Rising tides: resilient Amsterdam

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COUNTRY OF WATER

Like windmills, wooden clogs, tulips, and cheese, water is synonymous with the Dutch. More so, in fact, because the symbols of Dutch culture that we readily recognize all have water in their roots.

The connections are revealed everywhere; from the iconic canals edging the streets of Amsterdam, to the perfectly lined sluits of the country side. Water is what makes this country work, but now more than ever, the threat of water calls for some serious attention.

The resiliency of the Netherlands stems from its ability to adapt to change in climate, society, and the environment. In this way they have moved towards methods that aim to live with water rather than without. Informed by the methods of the past, the Dutch revive historic solutions to suite their modern needs. They celebrate water in their streets, canals, and rivers, they put water to use, they design with it in mind, and they resist it only when absolutely necessary.

This study looks at four methods for living with water while remaining resilient against it. These solutions prove that adapting to changing environmental conditions provides opportunity for improvement in design and function overall.
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FOREWORD

In an article by NPR's Richard Harris, researchers state that they are beginning to think that global sea levels are likely to rise two or three feet by the end of the century. With levels this high, places like New York City can expect devastating superstorms like Sandy much more often. "What today is a once-in-a-century storm surge event in New York City would happen every three years if you had a one-meter rise in sea level." said Stefan Rahmstorf from the Potsdam Institute for Climate Impact Research.

As a native New Yorker, it is no surprise that this news frightened me. I can easily recall countless stories from family and friends who suffered through devastation in the post-Sandy tri-state area. Half of the residents of Long Island were without power; their basements flooded, homes ripped from the ground. It was a shocking and disheartening mess to see the powerful city of New York crumble under one night of rain.

Disaster informs design. Unfortunately, or rather fortunately, New York has not previously had this type of devastation to learn from. It was not an event that was anticipated, and so it could not have been planned for. Lurching by the sudden onset and panic, our resources were spent on recovery, not on resiliency.

While the Dutch do not have hurricanes, they have had their share of tragedy. This country below sea level has combatted years of storms and flooding. In response they have sculpted the land to suit their needs. They have made a promise that those floods that occurred in their past would never happen again.
DEFINITIONS

Sluice Gate // A sliding gate devised to control the movement of water.

Runnel // A narrow ground channel utilized for the movement and drainage of water.

Dike // A man made embankment built to eliminate the risk of flooding.

Windmill // A moving turbine first used in the 1200's for the drainage and construction of dry lands.

Terp // A man made mounded landscape, in this case, built from clay and peat.

Polder // A region of low lying grounds that have been reclaimed from the water by means of protective dikes and drainage.

Enclosure Dike // A man made dike that is implemented to seal an inland area from the open sea.
STUDY QUESTIONS

I began my research with one overarching question. I hoped to discover how I could directly apply what I learned from the Dutch to New York's growing coastline resiliency issues. When I first dove in, I chose to look at many of the famed methods the Dutch utilize. In doing so, I had failed to understand the context of those designs and their relationship to one another.

I quickly understood that I was asking fundamentally the wrong question. There is no stamp, no fix all solution that can be applied directly from the Dutch examples to anywhere else in the world. The reason the Dutch are so successful at controlling the water is because each small scale intervention is reinvented to suit the needs of people and place. Their solutions seek to solve more than one problem at a time. In doing so, they have learned to live with water in order to live without it.

To really understand these complicated relationships I needed to take a step back and understand Dutch culture and history as it relates to water. For this I developed two subquestions. By asking how the Dutch have learned to live with water, I began to understand the rich history of water control that inevitably led to their simultaneous dependence and fear of it. This question encouraged me to look not only at the social aspects of water, but the geological changes, the types of water bodies in the country, and the historical methods of water resistance.

From there I asked how in the face of climate change the Dutch have remained resilient against rising sea levels and water inundation. For this I looked at the systems of storm water resiliency that are in use today.

MAIN QUESTION

How can Amsterdam's methods of storm water resiliency stand as framework for waterfront cities in the face of climate change?

SUB QUESTIONS

How have the Dutch learned to live with water?

How are the Dutch resilient against climate change?
METHODS

RESEARCH
To understand the historic methods used by the Dutch I combined the research and readings I had done in the Amsterdam Public Library and online literature with site observations. I developed a linear timeline that tracked both the movement/construction of land with historical advancements in water control technology. On that timeline I also included major political and social changes, flood events, and changes in water management practice.

In addition to literary research, I was able to reach out to design professionals, map makers, historians, and a preservation architect to further my understanding of water management and the Dutch.

SITE SELECTION
I utilized the book “Sweet & Salt, Water & the Dutch,” by Tracy Metz to begin my site selection process. Tracy’s book describes dozens of sites throughout the Netherlands varying in scale, type, and age.

I selected my sites based on the preliminary research I had done, Tracy’s book, my independent travels around the region, and maps of the country. I eventually settled on four sites that were very unique from one another. Two sites were in a coastal region that I felt could be most closely related to coastal cities in other countries that are facing similar issues with rising sea level. The other two sites are adjacent to the city of Amsterdam. These sites are secondary water resiliency methods that are primarily protected by a major dike called the Afsluitdijk. This dike eliminates tidal change and eliminates tidal fluctuation and storm surge events due to climate change. All four sites are diverse in their project type; architecture, landscape, engineering, or a combination of the three.

OBSERVATIONS
My observational research included sketching plans and sections of the selected sites as well as providing diagrams that illustrate how the site is used both to prevent water inundation and to encourage human use. I also chose to photograph my sites and create regional maps to understand their relationship to the surrounding environment.
MAN MADE LAND

The marsh landscape of the Netherlands was once the uninhibited delta of three major rivers, the Scheldt, Meuse, and Rhine. Soft peat soils, sand, and clay washed through the ever-changing low-lying region creating a landscape like nowhere else in western Europe.

The first to live in the harsh landscape some 7,000 years ago faced many extreme challenges. The changing landscape could be completely altered by a single storm. The benefits of this seaside landscape, with its rich soils, access inland, and plentiful grazing land, were their motives to stay.

It was then that the fight against water began. Modifications and trials have since shaped the Netherlands into the hard-edged delta we see today. As is said in the Netherlands, “God made the Earth, but the Dutch made Holland.”
LAND IN MOTION

An icy tundra shielded the land we know as Europe. Until 8,500 BCE, the land we know as the Netherlands was almost entirely uninhabitable. In the wake of the last glacial maximum, the once hardened landscape began to transform. Environmental forces began to break through, sculpting and forming the ground into a new landscape. Water movement from the east carved paths through the now softened permafrost. The sediments distributed by these rivers formed clay edges and embankments that would one day be the first inhabitable platforms. The swampy marsh landscape was swollen with nutrient rich soils. The sea edge was swept with early sand dunes. The east was steppd with highlands and river valleys - the gateway for the western delta.

The earliest known permanent settlements in the western wetlands of the Netherlands occurred nearly 7,000 years ago. The majority of the early settlers lived in the far east of the country, near present day Germany. The eastern lands are still today the highest points within the Netherlands. The settlements further west in the Delta, were able to prosper by utilizing the natural high points made from the meandering river and its clay deposits. These natural levees acted as mounds, or islands, which kept the settlements dry without impeding on their connection to the sea. This natural system lead to the man made version now known as “terps.” The terp settlements were successful in surviving frequent floods. Here they had access to the plentiful fish of the rivers and North sea, endless grazing land for early livestock, and rich soils for basic farming.

When the Roman empire reached the Netherlands between 50 BCE, and 100 CE. They considered the marshy delta to be unsavory - unsuitable as it was for standard development. Cold weather, fog, rain, and flooding were not ideal platforms for extending their empire. Determined to make use of their newly acquired bordering lands, the Romans began the search for solutions to modify the dangerous waterland. They began to develop techniques for dealing with the frequent flooding and marshy edges on a larger scale as well as small solutions to protect individual settlements.

Initial attempts were guided by the Germanic tribes already settled there at the time. Acting on their successful system of living on naturally made river mounds and the man made terps, the Romans added a basic system of sluices and water gates to strengthen the boundaries of land and water. The first attempt at reducing water quantity occurred in a trade canal that connected the Rhine and the Schie.

The Romans attempt to live in the region was short lived. By the 4th century AD, the Roman empire began to collapse. The only power that had ever existed in the marshlands evaporated, leaving behind only a few early versions of water management. Without central power, locals were forced to develop their own small scale methods of dealing with water and flooding. It was at this time that the fight against water really began. Early settlements started to incorporate multiple systems of flood defense that would be implemented and maintained by the collective community.
Maps adapted from De Groot, mw. drs. T. Palaeography of the Netherlands.
The first attempt at land building occurred around 500 B.C. The terps were inspired by the naturally occurring clay levees and mounds. While the natural mounds were the result of the heavy river flows and the sediment brought with them, the man made alternative required intensive labor for layering materials to raise the ground plane. Clay, sand, and peat were collected from the marsh and piled high above the surrounding landscape. These small islands were protected on the sides with any available materials, including additional peat, wood, grass with dense root systems, and animal hides.

The development of terps transformed the Dutch landscape. Settlements could occur wherever they were desired, not just where the river had created them. They provided the opportunity for building in the delta without fear of a slight rain flooding the land.

Mounding the peat and clay soils from the river allow for a raised living ground that is slightly protected from wet marsh grounds.

Terps began as simple structures with one level elevated above ground.
DIKES 50BC appx.

Through the addition of Roman water knowledge and collaboration among settlements, the simple raised structure developed into a complex system of connected mounds and dikes.

The shape of the terp itself varied. Stepped levels of the Terp provided room for living and agriculture. The upper terp could be devoted entirely to housing and communal life, while the lower terp was used for agriculture.

To protect the terp, primitive dikes were added to the system. Early dikes were simple constructs of clay and peat. They provided somewhat of a second defense to the larger settlement area. The dikes could be connected to one another and to other terp settlements. They provided a larger system of defense and allowed access when high water would have otherwise inhibited it.

Within these dikes came a series of small runnels or trenches by which excess water could be drained from the ground plane. Basic sluice gates could retain or drain water when necessary.

Terps became more complex as they began to combine multiple levels, one devoted to agriculture and grazing, the other to communal life.

Systems of dikes that connect terp communities began to develop over time.

Basic sluice gates were applied to the terp to allow a controlled drainage of the landscape.
With the success of livestock, agriculture, and trade, the once unsavory delta was now becoming an increasingly popular place to live. The opportunities that emerged encouraged civilizations from the east to move outward into the western edges of the Netherlands. Small terps, and their dike enclosures took on a much different appearance to make way for this swelling population.

A similar model was applied during the transition from terps, to what is now called a polder. Similar to a terp, the marshy land was mounded to create the base ground for living, working, grazing, and farming. Simultaneously, a dike would be built to enclose the new landscape. The use of a new invention, the windmill, beginning in the 1200’s distinguished polder lands from the original terp lands.

Windmills built along the surrounding dike could pump the remaining water from the interior. This included not only the occasional flood excess, but rainwater as well. The result was an entirely dry landscape with only runnels to drain excess water when necessary.

Windmills pump the poldered land dry; they remove not only flood water, but water from flooding and rain water as well.

Dikes protect the poldered landscape from the surrounding canals and rivers.

Runnels throughout the polder are multifunctional. They provide drainage away from the raised land, irrigation to crops, and act as a “ha ha,” to keep grazing animals from escaping.
The Dutch were highly effective at creating land with their new system of pumps.

Over time, however, the polders began to display some negative environmental consequences that would be nearly irreversible. As the windmills pumped the peat land dry, it exposed the base of the mounded grounds. Once exposed to the air, the organic materials used in construction began to oxidize and decompose. This resulted in the settling that is now visible today. As the ground settles, it become closer to the ground water requiring more frequent pumping and more windmills.

While settling occurs within the dike, the natural river system fights its way through the now rigid landscape. River waters carry with it greater quantities of water and sediment - quantities they would have dissipated gently in a natural delta. Channeled and steepened, the water flows violently through the canals meant to contain it. As the sediments drop out in this new landscape, the water levels rise. The dike walls must be strengthened and raised to accommodate the strength and quantity of the river.

The result is an ever sinking landscape within the dike, and a frighteningly elevated landscape beyond it. The appearance is that of a landscape below sea level.

As the peat land was exposed it began to oxidize and decompose; settling back into the ground.

More windmills were required to drain the land even further away from the lowered land.

Higher dikes were needed to protect the low landscape from the channeled waters beyond the dike.
The introduction of steam powered pump stations in the 1800’s revolutionized the process of land creation. Modern pump stations could drain land far more quickly and efficiently than their windmill predecessors. Electric and diesel powered pump stations are still utilized to drain poldered land today.

While this did little to solve the issue of “sinking” land described in the polders, it did allow for some of the largest land creation projects to date.
ENCLOSURE DIKES 1900 CE.

By the 1200’s, formal government groups called “waterboards,” had formed to solidify and protect the network of ditches, dikes, and dams that created the Netherlands. It was the responsibility of farmers to maintain the length of dike that edged their land, but the responsibility of the community as a whole to assist in times of impending danger.

Following the Saint Elizabeth’s Flood of 1421, a disaster that killed 10,000, government agencies began to re-evaluate the systems in place. With a booming economy, and continually expanding population, it was in their best interest to fortify these systems extensively. Relying on the community was just not enough. The peat, clay and wood dikes installed by the community and farmers, gave way to stone dikes, imported and installed by hired laborers. To support this, taxes collected by the municipality went directly towards the construction and maintenance of large scale water management interventions.

One of the later major interventions was the famous Afsluitdijk. Completed in 1932, the 19 mile dike severed the now non existent “Zuyder Sea” from the North Sea. This immense construct eliminated the tidal movements that had threatened the north for centuries. The resulting lakes were renamed the Ijsselmeer and Markermeer, or Ijssel and Marker lakes. Their connection to the North sea via the west is controlled through a series of dams, dikes, and sluices along the river Ij.

Large canals and rivers are coveted shipping routes. Their protection is as important as the inland communities. The enclosure dikes deflect storm surges, and high water from even entering the inland regions.
ISSUES ARISING

According to National Geographic, a recent study says global sea levels are expected to rise between 2.5 and 6.5 feet (0.8 and 2 meters) by 2100. While the rate of advance seems arguably slow, for coastal cities, a rise of any rate poses a tremendous threat.

In the Netherlands, 26% of land is below sea level. Without intervention, a drastic change in sea level would eliminate almost half of the country’s 10 largest cities. It would wipe out its capital city, Amsterdam, and the seat of government, the Hague.
With climate change, the threat of flooding is not the only concern. With it comes a number of subsequent issues which would directly affect the Dutch and their water. A changing climate also means changing weather patterns; longer periods of dryness and harsher, more frequent storms. Prolonged drought would salinize agricultural lands and ground water, the consistent settling of oxidized peat lands would accelerate, and flooding would continue to threaten inland towns and communities.\textsuperscript{10}

To face these potential threats, the Dutch government has since moved away from its goal of strictly hardening edge conditions. The belief that living with water versus without it, has taken hold.\textsuperscript{2}

“Reclaiming the Netherlands from the future,” the government’s water policy published in 2007, began the search for sustainable solutions to water management in the Netherlands.\textsuperscript{2} The policy established the second Delta Committee, who would be tasked with seeking solutions for the current and projected issues of water management and climate resiliency. In 2008, the committee issued its report “Working with Water.”\textsuperscript{2} The strategies outlined by this report truly grounded themselves with the Dutch. Since then the concept of living with water, instead of without, has held strong.
ADAPTIVE SOLUTIONS

In this section we will look at four unique solutions to living with water. The four solutions exemplify how the question of water resiliency has been answered across the Netherlands. The unique methods respond to the needs of a particular area. They become a piece of a much larger system of water management while maintaining their loyalty to the idea of “living with water.” Each responds to that need and without attempting to be “fix all,” simultaneously solves other necessary community and ecological needs.

LAKES MARKERMEER & IJMEER

NORTH SEA
The area of North Holland has arguably become the most modified landscape in the Netherlands.

For years the tidal salt inlet of the Zuyder Zee threatened the coasts of the North Holland. With crops, trade routes, and development all at risk, the population knew something had to be done. As early as the 1600's, the idea of enclosing the inlet was discussed. Such a massive construction project at the time, however, was just not feasible. Building a dike large enough to cross the nearly twenty mile wide inlet would require machinery and manpower that was unavailable. The enclosure dike would require the newly created lakes to be drained to provide necessary protection. Dependence on wind power made this immense task impossible.

As in many cases, it is through necessity that solutions develop. Following a major flood in 1916, it became clear that control over the lake then called the Zuyder Zee was necessary for the safety of the Dutch. Plans were developed, and with the new steam powered pump stations, the concept of draining the lakes would become a reality. In 1920, construction began on the Afsluitdijk. The 19 mile long dike would connect North Holland to Friesland and sever the inland towns from the open sea.

After the construction of the Afsluitdijk, the Zuyder Zee was no more. The resulting lakes, Ijmeer and Markermeer, eliminated the tidal influence that was once responsible for flooding the north country. Without this threat, damage from storm surges and flooding essentially disappeared.

With the Afsluitdijk enclosing the north, and a series of locks sealing off the river Ij to the west, the cities and towns of north Holland are essentially safe from rising tides. In combination with the years of canal and dike building, and a constant pumping of ground water, Amsterdam lies, “well above sea-level.” So when you ask a native Amsterdamer if they worry about a Hurricane Sandy type incident most will reply with certainty, “no.”

While the security of their overall system excels, there is no doubt that the challenges of living with water still do exist. In North Holland, the challenge has become how to make defenses more livable. In a place where open land is rare, the region must utilize every space wisely. The desperate need for more housing, park lands, recreational areas, land building, storm water treatment, and shipping/recreational water use must all be thought of and resolved in each new design move.
IJBURG FLOATING HOMES
IJBURG, NOORD HOLLAND

01
IMAGES://
01. View from the southeast of Rohmer’s Floating homes.
02. Close view of entrances and facades of the individual residences.
03. Dock extensions at the edge of the connecting piers.
04. The singular path which connects each floating home to land, the “street,” on which they all come together.
A growing population and a dire need for more housing have been a major issue for Amsterdam since the 1960’s. Despite the already dense city construct of Amsterdam, development expanded to its farthest edges. Beyond that, the city was enclosed by a restricting network of canals and poldered farmland.

In continuing with the Dutch history of land reclamation, the concept of creating a physical extension of Amsterdam arose. At first, environmental and economic limitations slowed the development. Eventually, in the mid 1990’s, the construction began for a collection of eight man made islands in the Ijmeer. These islands would become the Neue Oost, or “New East” of Amsterdam.

This achieved quite a few goals with its creation. It of course satisfied the need for new housing by creating living space for a projected 45,000 inhabitants. Beyond that, it proved that building with water in mind would eliminate future issues with sea level rise and drainage. The islands were outfitted with park lands, dikes, sluices, canals, and reclaimed marshland to buffer and protect the land. Commercial and mixed use development are densely arranged in a manner that is consistent throughout the city of Amsterdam.

While the development as a whole speaks to the idea of living with water, it is Ijburg’s 150 floating homes which are famous on the island. On Ijburg’s western edge, a dense collection of white boxes bob with the shallow waves. The work of architect Marlies Rohmer has been a long time coming. Getting homes to float is no easy task.

The homes of Ijburg are built using a series of connected pre fabricated units. For its base, the homes are fitted with a hollow concrete block. Above that two or three “living” floors are attached.
The homes are able to float by utilizing the Archimedian principle. The principle dictates that if the amount of water displaced by an object is equal to the weight of the object, then it will have positive buoyancy. While the concept seems relatively simple, it does pose some issues for the residents. The thickness of each wall of the base varies up to 5" depending on the weight it must counterbalance. Furniture placement, the weight of the furniture (up to half a ton), and the design of the home must therefore all be decided on prior to construction.

The number of units a family chooses to have must also be decided, as each of the 15' bases must be jointed after arriving to Ijburg.

Each of the homes are organized along a central axis which connects and anchors them to the ground plane of Ijburg. The axis is made of a metal grate material which allows for necessary drainage and conceals electric and sewage lines. Gated crosswalks connect the main axis to one another providing private access to residents. Like a typical Dutch city street, the narrow path is crowded with planters benches and bicycles. Unlike the traditional street, room for gardens, plazas, and parking are entirely eliminated. Boat parking, however, is entirely acceptable. In some plots, small gangways lead from homes to boat or kayak launches. The larger axis allow for additional boat parking at their terminus.
ANALYSIS

RESILIENCY
The floating home's location within the Ijmeer eliminates danger from rising sea level and storm surge. The ability to float during seasonal rain, however, are the homes testament to resiliency.

SOCIAL USE
Although it is unlike any community in the world, Ijburg still creates a feeling of comfort that one could find on any residential block. The dense mass of homes have an incredibly unique community of inhabitants seeking an alternative lifestyle. Finding the critical mass necessary to introduce this project elsewhere may be its first challenge.

Residents must be willing to make more than a few compromises for the novelty of their one-of-a-kind home. Privacy, for instance, is hard to come by. Most homes have at least two walls that are entirely windowed. In addition, the homes are placed very close to one another. In the center of the complex, the crowd of white homes seems almost maze like. If your hope is to have a scenic waterfront view, then Ijburg may not be for you.

The lack of accessibility also threatens the full success of the island as a whole. During its construction, homes on Ijburg were sold based on the promise of multiple bridges joining the mainland. In reality, only two bridges: one pedestrian/bike, and one auto/pedestrian/bike were constructed. While residents can access the majority of what they need right on Ijburg; grocers, schools, mixed commercial spaces, and recreation, city commuters do face the challenge of the island's jam packed commute.

GLOBAL APPLICATION
The application of floating homes in other parts of the world becomes an interesting design problem. On one hand, the floating homes are relatively self reliant. They don’t require a solid ground plane, are moveable and can be easily customized. On the other hand, the resiliency of the homes is based entirely on the home's location. If the homes were, as they are designed now, placed in a coastal setting, the constant waves and potential storms might be too much for a structure of their size to bare. In a coastal setting they would be subjected to far more rocking- uncomfortable for residents, or storm damage. The small boxes would require a buffer or protective barrier similar to the Afdluitdijk in order to exist outside of Ijburg.

From Ijburg, we don’t necessarily discover a home solution for the rest of the world to apply directly, but the idea of living with water. From this relationship we see that it is indeed possible to live directly adjacent to or in the water without it becoming a damaging force. It begins to explain the variety of aquatic qualities that could be incorporated onto existing homes or designed into them initially.
DIEMER POLDER & RIJNKANAAL DIJK
DIEMEN, NOORD HOLLAND

IMAGES://
01. View from within Diemer Polder facing Nort West
02. Rijnkanaal Dike, Pedestrian and bike path
03. Runnel within Diemer Polder
For centuries, poldering the landscape was the land reclamation method of choice for the Dutch. Surrounding the landscape first with a dike, mounding the interior landscape, and then draining the excess water, was a relatively basic method of creating viable land where it would not otherwise be found.

The process of poldering, however, began in a time when little thought was given towards the natural environment. Its negative impact on water flow, ecological communities, and ground water, have made the creation of polders a thing of the past. New polders haven’t been built since World War II.

The polders that do remain, serve as testament to the impressive power the Dutch had over water. The new way of looking at polders brings back a connection to nature that was otherwise forgotten in dense urban life.
Like their historic predecessors, modern polders are essentially low lying landscapes that are surrounded by dikes and pumped dry. The land within the polder is generally used for farming or grazing livestock, with homes built on terps within them. The Diem polder is adjacent to the Rijnkanaal dike on the eastern edge of Amsterdam. The dike is what keeps the high canal waters away from the low lying landscape. The most important component of the system is the sluice gate at the intersection of the River Diem and the canal. The Diem flows perpendicular to the major canal, and is separate from the polder by a lower dike. The excess water from the polder is regularly pumped over the dike back into the Diem. During normal conditions the sluice gate is left open, and the water of the Diem and Canal are level. During storm conditions, the sluice gate is closed to prevent excess water from the canal from inundating the low lands.

**NORMAL CONDITIONS**

The canal water level is well below the top of the berm and dike edge.

The sluice gate remains open, allowing water that is pumped from the poldered area to return to open water.

**STORM CONDITIONS**

The canal water is high, often reaching the highest points of the dike. Water within the polder fills and sometimes overflows runnels.

With high water levels outside of the dike and sluice, the gate must be closed. This prevents water that has already been drained from the polder, as well as storm water from the canal, from overwhelming the pump system and flooding the low lying landscape.
RESILIENCY
The canals, sluice gates, and polders that thread through the Netherlands are part of a complex system of primary and secondary storm defenses. One defense on its own is not enough to protect development. The resiliency stems from its interconnected reliance on other systems. If one system fails there are several others that can assist in the recovery.

SOCIAL USE
Like the ancient models, the green grass that results from the poldered landscapes are dotted with sheep and cows grazing lazily. Along Diemer polder, the Rijnkanaal dike guards the farmlands and inland communities from the rushing water of the canal. The dike is multifunctional. It was the first defense against flood in the times before the Afsluitdijk. Now, the calm canal edges past Amsterdam’s bustling port through to the neighboring countryside of Diemen. The unique spiraling Nescio bridge connects cyclists and pedestrians across the most heavily trafficked canal in all of western Europe; the Rijnkanaal or Rhine Canal. The seemingly endless straightway of the Dike connects the runners, bikers, and dogwalkers of the city with the farmers and grazers of the polder countryside.

Livestock grazing land is made accessible to everyone. No gates keep people out or away. Instead, criss-crossing over runnels and ditches are park paths bringing the community not just through the land but into it. The juxtaposition of these activities under a beautiful tree lined path gives new life and use to a landscape once created to sever the ties between natural and manmade.

GLOBAL APPLICATION
Polders are designed based on an ancient model that has worked successfully in the Netherlands for centuries. While they are considered an excellent tool for land creation, their feasibility in outside settings is limited. Historic polders have done extensive damage to the soils and surrounding lands. The settling and oxidation that occurred during the process of draining the water has in many cases resulted in a weakened soil structure. In the Netherlands, where there are already several barriers for water before they reach the polders, this weakness is not necessarily cause for alarm. In other cities poldering in the typical Dutch fashion would not be an environmentally mindful approach.

What can be drawn from the Dutch example is the integration of social use. Instead of a heavily engineered edge closed off to the public, the Dutch make use of this extensive greenspace by letting people in. By treating this important structure as both a protective edge and a park space, valuable land of this dense city is put to great use.
Unlike the areas of Markermeer and Ijmeer, the cities along the western coast of the Netherlands are defenseless against rising water. Tidal influence, storm surges, and rising sea levels still threaten the region neighboring the North Sea.

The west is the true delta landscape of the Netherlands. Here the major rivers meet the sea in a harsh unification that makes life on the coast challenging. Not only must the region face the harsh fluctuation of the sea, but it must be resilient against the flood inducing river basins. Large scale projects have been put in place to reduce the quantity of water outpouring into the south west of the country. The Room for the River project, is a major redevelopment project that seeks to do just that. A series of interventions aim to re-naturalize areas along the Rhine, the Meuse, the Waal, and the Ijssel rivers. De-poldering, creating flood plains, removing obstacles, and increasing green space, all contribute to improving the ecological systems of the river and in a way, give the river back to nature. De channelizing the waterways decreases the intensity and quantity of water that flow through the system.

The western coast, however, has more than the rivers to worry about. Bordering the coast on the western edge of the some of the country’s largest cities. The Hague, for example, is the Country’s seat of government and neighbor to some of the largest new coastal redevelopment projects in the country.
SCHEVENINGEN BLVD.
SCHEVENINGEN BEACH, THE HAGUE

IMAGES://
01. View of Scheveningen Blvd. Facing North
02. Stepped structure of Scheveningen Blvd.
03. Upper Pedestrian platform facing South
Scheveningen is the Hague’s coastal retreat. As a major tourist location in the summer months, Scheveningen provides not only a beautiful sandy beach, but a stretch of lively commercial destinations. Tremendous hotels and cozy restaurants line the town’s existing boardwalk.

Despite its seemingly endless beach, the coast of Scheveningen is fragile. The shoreline is subjected to the constant charge of the water. While hurricanes like Katrina may be atypical for this climate, wind storms and heavy rain still surge the shallow coast. To keep the coast safe, the beach requires yearly replenishments and relies heavily on protective infrastructure. The sea wall that was once responsible for protecting this edge began showing severe signs of wear; signs that urged the state to seek a new measure for protecting the coast. The poorly designed wall offered only views of the backside of restaurants and shops. Its massive size and unforgiving form severed the water from the inland communities. In planning for a new sea wall, it was deemed necessary to consider not only how to best modify the it for stability and resilience, but how to best incorporate the surrounding residents and site users. The solution is Schevengingen Boulevard. Standing 36 feet wide, and over half a mile long, the boulevard merges the needs of water resiliency with the aesthetic, economic, and connective needs of the coast.

Under grade, the scenic pedestrian causeway transforms into a hardened sea dike. The dike follows the same curve of the boulevard.

The Boulevard has separate paths for cyclists, pedestrians, motorists, and beachgoers.
The unobtrusive new sea wall extends well below the visible grade, far below that of its predecessor. The curving shape has been proven to withstand far greater impact than the straight edge dikes typical for the Netherlands.10

Above ground, varied pathways and roads wind along the curving plane. The Boulevard provides separate lanes for pedestrians, cyclists, and auto traffic. Simultaneously, it provides a large ramp and steps with direct access to the lower level beachfront. The width of the boulevard is enough to accommodate a variety of uses and user groups. On even an overcast day, the strip was bustling with runners, roller skaters, cyclists, and families.

In addition to the dike construction, the municipality also included beach fortification in their plan to redevelop the coast.15 By increasing both the height and width of the shoreline, less stress would be placed on the new sea wall. The combination of the two interventions strengthened the tourism pull for the area while increasing the safety of the coastal development overall.
ANALYSIS

RESILIENCY
While dikes and sea walls are not a new concept to the Dutch, the style of Scheveningen Boulevard is certainly unique. No where in the world has such flare been incorporated into such a meaningful and necessary device.

Unlike Amsterdam, the municipalities adjacent to the Hague are not fully protected from rising sea level. For the coast it is necessary to have multiple systems in check to reduce the risk of flood or storm damage. Addressing the weakness of the existing sea wall both physically and socially was sign of incredible forethought. By making the repairs before the failure of the dike they reduce the risk of an incident rather than address how to recover from one.

SOCIAL USE
Unlike the “Super Levee,” of New Orleans, this incredible engineering marvel hides delicately within social infrastructure. Without explanation, one might not ever consider that Scheveningen Boulevard is anything but a beach front promenade.

The improvements to the Boulevard provided a greater sense of security to inland residents. Beyond that, It gave them a sense of pride as their beachfront was reconstructed and beautified. 10

GLOBAL APPLICATION
When I visited New Orleans in 2011, I was part of a lucky group that was granted the opportunity to tour the Super Levee. The Army Corp of Engineers had, in rightful defense, planned for the worst in their war against the sea. It felt a bit silly, however, to step out onto this massive sea wall, armed with reflective coats, boots, and hard hats, only to look down at a seemingly shallow puddle. From our view, the water looked harmless.

With that in mind, the Dutch approach seemed daring. In Scheveningen, the Dutch were not only allowing people to play on the sea wall, but encouraging them to get closer to water. It was still an enemy, but an attractive one that the Dutch were fighting to live with.

The claim can again be made that infrastructure can always be multifunctional. There is no need to separate human use from defense infrastructure.
DELTA DUIN
"SANDMOTOR," THE HAGUE

IMAGES/
01. South West view of the Delta Duin, March 2012
02. Delta Duin during the rainbowing (Sand moving) process of construction
03. Beach during recreational use after official opening

All Delta Duin images are property of the Rijkswaterstaat
SAND DUNE SHAPE AS OF OCTOBER 2013 (GOOGLE EARTH)
2ND YEAR OF INSTALLATION

MAP/
Not to scale

DESIGNER
EcoShape
Rijkswaterstaat

COMPLETED
2011
To protect the fragile coastline, sand and dredge material is rainbowed every five years onto the western edge of the country. The costly but necessary process ensures the safety of the inland communities by securing the beach buffer. During those five years, wind, waves and currents displace that sand and re-expose the vulnerable edge.

As of 2011, a new concept was developed to test the necessity of that five year tradition. Just south of Scheveningen is a landscape called the Sand Motor, or more officially, the "Delta Dune." Here, 21.5 million cubic meters of sand form an iconic hook shaped peninsula into the North Sea. The dune is made up of the sand that would have been deposited in five year increments over twenty years.

Instead of controlling the shape and maintenance of their beaches, the municipality is giving all control back to nature, after installation, that is. Ocean currents and wind will displace the sandy peninsula; depositing sand where it is needed. The idea is that allowing sand to shift naturally will reinforce areas of the greatest land loss. With "nature," as the driver, the site begins to respond to environment. In addition, the large buffer provides the protection necessary for plant growth and shore stabilization. The protected inland landscape also becomes home to wildlife like seals and waterfowl-population that have been struggling over the past decade.
The solution provides not only ecological gain, but recreational as well. Windsurfers, surfers, and swimmers take advantage of the rougher sea water at the dune. The expanded beach also provides hiking paths inland.\textsuperscript{18} The entire process of the Sand Motor is being studied as a test project for future coastal protection measures.\textsuperscript{19} Results such as dune development, beach safety, recreational use, groundwater quality and movement, and beach ecology are all equally important in understanding the benefits of this project. Meanwhile, measurements of ocean currents, wind speed, and direction may help in understanding the transformation of the dune and its potential application elsewhere.\textsuperscript{10}
ANALYSIS

RESILIENCY
In terms of resistance to change, this project cannot clearly be defined as resilient. The Delta Duin is a project that is meant to be altered. Its very design begs for disintegration. The project is meant to be dissolved and dispersed and in a way, this “weakness,” is what strengthens the coast. By accepting that the coast wanted to change and evolve the Dutch responded in a way that strengthened the edge without resorting to an intensive sea wall barrier. By altering their existing processes of sand replenishment, new plant life was allowed to grow inland resulting in a hopeful reduction of land loss without additional costs and infrastructure.

SOCIAL USE
Like many of the previous examples, the Dutch do not restrict human use on site. Instead, visitors are encouraged to utilize the far edges of the dune that provide access to waves for recreational use and deeper waters for fishing that would otherwise be inaccessible.

There are some concerns with the strength of waves and currents at this distant shore. The municipality must constantly be monitoring these conditions to provide up to date warnings for the site users. On some occasions, users are deterred from accessing the far extents of the dune.

GLOBAL APPLICATION
Due to the newness of the project, the results have yet to be determined. While conceptually the site is strong in its consideration of natural systems—its success as a storm barrier and its longevity are still being studied. The multiple design groups involved plan to release a study of the entire process at the end of its first twenty-year cycle.

If the project does prove to be successful, its application could be very widely used. Because the system requires no additional infrastructure, it may prove to be a cost effective management plan for allowing revegetation and shoreline stabilization.
CONCLUSION

The Dutch have won an exhaustive battle against the sea. They have spent centuries reclaiming land, strengthening edges, and draining water. They are experts at controlling both the land and water. Despite climate change, I imagine that the remarkable engineers of the Netherlands could find a way to keep water out forever, if, of course, that was what they wanted.

It is obvious that the Dutch have dispelled the idea of living without the water. Their very culture depends on it. Instead, the approach of embracing water has changed the Netherlands forever. The success in recent years comes not only from their ability to remain resilient against devastation, but their ability to adapt and prevent it.

I initially approached storm water resiliency in the Netherlands by asking three questions:

How have the Dutch learned to live with water?
How are the Dutch resilient against climate change?
and ultimately,
How can Amsterdam’s methods of storm water resiliency stand as framework for waterfront cities in the face of climate change?

Over the course of three months, I was able to observe countless examples of their ceaseless relationship with water. By researching their rich history I not only understood how ancient models worked, but why and where they developed. Their dramatic approaches to securing land have shaped and hardened the edges of a once marshy delta. They have learned to control the sea out of necessity, and now that they have the upper hand- are willing to let go.

Resilience against climate change has created a new role for the Dutch. Famously living below sea level for centuries has proven this culture to be superior in the rising sea level debate. In true Dutch fashion, however, they have approached this new challenge with grace and the power of design. It would be near to impossible to find a facet of Dutch water culture that hasn’t been considered or explored. Their resilience, as a result, extends from their exhaustive search for solutions. No design ever attempts to be fix all. It is the wealth and variety of designs that secures the country. By developing an incredible network of both interdependent and independent systems, the Netherlands rarely worries about water-led destruction.

I initially approached each of my project sites with the hope of understanding how the design could be retrofit to suit a city like New York. While I was impressed with the ingenuity of the many projects I explored, I eventually came to the conclusion that none of these solutions could be fit as is. In fact, it was the individuality of each project that led to its success. So when I ask my self how Amsterdam’s methods of storm water resiliency could stand as framework for other cities, I realized that looking at their specific solutions was not the framework we needed. Instead, it was the fundamental concepts that backed Dutch design that should be carried forward;
Accept that no solution is fix all.
Incorporate human use with all necessary engineering feats.
& Learn to live with water rather than without.

An endless discussion of living with water has generated concepts for hundred of solutions across the Netherlands. In each, the designer seeks to adapt to the space. The solution always solves multiple objectives. It responds to the people, the place, and the environment.

Marlies Rohmer created water resilient homes while solving a land scarcity issue with the Ijburg floating homes. The Rijnkanaal Dijk and Diemer Polder provided recreational space in an area needed by farmers. Scheveningen revitalized a failing tourist economy while protecting hundreds of inland residents. Delta Duin revitalized natural ecology while replenishing beach buffers. Each design is multi purposeful, they are adaptable, and they are resilient.


16// Van Aalst, Jan-Willem . Topographie Diemen (Map).


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