The Dutch Experience in Flood Management: A History of Institutional Learning

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Historical Learning of Water Management

Over half of the land area of Netherlands is below mean sea level, and in the south-western part lays the marshy delta of three big rivers; the Rhine, Meuse and Scheldt. Though this geography provides fertile soil and easy access to the seas and waterways, these areas are also subject to the dangers of river flooding and of the ebb and flow of the sea.

To protect themselves against these dangers, create transportation avenues, and facilitate agriculture, the Dutch have built an elaborate system of dikes and drainage mechanisms. The earliest forms of water management came about in the twelfth century as the Dutch reclaimed, or drained and elevated, land covered by water. This obstructed natural sedimentation and peat formation, and discontinued the natural coastal equilibrium leading to severe land subsidence, which in turn led to the need for greater reclamation efforts. The end result of this cycle was that the Dutch faced increased vulnerability, both as "exposure of physical and societal frameworks to violent events" , and the "exposure of institutions and organized people to extreme events." Despite this vulnerability, the Dutch have achieved a highly developed and industrialized economy, with much of their growth and infrastructure occurring in large cities such as the Hague, Rotterdam, Dordrecht, Schiedam, Middleburg, and Amsterdam, which are in close proximity to water and, as a result, face the highest levels of vulnerability.

Though the vulnerability to flooding of the Netherland's most important settlements and infrastructure made water management of paramount importance, it was not until the formation of the national water authority, the Rijkswaterstaat, in the late eighteenth century that water management was handled by a structured government authority. Prior to this time, the task of building dikes and waterways was left largely to individual villages and communities. Local reclamation efforts, at least until the sixteenth century, consisted of simple technologies such as building dwelling mounds (higher ground) and basic dikes and polder systems to artificially manage the water flow. Technical innovation, fueled mainly by trial and error, nonetheless occurred during this time as water management and land reclamation efforts grew to accommodate increased transportation and agricultural demands.

One such technical innovation was the windmill. Funded by private interests, windmills were utilized in the seventeenth century to drain man-made lakes and return them to usable farmland. By the end of the first half of the seventeenth century, forty-eight lakes had been drained.

One of the greatest early technological feats by the Dutch was the draining of Haarlemmermeer, or Lake Haarlem, in the early nineteenth century. Lake Haarlem's flooding threatened nearby Amsterdam and Leiden. Lake draining was a common practice by this point, and the use of windmills had proven successful as a water management aid. However, Lake Haarlem was larger than any lake previously drained, and its reclamation required greater technology, planning, and funding than any prior project. This project was also the center of controversy among various stakeholders as conflicting interests hindered initial progress on the project. Both Amsterdam and Leiden regularly flushed their canal waters into the lake to maintain the quality of their drinking water, and Leiden held the fishing rights to the lake, an important source of revenue. After floods that reached the outskirts of Amsterdam

and flooded the streets of Leiden, the need for flood prevention took priority and the project began. The draining of Lake Haarlem ultimately became the first publicly funded project, and the first to use steam-powered windmills. Today the former lake is the site of Amsterdam's Schiphol Airport, one of the busiest in the world.

Learning from Disaster - Learning from Controversy

Another technological challenge faced by the Dutch was the closing off of the Zuiderzee. Closing off this saltwater inlet would create a freshwater lake, now-called Lake Ijssel, or Ijsselmeer, that would be unaffected by the rise and fall of the sea, and that would also allow for additional land reclamation in nearby areas. Proposed as early as the seventeenth century, the project remained out of the technological or logistical reach of the Dutch until the early twentieth century. A plan for the project was ultimately approved in 1916 , when a storm surge rekindled interest in a proposal from 1886 which, at the time, lacked both sound engineering planning and government support. After additional engineering research, the first phase began construction in 1920, and was completed twelve years later in 1932, but it took nearly four times as long for the land to become dry and usable. Unsurprisingly for a project spanning such a large period of time, the needs of the country changed during this time, forcing the plan to be continuously updated and revised to reflect the changing needs of Dutch society. For example, instead of converting the newly acquired land for agricultural uses, urban areas were built on it and expanded upon.

By the late 1930s and early 1940s, there was ongoing research to determine the strength of the next big storm surge, and to determine the country's greatest vulnerabilities. The predictions revealed that the barriers in place at the time would not be sufficient, and that greater protections would be necessary. These warnings went unheeded. With the disastrous flooding of 1916 having occurred decades earlier, the attention of the government and greater public was instead devoted to rebuilding the dikes that had been destroyed during World War II. On 1 February, 1953, a strong storm in the North Sea, coupled with exceptionally high spring tides, led to a breach of the dikes protecting the southwest part of the country. The resulting flooding killed 1,835 people. Approximately 200,000 hectares of land (535,575 acres) were swamped, and 26,000 homes and 300 farms were destroyed. The total damage amounted to about 5% of the country's GDP, a devastating blow to a nation recovering from World War II.

The 1953 flooding was one of the worst disasters ever to strike the Netherlands, and was the result both of an unusually powerful storm and an inability to conceive and prepare for it. The storm was of the strength and severity seen only once every five hundred years. The Dutch infrastructure was simply not built in anticipation of such a fierce storm, though the possibility that the dikes were too low for calculated maximum water levels had been raised by experts at the Rijkswaterstaat prior to the floods . The government deemed the risk too remote to justify the enormous expense required to raise and strengthen then dikes. Once the storm surge reached the Netherlands, the elaborate system of dikes and pumps gave way. Entire villages were submerged as water cascaded over the tops of the dikes. In all, eighty breaches were recorded, some of them six-hundred feet wide. It was later found that many miles of dikes needed serious repair or replacement.

Just as the Dutch Government failed to imagine a storm strong enough to overpower the dikes, so too did the Dutch people, whose unquestioning trust in the Netherlands Waterways Authority and the dikes led to low levels of preparedness for flooding and the inability to communicate the dangers either before or during the flooding. As the storm approached and the first signs of potential flood could be perceived, many mistook these warnings for routine

weather occurrences that happened every winter. Once the extent of the danger was realized, it was too late for many to act and many villagers were not warned of the danger until the threat was imminent. In a foreshadowing of the experience of many New Orleans residents during Hurricane Katrina, many villagers sought refuge in their attics and roofs once the waters rushed into the villages and housing, forcing many to wait for days until the water receded. The immediate rescue and relief work lasted several weeks. Unsurprisingly, the damage also had a psychological impact: "the events were so all-embracing that everything that happened afterwards was viewed and interpreted by the flood victims in relation to the disaster."

Neither the Dutch Government nor people were prepared for such a disaster. Having built a system of dikes widely perceived as infallible, the risk of dike failure was thought negligible. Because they relied so heavily on infrastructure-based protection, they had not adequately planned for a disaster.

After the flooding, the national government assumed control of disaster recovery. It reorganized the civilian life in stricken areas, managed the flow of evacuees, coordinated spontaneous relief activities, organized a disaster damage indemnification scheme, and executed repair works. Well-equipped and well-organized military organizations were immediately mobilized to help with rescue, compensating for the failures of local institutions. Still, with the collective awareness of the country's vulnerability newly refreshed, the government soon shifted its focus from disaster response, and immediate dike repair, to a plan of action to ensure that such a tragedy wouldn't happen again. The nation's long-term response was centered on promoting awareness of flooding, reducing vulnerability, increasing resilience, and adequately preparing for potential future disasters.

The Delta Project

The Delta Commission was formed shortly after the floods to determine a course of action. The commission put forth the Delta Act, passed by the government in 1957, which proposed shortening the coastline and called for the construction of a series of primary and secondary dams to strengthen flood defences.[1] The Delta Project was the first comprehensive approach designed to address the vulnerabilities of the nation.

The scope and technological vision of the project rank it among the greatest engineering feats ever accomplished by any country. The first projects to be implemented were those in areas most in danger of flooding. Second, the most basic projects were undertaken first, allowing lessons learnt to be applied to the later, more technologically advanced projects.[2]

One lesson learned in the process of the implementation of the Delta Project wasn't so much technological as it was procedural. Because of the lengthy timeline of the Delta Project, as with the Zuiderzee, societal values changed over the course of time. Originally intended to protect people against flooding from the sea, the barrier designs took little else into consideration. Construction on the ambitious Eastern Scheldt dam was halted in 1967 due to public protests over the plans negative ecological externalities on the estuary. The project,

[1] Hoeksema, p.108 (Previous studies had proposed closing the tidal inlets for flood protection and salt exclusion. These studies greatly influenced the direction taken by the Delta Commission. The main advantages to this approach were clear: it would limit intrusive construction to the outer coastline, and it would significantly reduce the length of the North Sea coast. Shortening the coastline reduces the cost of maintenance and future upgrades. Furthermore, the damming of the Zuiderzee inlet earlier in the century was a major success. It only made sense to continue on the same path.)

[2] Hoeksema, p.108

which had broad public support fresh after the flood of 1953, waned in popularity by the late 1960s. Eventually, plans for the dam were replaced with a storm surge barrier, completed in 1986, which allows water to flow in an out with the tides but closed during threatening storms.[3]

The original proposal called for closing off the Eastern Scheldt, which would shut off the flow of seawater creating a body of fresh water. This task was accomplished successfully before with the Zuiderzee project and praised by many. However, at the time of initial construction there was an increasing awareness and renewed appreciation for natural ecological ecosystems, which would be damaged if the plan were to continue as planned. Additional resistance came from people whose livelihoods depended upon this marine life, such as harvesters of oysters and mussels.

Because of the controversy, and the eventual political willingness to incorporate a dialogue on the process surrounding the project, technical innovations exceeded expectations and now the barrier is one of the most highly regarded water management structures in the country, if not the world:

> *"Nowhere in the world had such a barrier been designed or built before. The technology needed to construct it had yet to be invented, and the experience gained building the other dams in the Delta was insufficient. In the short time at their disposal, the engineers came up with a solution that was as simple as it was revolutionary."*[4]

The second major technological accomplishment of the Delta Project was the Maeslant Barrier constructed in the New Waterway. The New Waterway is a shipping avenue connecting the city of Rotterdam to the North Sea, making it an invaluable commercial route but also one that posed a risk from storm surges. One option would have been to raise existing dikes, which had proven costly in the past and had also generated protests from residents. Dikes in the Netherlands can be several meters wide and homes have been constructed upon them, so building higher dikes often means removing property, often at great cost. To devise a solution that was acceptable across the spectrum of stakeholders, the Ministry of Transport, Public Works and Water Management held a competition for an innovative design for the New Waterway. The winning proposal had two curved gates, kept in docks on the banks most of the time, but when needed can be pivoted out into the canal and sunk to form a barrier.[5] Like the Eastern Scheldt dam, the Maeslant Barrier was a technological breakthrough, capable of mitigating flooding during storms without hindering Rotterdam's commercial linkages to the North Sea. The Maeslant Barrier was the final component to the Delta Project. It was completed in 1997 – 40 years after the Delta Act was passed.

The open process was longer and ultimately costlier, but resulted in a proposal that address a wide range of concerns – ecology, economy, and society.[6] The barrier bridges the two technological regimes in estuary closure: "the old regime based on the absolute primacy of safety from flooding and a new regime in which compromises are sought between the demands of nature and those of 'culture'."[7]

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[3] *Ibid*, p. 109

[4] Delta Project, p. 14

[5] Delta Project, p. 22

[6] Disco, 2002, p.29

[7] Disco, 2002, p. 211-212

Learning from the Past to Plan for the Future

Even with the successful implementation and innovations of the Delta Project, the Netherlands was still vulnerable to water. This became evident in the river floods of 1993 and 1995, when excessive precipitation caused the Rhine and the Meuse rivers to overflow. Two-hundred and fifty thousand people were evacuated. Since 1953, the Dutch had focused on protecting themselves from the North Sea's storms and flooding, but had largely ignored the rivers, as the last river flood had been nearly seventy years earlier.

Whereas the Delta Project aimed to control the waters with man-made barriers, new policies were implemented in the late 1990s that prioritized reducing risks rather than controlling and taming the rivers as had been done in the past. Risks and vulnerabilities had increased over the years due to weakened river barriers and changes brought by urbanization in adjacent areas. A recognition of river flooding as a natural process informed new perspectives on the issue, as the government report, "Creating Space for the River," illustrates:

> *"In the longer term enduring protection will mean not only continuing to raise the level of the dikes but more importantly, measures aimed at giving the river more space to accommodate greater river discharges. This will then help to limit the effect of higher water levels due to a worsening climate, for example. Dike reinforcement and building embankments will then only be necessary as an additional measure if other measures are ineffective… New high water situations cannot be avoided, but further damage can."*[8]

In addition to national policies such as the Room for the River policy (2000), and the Flood Defences Act (1998), international agreements and joint action plans for the rivers were also formed between countries that the rivers flowed through. International protection of the Rhine had been in practice since the 1940's, mainly in respect to trade and pollution issues, the floods in the 1990's renewed the conversation. The Netherlands government realized that cooperation with countries upstream was essential in preserving their own cities and interests. In 1998 France, Germany, the Netherlands, Belgium and Luxumbourg adopted the Action Plan on Flood Defence for the Rhine.[9]

All major works in the Netherlands have been undertaken as reactionary responses to major disasters. In 1916, 1953, and later in the 1990's safety standards and precautionary measures were implemented only *after* a natural disaster exposed the nation's vulnerabilities. However, the responses entailed more than the repair of old barriers. The Dutch learned from these disasters and sought opportunities to reduce their vulnerability to future events.

The government of the Netherlands is actively addressing the potential threat posed by climate change, even though government issued reports have stated that "to date, climate change has not led to any serious problems in the Netherlands,"[10] and "there are still considerable uncertainties with respect to the measures that will eventually be needed."[11] Though still a controversial issue, the Dutch government is preparing to address climate change issues that may arise in the coming decades.

The Netherlands Environmental Assessment Agency created a report entitled "The Effects of Climate Change in the Netherlands" which explores scenarios for the future of the

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[8] Ministry of Transport, Public Works and Water Management, 1998

[9] Fritjers, 2001

[10] The Effects of Climate Change in the Netherlands, p. 8

[11] The Effects of Climate Change in the Netherlands, p. 48

Netherlands and its inhabitants. Questions posed by the paper include: How is the climate in the Netherlands changing? What do residents in low-lying and river areas need to bear in mind? How will climate change affect agriculture? While the answers to these questions lie in the realm of uncertainty, the report concludes that planning for adaptation must begin now in order to preserve the country's economic, social and natural vitality.

Central to Dutch water management policies is a realization of the country's geographic vulnerability. In "Resilience and Vulnerability: Coastal Dynamics or Dutch Dikes?" the authors elaborate on definitions of resilience and vulnerability in relation to the Netherlands' policies. "Human activities often reduce coastal resilience, but planned adaptation can serve to enhance it and thereby add to the effectiveness of autonomous adaptation."[12] The authors also note that due to the extensive man-made barriers the Dutch have constructed to preserve their way of life, risk has inadvertently been increased:

> *"By continuously reducing the natural interaction between land and sea, the Dutch have created a situation that appears to leave no option but to continue current practices of stringent dune management and building hard sea-defence structures…natural and socio-economic adaptive processes are constrained, owing to the limited availability of land and the diminished resilience and flexibility that have resulted from technological solutions and legal provisions. This is increasingly leading to conflicts between housing, agriculture, industry, recreation nature and landscape conservation."*[13]

Conclusion: What can the world learn from the Dutch?

After Hurricane Katrina and the devastation of the levee in New Orleans, many cited the Netherlands as an example of successful water management. On October 20, 2005 Jan R. Hoogland, retired Director of Rijkswaterstaat, made a statement to the U.S. Congress on flood protection policy. His message emphasized an ongoing learning process: "Each flood disaster in the Netherlands – from the 13th century onwards – has brought us new lessons to be learned for keeping our country habitable, livable, and attractive to citizens and businesses."[14]

Like New Orleans, the cities of the Netherlands are ultimately dependant on water management policies for the greater region. Although Disco cautions against uncritically replicating the policies of the Netherlands, in an essay written after the Katrina disaster, he states: "the Netherlands is a small country – just about as big as the Mississippi delta, in fact. Hydrologically speaking, the two regions are quite comparable. However, in the Netherlands, the delta, one way or another, comprises almost all of the country. The concerns and problems of its several parts have in the course of time become the concerns and problems of the nation as a whole."[15]

[12] Klein, et al. p.260

[13] Klein, et al. p. 264

[14] Hoogland, 2005

[15] Disco, 2006, p. 344

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