Ewout Leeuwenburg

21 February 2023

Managing a perpetual struggle by befriending the enemy

Introduction

At approximately one third the size of Ohio, the Netherlands is a relatively small country. Despite its size, the Netherlands plays an important role in the global economy and geopolitics. It is the world's 30th most densely populated country with 17 million total inhabitants and a population density of 1,341 inhabitants per square mile (Statistics Netherlands). The Netherlands is the 17th largest economy in the world and 5th largest in the Eurozone (US International trade Administration) Moreover, its GDP per Capita ranks 14th in the world at $66,284 (World Economics Research), supported by strong exports due to its strategic commercial location. One third of the population of the European Union – over 170 million customers - are within a 300-mile radius of the country. The country is a key logistics hub with Rotterdam as the largest port in Europe and Amsterdam Schiphol Airport as the 4th largest airport in the Eurozone. Capitalizing on its advanced economy and superior logistics position has made The Netherlands one of the top trading countries in the world.

The global position of the Netherlands cannot be decoupled from its geography, namely its water. The Netherlands is comprised of several deltas, flood plains, rivers, and 250 miles of coastline. In fact, almost one third of the Netherlands is situated below sea level and more than half the nation's 17 million population live on land below sea level. The coastline consists of three sections (Van Koningsveld et al): tidal inlets and estuaries in the south, the Wadden Sea in the north, and dunes in between. Another third of the Netherlands is subject to flooding from rivers during periods of excessive discharges. (Van Koningsveld et al). The Scheldt and Meuse rivers enter the country in the south, largely from catchment areas in Belgium and France. The Rhine River flows into the country from the east from catchment areas in Germany, France, Switzerland, Luxembourg, and France.

The Dutch have a great history of finding ways to combat the water. Due to rising sea levels and its location in a low-lying river delta, The Netherlands has been exposed to flooding on an almost continuous basis. The Dutch ingenuity and water management skills were fundamental contributors to providing flood protection and essentially have allowed the Dutch to be secure and live behind large rigid barriers, dams, and dikes in what one could describe as an engineered landscape that is largely reclaimed from the water.

Unfortunately, climate change is proving many Dutch water-management methods to be insufficient. The Netherlands has higher than average exposure to the risks of climate change in the form of increased rainfall intensity, instances of extreme drought, and rising sea levels. Traditional measures that focus on flood avoidance (e.g., dams and dikes) rather than flood management are increasingly becoming less effective. To combat this, the Netherlands needs to modify its landscape to heighten protection against rising sea levels, isolate saltwater encroaching on agricultural areas, absorb water in wet periods, and store water for dry periods.

The war on water: A historic perspective

Glaciation shaped much of the Netherlands' low elevation and numerous basins. Much of the Netherland's topography was formed during the Pleistocene period which started more than 2 million years ago. During this era, the ice cap from Scandinavia reached the northern parts of Netherlands several times, shaping basins into the landscape. The ice cap did not reach the Netherlands during the last ice age (110,000 – 10,000 years ago); however, during this period sparse vegetation caused large quantities of sand to be deposited throughout parts of the south and east of the country (Van Koningsveld et al). The western and northern coastal part the country was formed during the Holocene period (10,000 to 2,000 years ago). The coastal landscape was made up of sandy beach barriers and dunes, with occasional water inlets providing access to tidal basins, marshes and swamps (Van Koningsveld et al). In waterlogged areas, the cool and humid climate was ideal for the accumulation of thick layers of peat and deposits of other organic matter. A Holocene sediment wedge up to 90 feet thick was formed in the western part of the Netherlands, which provided protection against the sea.

More recently, humans have heavily influenced the topography of the Netherlands. For early settlers, sea level rise necessitated the development of defense mechanisms against floods. The first dikes were built in the Netherlands by the Romans over 2,000 years ago. At the time, sea level was approximately 1.5 meters below current levels (Van Steen & Pellenbarg). Continued sea level rise during subsequent centuries drove continued dike and dam construction, as well as an increase in the amount of dike failures and subsequent floodings.

The amount of dike breaks was largely caused by human behavior as well. In the period following 800 A.C., early settlers started exploiting the land in the northern and western peat areas. They installed drainage systems that impeded the natural process of peat formation, which caused the land to descend. As a result, lower lying areas became more vulnerable to floods, which slowed down the buildup of peat and caused the land to descend further (Van Steen & Pellenbarg). In addition, as more people settled in the area, they began to extract peat to use as fuel for heating purposes. The resulting subsidence combined with rising sea levels made the land even more prone to flooding, ultimately leading to substantial land loss between 800 and 1250. Subsidence is defined as the gradual settling or sudden sinking of the earth's surface (National Ocean Service, NOAA). By 1250, the Netherlands had changed from a country with a mostly closed coast in 800 to one that was exposed to the sea. Rising sea levels had altered the Dutch topography, but for the first-time man had played a major role in the process as well. His efforts to seek protection from the water had worsened the problem. A battle had started combatting the continual increasing disparity between the rising sea and descending land.

Between 1250 and 1600, the western and northern parts of the country were still subjected to flooding. As the sea-level rise had decelerated to approximately 10cm/century, the exposure was now mainly due to storm surges widening tidal inlets and increasing tidal volumes (Van Koningsveld et al). Dikes experienced increasing rates of failure. This was partly because of the land subsidence in drained peat areas and partly because of dikes collapsing as they were built on peat areas, which provided poor foundation due to excessive drainage.

The subsequent need to upgrade and rebuild water protection drove the need for more strategic water management. Historically, the management of water was organized locally. But as the Dutch population continued to grow, a more institutionalized organizational structure became required. This led to the formation of waterboards in the 13th century, which were decentralized public authorities with far reaching authority dealing with a multitude of aspects of water management including water control, water quality, water quantity and the management of inland waterways and roads. Waterboards still exist in The Netherlands today.

Starting in the 16th century, windmills emerged as a new form of drainage technology. Areas subject to waterlogging due to continued land subsidence and flooding during the 14th and 15th century could now be drained. Large areas were reclaimed, exposing land with soil structure that was well-suited for agriculture (Van Koningsveld et al). Digging drainage canals in much of the newly exposed low-lying areas increased the rate of land subsidence relative to still rising sea levels. At the same time, improved drainage technology and more institutionalized water management brought the loss of land gradually to a halt.

As technological innovation continued, the Dutch became more and more effective in the fight against water. Developed in the 1800s, the steam engine allowed larger and deeper lakes to be reclaimed and for precise control of groundwater (Van Steen & Pellenbarg). In parallel, strong population growth caused land prices to increase and made investments in reclaiming land more profitable. This land was attractive for agriculture, further stimulating the economy. Over time, a positive feedback loop developed between water management and the economy. International trade conducted by the Netherlands funded improvements in water protection, which in turn enabled population and productivity growth. Land reclamation continued during the 19th and 20th centuries (Van Koningsveld et al).

Although the enhanced water management had significantly reduced the risk of river flooding and the impact of storm surges, the country was still subject to flooding. Several major river floods occurred during the 19th century and serious storm surges occurred in 1916 and 1953. These events led to the development of protective measures on a much larger scale. The flood of 1916 and resulting vulnerability of food supply during World War One drove the Dutch to build a large dam closing the Zuiderzee, a bay of the North Sea in the northwest of the Netherlands. This project shortened the coastline by 300km and created 200,000 hectares of land.

In February of 1953, a 3.4-meter storm surge resulted in an aggregate 180 km of dike failures and flooded 160,000 hectares of land in the southwest part of the country. The flood resulting from the 1953 storm surge disaster claimed 1,835 lives, which initiated another massive project to protect the country against the water. The Delta project involved building large, solid, and inflexible walls against the sea that also substantially shortened the coastline. Several estuaries were closed off from the North Sea through the construction of massive dams, turning them into non-tidal lakes.

Increasing care for ecology and the environment by the Dutch has furthered water management innovation. The original Delta Plan called for one of the estuaries, the Oosterschelde, to be closed off from the North Sea by a 9km dam. This initiative ran into broad societal protest, as many people expressed concerns about protecting the area's unique natural environment and resources. As a result, the government decided to construct a storm surge barrier instead. This barrier was designed to enable tides to enter the estuary freely under normal and safe circumstances. In the circumstance of a dangerous storm surge that presents a risk to the human population, the barrier could be closed completely. Still in use today, the Oosterschelde Storm Surge Barrier has been declared one of the modern seven wonders of the word by the American Society of Civil Engineers. It is comprised of 65 concrete pillars with 62 steel doors, each 140 feet wide. Each pillar is approximately 120 feet high and weighs 18,000 metric tons.

Since 1200, 570,000 hectares of land had been lost to water, but 520,000 hectares were reclaimed, a remarkable indicator of success of Dutch efforts in the thousand-year battle against rising sea levels and the subsidence of land. The general success of the battle led to a belief that engineering capabilities and technology would always provide sufficient protection against floods from the sea and rivers, an idea specifically embodied by the Delta Project. However, the construction of the Oosterschelde Storm Surge Barrier in 1986 marked a change in direction in Dutch water management towards a more holistic approach.

A paradigm shift in water management

Climate change is further impacting the rising of the sea levels. A mid-range estimate indicated that a temperature increase of 2°C by 2100 would cause sea levels to rise by 60 cm (Kabat et al). Increased precipitation in the Meuse and Rhine River basins are expected to increase discharge into the Netherlands and therefore flooding (Hein et al) The mid-range expectation resulting from a 2°C temperature increase is for average summer precipitation to increase by 2% and winter precipitation to increase by 12% (Flood defense).

The Netherlands has also experienced an increased frequency of summer droughts (Metz & Van den Heuvel). Extreme drought conditions cause low discharge and expose a water-related battle, which is the one between salt and fresh water. During dry periods, salt water from the North Sea encroaches the country further through water ways and ground water because there is not enough fresh water to hold it back. This has significant impact on the Dutch population and its economy. Farmers can no longer grow crops in the increasingly saline soil. Potable water companies are forced to move further inland to draw water for drinking water production. Barges cannot be fully loaded or are prohibited from operating altogether. It is hard to imagine that a country that was solely focused on dealing with excess of water one generation ago, now is also facing challenges resulting from a water deficiency (Metz & Van den Heuvel).

Land reclamation during the last 200 years has largely been focused on the development of agriculture (Smits et al). Several regions of the country that benefited from the addition of land were rural areas where agriculture was the dominant economic activity. The modern Dutch economy supports a more urbanized society, and one could question the future role of agriculture in the Netherlands and the amount of land this sector utilizes going forward.

The Rhine and Meuse have seen dramatic hydro morphologic changes over the last 100 years. Many sluices, dams, weirs, and fortified riverbanks have been added. Increased agricultural activity has led to more intense drainage, and the substantial increase of impervious area resulting from urbanization has increased rainwater runoff into the rivers. Additionally, the length of the Meuse in the Netherlands was reduced by nearly 30% (Hein et al). Most importantly, the massive land reclamation of wetlands has decreased the hydro morphological resilience of both the Meuse and Rhine River basins. This means that periods of high or low precipitation levels are now immediately reflected by extreme high or low water levels in the river (Hein et al).

The environmental costs of water management have also become clear. The hydrodynamic tidal balance in the estuaries was disturbed, triggering geomorphological change. Natural habitats disappeared and were replaced by manmade habitats (Smits et al). Closing the estuaries in the Delta has prevented adequate discharge for the Rhine and Meuse rivers, causing polluted sludge to settle in the river basins. Some of the areas in and upstream of the delta have become chemical depots for the Rhine and Meuse Rivers (Smits et al).

The Netherlands has always trusted its ability to protect itself against the water (Smits et al), which has often disguised the extent of the real exposure. Every attempt to improve flood protection through improved and higher dikes reduces the population's fear of the threat. This typically increases investments and development in areas with high flood risk, thus actually increasing risk. Ultimately, the probability of a disaster has been reduced significantly, but the potential impact of disaster has increased dramatically.

During the 90's and early 2000's, the mindset on protecting the country against the water changed. The fight against the water that had started a millennium ago led to a vicious cycle of compensating the need for flood protection with rigid structures. During the winters of 1993 and 1995, Western Europe encountered intense precipitation, resulting in a flood that nearly overtopped the dikes. 250,000 people had to be evacuated as a precautionary measure. This near disaster spurred public debate about the consequences of increasing the height of the dikes and the subsequent potential impact on the landscape (Hein et al). This ultimately led the government to release guidelines that, despite expected increased river discharge in the future, focused on expanding the flood plain by moving dikes further inland rather than heightening them.

The government implemented water management policies that no longer solely focused on safety and security. Protecting the country against flooding would now be evaluated more holistically, considering all functions, uses, and values of water areas (Van Koningsveld et al). In addition, coastal and water policy became an integral part of spatial planning policy in the Netherlands. From a technological perspective, the focus was on designing solutions that work with nature. This signified a gradual paradigm shift from water as an enemy toward water as an ally. The strategy had shifted from protection to accommodation. The resulting challenge is that the Netherlands must design a landscape that provides protection against rising sea levels, absorbs water in periods of excessive discharge levels, provides sufficient storage of water to support dry periods, and ensures the isolation of salt water from agricultural areas.

Working with nature through innovation

Working with nature is a design approach that adopts the natural system as the basic premise. The guiding principle is to work with nature and not against it. New innovative designs encompass the use of natural dynamics and processes such as current, wind and natural materials. They also recognize that social, economic, and environmental dynamics are fundamentally interlinked.

Room for the Rivers is an example of innovative thinking in working with nature. In response to flooding of the Rhine and Meuse during late 20th century, the government issued a policy called Room for the Rivers serving two goals: ensuring the required level of protection against river flooding and improving spatial quality in the river area (Van Alphen). In addition to a focus on more commonly applied measures such as raising, widening or strengthening of dikes, substantial emphasis was put on expanding the riverbed and allowing the rivers to overflow into areas that had previously been reclaimed and were primarily used for agriculture. The implementation of flood protection measures in the past had met increasing resistance as it often involved demolishing historical buildings and relocating local populations. Ensuring spatial Quality was therefore set as the second goal of the Room for the Rivers initiative. Its focus was to strike a balance between protecting the land from flooding, ecological robustness through building natural processes that require little maintenance, and enhancement of existing landscape qualities (Klijn et al. 2013).

A prime example of a strategy implemented under the Room for the Rivers initiative involves the Noordwaard. The Noordwaard is an area in the Southwestern part of the Netherlands that has gradually developed over the past centuries due to natural and manmade accretion. Land reclamation and consolidation reached its peak in 1980, at which point the 2,500-hectare area largely consisted of large patches of agricultural land with little water in between them. In 2006 the Noordwaard would be designated as a high-water bypass area, lowering the water level in the Rhine by 30cm and thus protecting the cities of Dordrecht and Rotterdam that are located downstream. (Van Alphen) The dikes that originally protected the area were redesigned to allow the Rhine to overflow into this previously reclaimed area. The Noordwaard partly lost its agricultural function: 15 out of 25 farms had to leave. About 75 houses were impacted as well. Some people left, and others were accommodated by allowing appropriate flood mitigation measures such as building houses on terps or adding local dike rings. (Van Alphen) The area now serves a recreational purpose. Due to the aesthetical enhancement resulting from the reintroduction of the water and the development of infrastructure, activities such as biking, hiking and kayaking are common in the Noordwaard.

Another example of accepting water rather than avoiding it, is exemplified in innovative urban design concepts. The City of Rotterdam has taken a leading role in this and issued a water plan that outlines its strategy of avoiding the construction of expensive water-management infrastructure that is not needed 90% of the time (Metz & Van den Heuvel). The focus is to work with nature, to collect water and integrate it into the overall city planning and design in order to make the area more livable and appealing. The parking garage under Museum Park sits on top of a concrete holding tank that can store 2.8 million gallons of storm water during peak precipitation events. The water can then be gradually released to avoid flooding. Many more parking garages that can serve as storm water storage facilities are being considered. The city is also planning on installing 8 million square feet of green roof area in order to retain storm water. In addition, there are plans to build several water plazas. These are large, recessed plazas mainly used for recreational purposes. During a normal storm event, water flows into the area and fills gullies, rivulets and small pools. During a more intense storm event, the entire area fills up and water ponds in the area. It then drains gradually finds it way back into the ground or streams (Metz & van den Heuvel)

For years, the Dutch would adapt the landscape to their needs. Technological development enabled the effective drainage of water and people settled where they felt it was most convenient, not where the physical conditions were most logical. The current need for more space for water is shifting the approach to urban design to make homes more resilient to floods (Smits et al). Plan Tide in the city of Dordrecht is a prime example of such development. Ninety-six homes were built in an area close to a National Park called the Biesbosch. The area was given back to nature by leveling dikes that previously protected the area from flooding. Despite the area now being subjected to a one-meter tidal movement, the houses are built on concrete slabs that rest on posts and they are surrounded by water. Most of them have private boat docks, as the water provides access to neighboring areas that are well suited for recreation. It is a residential area which is in balance with nature.

Floating construction is also gaining momentum in the Netherlands. Although still at a small scale, several smaller developments have allowed for the concept of a floating home to be tested and proven as a viable solution for people to live in harmony with water. Floating homes are usually attached to steel poles and connected to the local sewer system and power grid. They can be fully floating buildings or have a more amphibian design in which they rest on land and will only float when circumstances require it. Their foundation is typically a partially submerged basement in the form of a concrete hull that acts as a counterweight, allowing them to remain stable in the water. The house typically is constructed using conventional materials like timber, steel, and glass (Rubin). The City of Rotterdam is working on a new urban development project called Stadshavens (City-Docklands). It involves the redevelopment of 4 ports, ultimately giving room for 13,000 new dwellings, 5,600 of them floating (Metz & Van den Heuvel). A multitude of concepts are being developed for commercial applications as well, such as green houses, dairy farms, parking garages, and theaters.

Conclusion

Innovation is playing a key role in making partnership with nature a reality. It is re-integrating water into communities. It is creating a landscape in which water is no longer the enemy but rather an opportunity. As the Netherlands deals with more extreme climate events in the future, it will have to continue to adapt. It’s population of 17 million spread across urban, industrial, and rural landscapes will have to live in harmony with the water, partly protected by dikes, but increasingly surrounded by and floating on water.

1.8 billion (23%) of the world population faces significant flood risk due to rapid urbanization in flood zones and rising sea levels. Of those at risk, 89% live in middle or low-income countries (Rentschler et al). Those poorer areas are also likely to face the most devastation from floods. Dutch water management expertise is unparalleled and provides an opportunity for collaboration with other parts of the world. One could say that the Netherlands is a massive water management laboratory that has been testing strategies for centuries. Cities around the world have been turning to the Dutch for expertise on water management and navigating the impact of climate change. In return, the Dutch have been exporting their technology and processes around the world. Perhaps more than any other problem that humanity has faced, climate change requires trans-national problem solving and collaboration. This signals a shift toward a new phase in the relationship between the Netherlands and water, one of using accumulated knowledge and expertise to help other parts of the world address an existential threat.

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