Cultivating the Desperation Point
Amplifying the Perceptibility of Climate Resilient Design

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Abstract

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Utilizing the psychology of emotional connection and response to art, this thesis aims to amplify climate-resilient site and ecosystem design methods through the use of art - pavilions, exhibits, sculpture, and art installations – to connect the visitor emotionally with the facts and effects of climate change, with the ultimate goal of persuading behavioral change needed for a paradigm shift in climate responsiveness and action. The project's climate-resilient design tactics include ecosystem regeneration, a sculpture park and an educational space on Copenhagen's harbor front. Starting with the underwater ecosystem adjacent to the site and moving inland through salt marsh, wetlands, meadow, urban agriculture, and forested zones, the design will apply resilient design tactics to the site's intersecting ecosystems to educate visitors about the magnitude and challenges of climate change.

CULTIVATING THE DESPERATION POINT

amplifying the perceptibility of climate resilient design

For my family, who have supported me wholeheartedly and loved me unconditionally through all of the steps that I've taken to get here.

ONE

Introduction

Cities must be designed and built to mitigate and adapt to climate change, yet we also need a far more systematic approach to engaging humans to become active on the climate crisis. Leveraging a mentality of incorporation, this thesis aims to demonstrate an approach to climate change awareness from a systematic viewpoint. It proposes a site plan and landscape design that visually demonstrate climate resilient change over time. It then programs the site as a sculpture park, allowing artists to contribute on an international scale to amplifying the human connection to the site through emotion, encouraging a deeper understanding of human impacts on the landscape and our role in climate change.

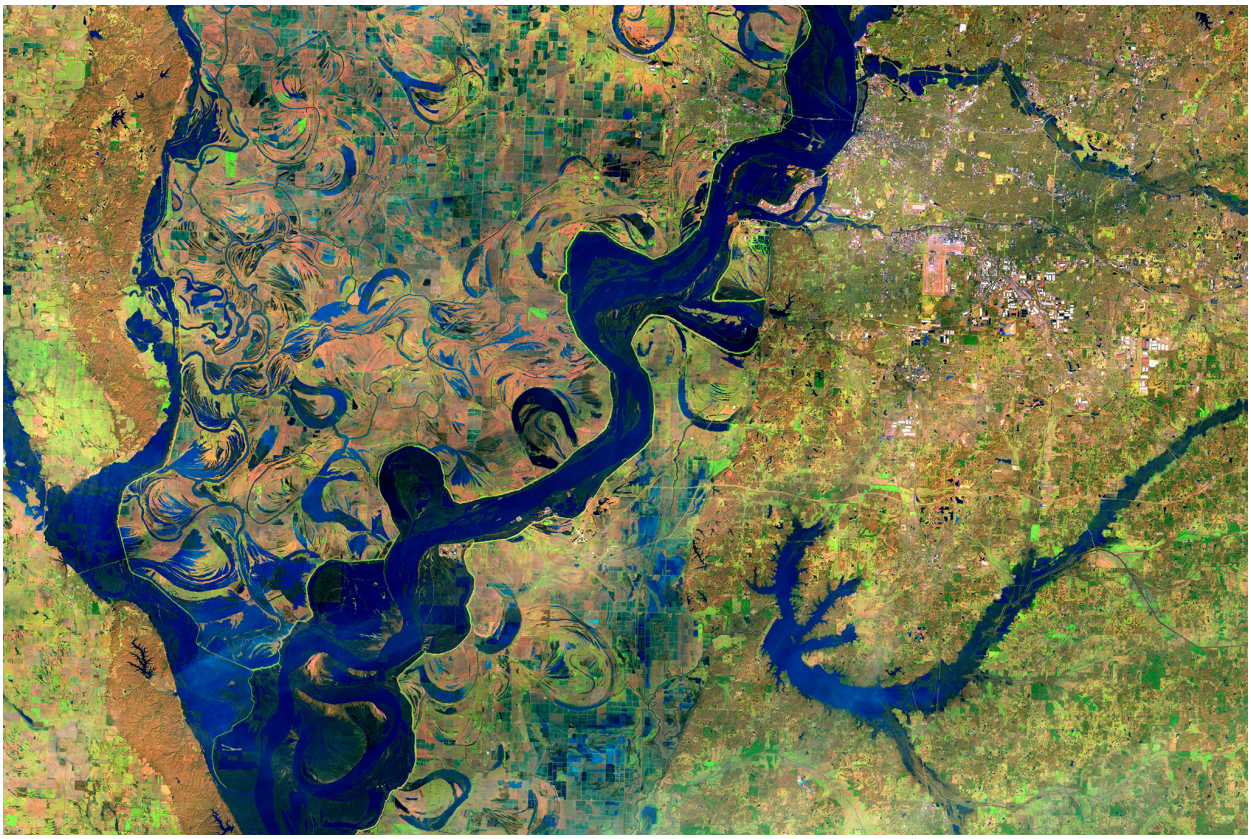


fig. 1, 2 "Flooding along Mississippi River", Feb. 27 2014 + Feb. 25 2019

CLIMATE CHANGE

Climate change, defined as "change over time in the averages and variability of surface temperature, precipitation, and wind as well as associated changes in Earth's atmosphere, oceans and natural water supplies, snow and ice, land surface, ecosystems, and living organisms"[1] is the most critical problem of our time, with global temperature rise affecting the world as we know it in catastrophic proportions.

Holly Jean Buck wrote:

"December in California at one degree of warming: ash motes float lazily through the afternoon light as distant wildfires rage. This smoky "winter" follows a brutal autumn at one degree of warming: a wayward hurricane roared toward Ireland, while Puerto Rico's grid, lashed by winds, remains dark. This winter, the stratospheric winds break down. The polar jet splits and warps, shoving cold air into the middle of the United States. Then, summer again: drought grips Europe, forests in Sweden are burning, the Rhine is drying up. And so on."[2]

CLIMATE CHANGE VISUALIZATION

Threatening as these trends may be, visualizing a world deeply entrenched in climate change is difficult to imagine, as we have no precedent in our lifetime. As it is often perceived as a distant, uncertain threat, many people discount the importance and urgency of mitigating climate related risks or building resilience to the guaranteed impacts. How can climate change threats, and its risks, be better communicated to people so they will act to address it?

fig. 3, 4 "Imja Glacier melt, Himalayas", Autumn, circa 1956 + October 18, 2007

Climate change and its risks can be explained using facts and numbers, but many people do not respond to this type of communication. There is enhanced value in sparking an emotional response and connectivity between humans and climate change, because emotional reactions can create a deeper understanding of the response necessary to address these issues.[3]

For example, NASA's Images of Change are an element of the agency's initiative to educate and inform on climate change mitigation and adaptation. The project focuses on making change over time visual to demonstrate flux on earth. The photos on pages 12 and 14 demonstrate examples of this project, showing climate impacts in a visible and visceral way.[4]

Emotional response is an incredibly important component of the human experience of artwork, and has been argued to be the purpose of artistic expression.[5] Psychological research has shown that the experience of art differs from that of standard object recognition.[6]

Utilizing the psychology of emotional connection and response to art, this thesis aims to amplify climate resilient site and ecosystem design methods through the use of art - pavilions, exhibits, sculpture and art installations –to connect the visitor emotionally with the facts and effects of climate change, with the ultimate goal of persuading behavioral change needed for a paradigm shift in climate responsiveness and action. The project's climate resilient design tactics include ecosystem regeneration, a sculpture park and an educational space on Copenhagen's harbor front. Starting with the underwater ecosystem adjacent to the site and moving inland through salt marsh, wetlands, meadow, urban agriculture and forested zones, the design will apply resilient design tactics to the site's intersecting ecosystems to educate visitors about the magnitude and challenges of climate change.

TWO

Research

THE EMERGENCE OF CLIMATE AND SUSTAINABLE DEVELOPMENT POLICIES

Current climate policy emanated from a momentous global consensus on the growing problems of environmental degradation, global poverty, and inequality that coalesced around 1990. In 1987, the Brundtland Commission of the World Conference on Environment and Development (WCED) published "Our Common Future," which attempted to integrally resolve these challenges by presenting the first widely regarded definition of Sustainable Development as intergenerational equity: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[7] Its key corollary was the conceptual framework of three equal pillars of sustainable development: economic growth, social equality, and environmental protection.

This was followed by the pivotal and unprecedented UN Conference on Environment and Development (UNCED) in 1992, sometimes called the "Earth Summit" or the "Rio Summit" from its location in Rio de Janeiro. This summit was exceptional in size, with 172 states represented, 108 heads of government, 2400 NGOs, and 17.000 participants. It was the first time that the global community systematically addressed solutions to a wide range of environmental concerns (including air, climate, water, land, forests, biodiversity, energy and more) in tandem with global poverty and development. Many significant environmental documents and agreements emanated from the UNCED, including the Rio Declaration, the UN Framework Convention on Climate Change, conventions on forests, biological diversity and sustainable development, and Agenda 21, paving the way for the Millenium Development Goals and Sustainable Development Goals.

UNFCCC AND IPCC: UN FRAMEWORK CONVENTION ON CLIMATE CHANGE AND INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

The UN Framework Convention on Climate Change emerged at the UNCED Earth Summit in 1992, following the establishment of the IPCC, or Intergovernmental Panel on Climate Change in 1988. The IPCC panel's purpose is to provide individual nations with the scientific information to develop policy on climate change. The IPCC currently has 195 member nations with thousands of scientists volunteering their time to develop climate reports internationally. It should be noted that the process of developing IPCC reports is open and transparent, and that the IPCC does not conduct its own research.

The First IPCC Assessment Report, written to highlight the importance of climate change as a global topic, came out in 1990 and was instrumental in establishment of the UNFCCC in 1992. Subsequently, the Kyoto Protocol (1997/2005) was the first major global agreement on reduction of greenhouse gas emissions but it was fraught with political controversy especially from countries with strong climate denial populations, and struggled to achieve meaningful goals. However, it addressed concern for the variable needs of poorer countries and voiceless populations (such as indigenous peoples) and set the stage for its improved successor, the Paris Agreement, adopted in 2015, which was based on the Fifth Assessment Report, finalized between 2013 and 2014. This Agreement specifically addressed the need to keep global temperature rise below 2 degree celsius above pre-industrial levels through the reduction of greenhouse gas emissions on global and local scales. Since then, the world governments under the Paris Agreement have requested three Special Reports which will precede the Sixth Assessment Report, due out in 2022. The three Special Reports are Global Warming of 1.5, the Special Report on Climate Change and Land, and the Special Report on the Ocean and Cryosphere in a Changing Climate.

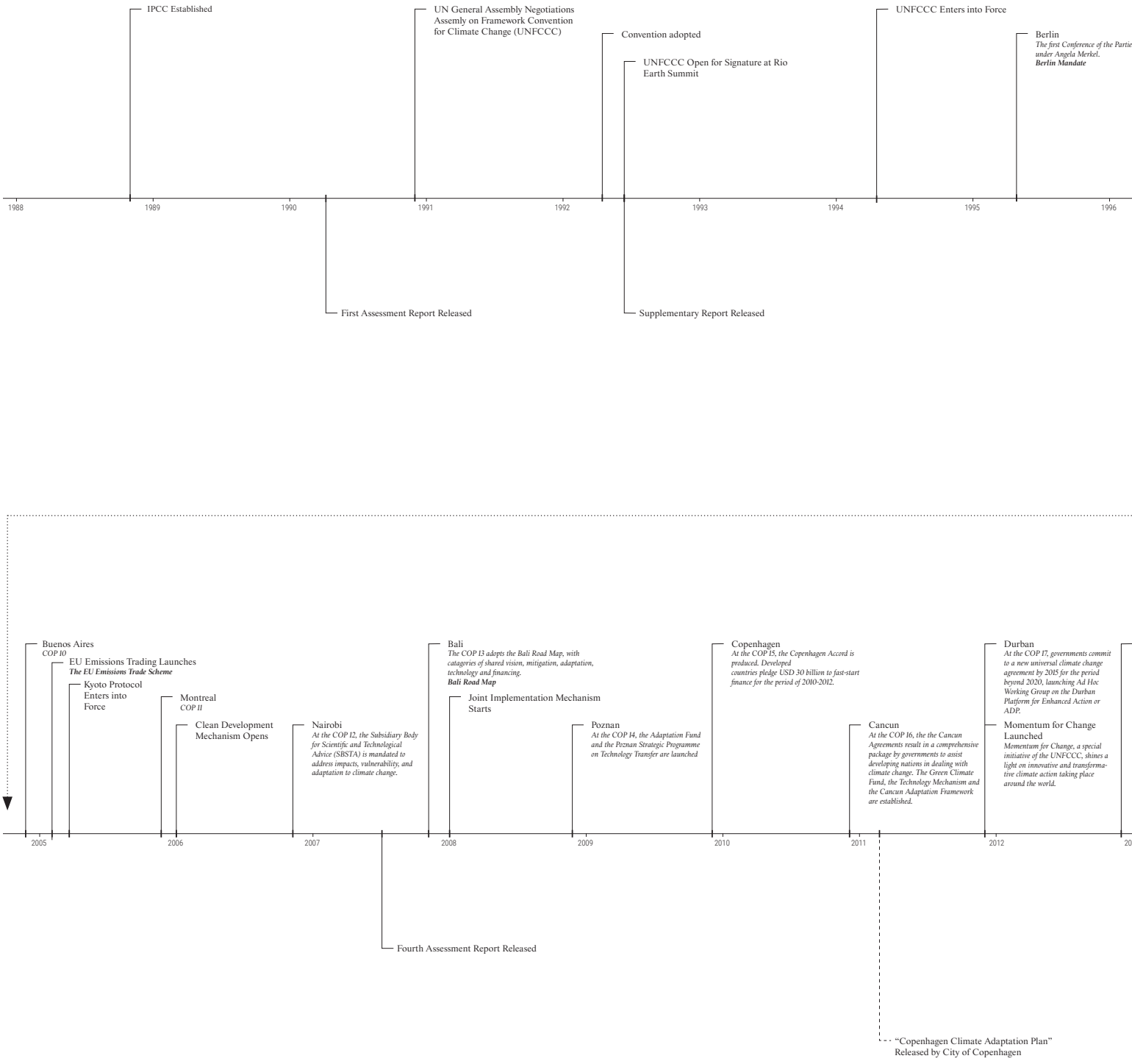
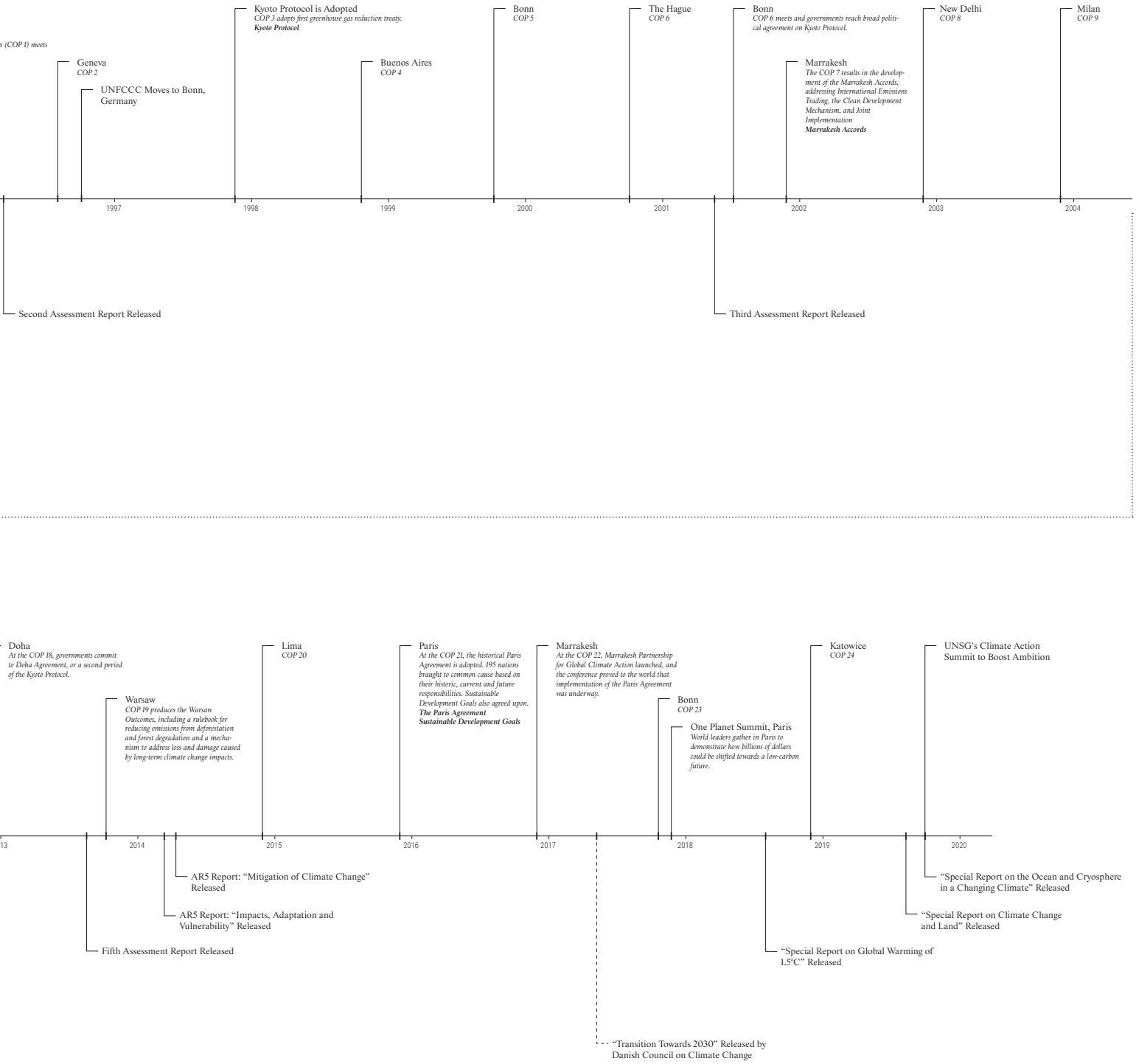


fig. 5 IPCC Timeline, 1988-2020


s (COP 1) meets
Geneva
COP 2
UNFCCC Moves to Bonn, Germany
Kyoto Protocol is Adopted
COP 3 adopts first greenhouse gas reduction treaty.
Kyoto Protocol
Buenos Aires
COP 4
Bonn
COP 5
The Hague
COP 6
Bonn
COP 6 meets and governments reach broad political agreement on Kyoto Protocol.
Marrakesh
The COP 7 results in the development of the Marrakesh Accords, addressing International Emissions Trading, the Clean Development Mechanism, and Joint Implementation
Marrakesh Accords
New Delhi
COP 8
Milan
COP 9
1997
1998
1999
2000
2001
2002
2003
2004
Second Assessment Report Released
Third Assessment Report Released
Doha
At the COP 18, governments commit to Doha Agreement, or a second period of the Kyoto Protocol.
Warsaw
COP 19 produces the Warsaw Outcomes, including a rulebook for reducing emissions from deforestation and forest degradation and a mechanism to address loss and damage caused by long-term climate change impacts.
Lima
COP 20
Paris
At the COP 21, the historical Paris Agreement is adopted. 195 nations brought to common cause based on their historic, current and future responsibilities. Sustainable Development Goals also agreed upon.
The Paris Agreement
Sustainable Development Goals
Marrakesh
At the COP 22, Marrakesh Partnership for Global Climate Action launched, and the conference proved to the world that implementation of the Paris Agreement was underway.
Bonn
COP 23
One Planet Summit, Paris
World leaders gather in Paris to demonstrate how billions of dollars could be shifted towards a low-carbon future.
Katowice
COP 24
UNSG's Climate Action Summit to Boost Ambition
13
2014
2015
2016
2017
2018
2019
2020
AR5 Report: "Mitigation of Climate Change" Released
AR5 Report: "Impacts, Adaptation and Vulnerability" Released
Fifth Assessment Report Released
"Special Report on Global Warming of 1.5°C" Released
"Transition Towards 2030" Released by Danish Council on Climate Change
"Special Report on the Ocean and Cryosphere in a Changing Climate" Released
"Special Report on Climate Change and Land" Released

SPECIAL REPORT 1.5

The Special Report on Global Warming 1.5 demonstrates the quickening pace of climate change and the urgency of the challenge. It suggests that a 2 degree cap is not adequate to avert disastrous global warming and suggests the Paris Agreement be revised downward. For the first time, an IPCC report directly addresses global greenhouse gas emission in the context of the UN Sustainable Development Goals as a framework through which to address climate change.

UN SUSTAINABLE DEVELOPMENT GOALS

The 17 Sustainable Development Goals are the groundwork for this thesis, as they, along with local risks, are important and feasible to address with the technology we already have available in a cost effective manner. They relate to poverty, inequality, health, climate change, environmental degradation, peace and justice, and are broken out into hundreds of sub targets and indicators, which facilitate concrete monitoring. The SDG's are set to benchmark their targets in 2030.

fig. 6 UN Sustainable Development Goals

INTEGRATION OF CLIMATE POLICY WITH SUSTAINABLE DEVELOPMENT GOALS

Like global climate policy, the Sustainable Development Goals (SDG's) also emanated from the 1992 UNCED Earth Summit through Agenda 21, which set the stage for the SDG predecessor, the Millennium Development Goals (MDGs). The MDGs were issued in 2000 and targeted achievement of 8 global goals around poverty, hunger, health, education, gender equality, environmental sustainability, and global partnerships on these topics by 2015 and established mechanisms for implementation and monitoring.

The integration of the two key strands of climate related policy is a critical step in solving climate crisis, as the SDGs (and their sub targets/indicators) provide a useful mechanism to assess the success of a mitigation or adaptation tactic. Integration also provides synergistic solutions to climate change that will more efficiently address the needs of all populations and that can be applied across countries. Climate mitigation efforts will require us to reduce greenhouse gas emissions and climate adaptation will require climate resilient design that reduces the risk factors associated with critical events. Together, these two intertwining aspects of climate action demand simple, flexible, and synergistic solution systems that help us understand, act on, and adapt to climate change on local and global scales.

All 232 SDG Indicators: What data is availabl

This visualization shows for which of the 230 *Sustainable Development Goals (SDGs) Indicators* data is ava

= Indicators for which recent global official metrics are available,
or for which alternative good-quality cross-country source are available (e.g. estimates from i

= Indicators that do have official metrics, but for which available data is very incomplete or out
Yellow boxes also mark Indicators for which there are no official metrics, but for which closel

= Indicators for which – to the best of our knowledge – global monitoring is not currently possi

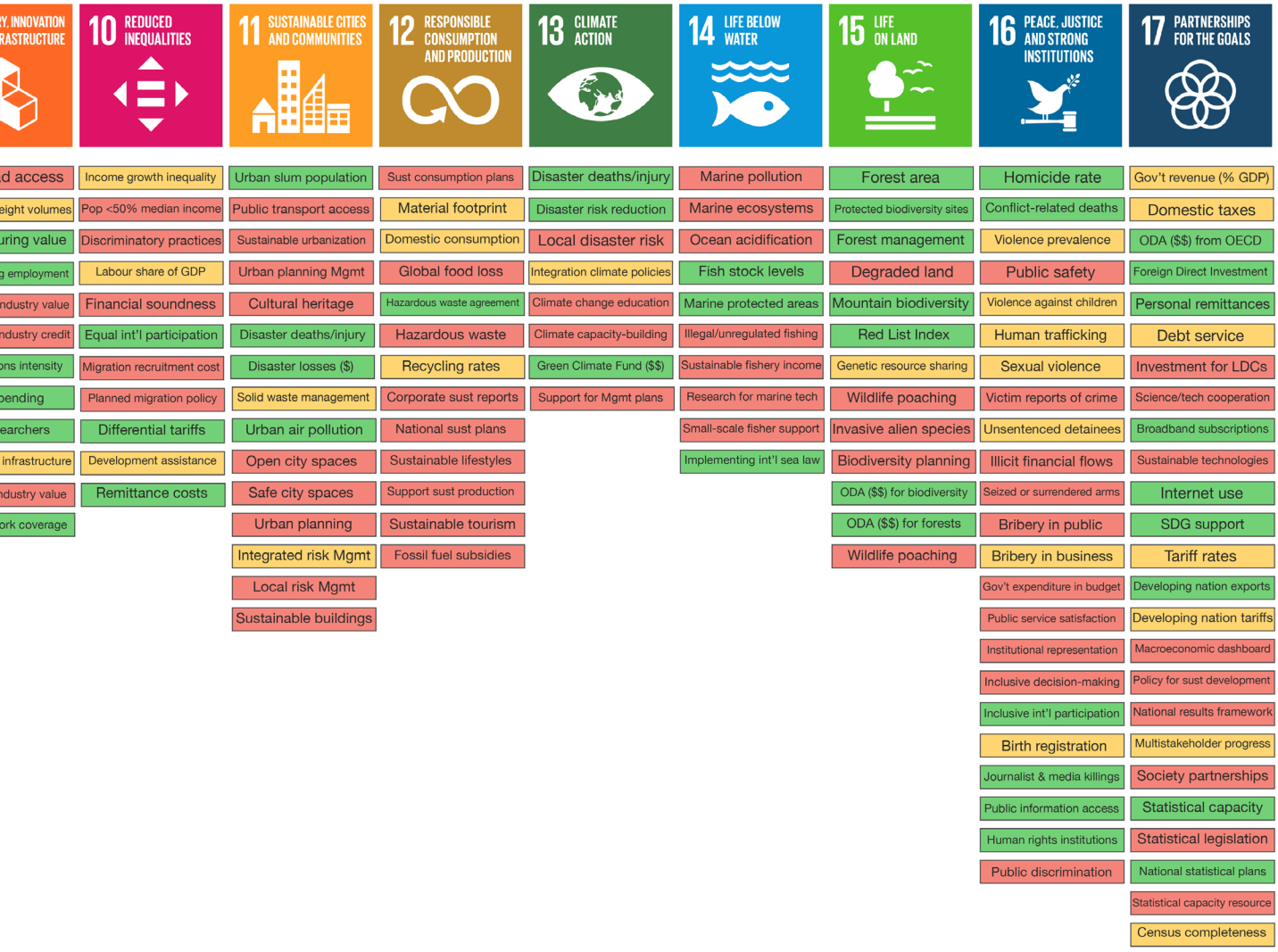
Extreme poverty	Undernourishment	Maternal mortality	Reading proficiency	Frameworks for gender	Safe drinking water	Electricity access	GDP per capita growth	Rural roa
National poverty lines	Food insecurity	Health staff at births	Children on-track	Violence by partner	Sanitation & handwashing	Access to clean fuels	GDP growth per employed	Passenger-fr
National poverty	Child stunting	Child mortality	Pre-primary participation	Violence by non-partner	Treated wastewater	Renewable energy	Informal employment	Manufactu
Social protection	Child wasting/obesity	Neonatal mortality	Access further education	Forced marriage	Ambient water quality	Energy intensity	Material footprint	Manufacturin
Basic services	Prod per labour unit	New HIV infections	ICT skills	Genital mutilation	Water use efficiency	Clean energy investment	Domestic consumption	Small-scale i
Secure land rights	Small-scale farmer ($$)	Tuberculosis incidence	Disparities in edu access	Time on domestic work	Freshwater stress	Energy service investment	Hourly earnings	Small-scale i
Disaster deaths	Sustainable production	Malaria incidence	Literacy & numeracy	Women in parliament	Integrated water Mgmt		Unemployment rate	CO_2 emissio
Disaster costs ($)	Genetic resources	Hepatitis B incidence	Edu for sust development	Women in management	Transboundary cooperation		Youth education/training	R&D sp
Disaster risk reduction	Local breed extinction	Neglected tropical disease	Inclusive & safe schools	Own health decisions	Water ecosystems		Child labour	R&D res
Local disaster risk	Agri orientation index	Non-communicable (NCD)	ODA ($$) for scholarships	Sexual health access	ODA ($$) for water		Occupational injuries	ODA ($$) for
Poverty reduction prog	ODA ($$) to agri	Suicide mortality	Qualified teachers	Female land ownership	Local sanitation Mgmt		Compliance labour rights	High-tech i
Gov't spending	Agri export subsidies	Substance use treatment		Female land rights			Tourism GDP contribution	Mobile netw
Inflows to poverty red	Food price anomaly	Alcohol intake		Mobile phone ownership			Sustainable tourism jobs	
		Road traffic injuries		Tracking gender equality			Financial services access	
		Family planning					Financial account access	
		Adolescent births					Aid for Trade	
		Healthcare coverage					Youth employment strategy	
		Health expenditure						
		Air pollution deaths						
		Water, sanitation deaths						
		Unintentional poisoning						
		Tobacco use						
		Vaccine coverage						
		ODA ($$) to health						
		Medicine availability						
		Health workers						
		Emergency preparedness						

fig. 7 SDG Indicators by goal

e?

ilable at **SDG-Tracker.org**.

ndependent research institutes).
dated.
y related estimates are available that allow informative but imperfect monitoring.
ble.



THREE

precedents

Inspiration for this thesis came in many forms: landscapes themselves, architectural forms reacting to landscapes, human imprint on landscape, and art reacting to landscape. All of these forms have something in common: they highten the experience of the landscape, creating a dynamic emotional interchange between human and nature. The most successful precedents were those that underlined the character of the landscape powerfully yet simply.

Because the purpose of this thesis is to connect humans with the notion of climate change through awareness of landscape, it was important to look at a variety of landscape interventions that address different variables within the landscape. The following projects provided inspiration in a myriad of ways:

1. *Bukkekjerka, MORFEUS arkitekter, Andoy, Norway*
2. *GASP!, Room 11, Rosetta, Australia*
3. *Lines, Pekka Niittyvirta and Timo Aho., North Uist, Scotland*
4. *Ice Watch, Olafur Eliasson, Paris, France + Elsewhere*

fig. 8, 9 seating and rest stop at Bukkekjerka

BUKKEKJERKA

MORFEUS arkitekter
Andoy, Norway

Located along Norway's Andøya scenic route, Bukkekjerka provides visitors with a stop to rest, relax and picnic. One of 18 stops along the highway, this space was once a sacricificial spot for the Sami and is now a protected cultural monument. The highway is known for winding through wild, rocky landscapes, and the architectural forms here provide many ways of experiencing nature. From the mirrored bathrooms that reflect the site around to benches used for open-air church services, all forms were thoughtfully placed to highten the experience of place.[13]

GASP!

Room 11
Rosetta, Australia

GASP!, or the Glenorchy Art and Sculpture Park is a three kilometer riverside pathway that includes experiential stopping points along the way in the form of boardwalks and pavilions. Made with children in mind, this project looks into the nostalgia of placemaking through a playful lens. Experiences are punctuated by bright colors and different types of spaces to create an adventurous path.[14]

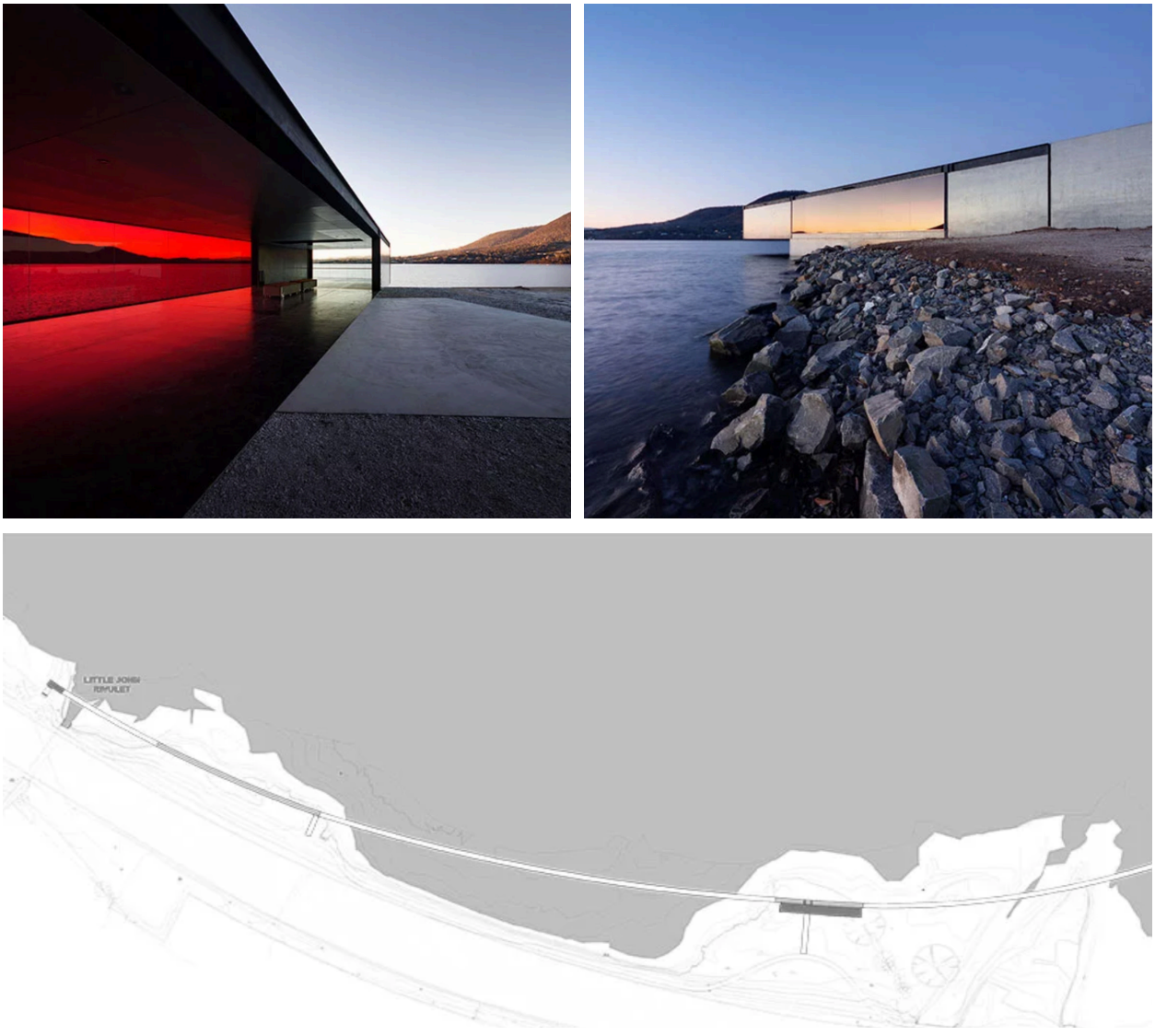


fig. 10, 11, 12 pavilions and plan of pathway for GASP!
fig. 13 (opposite) LED lights showing sea level rise on buildings

LINES

Pekka Niittyvirta and Timo Aho.,
North Uist, Scotland

Lines, an art installation in North Uist, Scotland, uses sensors in conjunction with tidal changes to project expected water levels after a period of sea level rise onto buildings and within the landscape. Located in a remote region that has already been affected by sea level rise, the poigniency of this project cannot be overlooked. Bars of LED lights illumate throughout the village, giving tangible context to our rapidly changing reality.[15]

ICE WATCH

Olafur Eliasson
Paris, France + Elsewhere

Ice Watch, an art installation that confronts humans with climate change in a literal manner, brings ice from Greenland to major cities. By placing large glacial blocks in public space, visitors can interact with melting glaciers first hand. To see how little time is needed for the glacier to melt firsthand is incredibly powerful and confronting.[16]

Though this project is about the fragility of nature in the context of climate change, a source of joy is enabled through the tactile means by which it is displayed. Olafur Eliasson has said that it's both equally important to highlight climate change but also to reduce the negativity of the message. We can find beauty in our world and use it as something that is easier to emotionally connect to than negativity.

fig. 14 Ice Watch in Paris
fig. 15, 16 (opposite) Ice Watch in Copenhagen
fig 16. (opposite) process photo from Ice Watch, Greenland

FOUR

site analysis

COPENHAGEN

One of the goals put forth by the Paris Agreement and reinforced in SR 1.5 is the need for nations with the means to take initiative on research and implementation of the SDG's to do so. I've chosen Copenhagen as an appropriate site to develop climate resilient solutions because it has already demonstrated leadership in addressing climate change. Because of its temperate climate, robust economy and progressive political outlook, many of the SDG's can be applied to design in Copenhagen. It has experimented with many climate related solutions, and serves as a role model for many of the innovations that can be adapted and customized elsewhere.

In 2011, the City of Copenhagen published the *Climate Adaptation Plan*, providing an overview and toolkit to help Copenhagen restructure and mitigate for climate change. Several important aspects of this report include the use of already developed technologies and the increased greening and bluing of the city as a strategy for management. This is both economical and makes for successful public space, each of which Copenhagen is known for doing well. Specific risks outlined in the Adaptation Plan include cloudburst flooding, storm surge flooding and heat island effect.[8]

fig. 16 (opposite) Nyhavn, Copenhagen
fig. 17 Cloudburst flooding
fig. 18 Storm surge flooding
fig. 19 Heat island effect

1. Cloudburst Flooding

Cloudbursts are extreme rain events that exceed 100mm of rainfall per hour and generally happen in warmer months. Copenhagen has seen an increase in extreme rain events in the past 20 years, both in severity and frequency, which have caused massive amounts of damage.

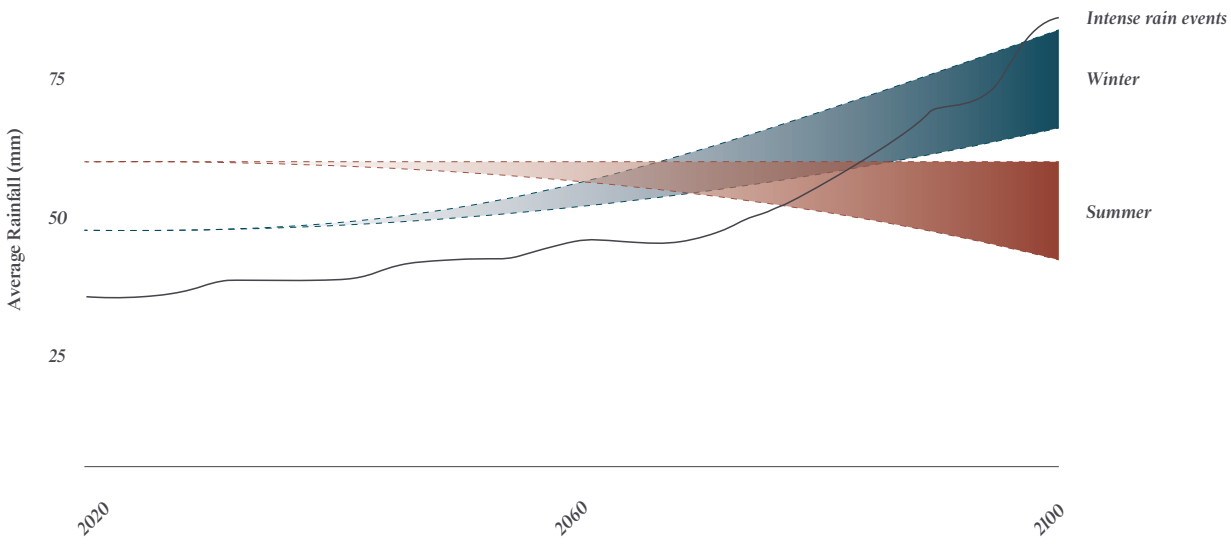


fig. 20 average rainfall 2020-2100, winter and summer + number of intense rain events

2. Storm Surge Flooding

Storm surges are rising water, above that of a normal tide, usually due to low pressure systems. Copenhagen Harbor is currently at risk for storm surges because it does not yet have a barrier system in place. The rist of storm surge in the harbor is increasing steadily, with the frequency of extreme events becoming higher. Further, the baseline water level will be rising, increasing the flood in years to come.

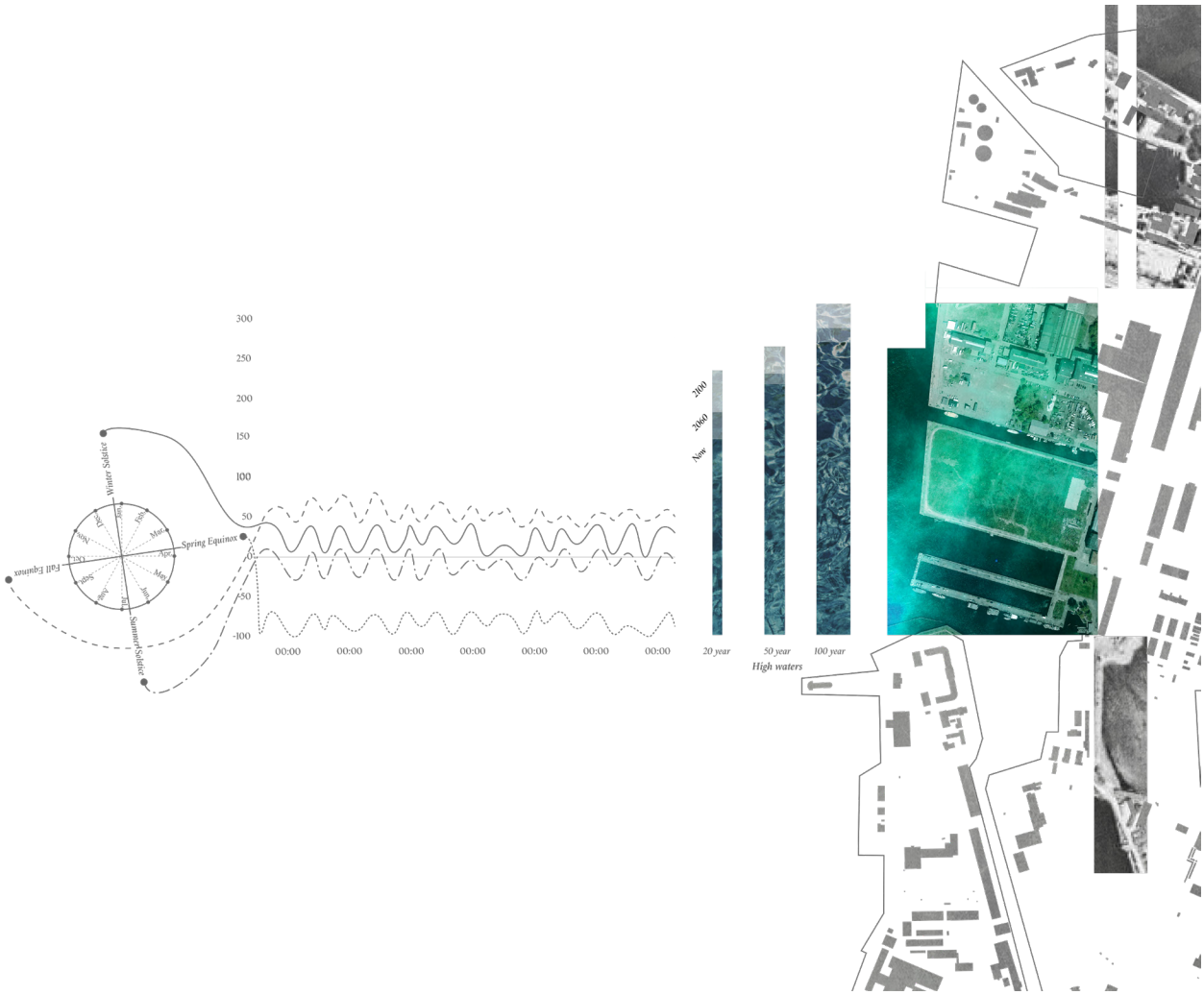


fig. 21 weekly tidal flux by season + high water events 2020-2100

3. Heat Island Effect

Urban heat island effect is a temperature increase in urban areas due to human activities and large amounts of impervious surfaces. Heat island effect has become an increasing problem due to heat waves internationally and specifically throughout Europe. Increasing green space and shaded areas mitigates the occurance of heat islands.

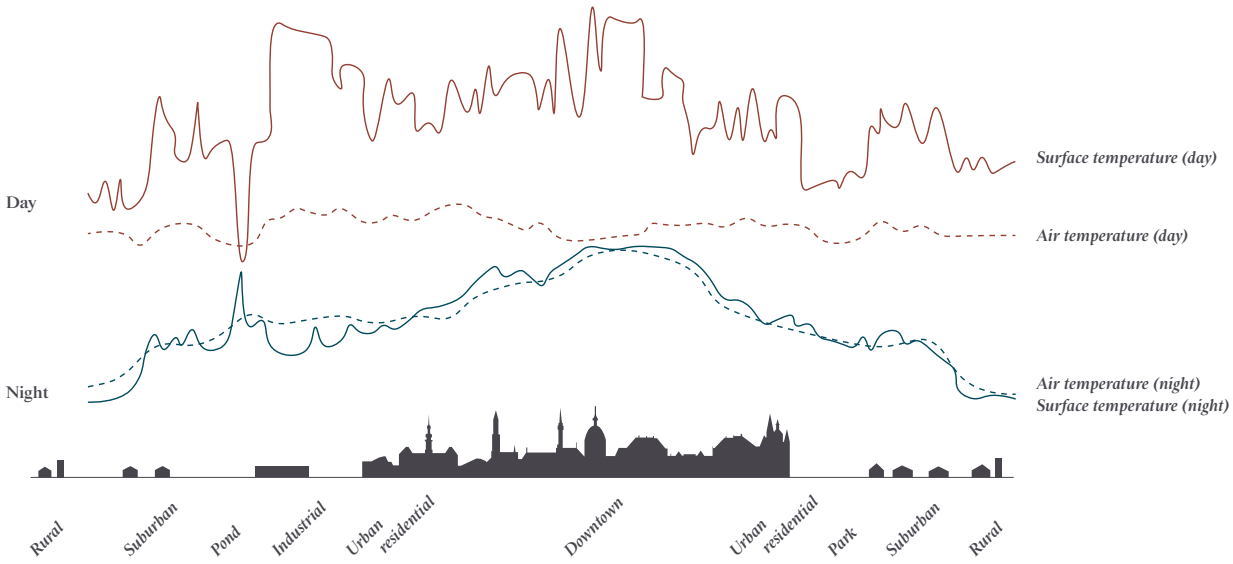


fig. 22 daily temperate averages in rural to urban environments in Copenhagen

The *Copenhagen Climate Adaptation Plan* specifically addresses these three risks through an economic and design related lens in order to plan for its future. Though the city has done vast amounts of work, especially in comparison to most other cities globally, more industrial parts of the city that are less frequented by tourists have yet to be addressed.

REFSHALEØEN

Refshaleøen is located on the northeastern side of Copenhagen Harbor. A manmade island, the site was a shipyard from 1871 to 1996. The original island, which was much smaller at the time, was built in 1624 and used as a port of entry to the harbor. Just south of the site is the Danish Navy Yard which is still in use today. Since 2010, the site has been used as a concert and events venue, hosting events such as Distortion and Copenhell - as well as a food truck market. Many of the existing industrial buildings have been repurposed for artist collectives, trendy restaurants, a climbing gym and the Copenhagen Contemporary Museum. Though the reclamation of the shipyard has been creative and prosperous, the site itself sits outside of the city center and has difficulty drawing visitors other than locals, especially in cooler times of year, as the main routes of transportation are by bus, harbor taxi and a fairly lengthy bike ride.

fig. 23 Refshaleøen aerial looking from south
fig. 24 map of Copenhagen


Site, Refshaleøen

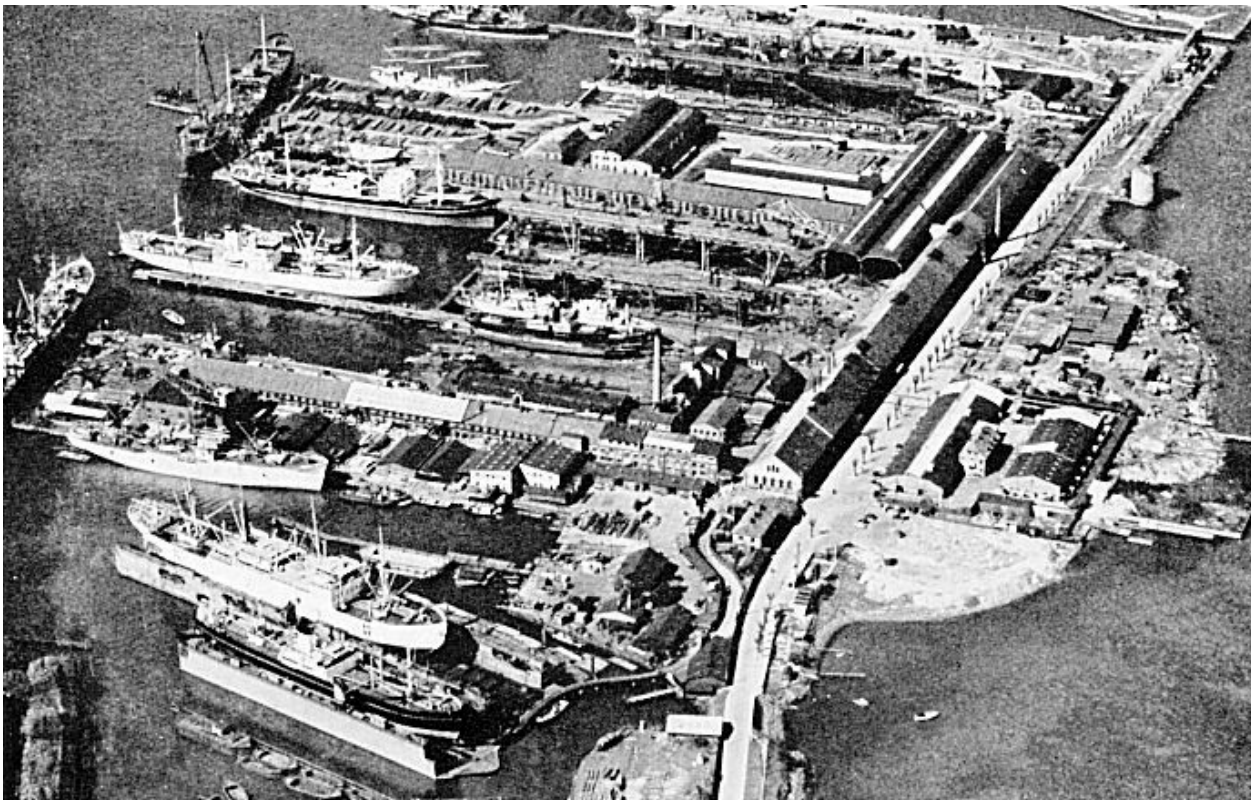


fig. 25 Refshaleøen transportation routes
fig. 26 historic photo

The site itself sits bordered by industrial buildings and roadways on two sides and harbor on the others. An open field used for ship storage, which now serves as camping for festivals a few weekends a year and houses a small garden for the restaurant Amass, makes up a large portion of the site, yet is flanked by dry docks and inlets used as swimming areas and boat docking.

Though the site has been used throughout the years, it remains a significant piece of land that could be repurposed and utilized in a more productive way. It's proximity to the harborfront suggests a water related function and its brownfield condition lend it to habitat restoration. While there may be more economically viable uses such as industrial or commercial development, the public benefits rationale of climate change education suggest alternative programming. For these reasons, this project is perfectly suited to develop this site as a sculpture park that leverages it as a space for arts, culture and public education. Finally, its location on the harbor lends it to it playing a role in the cultural/ecological network of the city, linking it with the many other important cultural sites and buildings that are situated along Copenhagen's harborfront.

fig. 27-32 site perspectives

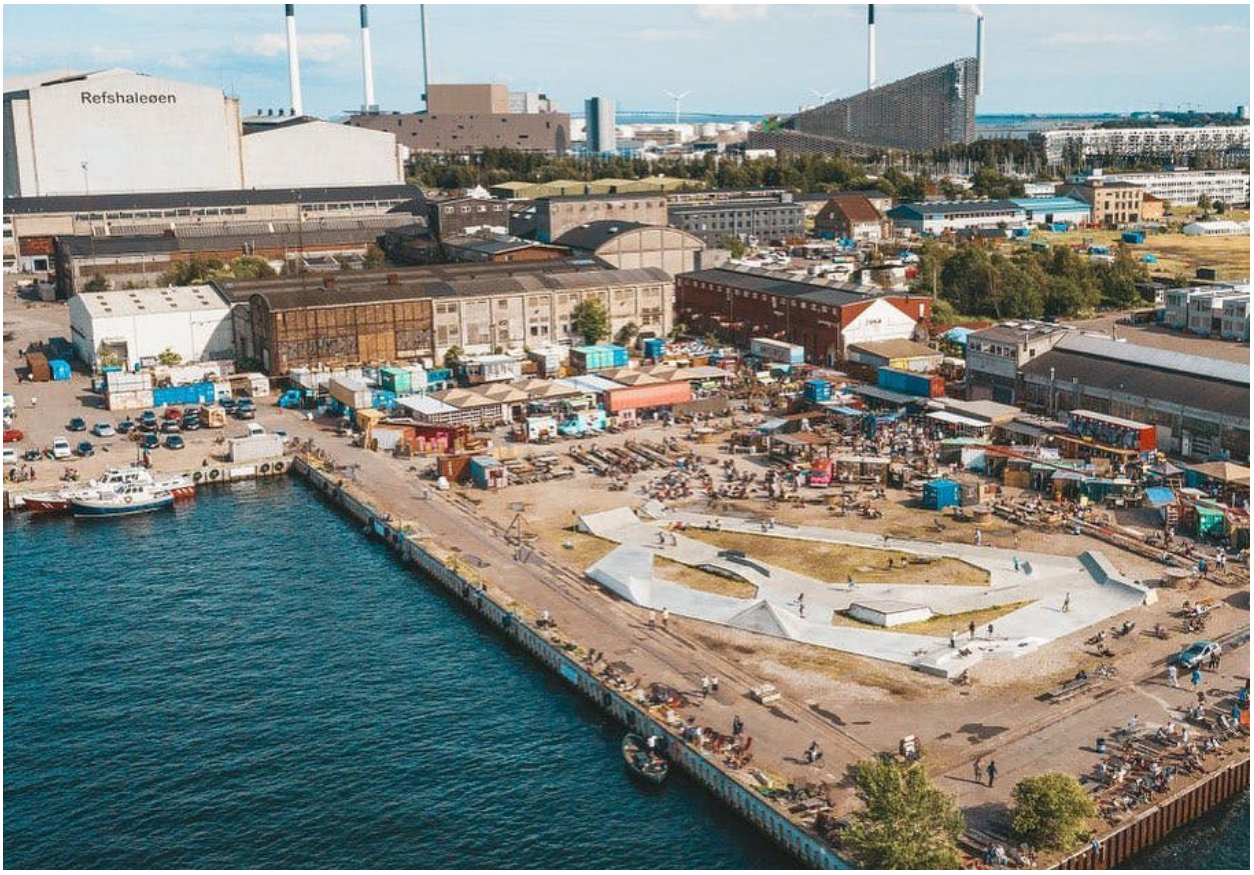


fig. 33 aerial view of Reffen from northwest

FIVE

methods

Using the framework of the UN Sustainable Development Goals, as well as the site specific risks outlined in the Copenhagen Adaptation Plan, I've identified 7 strategies that address climate change in Copenhagen. These 7 strategies can be directly applied to different ecological zones that occur at the site as well as the along the waterfronts of Coastal Denmark and similar locations.

STRATEGIES


1. Carbon sequestration


2. Increased food production


3. Biodiversity


4. Biofiltration


5. Cloudburst flooding mitigation


6. Storm surge flooding mitigation


7. Heat island effect mitigation

These strategies are a result of cross referencing the SDGs and Copenhagen climate risks/adaptations to create a list of key resilience strategies. The strategies chosen can each be utilized to achieve different goals and work simultaneously to combat climate change within the landscape. Working as a web, the strategies chosen are stronger working together than they are seperately.

fig. 34 Jutland, coastal Denmark

CARBON SEQUESTRATION

Carbon sequestration is "the long-term storage of carbon in plants, soils, geologic formations, and the ocean. Carbon sequestration occurs both naturally and as a result of anthropogenic activities and typically refers to the storage of carbon that has the immediate potential to become carbon dioxide gas."[9] Carbon sequestration is an incredibley powerful tool in mitigating climate change and can be carried out in many ways. Further, the technology to sequester carbon is already readily available and in many cases is simply a natural process. As long as we are aware of a need for higher levels of carbon sequestration, this strategy is easy to develop and maintain within a landscape.

Sustainable Development Goals Assocaited with Carbon Sequestration:

INCREASED FOOD PRODUCTION

Increased food production is important in respect to climate change because the world is quickly entering a food shortage. With more people on the planet and current croplands facing drought and extreme weather, finding new solutions to food production is imperative. Further, moving agriculture to new locations opens up land for afforestation and regeneration of lost habitats.

Sustainable Development Goals Assocaited with Increased Food Production:

BIODIVERSITY

Biodiversity is in decline due to climate change, with shifting and reduced habitats affecting species' prosperity. When one species is lost or affected by a changing climate, the entire ecosystem associated with said species is impacted.

Biodiversity is incredibly important for a healthy ecosystem because it boosts productivity on all levels of the ecosystem. For instance, the greater number of plant species there are, the greater number of species can be supported from those plants. A diverse ecosystem allows for balance.

Sustainable Development Goals Assocaited with Biodiversity:

BIOFILTRATION

Storm water runoff, especially due to flooding, increases pollutants entering both our drinking water and waterways, which in turns affects habitats and ecosystems. Biofiltration naturally occurs when water is able to soak through nutrient rich soil, like that found in wetlands, and allow for clean water to re-enter the system. Biofiltration is an incredibly simple strategy to employ within a landscape and has extremely beneficial results, all through natural process.

Sustainable Development Goals Assocaited with Biofiltration:

CLOUDBURST FLOODING MITIGATION

Cloudburst flooding mitigation occurs when rainwater is directed into basins and allowed to soak slowly into the soil. This takes pressure off of sewers and lessens damage from both surface runoff and sewage overflow. Cloudburst flooding is important to mitigate because, as discussed previously, these intense storms can produce incredibly damaging floods that have drastic economic consequences.

Sustainable Development Goals Assocaited with Cloudburst Flooding Mitigation:

STORM SURGE FLOODING MITIGATION

Storm surges are highly detrimental to coastlines. They are erosive and can damage and deplete ecosystems on a large scale. When high enough, storm surge flooding can extend past coastal barriers and cause damage to people, infrastructure and buildings. Stormsurge flooding mitigation tactics include adding buffer zones to coastal regions. Extending the coast outwards more gradually allows for water flowing and absorption from higher sea levels. The natural buffer zone is also able to be inundated with water to an extreme level without damage.

Sustainable Development Goals Assocaited with Storm Surge Flooding Mitigation:

HEAT ISLAND EFFECT MITIGATION

Heat island mitigation occurs when the use of impervious pavement is limited and cooler ecosystem zones, such as forest and wetlands, provide refuge through increased humidity, cooler ground temperature and shade. This strategy is easily employed and implementation also provides solutions for many of the other strategies.

Sustainable Development Goals Assocaited with Heat Island Effect Mitigation:

DIAGRAMMING THE PROCESS

The diagram on the following page visually demonstrates the process I went through in interpreting the policy researched. The ecological zones highlighted, which will be addressed in the following chapter, are used to employ the strategies laid out in this chapter, which mitigate the local risks and help to benchmark the Sustainable Development Goals.

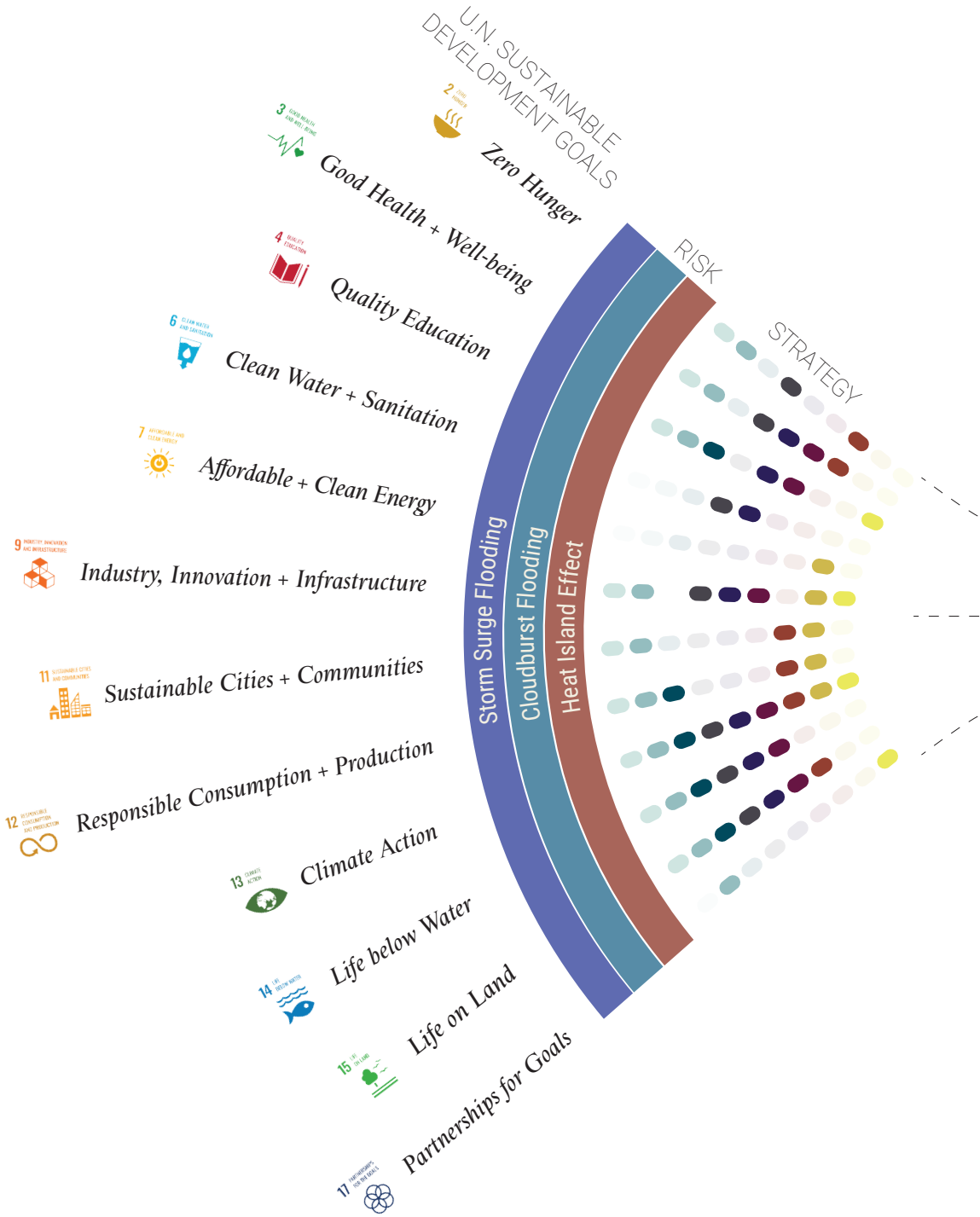


fig. 35 synopsis of integration of SDG's, risks, strategies and ecological tools

- Carbon Sequestration
- Food Production
- Biodiversity
- Biofiltration
- Cloudburst Flooding Mitigation
- Storm Surge Flooding Mitigation
- Heat Island Effect Mitigation
- Wind Energy
- Art Installations

SIX

ecological zoning

The previous strategies can now be linked to the ecological zones native to coastal Denmark and similar sites. The ecological zones that effectively employ the 7 strategies in Denmark's climate are forest, meadow, wetland, salt marsh and marine landscape. When these ecological zones are applied to the site in its current state, the zones are unproductive and will not heed the desired results of the employed strategies.

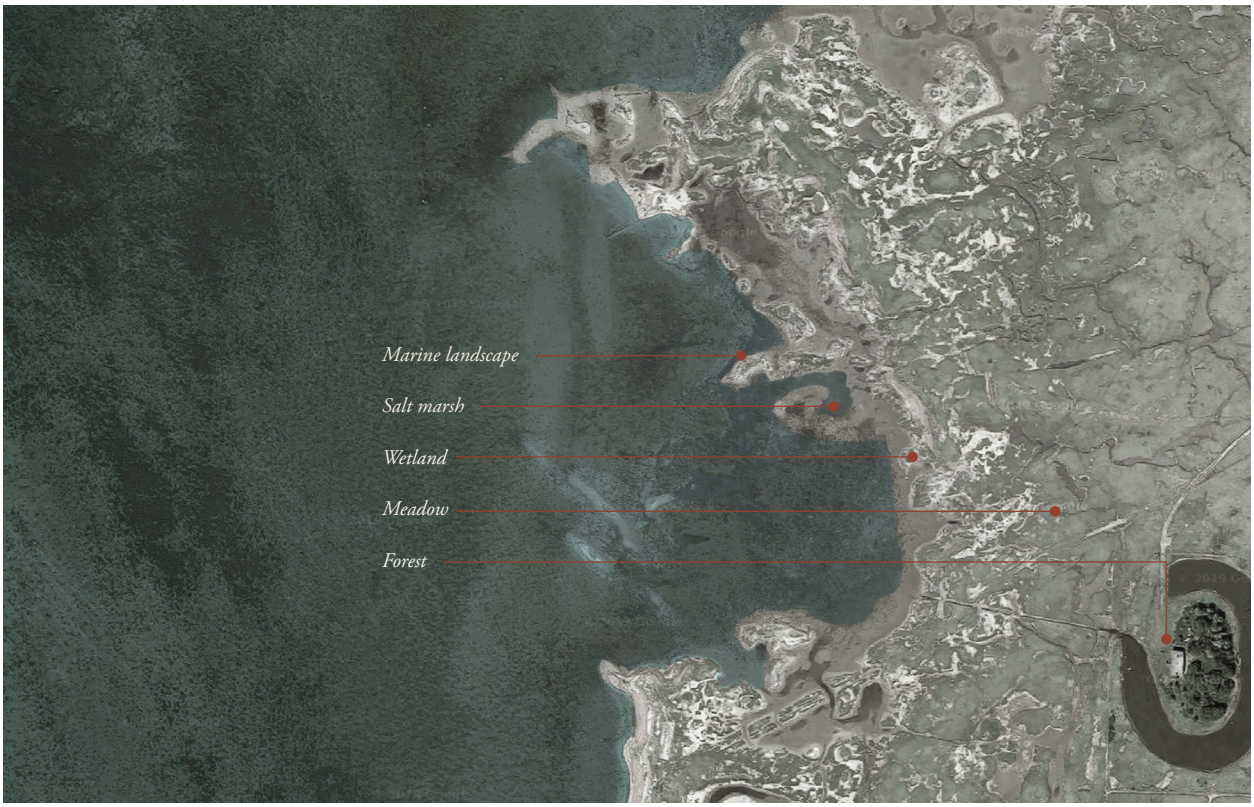
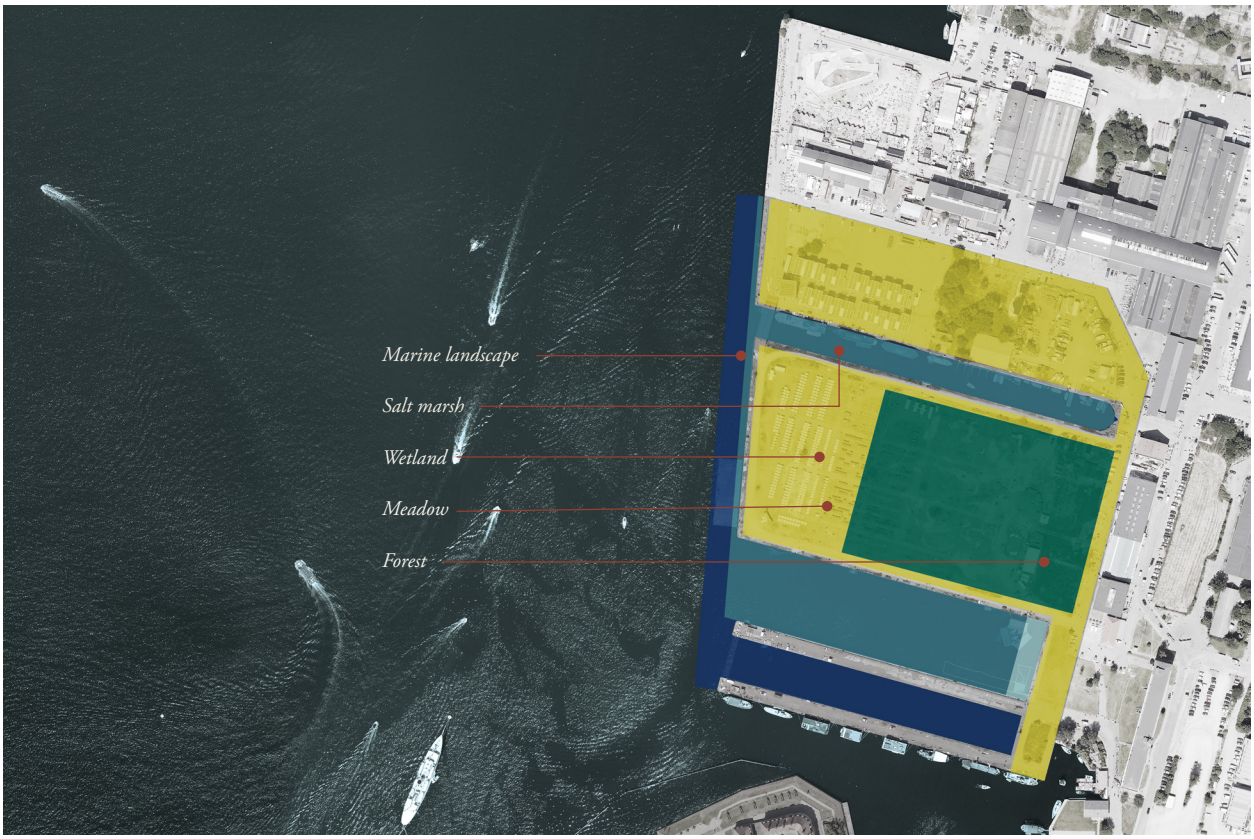


fig. 36 ecological zones naturally found on Saltholm
fig. 37 (opposite) site outline
fig. 38 (opposite) ecological tools used on existing site


Marine landscape
Salt marsh
Wetland
Meadow
Forest

In order to design the most effective landscape that address both the SDG's and associated risks, we can look at an island just south of the harbor, Saltholm, still essentially in its natural state. The island of Saltholm, used in past centuries as a military outpost and quarantine area in times of disease, has been made into a migratory bird sanctuary. Resilient in times of flood and interweaving all of the ecosystem zones, Saltholm is a natural model of coastal conditions most effective in the face of climate change.

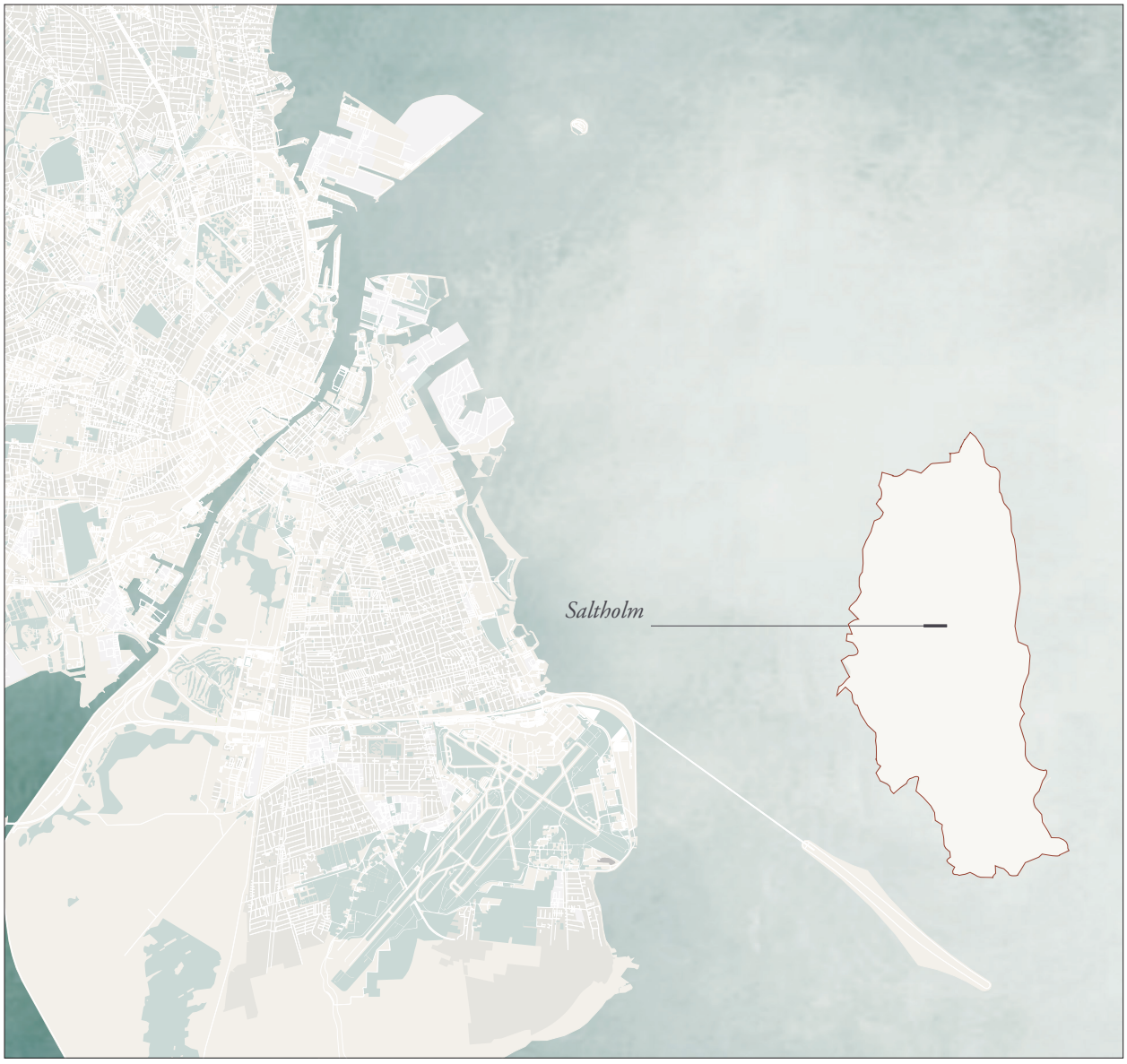


fig. 39 Map of Saltholm
fig. 40 (opposite) marshlands of Saltholm
fig. 41 (opposite) "Geese on the Island of Saltholm" - Theodor Philipsen, 1897

OVERLAYING THE EDGES

Overlaying Saltholm's edge with that of the site in Copenhagen produces an historic ecosystemic reference point suitable for landscape restoration and that is why is suitable as a basis for this climate resilient design program.

fig. 42 image of Saltholm
fig. 43 image of site
fig. 44 overlay of site outline on top of Saltholm edge

APPLICATION OF THE ECOLOGICAL ZONES TO THE PROJECT SITE

In this section, the ecological zones excavated at Saltholm are applied to the elaboration of the site design. Each of these zones applies one or more of the climate resilience tactics to one or more of the SDG objectives. Together, they provide an ecosystemic sampler that demonstrates climate mitigation and resilience strategies, and a living backdrop to the cultural project on the site.

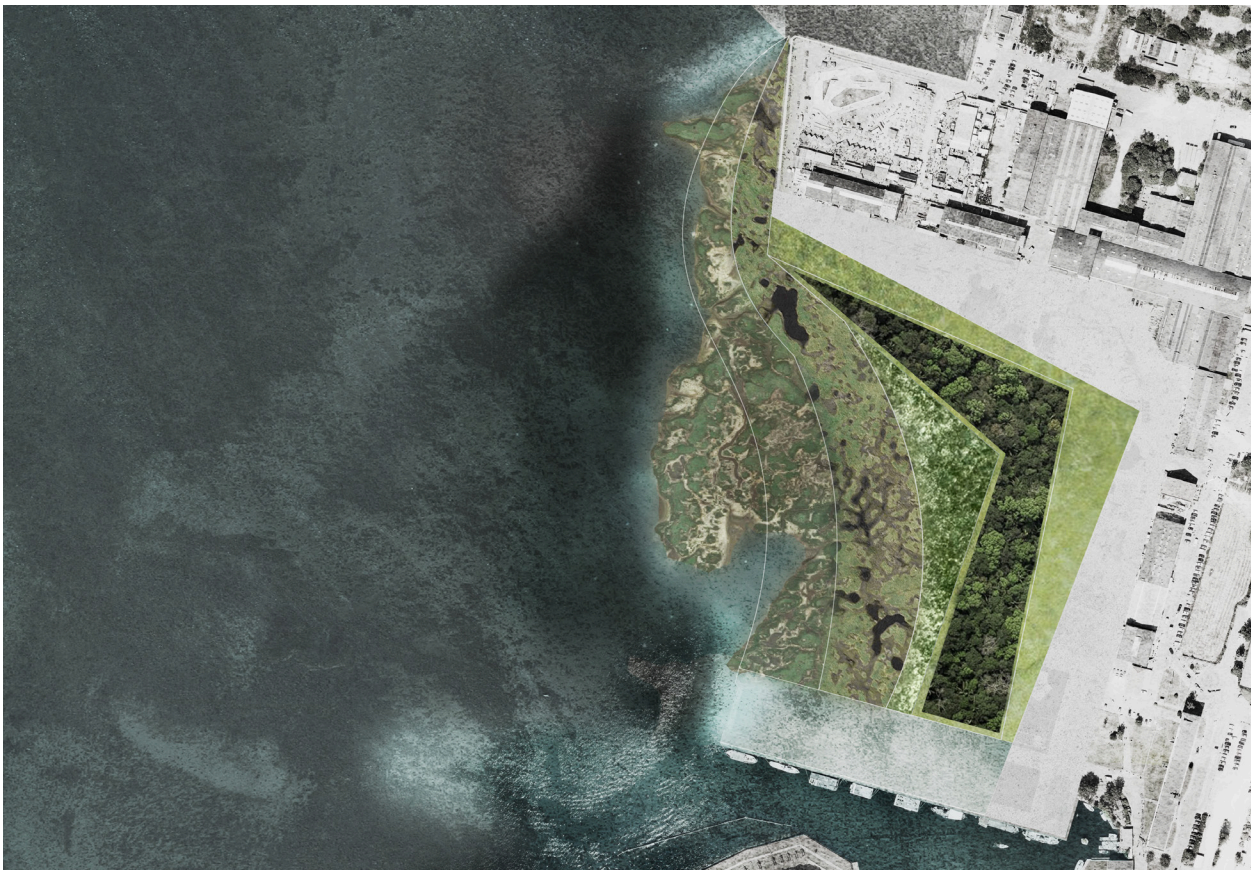


fig. 45 new site plan

FOREST

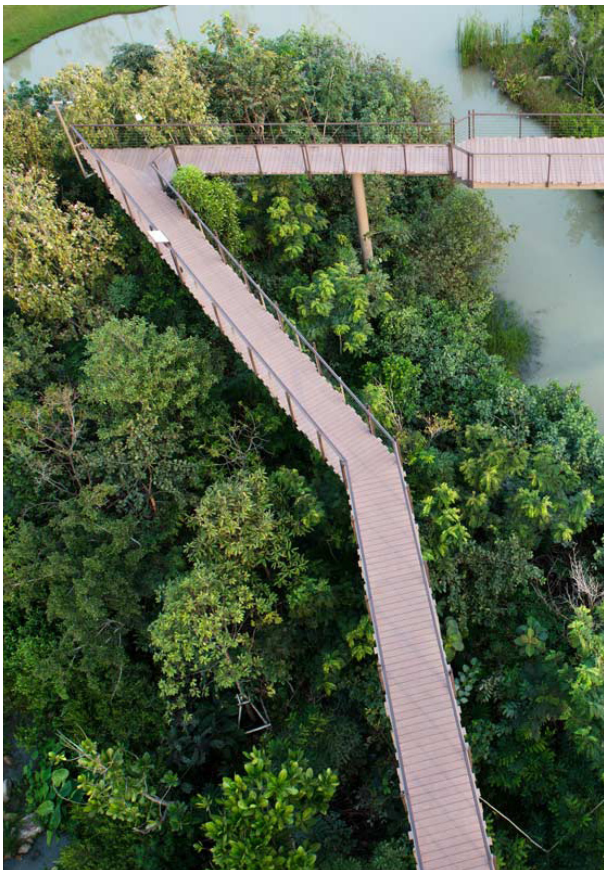
"A recent study published in Science posits that an increase in 0.9 billion hectares (2.2 billion acres) of new forests, an amount that would cover about 14 percent of habitable land, could sequester 205 gigatons of carbon from the atmosphere. This means a forest roughly the size of the United States or China could sequester more than five times the annual carbon output of the planet."[10]

Increasing forest not only sequesters carbon, but also cools the surface temperature and increases habitat. Further, forests provide a natural source of permaculture, or regenerative agriculture, to produce food with little maintenance or carbon emissions.

fig. 46 new site plan, forest zone

The Metro-Forest Project
LAB
Bangkok, Thailand

The Metro-Forest Project increases forested area in an urban location and allows visitors to experience the ecological zone from different perspectives. The project places value on increasing forested area in a location where many would argue that a different program would be more economically feasible. They have taken valuable land and demonstrated that climate resilient design is to be coveted and can be an enjoyable public space.



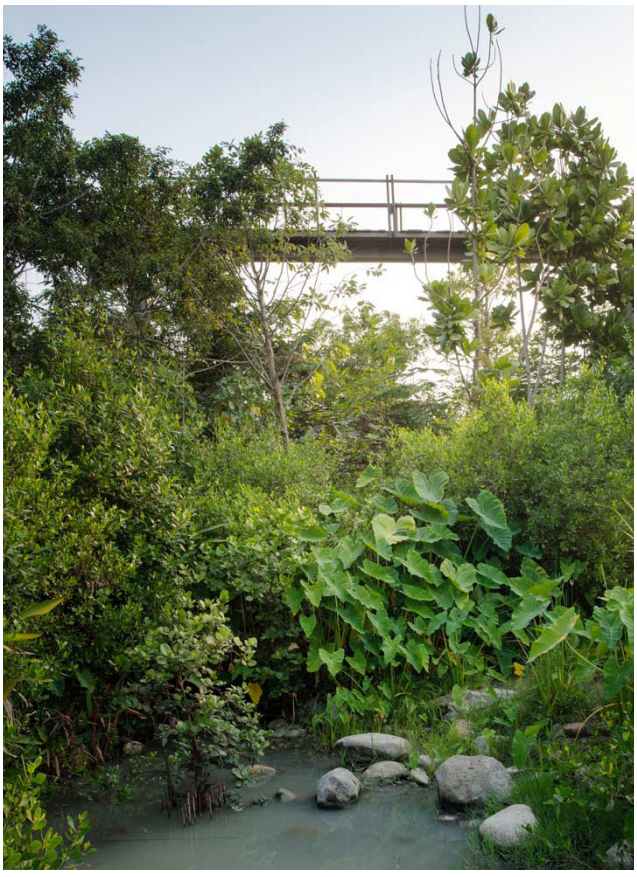


fig. 47, 48 The Metro-Forest Project walkways

MEADOW

Meadows are an integral part of ecosystems, as pollinators, which make up the regeneration of 90% of the earth's flowering plants, produce a large portion of fats and oils that humans consume. Meadows also sequester carbon and filter stormwater.

fig. 49 new site plan, meadow zone

Lurie Garden
GGN
Chicago, Illinois

This project is a prime example of a pollinator garden in an urban location. Located on Chicago's waterfront, the garden provides respite from the city but also increases habitat for pollinators. A beautifully designed space, this garden is used as an educational tool where visitors can interact with the different plantings throughout the year.

fig. 50 Lurie Garden, Chicago

FRESHWATER WETLANDS

Wetlands are incredibly resilient and adaptive, as the species supported there can live through dry and wet conditions. Many organisms live within this zone and wetlands are very effective at mitigating flooding as they slow and filter water.

fig. 51 new site plan, wetland zone

Shanghai Houtan Park
Turenscape
Shanghai, China

This project rehabilitated a brownfield, restoring wetlands and utilizing existing industrial structure for pathways and sculptural elements. Turenscape often works on projects that have a duality of purpose, like increasing green infrastructure and public space for residents as well as rehabilitating the land. They do so in a sustainable manner, utilizing existing materials when possible. Their designs are also often playful as well as educational.

fig. 52, 53 Shanghai Houtan Park wetlands and industrial infrastructure

SALT MARSH

Salt marshes provide buffer zones for storm surges and high tides. The plants in these zones are hearty and do well in salt conditions but can tolerate fresh water. These buffers are seeing an increase in their importance globally, as coastal regions require these areas to mitigate against flooding and protect against increasingly powerful storms. More shallow marshes that extend further out into the sea provide an increased area to mitigate against flooding.

fig. 54 new site plan, salt marsh zone

Oyster-Tecture
SCAPE
Brooklyn, New York

Oyster-Tecture focuses on salt marsh and breakers, increasing habitat areas while using marine landscape to mitigate flooding. Using the anatomy of an oyster, the system filters water and protects against flooding. A boardwalk system running throughout the site also connects the waterfront to the urban landscape so residents can enjoy the water.

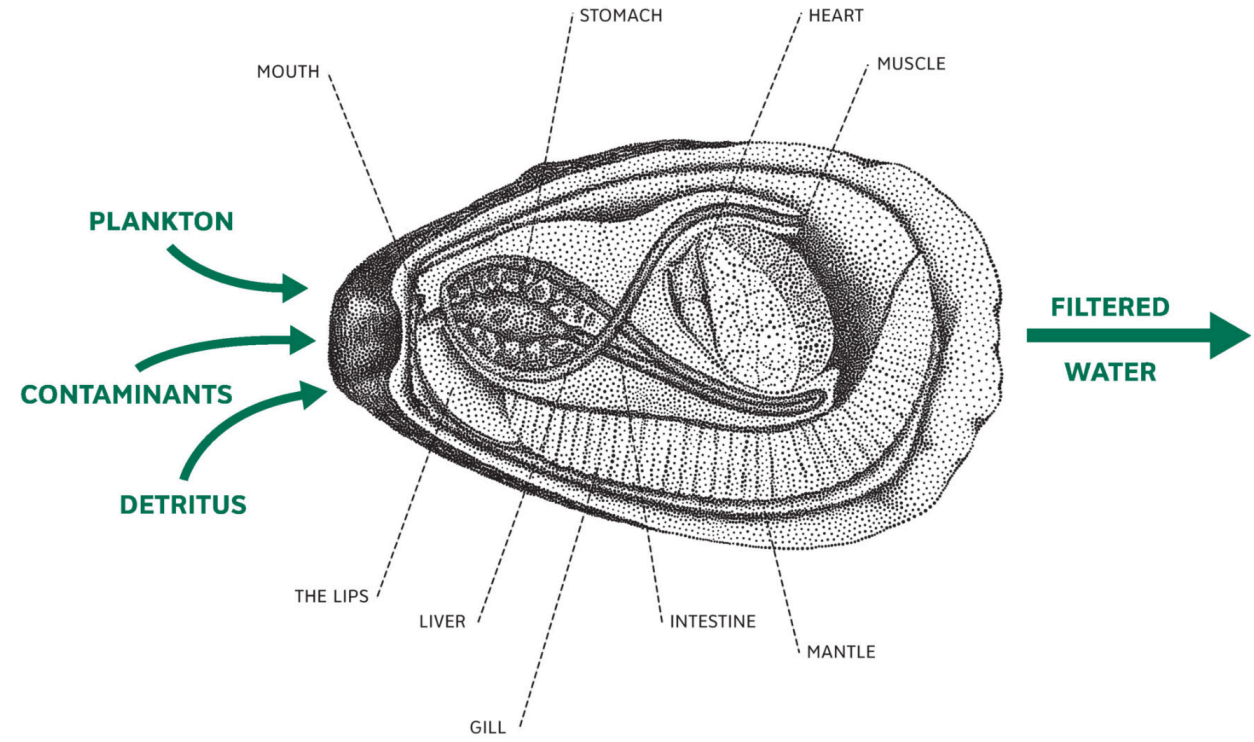


fig. 55, 56 Oyster-Tecture processes diagram and section

MARINE LANDSCAPE

Marine landscapes are incredibly rich in biodiversity and can host many different species within their ecosystems. Because of this diversity, there is ample opportunity for food production in shallow, light filled waters.

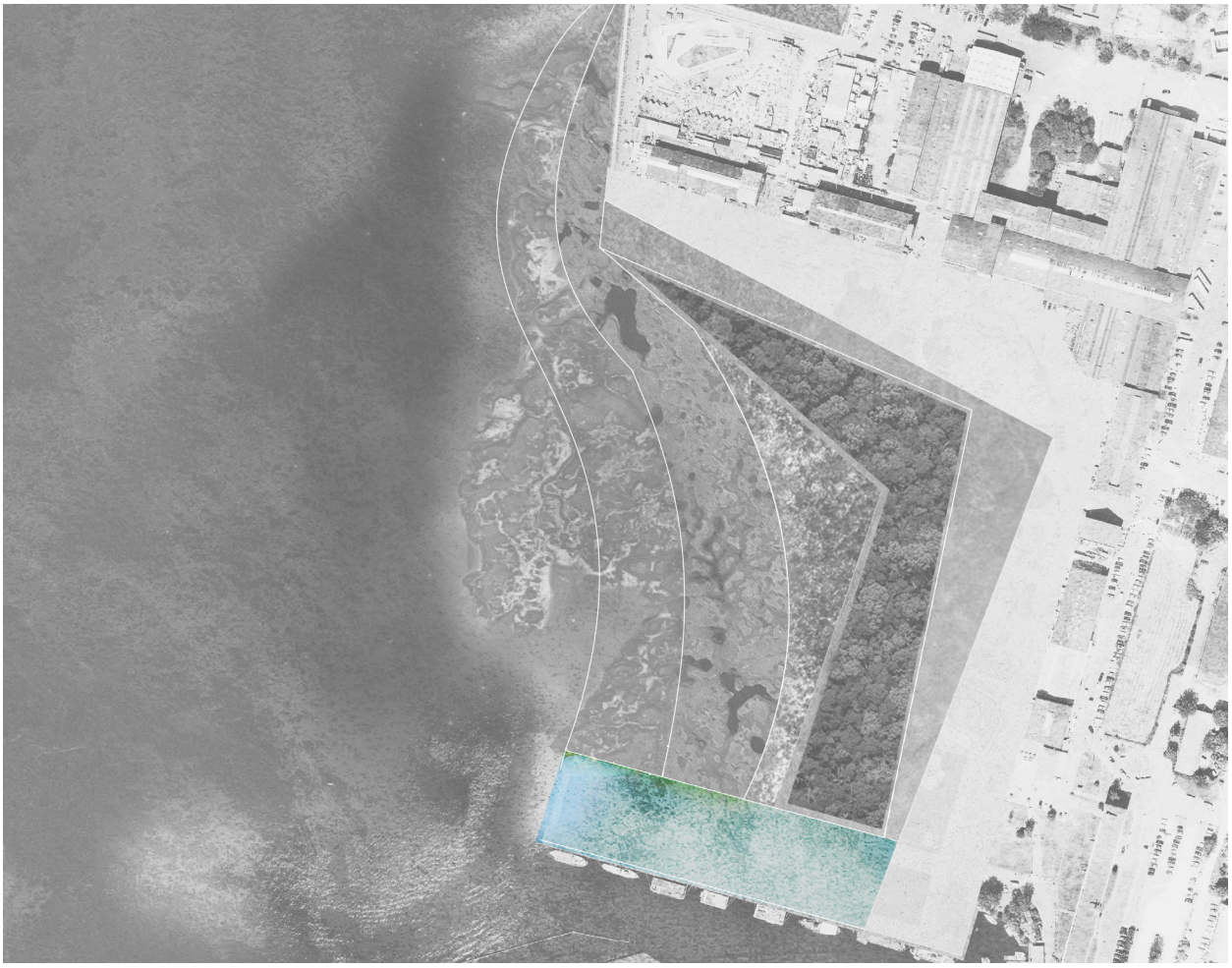


fig. 57 new site plan, aquaculture zone

3d Aquaculture
Bren Smith, GreenWave
Multiple Locations

Aquaculture is the farming of fish, crustaceans, molluscs, aquatic plants, algae, and other organisms. 3D ocean farming is a new development in aquaculture, which grows seaweed, oysters, scallops and mussels together vertically. They are quick growing, sequester carbon, filter water, and support seafood production to help offset overfishing.[11]

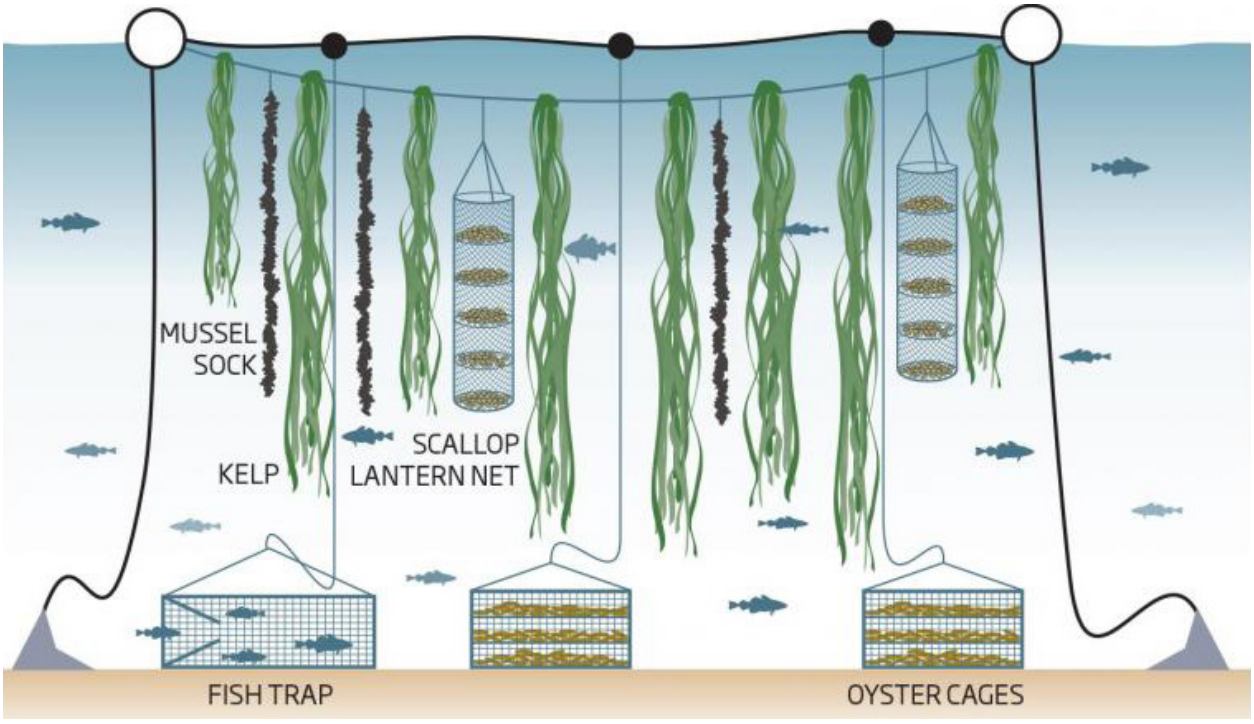


fig. 58 3D aquaculture diagram

SITE EDGES OVER TIME

This site is designed so that over time it becomes more natural, with edges and barriers shifting and changing. Because two of these edges are situated adjacent to manmade structures, the north and east sides of the site have harder, more constructed lines, with the zones transitioning to more natural edges as they work their way out to the water.

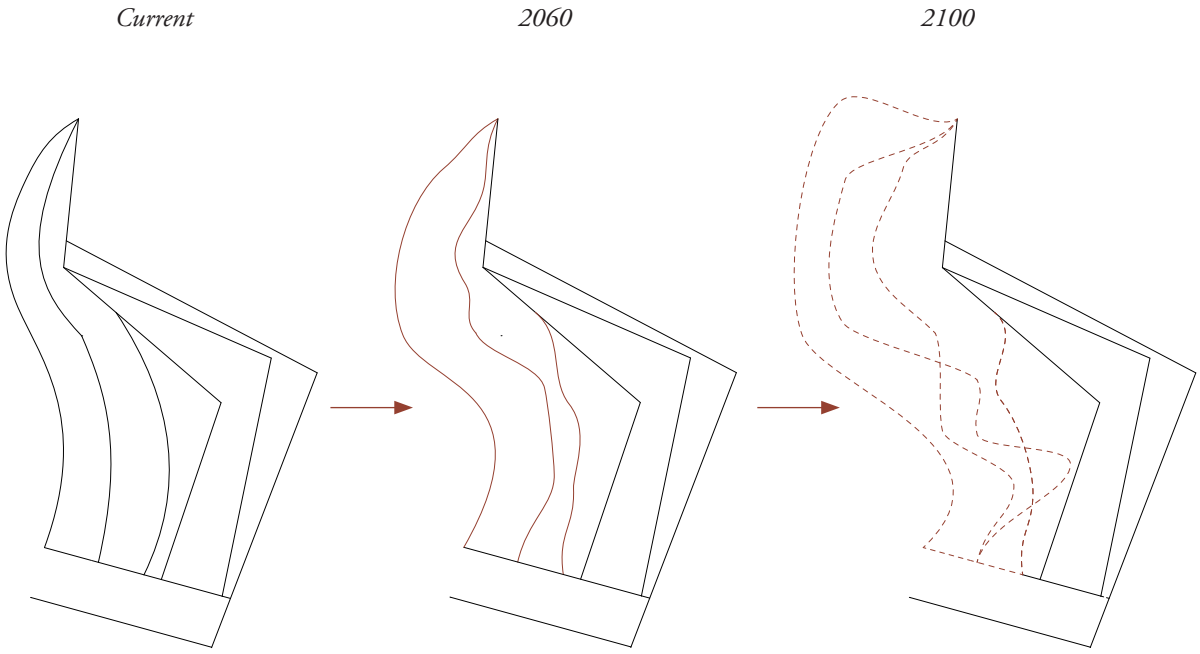


fig. 59 diagram of zone changes over time

Thes edges of these zones shift more naturally as they go through natural processes with the seasons, tides and floods.

SEVEN

human connection

Because Climate Change expands so much further past human scale temporaly and physically, the notion of emotionally connecting to a site so large needs to be addressed on a smaller scale to make it digestible. In order to give scale to a vast landscape, humans need to have a comprehensible marker that they can relate to.

FIDUCIAL MARKERS

Fiducial markers are "objects placed in the field of view of an imaging system which appear in the image produced, for use as a point of reference or a measure."[12] Historically, fiducial markers have been used to provide reference points when other scale markers are not visible. As with the markers in this image, we can place similar markers in the sculpture park to give point of reference and create a human scaled element of the park, thus making it more relatable for the visitor.

By placing pylons on the site in 20 meter intervals on a north-south grid, a framework for connecting humans and landscape is created. The top of the pylons are all at the same level, creating a datum for the site. This means that they rise 10 meters out of the water and stand at 7 meters in the forest, as there is a 3 meter change in topography over the site. The steel pylons provide structure for a tension system which allows visitors to navigate throughout the ecosystems of the site on boardwalks and platforms, each of which are suited to different environments. Using a tension system reminiscent of a ship's mast, the boardwalks are suspended in air, laying lightly on the land and creating minimal impact. Furthermore, these pylons support variable art installations over the site over the course of time.

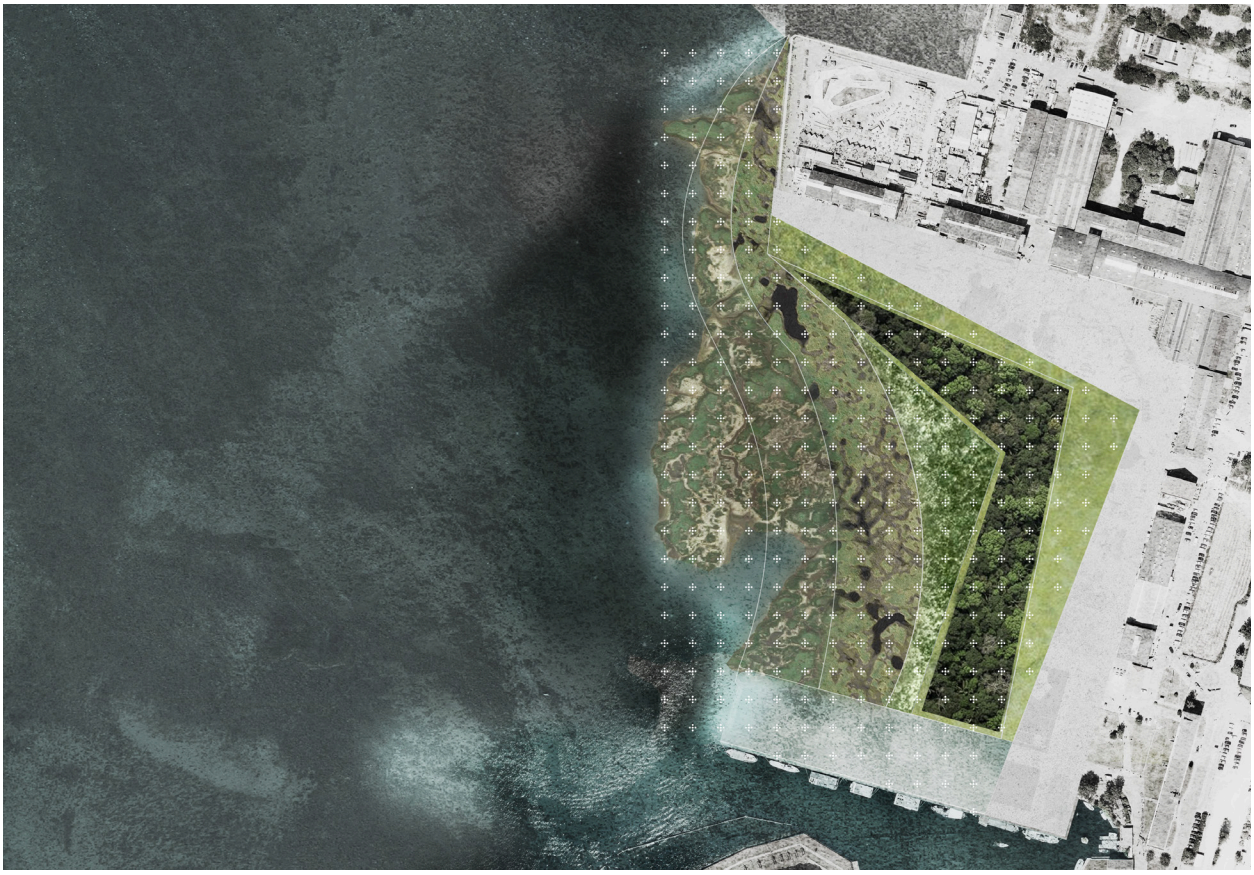


fig. 60 (opposite) fiducial markers on a NASA photograph, Apollo 14 crew
fig. 61 new site plan with pylons

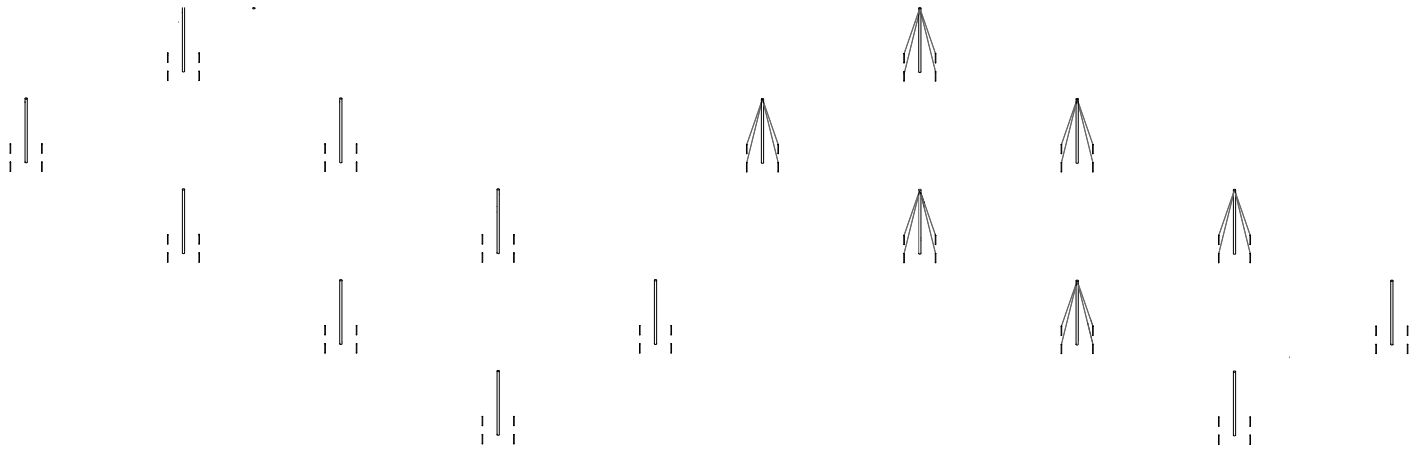
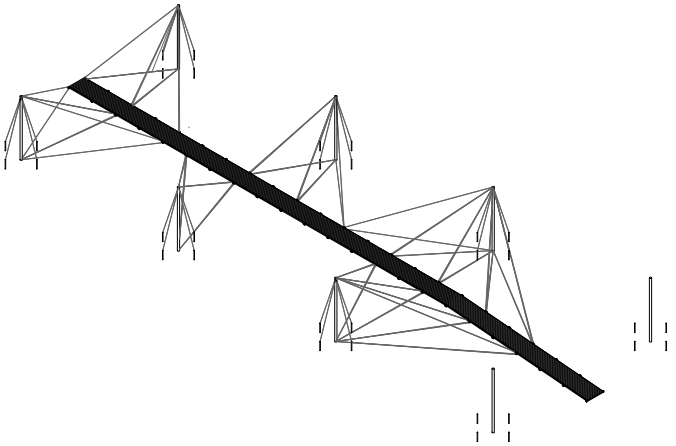
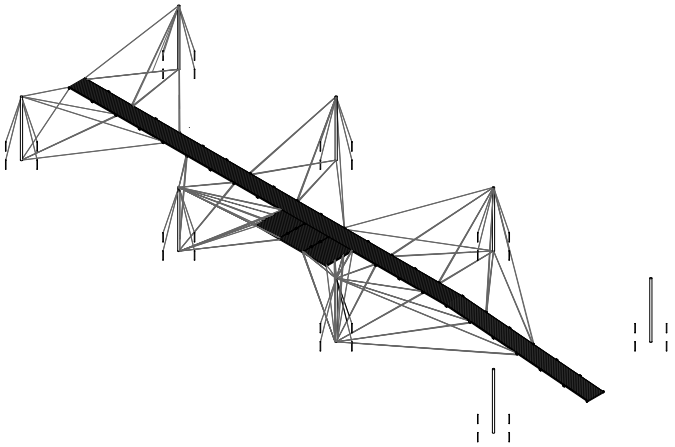


fig. 62, 63, 64, 65 pylon boardwalk structrure activation

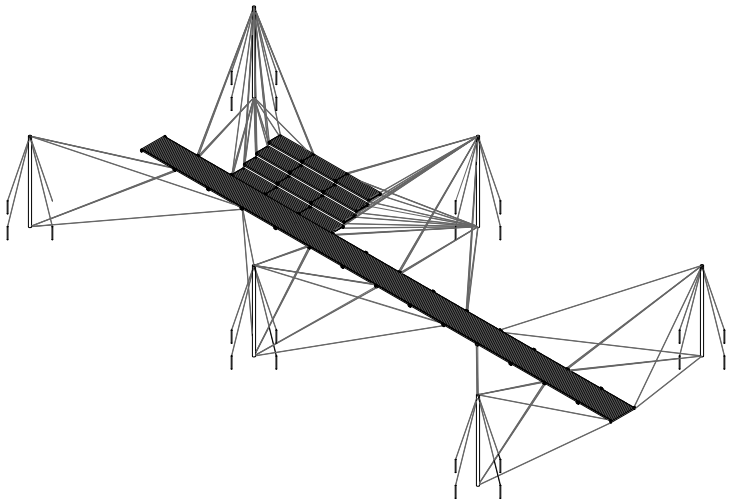
Pylons are activated through a tension system that allows for flexibility in design of where the boardwalks are placed. The grid structure makes it so platforms can be incorporated along the pathway at regualar intervals.

The pylons themselves demonstrate climate change, as they weather with floods and storms, marking historical events.



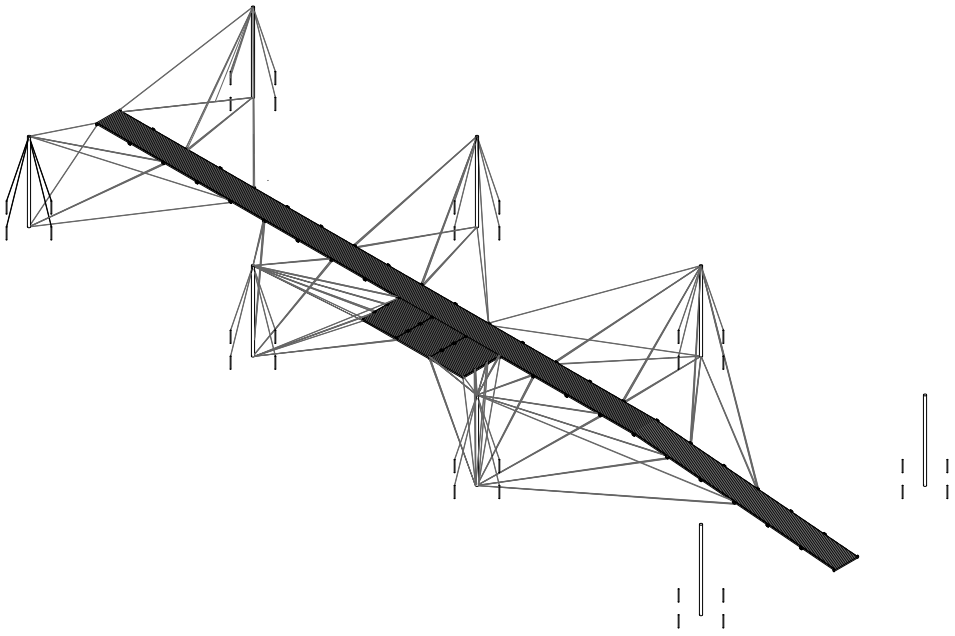


1. Forest



Boardwalk platforms within the forested zones extend upwards so the forest canopy can be experienced at a different level.

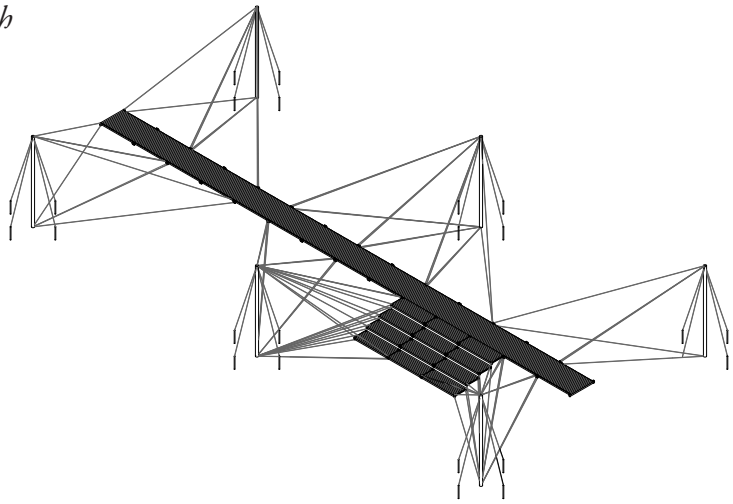
2. Meadow



Boardwalk platforms in the meadow remain flat but extend outwards. The horizontal nature of the landscape lends itself to the shape of the platform

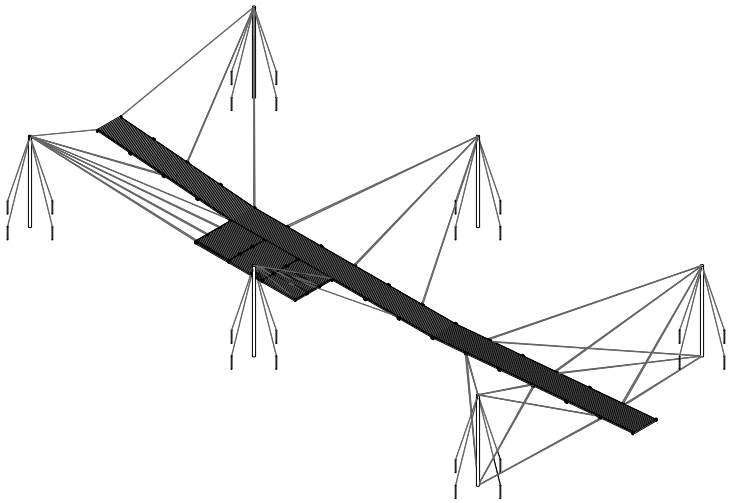
fig. 66, 67, 68, 69 pylon boardwalk structrure

3. Wetland/Salt Marsh



Boardwalk platforms within the wetter area of the landscape lower down so that visitors can have a closer view of the site without getting wet or disturbing the ecology.

4. Salt Marsh/Aquaculture



Boardwalk platforms in the water zones of the site float atop the surface. This type of platform can be used for swimming or the more utilitarian purpose of tending to the aquaculture.

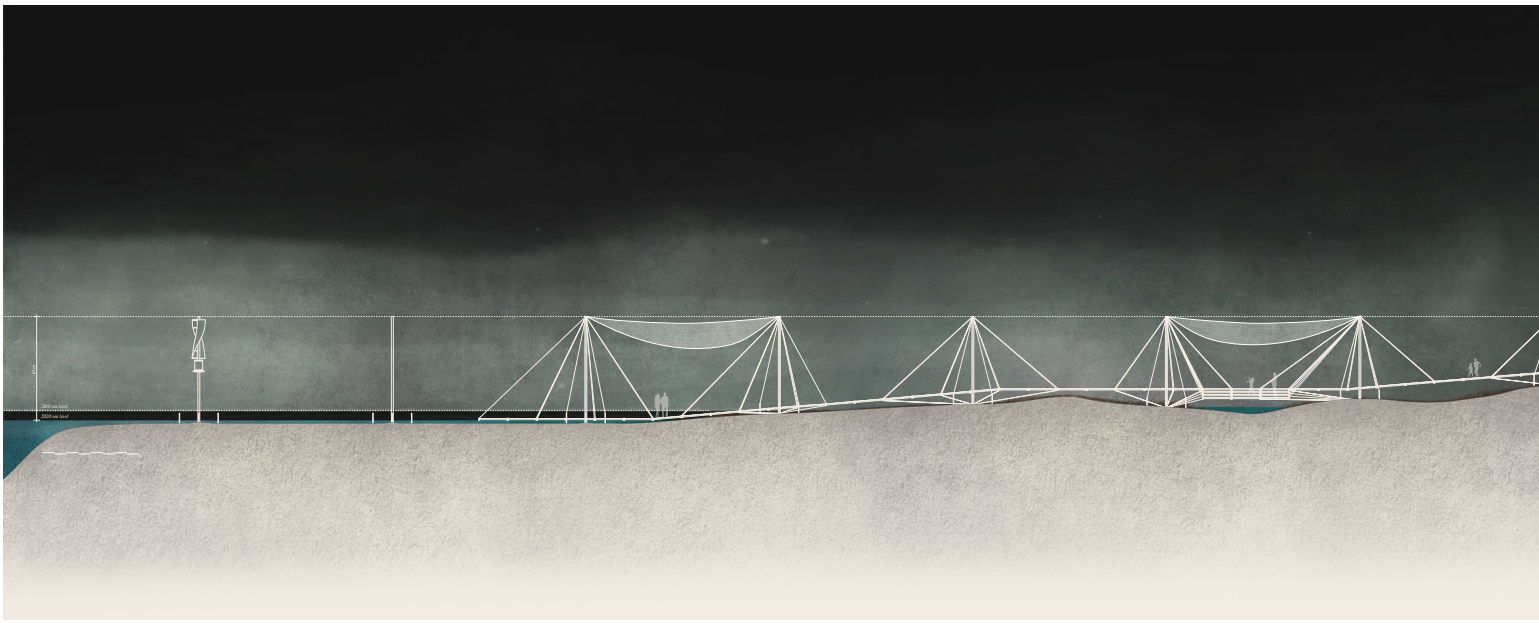


fig. 70 transverse section through ecological zones

fig. 71 (previous) site aerial looking east
the pylon structure allows for variability in the pathway system,
allowing for many different circulation options through
ecological zones

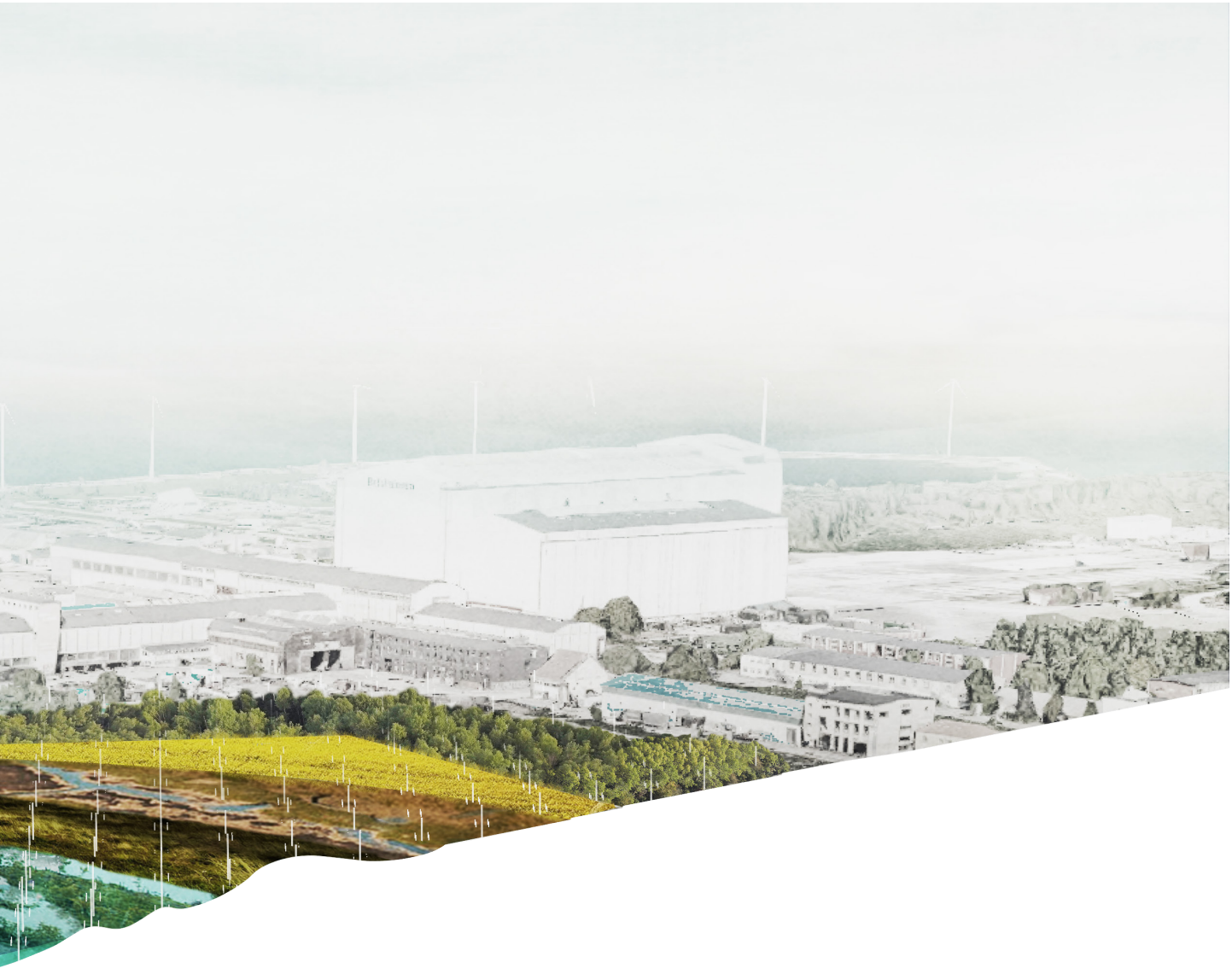


fig. 72 section perspecive of site

ART IN THE LANDSCAPE

Building on the site's ecological restoration and evolving nature over short and long term time, artists creating climate change art are invited to exhibit their works throughout the site, interpreting their own procession through the environment using the kit of parts. This can relate to a certain narrative from the artist, a specific ecosystem that they wish to address, or otherwise.

The pathway system also provides the aquaculture portion of the site with utilitarian circulation, with floating platforms working in conjunction with boats to harvest oysters, mussels and seaweed. The westernmost line of pylons are vertical windmills, which harness wind energy while maintaining a safe habitat.

STRATEGIES EMPLOYED IN ECOLOGICAL ZONES

Each of the seven strategies outlined in the previous chapter are utilized in multiple ecological zones on the site. For each individual zone, the strategy may be used in a different way to achieve the desired goal, helping to mitigate climate change and employing climate resilient design tactics.

1. Forest


Carbon Sequestration - planting a large number of trees on the site increases carbon sequestration.


Increased Food Production - permaculture within a forested area allows for low-maintenance food production from fruit-baring trees.


Biodiversity - The many different layers of habitat in forests provide a wide range of homes. Many different species are able to co-exist within this ecosystem.


Biofiltration - nutrient rich soils filter out contaminants, allowing water to slowly soak through.


Cloudburst Flood Mitigation - As with biofiltration, the forest slows and absorbs water from heavy storm events, decreasing the liklihood of flood.


Heat Island Effect Mitigation - Perhaps the best mitigating tactic against heat island effect, the forest provides shade, shelter and higher humitidy than the areas surrounding it.

2. Meadow


Carbon Sequestration - meadows are teaming with plant life and nutrient rich soil, enabling them to sequester large emounts of carbon.


Increased Food Production - meadows can grow many different types of food, from grains, to flowers to fats and oils. Further, bees, which pollinate these meadows, produce honey.


Biodiversity - much like the forest, different meadow regions provide different habitats, increasing biodiversity. Pollinators in these meadows thrive and are often a good indicator of the health of the ecosystem.


Biofiltration - nutrient rich soils filter out contaminants, allowing water to slowly soak through.


Cloudburst Flood Mitigation - As with biofiltration, the meadows slows and absorbs water from heavy storm events, decreasing the liklihood of flood.

Heat Island Effect Mitigation - The large amounts of plant life in meadows provide a cooler atmosphere during heatwaves. The ground also holds more water, mitigating heat island effect.

3. Freshwater Wetland

Carbon Sequestration - Wetlands sequester huge amounts of carbon, as they are diverse and hold dense, decomposed material within their nutrient-rich soils.

Biodiversity - Wetlands are very diverse because they have a range of different ecosystems, ranging from dry to wet.

Biofiltration - nutrient rich soils filter out contaminants, allowing water to slowly soak through.

Cloudburst Flood Mitigation - As with biofiltration, the meadows slows and absorbs water from heavy storm events, decreasing the liklihood of flood.

Heat Island Effect Mitigation - The large amounts of plant life in wetlands provide a cooler atmosphere during heatwaves. During many parts of the year, large amounts of water are held in this ecosystem, keeping the ground cooler than when dry.

4. Salt Marsh

Carbon Sequestration - Salt marshes sequester huge amounts of carbon, as they are diverse and hold dense, decomposed material within their nutrient-rich soils.

Biodiversity - Salt marshes are very diverse because they have a range of different ecosystems, ranging from dry to wet.

Biofiltration - nutrient rich soils filter out contaminants, allowing water to slowly soak through.

Storm Surge Mitigation - The slowly sloping edge condition creates a buffer region, mitigating damage from flooding.

5. Aquaculture

Carbon Sequestration - Seaweed grows at an alarming rate and the vast amounts of it are able to sequester huge amounts of carbon.

Increased Food Production - Aquaculture grows different species simultaneously while offsetting overfishing by providing an alternate source of food.

Biodiversity - By practicing aquaculture, species are able to grow and coexist in their natural habitat.

fig. 73 forest section with boardwalk, associated strategies

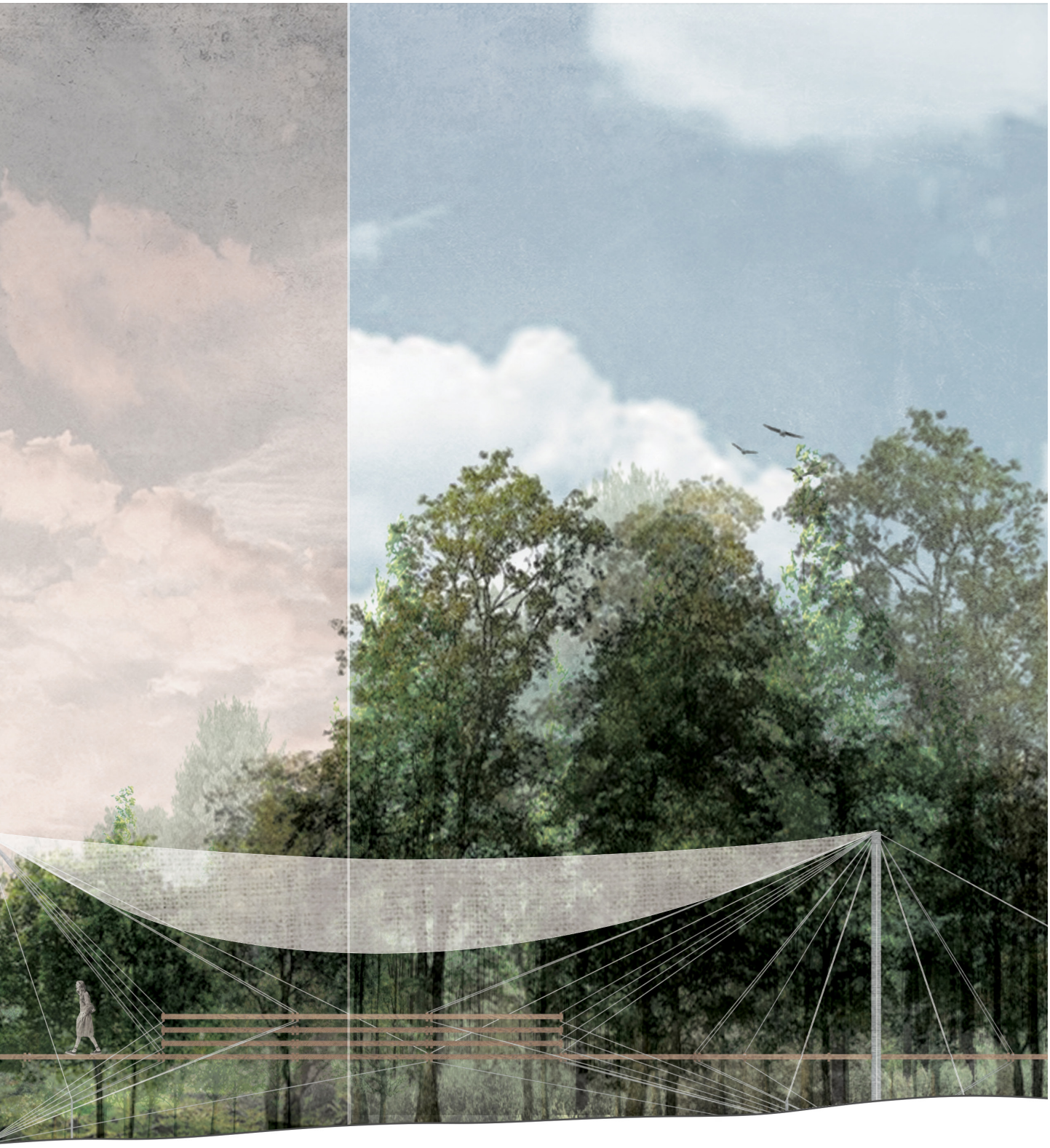


fig. 74 forest section with boardwalk, associated strategies

fig. 75 wetland section with boardwalk, associated strategies

fig. 76 salt marsh section with boardwalk, associated strategies

fig. 77 aquaculture section with boardwalk, associated strategies

EIGHT

conclusion

Climate Change is the most existential threat facing mankind. While we technically know what humans must do to cut emissions to keep global warming under 1.5 degrees celsius, the urgency and complexity of transition is daunting. In Special Report 1.5, IPCC scientists noted that we have only eleven years to get emissions on track to reach net zero carbon emission by 2050. Implementing the necessary behavioral and institutional changes is extremely difficult: most people find it difficult to comprehend the enormity of the challenge, our institutions and private sector must rise to the task, and we need good data to measure progress. All of these factors imply a rational response to the climate challenge.

An alternative approach to leverage human climate responsiveness is to combine ecological education with the emotional power of art. This project demonstrates such an approach, using a case study brownfield site in the Copenhagen harbor front. The methodological basis of the project was to integrate Copenhagen Climate Adaptation planning with UN Sustainable Development Goals to identify seven key climate resilience tactics. These formed the basis for the site design, which used a nearby reference ecosystem to restore the site to five typical ecosystemic zones, including: forests, meadow, freshwater wetland, saltmarsh, and aquaculture. This ecological system sets the stage for a sculpture park built on a flexible grid of pylons.

Placing a sculpture park on Copenhagen's harbor front that puts climate resilient strategies first and encourages the user to visit for cultural reasons, promotes human connection with natural

processes that are too difficult to otherwise understand. Having regular interactions with this park allows visitors to see the site change and evolve over time with the effects of climate change, and see the impact that they themselves are making. Visitors can also see the solutions and strategies being implemented through the site itself and exhibitions highlighting and explaining the sustainable development goals to combat climate change. This will help the citizens of Copenhagen understand climate change from both a theoretical and emotive level, building momentum for a global movement to combat the largest issue faced by our generation.

fig. 78 boardwalk perspective in forest
AgrAir, Piuarch
Original location: Milan, Italy

fig. 79 boardwalk perspective in meadow
Waves, One Works
Original location: Milan, Italy

fig. 80 perpective over time, view from the edge of the site. from right tleft, existing conditions, the year 2020, and the year 2100
Naoshima Pavilion Sou Fujimoto
Original location: Naoshima Island, Japan

FIGURES

All images created by author unless otherwise noted

32. site perspectiv
33. aerial view of Reffen from northwest
https://www.visitcopenhagen.com/copenhagen/eat-drink/copenhagen-food-markets
34. Jutland, coastal Denmark
https://reversehomesickness.com/europe/nature-west-coast-of-denmark/
35. synopsis of integration of SDG's, risks, strategies and ecological tools
36. ecological zones naturally found on Saltholm
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39. Map of Saltholm
40. marshlands of Saltholm
41. "Geese on the Island of Saltholm" - Theodor Philipsen, 1897
https://en.m.wikipedia.org/wiki/File:Theodor_Philipsen_-_Geese_on_the_Island_of_Saltholm_-_KMS4176_-_Statens_Museum_for_Kunst.jpg
42. image of Saltholm
43. image of site
44. overlay of site outline on top of Saltholm edge
45. new site plan
46. new site plan, forest
47. The Metro-Forest Project walkways
http://landezine.com/index.php/2016/07/metro-forest-bangkok-urban-reforestation-by-lab/
48. The Metro-Forest Project walkways
http://landezine.com/index.php/2016/07/metro-forest-bangkok-urban-reforestation-by-lab/
49. new site plan, meadow
50. Lurie Garden, Chicago
https://www.ggnltd.com/the-lurie-garden-at-millennium-park
51. new site plan, wetlands
52. Shanghai Houtan Park wetlands
https://www.archdaily.com/131747/shanghai-houtan-park-turenscape
53. Shanghai Houtan Park industrial infrastructure
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54. new site plan, salt marsh zone
55. Oyster-Tecture processes diagram
https://www.scapestudio.com/projects/oyster-tecture/
56. Oyster-Tecture section
https://www.scapestudio.com/projects/oyster-tecture/
57. new site plan, aquaculture zone
58. 3D aquaculture diagram
https://climate.mit.edu/climate-change-ocean-aquaculture-resiliency-and-re-inventing-food-system
59. diagram of zone changes over time
60. fiducial markers on a NASA photograph, Apollo 14 crew
https://www.lpi.usra.edu/resources/apollo/frame/?AS14-68-9487
61. new site plan with pylons
62. pylon boardwalk structrure activation
63. pylon boardwalk structrure activation
64. pylon boardwalk structrure activation
65. pylon boardwalk structrure activation
66. pylon boardwalk structrure
67. pylon boardwalk structrure
68. pylon boardwalk structrure
69. pylon boardwalk structrure
70. transverse section
71. site aerial looking east
72. section perspective of site

73. forest section with boardwalk, associated strategies
74. meadow section with boardwalk, associated strategies
75. wetland section with boardwalk, associated strategies
76. salt marsh section with boardwalk, associated strategies
77. aquaculture section with boardwalk, associated strategies
78. boardwalk perspective in forest
79. boardwalk perspective in meadow
80. perpective over time, view from the edge of the site. from right to left, existing conditions, the year 2020, and the year 2100

CITATIONS

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