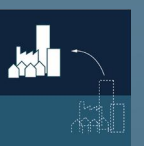
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**RELOCATE**  
Due to high risk vulnerability of flooding and rising sea level, this tactic aims move buildings to another location (ICAP 2015). To move houses where it is more suitable and the risk for further flooding or coastal erosion is less.

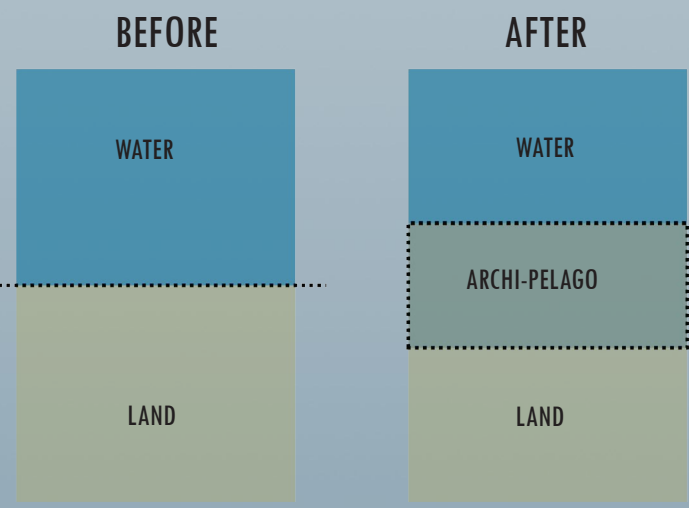


**RESTRICTED EXPLOITATION**  
To restrict exploitation means to establish areas where construction is not allowed (ICAP 2015). This works preventative in securing the coastal areas and postponing the eventual risk of moving land (the need emergency).

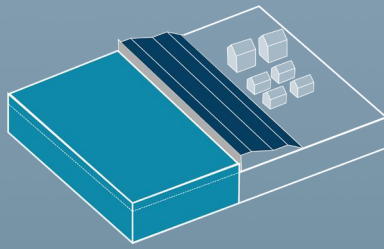


**RETREAT**  
Due to high risk or scale vulnerability of flooding and rising sea level, this tactic aims move settlement, infrastructure and all other productive activity to another location (ICAP 2015). This approach to inhibit when the risk for natural disasters to occur are too high, and the loss of such an event would cause huge damage and not worth making (Waters & Adams 2013). Retreat as a solution has been taken on Isle de Jean Charles, where the climate threats were too high and constituted as a high-risk area, leaving no other option than to retreat to safer areas (Isle de Jean Charles n.d.).

## THE CONCEPT OF ARCHI-PELAGO



### DESIGN PRINCIPLE: PROTECT



### DESIGN TACTICS: PROTECT

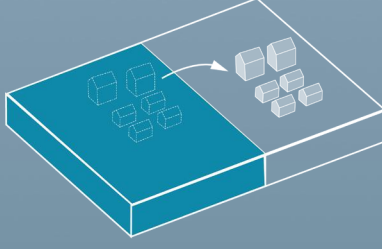
PROTECTED AREA FLOMMEN

REEF OF FALSTERBO

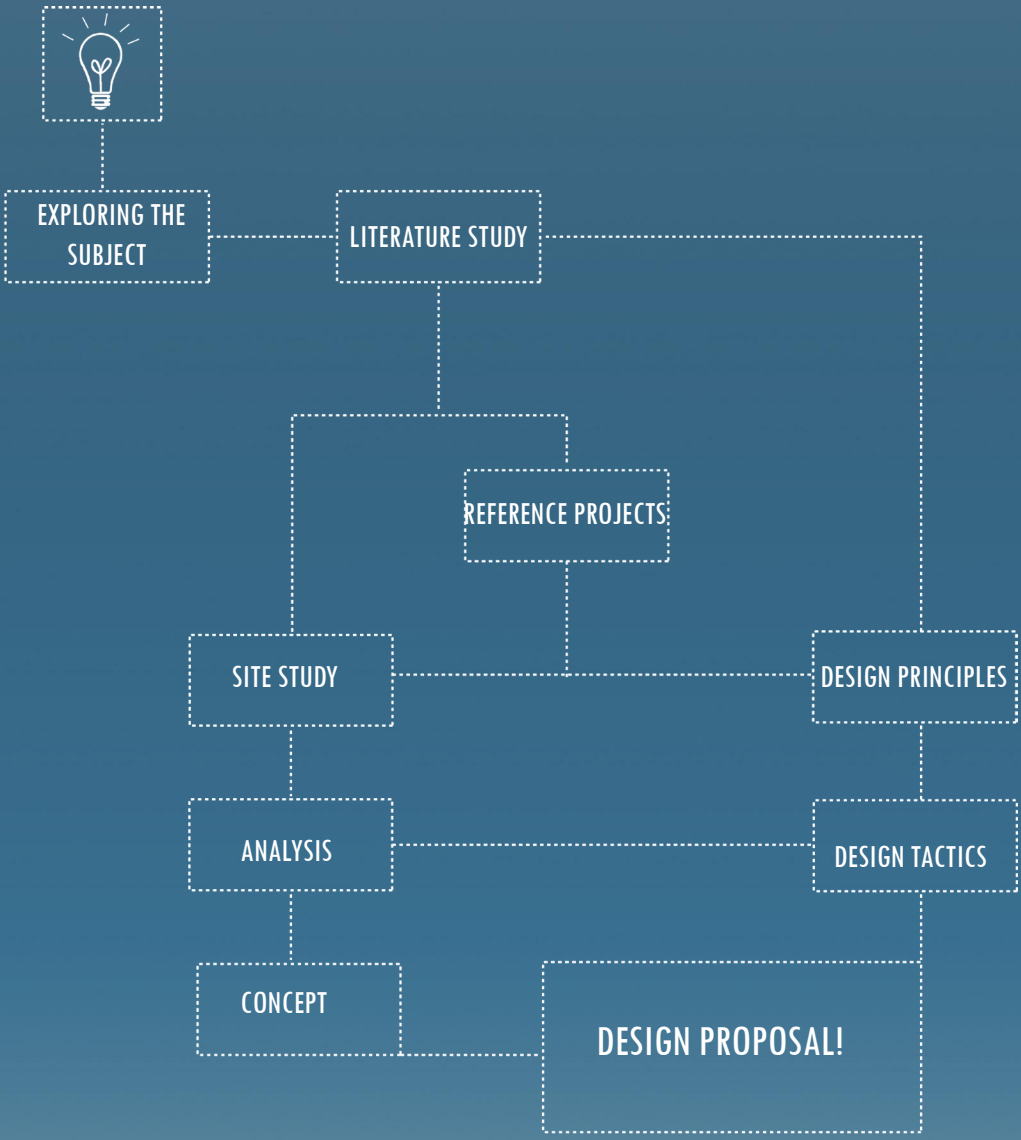
## ANALYSIS



### DESIGN PRINCIPLE: SEPARATE



### DESIGN TACTICS: SEPARATE



HELLO!

NICE RAFT!