Water wizards : reshaping wet nature and society

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Water Wizards: Reshaping Wet Nature and Society

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The article investigates how humans 'networked' wet nature and how this affected the shaping of Dutch society. First, it takes a grand view of Dutch history and describes how wet network building intertwined with the shaping of the Dutch landscape, its economy and its polity. Second, it investigates the specific challenges of wet network building—integrating potentially conflicting uses of water into one design—for the case of the national fresh water supply network (1940–1971). Finally, it discusses ecological damage, emerging new risks and cultural patterns related to wet network building.

Keywords: Water Management; Large Technical Systems; Network Society

The Netherlands is structured by water. To the West and the North the country is bordered by the North Sea. Large European rivers like the Meuse, Rhine and Scheldt meander their way through the country that is in fact their common delta. A large inner sea (currently dammed and partly reclaimed) and large former estuaries in the Southwest part of the country are prominent geographical features. Zooming in, one sees water-related infrastructure all over the landscape. In the absence of adequate water management, two thirds of the country would be regularly flooded. Michel Mollat du Jourdin sees the 'mutual penetration of land and water' as one of the most striking features of Europe from a birds-eye view. This observation seems even more apposite for the Netherlands.[1]

In this article, we shall investigate how the manipulation of wet nature and the evolution of Dutch society have gone hand in hand. A wet network of natural rivers and creeks obviously predated human habitation. However, from the moment humans set foot in the bogs and marshes of the primeval Netherlands, these pristine natural networks became objects of human manipulation and elements of their social order. As

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far as the historical record goes, natural wet networks in the Netherlands were always—at least potentially—being used, incorporated or manipulated for human purposes.[2]

The resultant semi-natural networks closely resemble the networks described elsewhere in this special issue. They possess main arteries and subsystems (like agricultural, industrial or urban waste water networks), are transnationally connected, and can be densely branched: individual buildings and fields have their own systems of water circulation, which ultimately connect to the large rivers and to the sea. Moreover, a tight systemic interaction exists between distant locations. Dike building may cause floods many kilometres downstream, high water levels in the main rivers can frustrate the functioning of public sewers, polluted Rhine water may end up in the drinking water of Dutch households, and crucial weirs may simultaneously affect the quantity and quality of drinking water and navigation in the West and the North of the country.

How, then, did wet network building and Dutch society co-evolve? In the first section we take a grand view of Dutch history since the Middle Ages and review three remarkable co-constructions: the interplay between, on the one hand, wet network building and, on the other, the evolution of the Dutch landscape, its economy and its polity.

In the second section, we investigate the specific challenges of wet network building. Different wet networks are impressed, as it were, on the same bodies of water and thus induce potentially conflicts of interests and functional clashes. We illustrate this with respect to the national fresh water supply network built in the 20th century, which simultaneously incorporated functions like flood control, fresh water supply and navigation.

Finally, we argue that the trust that is currently placed in hydraulic infrastructure and the caste of 'water wizards'[3] who construct and maintain it is not without its historical ironies. While the taming of the 'Water Wolf' transformed wet nature from, to speak with Luhmann, a danger to a calculable but ever-present risk, the consequent complacency has become a danger in itself.

Wet Networks and the Dutch Geography, Economy and Polity

Water Control Networks and the Dutch Geography

The earliest efforts in the Netherlands to adapt wet nature for human purposes were directed at improving drainage and flood control. Water historians situate a decisive break in this history in the Middle Ages.[4] From the ninth century on, settlers massively colonized and cultivated the peat bogs that covered perhaps half of the present country, in the so-called Low Netherlands, and within four centuries these had been transformed into fertile agricultural lands thanks to the construction of elaborate gravity-operated drainage systems.

In the process, human action became the most prominent factor shaping the landscape of the Low Netherlands. Rectangular blocks of parallel ditches dug in the Middle Ages still structure these landscapes (and in some cases cityscapes) today. However, a second, unintended effect of wet network building was at least as important. The peat soils, increasingly exposed to the air as a result of drainage, started to decompose by oxidation. The resulting soil subsidence was dramatic, sometimes amounting to several meters within a couple of centuries. Large areas descended to or below average sea level. The consequences were devastating. Lowlands fell prey to storm surges and eventually succumbed even to normal high tides. The scouring action of the currents eroded tidal channels, which in turn again encouraged greater inflow of tidal water. This vicious circle resulted in a transformation—or 'perforation'—of the coastline, which in the period between 800 AD and the early 20th century, increased from approx. 800 to 3400 km. Furthermore, the Saint Elizabeth's flood of 1134 transformed the main river mouths in the South-Western Netherlands into large estuaries and tidal channels surrounding newly fragmented land. Floods in 1170 and 1196 turned a complex of contiguous fresh water lakes into the large salty inner sea, the *Zuiderzee* (currently dammed and called the *IJsselmeer* lake, see Figure 1). In all, some 920,000 hectares of land were lost to the sea.[5]

Human responses to increasingly frequent flooding further changed the Dutch geography. From the 12th and 13th centuries, river mouths were equipped with dams fitted with discharge sluices so as to allow for drainage at low tide while preventing the intrusion of (salt) water during high tide. Towns like Amsterdam and Rotterdam developed around such dams. Subsequent centuries witnessed the construction of a large number of dams in smaller rivers and tidal creeks, not all of which could be counted successes.[6] In the 20th century, two large-scale coastal damming projects achieved international renown: the closing off of the Zuiderzee in 1932 and the majority of the sea arms in the Southwest (the Delta Works) between 1954 and 1985. Mainly due to these two projects, the total length of the Dutch coastline was again decreased to some 650 km, reducing the risk of flood catastrophes correspondingly.

While dikes may seem technologically less sophisticated than big dams, they are neither less impressive nor less visible. Initially villages were surrounded by their own ring-dikes, but by the 12th and 13th centuries, dikes were being chained together at the behest of regional water boards, monasteries and feudal lords. Thousands of kilometres of dikes formed and form long uninterrupted chains along the coasts and rivers.

Among the first 'river improvements' of national significance was the 18th century stabilization of the division of Rhine water over its major branches—the Waal, the Nether Rhine and the IJssel—in a ratio of 6:2:1. This put an end to the fluctuations, which in dry periods would leave the latter rivers almost empty so that they could no longer handle peak discharges without flooding. The 19th century saw the normalization of hundreds of kilometres of riverbeds, mainly by dredging, the elimination of meanders and the placing of numerous groynes. It also witnessed the construction of three new artificial river mouths. The nationwide management of river flows was completed in the 20th century with the construction of a national fresh water distribution network (see below).

By means of the technologies mentioned above, but especially thanks to various forms of mechanical pumping, the Dutch were eventually able to 'reconquer' land from the sea and lakes. The 16th century marks a turning punt, after which more land was gained than lost to the sea. Total land gains amount to some 713,000 hectares, only slightly less than the area lost to the sea. Coastal shallows and lakes were diked and pumped dry, constituting new and sometimes quite extensive local hydraulic subsystems. The Haarlemmermeer lake (18,100 ha) drained in 1852 currently houses Schiphol, Amsterdam's airport, while the damming of the Zuiderzee in the 20th century was followed by reclamations that increased the country's surface area by 6%.

From the 19th century on, the same techniques of water control were applied in the so-called High Netherlands. Although less crucial and life-threatening, drainage was an important element of peat-mining in the high moor lands and, from the 1880s, the cultivation of undeveloped heath and sandy 'waste grounds' into agricultural land or forests (amounting to as much land gains as by reclamation). Here too unexpected effects ensued, such as a significant decrease of the groundwater level due to improved drainage of rainwater.[7] As in the lowlands, combating these effects required a new layer of hydraulic countermeasures (e.g. irrigation systems), which again reshaped the landscape.

Navigation and the Dutch Economy

The manipulation of wet nature shaped the Dutch economic system as well. Although inland navigation had been an important pillar of Dutch commercial success even in the Middle Ages, this quasi-natural advantage revealed its true worth only with the booming economy of the Dutch Republic in the so-called Golden Age (ca. 1580–1650). This period has attracted the attention of historians because the Dutch economy became the centre of a rapidly expanding Eurocentric world economy. Despite stagnation after the mid 17th century, the Republic remained among the world's richest countries up to its demise in the 1790s.[8]

The causes of the economic boom have occasioned much historical debate.[9] Few, however, question the fact that the economy developed around navigable waterways, maritime and inland, natural and man-made. From the 15th century on, the Low Netherlands developed an elaborate inland navigation network connected at seaports to a maritime trade network that would eventually span the globe. Conversely, areas marginal to this waterway network, particularly in the High Netherlands, remained outside the economic pale. This economic differential would persist until the transport revolution of the 19th century.

Historians have devoted much attention to the successful efforts by the Dutch to develop a worldwide maritime shipping network. However, Dutch prosperity depended equally on the continual improvement of the inland navigation network. This network sustained what was, by contemporary standards, a large and rapidly specializing hinterland that further bolstered the competitive position of the international ports.[10] By the mid 17th century, the development of three overlapping inland shipping networks would integrate the many scattered small cities into 'an integrated urban system of major ports, industrial cities, specialist trade centres, and market towns.'[11] The first of these inland shipping networks, a flourishing enterprise by the 1580s, was the so-called *Beurtvaart* network. Despite some marginal adaptation of existing wet infrastructure the outstanding achievement of this sail-powered network was the imposition of a regular schedule on inland transport.[12] The network was not centrally co-ordinated but emerged on a bilateral basis between interested cities in the Low Netherlands. By the mid-17th century, about every city of importance was included in this network. From the early 17th century, regularly scheduled *marktveren* (market-boats) were also plying between the city and its rural hinterland on market days. All this added up to a transport network which was, by the standards of the time, nothing short of impressive: in the mid-18th century, an observer estimated that some 800 vessels departed weekly to connect Amsterdam with some 180 inland destinations.

The same bilateral strategy was responsible for a second network of faster horse-drawn barges for passenger, parcel, and mail service. These scheduled services, unlike the *Beurtvaart* connections, were immune to the vagaries of currents and winds: Existing waterways were equipped with tow-paths enabling horses to pull the barges, while from 1631 to 1670 some 658 km of entirely new canals were constructed. This network remained in service until the railroads forced it out of business in the mid-19th century.

Finally, a third network was established by private shipping companies for the bulk transport of commodities like peat, agricultural products, wood, stones and sand. For instance, 17th century Amsterdam was visited by 60–100 peat ships daily. The cutting and transport of peat was particularly big business, providing by far the bulk of the fuel for (urban) heating and cooking in the Dutch Republic. Private investors founded so-called peat companies, which eventually also exploited upland peat bogs made accessible by ship through networks of narrow but serviceable navigation canals.[13]

Changing patterns of international trade and increasing British hegemony during the 18th century eroded the water-based Dutch economic system. However, in the 19th and 20th centuries, the Dutch repeatedly attempted to revivify their economic system according to the 'Golden Age' ideal, including heavy reliance on inland waterways.[14] In the first half of the 19th century, the intensification of colonial exploitation in the Dutch East Indies coincided with the enlargement of navigation canals and the construction of railways between the harbours of Amsterdam and Rotterdam and the German hinterland. By the 1840s, Amsterdam had once more become the major European market for a limited range of colonial products, particularly coffee and sugar. Yet, fixation on colonial trade made the new economy extremely vulnerable and when Dutch colonial shipping succumbed to the competitive force of London in the 1860s and 1870s, Dutch commercial capitalism foundered once again.

From the 1860s the government sought to stimulate national integration by abolishing sectoral and local tariff barriers and by supporting the construction of nationally integrated transport networks, including a waterway network.[15] The domestic transport sector became a 'leading sector' in the process of 'modern economic growth.'[16] In the 20th century, Dutch economic policy was once more to become a 'gateway to Europe' and investments in the so-called 'main ports,' the Rotterdam harbour and the Amsterdam airport, and their access routes followed (Verbong and Van der Vleuten, this issue). This priority still stands today. Even in the eras of rail and automobility, waterways navigation remained crucial: in 2000 maritime and inland navigation jointly accounted for more than half of Dutch freight transport in tons (29% and 21% respectively).[17]

Wet Nature and War

In the Netherlands, wet nature was also mobilized for purposes of war. In Antiquity and the Middle Ages, the swampy constitution of the Low Netherlands had already thwarted effective domination by the Roman and Carolingian Empires. The offensive and defensive use of water was also crucial to Dutch military successes in the Eighty-Years War (1568–1648) against Habsburg Spain, from which the Dutch had salvaged their independence as an autonomous state by the late 1570s. Among the first instances were the breaking of the Spanish sieges of Alkmaar (1573) and Leyden (1574) by flooding the surrounding fields, and the severing of a Spanish supply artery by mining a critical dike in 1573. Subsequent naval successes turned the tide of war, but land warfare also remained decisive and continued to involve the mobilization of the wet landscape. From the late 1580s, the Rhine and its subsidiaries Waal and IJssel were flanked by a chain of fortified cities and guard posts, spaced closely enough to communicate by optic telegraphy. This defensive ring connected the Western coast with the Zuiderzee in order to protect the 'Western core' of the Republic.

While the Dutch just managed to maintain their dominant naval position against the English in the 17th century, the biggest threat came by land. Having failed to vanquish the Dutch by economic means, Louis XIV of France tried plain conquest, and managed to gain support from the English and the Bishops of Münster and Cologne. The idea was to divide the spoils among the aggressors. While the Dutch navy managed to hold off the English at sea, the German Bishops conquered large parts of the country, and a French army of 120,000 troops crossed the Rhine during low waters in the summer of 1672. Conquest of the Western province of Holland was stopped only by the improvised construction of a water defence line, the *Hollandsche Waterlinie*. A series of inundations created a wet barrier between the Zealand delta and the Zuiderzee. Breaches ('accesses') in this line, such as high grounds and dikes, were defended with walls or fortresses.

It was not the first inundated defence—the first permanent water defence line had been instituted around 1628 to protect a strategic island (Tholen)—but its success gave it mythical status and inspired a defence policy based on water defence lines. Obviously it is difficult to assess how important wet military network building was to the history of the Netherlands as an autonomous state; yet from the late 17th century military wet network building certainly became a cornerstone of Dutch military policy and thereby intertwined with political history.[18]

After the Peace of Nijmegen (1678), the *Hollandsche Waterlinie* was made permanent. Fortifications were modernized and inundation sluices added. The lands along the *Waterlinie* could be flooded to a depth of a few decimetres, deep enough to hide the treacherous drainage canals from sight, but shallow enough to prevent navigation. Furthermore, in the following decades a new national defence scheme designed by Menno van Coehoorn, the Dutch counterpart of the French engineer Vauban, aimed at defending the borders of the Republic by interconnecting impassable areas (swamps and heathland) by water defence lines.[19]

In the late 18th century, fortunes changed: A devastating Fourth Anglo-Dutch war (1780–84) meant the definitive end of Dutch hegemony at sea. The fate of the Republic itself was sealed when French forces crossed the frozen water defence lines in the winter of 1794-95. Upon the restoration of independence in 1813, the water-based defence network was reconstructed. In the course of the subsequent century, the lines were drawn back from the country's borders to a smaller perimeter around the Western 'core area.' After 1922 these were united under one commander as the 'Fortress Holland.'[20]

The Second World War proved the old lines thoroughly obsolete due to improved airpower. During the Cold War, however, the Dutch once more developed a giant scheme for a water defence line.[21] The Dutch had an interest in extending the main allied line of defence, the Rhine, North along the river IJssel to the IJsselmeer. This would include the cherished Western 'core' of the country behind the primary NATO defence line. Initial allied scepticism (Montgomery: 'your river IJssel is no obstacle at all, I can jump over it'[22]) inspired the Dutch to devise a grand scheme: by sinking floating dams into the Rhine riverbed, extra water could be diverted to the IJssel. There, a system of inundation sluices could rapidly create a wet barrier of roughly 100 x 5 km. The new IJssel water defence line was accepted by NATO and was operational from 1952 to 1963. Until 1958, the line was seriously defended; all too curious passer-bys were forcibly removed or even shot at. But the eastward progression of NATO lines of defence after 1958 eventually made it redundant. Yet, during the Cuban Missile Crisis of 1962 phase one was activated, closing the sluices in the IJsselmeer dam in order to accumulate inundation water in the lake and the river IJssel. More than 200,000 people, who did not even know of the defence network's existence, were close to being evacuated.

The National Fresh Water Supply Network (1940–1971)

We have seen how the construction of wet networks intertwined with the shaping of Dutch society in multiple ways. In this section, we shall zoom in on the process of wet network building itself. The key feature here is that any single body of water can be enrolled into multiple and potentially conflicting projects: e.g. land reclamation, drainage, flood control, water supply, navigation improvement, military defence, fishing and (most recently) electricity supply and recreation. The challenge of accommodating potentially conflicting uses of the same bodies of water is endemic to wet network building.[23] Until the 19th century, different networks were supported by different interests and conflicts were abundant. In the centralized state that succeeded the decentralized Republic after 1800, the responsibility for water management was assigned to a single minister, who presided over a professional agency for water management, the *Rijkswaterstaat*. Juggling interests in water became a national preoccupation, and the required political finesse was especially in demand during the creation of a national fresh water supply network in the mid-20th century.

Background

In the 1930s, the transformation of the salty inner sea *Zuiderzee* into the large fresh-water lake *IJsselmeer* brought the interactions of different wet networks into national focus. The closure had first been proposed in the 17th century by Simon Stevin and had been the object of more or less realistic plans since the mid-19th century. The Zuiderzee was severed from the North Sea by a 31 km long dam in 1932, declared fresh in 1936 and under its new name of IJsselmeer, became the pride of Dutch civil engineering.

Simultaneously, however, a struggle erupted among various fresh water constituencies, each of which laid claim to a generous share of the new lake's water. The struggle was exacerbated by doubts whether there would be enough fresh water of adequate quality available. Salinity and organic pollution, deriving in large part from the leaching of new polders (these were former sea bottoms impregnated with salt water to a considerable depth) and discharges from the main Amsterdam sewer outlet, threatened the quality of the lake's water. Trying to extract potable water from the lake, in the view of many, might just be a bridge too far. As the director of Amsterdam's Municipal Water supply put it at a meeting of health engineers in 1940:

> The future manager of the IJsselmeer will bear a heavy burden. We have heard that the eel fisheries want a sizable fresh water discharge in spring [through the dam sluices, in order to attract elvers into the lake]; the water boards in North-Holland and Friesland do not want to be rationed in their intake of water [needed to flush out salt drainage water and to irrigate fields]; in dry periods shipping on the Nether-Rhine demands a sizable increase in water level in the IJssel River; moreover, all want to maintain the waters of the IJsselmeer as fresh as possible.

The speaker strongly doubted whether in this minefield the manager of the IJsselmeer should be burdened with the additional 'painful responsibility for the public water supply.'[24]

Conceptualizing a National Water Management System

By 1940, the discussion on the use of the IJsselmeer had become entangled with inland navigation interests. To understand how, a brief resume of Dutch river geography is necessary (see Figure 1). Rhine water entering the Netherlands from Germany can follow three possible routes: South-West via the Waal river to the Hollands Diep and the Haringvliet; West via the Nether Rhine and the Lek rivers to the New Waterway, Rotterdam's artificial river to the sea; and North via the IJssel river to the IJsselmeer. All these rivers and channels are also major inland shipping routes.

The navigability of the IJssel river, the route to the North and East of the country, was a recurring problem. Plans for canalization of this river were submitted to Parliament in 1940 just before the German Occupation. The proposed IJssel canalization would greatly affect the distribution of Rhine water. In times of drought, canalization

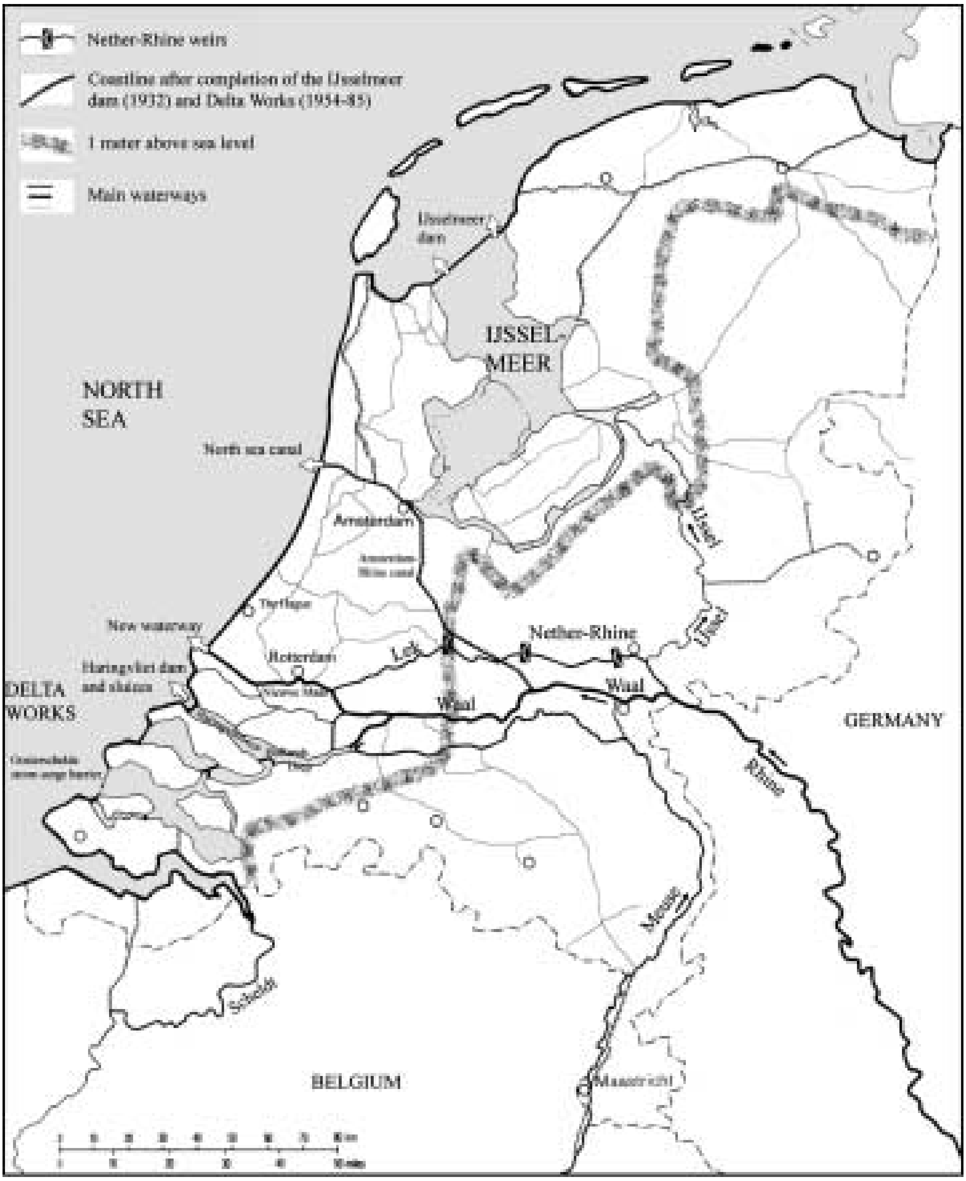

Figure 1 Water and the Dutch Geography.
Redrawn from: *Kortfattet oversigt over Nederlands geografi* (The Hague: Informatie-en documentatiecentrum voor de geografie van Nederland, 1974), 35; Disco and Lintsen, 'Het nijvere verbond', 60; and Van de Ven, *Man-made Lowlands*, 170.

of the IJssel—implying artificial higher water levels—would reduce the flow from Rhine water to the IJsselmeer to a mere trickle as the waters of the Rhine would choose the path of least resistance and flow westward to Rotterdam and the North Sea. This was fine for greenhouse farming in the West, which needed as much fresh water as it could get in order to keep the intruding 'salt-tongue' in Rotterdam's New Waterway from moving further upstream. However, a reduced flow in the IJssel in times of drought would increase the IJsselmeer's salinity and compromise it as a source for irrigation and drinking water. Interests in navigation, drinking water, Western agriculture and Northern agriculture were at loggerheads in an increasingly vehement debate about the national distribution of fresh water.

Finding the hydrological basis of an equitable solution devolved in the first place upon the Rijkswaterstaat agency. In the course of finding a solution the Rijkswaterstaat's Director-General L. R. Wentholt (re)defined the concept of national water management in late 1940. He listed twenty aspects of national water circulation affecting 'the feeding of canals, pollution of public waters, increasing salinity in the Western and Northern Netherlands, and the public water supplies of the large cities.'[25] He argued for co-ordinating these water flows in one national plan so as to optimize the use of the available river water.

Having defined the matter as a national problem, Wentholt sought advice from a number of his chief engineers. The canalization of the IJssel was cancelled and an alternative put forth that seemed to serve most interests: the canalization of the Nether-Rhine. A plan was rapidly developed, involving the construction of three weirs. Manipulation of the upstream weir just below the junction with the IJssel would force more or less water into the IJssel as needed. Now, during droughts, almost all Rhine water could be diverted into the IJssel to the IJsselmeer. It would secure the lake's role as a freshwater reservoir and enable further land reclamations to proceed. The new plan also guaranteed the IJssel's navigability under almost all conditions. Canalization also secured the navigability of the Nether Rhine itself.

The problem had been moved to the West, where, as noted, the lower delta and especially the Westland with its water-hungry greenhouse agriculture counted on a steady flow of water through the Nether-Rhine/Lek Rivers to keep salt intrusions at bay. The main source of saline intrusion, Rotterdam's New Waterway, was also the nation's chief artery of maritime commerce and could not be dammed. To assuage these interests without sacrificing the IJsselmeer, Wentholt was able to draw on another project worked out by chief engineer Johan Van Veen, director of the Research Department of the Directorate for the Maritime Rivers. Van Veen and his staff had been measuring and mathematically modelling the Delta system since 1930, partly in order to find a solution for this salinity problem.[26] In 1936, he proposed the closure of the main river estuaries in the South-Western Delta, a measure that was not only aimed at reducing salinity, but also at improving navigability and safety from flooding. In what would become known as the 'Five Islands Plan,' which he presented in 1941 to his chief, Van Veen proposed to dam up a number of tidal channels to the Southwest of Rotterdam thus rerouting fresh Rhine water through Rotterdam's New Waterway, to counter the 'salt-tongue.' These measures would compensate the reduced freshwater flow through the Nether-Rhine as a result of the new canalization plans. Wentholt integrated this Five Islands Plan into his vision of a national water management system for the Netherlands, in which strategically situated hydraulic works (weirs and dams) would make it possible to distribute fresh Rhine water throughout the country as needed.

The Final Construction

The canalization of the Nether-Rhine raised its own engineering problems, but of a technical rather than political nature. Three sorts of requirements related respectively to the roles of the canalization as an element of the new freshwater distribution network, the existing navigation network the existing drainage network, and demanded imaginative engineering design that went considerably beyond what had been done on the Meuse 20 years earlier. The Second World War delayed the actual construction of the network, among other reasons because the working drawings were literally reduced to ashes in the bombings associated with Operation Market Garden, and the canalization project languished until 1950. In that year a Rhine Canalization Service was created to design and co-ordinate weir construction on the Nether-Rhine. In the event, it took until 1970 before the last of the three weirs was actually commissioned.

The delay was due primarily to the massive shift of national hydraulic engineering resources into the Southwestern Delta in the wake of the devastating 1953 storm surge. In the much more ambitious Delta plan that succeeded the Five-Islands Plan, more and larger estuaries were to be dammed up and the dams were to be located further seaward. Behind them large fresh water basins were to be created. These basins would be fed by the Meuse as well as by the Rhine. The water level in the basin could be controlled by concerted manipulations of the Nether-Rhine sluices and a set of large sluices to be incorporated in the Haringvliet dam (see Figure 1). The basin was connected via several smaller rivers to the Nether Rhine-Lek-Nieuwe Maas river system and thus with the New Waterway. The closing of the Haringvliet sluices could increase the water level of the new fresh water basin and reroute stored Waal and Meuse water to the New Waterway. The downstream weir of the Nether Rhine canalization prevented this water from flowing upstream. A certain minimum flow through the Nether Rhine, still required under the Five Island Plan, could now be dispensed with: The upstream weir at Driel could now direct all available Rhine water through the IJssel into the IJsselmeer. The national fresh water supply network became functional with the inauguration of the Haringvliet sluices in 1971.

The Haringvliet sluices are part of all three networks discussed up to this point and eloquently demonstrate how the functional networks are superimposed on the same material infrastructure. The sluices are kept shut during high tide, thus maintaining both a reasonably stable internal water level and keeping salt water out. In this way, the former Haringvliet estuary has itself become a large fresh water reservoir. It goes without saying that during storm surges the sluices are also tightly closed and the sluice simply functions as part of the coastal defences. During such periods, its drainage function is suspended and the Rhine must make its way to the sea entirely via the New Waterway. Under normal circumstances, the sluices are opened to a greater or lesser degree during low tide, so that excess Rhine water can flow directly to the sea via the Haringvliet.

The Demise of Hans Brinker

The implications of wet network building for Dutch society are myriad. Some accomplishments have gained almost mythical status, such as the shaping of the economic system of the Golden Age; the prevention of an invasion by the Sun King's army; and, of course, the heroic struggle against floodwaters. The latter is mythologized in the legend of Hans Brinker, the boy who protected his village from flooding by sticking his finger in a dike.[27]

However, the bold manipulation of wet nature by generations of Dutch Hanses was not merely heroic; it also had its downside in the form of unintended and undesired consequences. The most immediately affected domains were of course the other wet networks. However, in the course of the 20th century, as large-scale water management increasingly passed into the hands of a single national agency (the Rijkswaterstaat) such unwanted interferences became less frequent. Contradictions were increasingly resolved by compromise designs and workarounds, recently instituted in a comprehensive planning approach called 'integral water-management.'[28] In the 20th century, the most creative interactions of this sort were between the flood-control network and the fresh-water supply network. Both the Zuiderzee Works and the Delta Works were imaginative combinations of flood-control and fresh-water supply infrastructure—with, of course, all kinds of effects on the drainage and navigation networks as well.

However, the various wet networks, entailing the mastery of risks and massive infrastructure construction, have also had a broad range of more diffuse effects on other domains. In a more speculative discussion, we shall now address three of these: damage, risks and complacency, and cultural patterns.

Damage

The large 20th-century projects to improve flood defence by damming up bays and estuaries and thus shortening the coastline produced extensive collateral damage in the ecological and economic spheres. Unique estuarine wetlands and salt-water fisheries and shellfish industries were threatened or destroyed. And while the integration of economic and ultimately even ecological criteria into the design of wet networks has now been institutionalized, this was not accomplished without considerable struggle, and has not been achieved across the board. Therefore, while river flooding is still an ever-present threat, improving dikes along the rivers means destroying traditional riparian landscapes and villages, and has engendered fierce opposition. This stalemate remains unresolved.

With regard to the drainage network, the most serious damage resulting from more effective drainage is—as mentioned above—increased compaction of boggy soil due to oxidation. This has required ever more effective drainage networks and has increased the calamitous potential of any future flood. Moreover, since the late 19th century there has been extensive drainage of peat bogs in the higher regions of the country for the purpose of extracting fuel. This has of course destroyed unique ecologies and habitats. This process occurred three centuries earlier in the low-lying regions and resulted in a legacy of large and sometimes treacherously self-expanding lakes, which, though they are today tamed and have become recreational paradises, have nothing in common with the original ecology of the peat bogs they replaced.

Another irony plays around the tension between local drainage networks and the core network composed of large rivers and canals. The more effective local drainage, the quicker and more heavily the core network becomes loaded in the event of heavy and especially prolonged rainfall. Whereas previously the (inefficient) local network retained runoff (at the cost of local flooding) now superior drainage networks transfer the load more quickly to the core network, preventing local flooding but inundating the core network. Because the watersheds of rivers like the Rhine and the Meuse reach far into the European hinterland, and have become human-regulated instead of natural drainage networks, the many local improvements there have dramatic effects on the functioning of the 'cosmopolitan' drainage network and especially on the delta region of the Netherlands, causing annually recurring flood threats.

Finally, major canals have caused considerable damage to the landscape and to regional coherence. As a result of repeated up-scaling in the 19th and 20th centuries, they have become a kind of wet superhighways, sundering local communities and regions with their disproportionate scale. Moreover, incorporating rivers into the navigation network by normalization or canalization implied destruction of much of the original ecology. Finally, the presence of a large fleet of barges has resulted in a waterways-based industrial sector that has contributed its share to the pollution of surface waters. Most of the time, this is incremental if persistent, but sometimes, as in the case of collisions involving chemicals tankers, the results can be catastrophic.

Risks and Complacency

In view of the successes of Dutch water management since the 1950s, the Dutch have come to confer blind trust in their hydraulic infrastructure and in the contemporary water wizards who manage them. Nevertheless, this increasing complacency may entail several dangers in the long run. We will discuss a few of them.

The 20th-century reduction of the coastline to some 650 km has resulted in at least a proportional decrease in the chance of calamitous dike breaches. In addition, all sea-dikes have been raised to the so-called 'delta-height,' i.e. a storm-surge height expected to occur no more than once in ten thousand years. In short, the flood control network has been normalized, rationalized and largely nationalized. Confidence in the flood control network, at least insofar as it pertains to flooding from the sea, has probably never been greater.

But while the risk of calamitous flooding due to storm surges appears to have been reduced to a statistically acceptable level, new dangers have emerged. With the concentration of seaward defences at a few strategic dams, safety from flooding stands or falls with the integrity of these structures. They remain vulnerable to destruction not only by natural forces, but also by social ones like slack maintenance, management errors or sabotage. In practice, the situation is less alarming than it might seem because older (and in themselves already multi-layered) lines of defence have been retained as secondary defences.

The rivers are another story. The 1990s' near-catastrophic flooding of the Rhine and Meuse re-focused attention on risks and their perception. Historically, long periods of quiescence on the flooding front have always tended to engender complacency about the immanence and severity of water-borne danger. This shows in many ways, from funding cutbacks for dike building and maintenance to complacency about risks. The use that is made of the floodplains—the no-man's land between the so-called summer and winter dikes—is an indicator of the state of play in the politics of riverine risk. In the case of the Meuse in the Southern province of Limburg, more adequate flood-control measures and the absence of flooding for many years led to such complacency that municipalities and developers began to populate the flood-plains with new housing and even a hospital. Abnormally long and heavy rainfall eventually caused serious flooding and victimized homeowners blamed the government for having taken inadequate measures to protect them.

On a larger scale, similar complacency may be settling in about the dangers of flooding from the sea. The fear of a major flood is not manifest in public consciousness; in any case, such fears seem to play a subordinate role in decisions about regional planning or the reallocation of polder lands for housing projects and urban expansion. While this may not be a problem in the short run, in the long run (say a hundred years) it is clear that more draconian measures will have to be taken to ensure an 'acceptable' level of risk. One of the effects of the impressive flood-control network that now exists may well be to delay the implementation of such measures until a new flood again mobilizes funds and political legitimacy.

Moreover, several other dependencies on the societal control of wet networks may increase future risks. In agriculture, more effective drainage has unquestionably been very beneficial to productivity. Yet, it has also influenced the choice of crops. Farmers can now specify their own groundwater levels to suit high-value produce. The better the drainage network, the greater the dependency on the continued maintenance of normalized water levels. When things do go wrong—as inevitably it seems they will—the losses will be greater and in the same measure the tendency to blame the human network builders and their unruly technology instead of, as in former times, unruly nature. So as in the flood-control network, there is a transformation of risk and blame, which resonates, precisely with the 'risk society' thesis of Ulrich Beck *et al*.[29]

A similar logic applies to the fresh water supply network. The natural wet bounty of the country, augmented by the networks infrastructure described above, has given rise to a water-intensive society. As in most other developed societies, there is enormous waste in private and industrial use, but this is exacerbated in the Netherlands by the fabulous amounts of fresh water used in the national network of water management to fight saline intrusions from the sea—in the first place on Rotterdam's open highway to the sea, the New Waterway. This spendthrift attitude to fresh water has created a new risk of dependency on 'clean' Rhine water, which translates into an absolute dependence on transnational organization and compelling Euro-legislation with, of course, its own panoply of political risks.

It is hard to assess whether the complacency about these risks is misplaced. However, it may well be that continued efforts to push the network will at some point begin producing normal accidents at a rate sufficient to cause general concern. For the moment it seems to be a problem only for insurance companies.

Cultural Patterns

It is a commonplace that Dutch national character and its political and cultural institutions have been shaped by the common struggle against floodwaters, also known as 'the hereditary enemy' or the 'water wolf.' This was canonized in the myth of Hans Brinker. It is difficult to assess how much of this 'holds water,' certainly not in the scope of a review like this. Insofar as the fight against water has formed characters and institutions, however, the conditions have certainly changed in the course of the twentieth century, particularly since the flood of 1953. In former times, fighting floodwaters and simply remaining vigilant was first and foremost an immediate and local activity, undertaken in the context of local or at best regional polders and water boards. The fight, to put it simply, was close to home and exerted its disciplinary force directly on the participants.

In the course of the 20th century, the fight has become increasingly professionalized chiefly through its appropriation by the Rijkswaterstaat. This has made the building and maintenance of the flood-control network—at least of its essential seaward components—more a spectator sport than a participatory ritual. Now that the heroic mission has (for the time being at least) been accomplished, even the element of national spectacle has vanished. Whereas formerly the fight against the floods built character, institutions or at least national pride, now it has become a distant and alienating activity of bureaucratically organized civil engineers—in the popular perception about as exciting as the work of the internal revenue service. Probably for the first time in Dutch history, no one seems really interested in the 'eternal fight' anymore, unless it threatens interests closer to home, like dry cellars, cherished landscapes or unique ecosystems. We may well be witnessing the demise of its 'shaping' effect on Dutch character and culture, although the current state of play in the domain of flood defence—given the effects of global warming and 'streamlined' watersheds—is too dynamic to support facile conclusions.

In the field of drainage, too, a speculative case may be argued for the culturally formative influence of elaborate networks of drainage and water-level management. The Dutch have a (possibly apocryphal) penchant for order, tidiness and precision and it is not inconceivable that the constant vigilance and administrative precision necessary to maintain water levels within a range of a few centimetres has had its formative influence. One could at least argue that building and maintaining the drainage network demonstrated the practical utility of precision, punctuality and order. It also demonstrated the practical utility of divisions of labour and responsibility, the need for accountability and the need for co-operation and maintaining good relations across large tracts of wet and dry territory.

In the 20th century in any case, drainage, like flood control, became a thoroughly professional and bureaucratic activity. The average citizen, including the farmer who formerly had a hand in maintaining normative water levels, is no longer an actual participant in regulating the drainage network and has become a mere consumer of stipulated groundwater levels and a producer of waste-water. The actual processing and regulation is carried out by government bureaucrats. The tutelary effect of the drainage network on the population in general thus seems to have passed its zenith. However, here too, rapidly changing climatic conditions in conjunction with continuing secular trends like the subsidence of the former peat marshes and rising sea levels, may in the near future make the management of drainage networks a more salient determinant of politics and culture once again. In order to deal with the dramatic increases in precipitation and runoff predicted by experts, the network-building authorities will need the active consent and quite possibly the practical participation of farmers, landowners, consumers of fresh water and purveyors of wastewater. A broad-based political culture of precision, punctuality and accountability may once again come to prove its survival value.

The 20th century, as the above account suggests, was rich in hydraulic ironies. So rich, in fact, that in order to manage them, the dynamics of wet network building seem to have been altered forever. Still, looking back to the Middle Ages it is clear that the ironies of the 20th century are merely the logical culmination of original ironies embedded deeply in the history of settlement of the Low Countries and the wet network building that made that settlement possible. The key irony was that, from about AD 850 onward, the very hydraulic measures necessary to improve habitability of the new territories indirectly reduced habitability in the long term. Wet network building offered short-term solutions, but implied structural deterioration in the long term. If history is any indication, recent great accomplishments in Dutch wet network building will only provide cause for yet more ambitious investments in the future.

Notes

[1] Mollat du Jourdin, *Europe and the Sea*.

[2] Kaijser, 'Technological Systems'; Radkau, 'Zum ewiger Wachstum verdammt?'; Ravensteijn *et al.*, *Participation and Globalisation*.

[3] Cited from the novel Den Doolaard, *Roll Back the Sea*.

[4] Standard works on Dutch water management and geography include: Van de Ven (ed.), *Man-made Lowlands* and Reuss (ed.), *Water Technology in the Netherlands*.

[5] Van de Ven, *Man-made Lowlands*, 34-35. Disco and Lintsen, 'Het nijvere verbond,' 57.

[6] Berkers, 'Kustlijnverkorting,' 71.

[7] Van de Ven, *Man-made Lowlands*, Ch. 7.

[8] The current standard work on the economy of the Dutch Republic is De Vries and Van der Woude, *The First Modern Economy*. See also Israel, *Dutch Primacy*.

[9] See also the excellent discussion papers: Van Zanden, 'Economic Growth in the Golden Age'; Lindblad, 'Foreign Trade'; Lesger, 'Intraregional Trade'; Davids, 'Technological Change.'

[10] Lesger, 'Intraregional Trade'; Lesger, 'De mythe.'
[11] De Vries and Van der Woude, *The First Modern Economy*, 40.
[12] De Vries, *Barges and Capitalism*; Filarski, *Kanalen van de Koning-koopman*.
[13] De Vries and Van der Woude, *The First Modern Economy*, 37-40. Filarski, *Kanalen van de Koning-koopman,* 75–6.
[14] Smits, 'Economische groei.'
[15] The characterization of Dutch inland waterway network as national is contested. Fremdling, 'The Dutch Transportation System.'
[16] Smits, 'Economische groei.'
[17] CBS, 'Nationaal en internationaal goederenvervoer.'
[18] Van Hoof, 'Met een vijand als bondgenoot'; Van Hoof, 'De rol van inundaties'; Janssen, 'De IJssellinie.'
[19] Van Hoof, 'Met een vijand,' 650.
[20] Zeeman and De Vries, *Onze landsverdediging*.
[21] Van Kerkum, 'IJsselverdediging.'
[22] Cited in Haex, 'Inleiding,' 12.
[23] Disco and Van der Vleuten, 'The Politics of Wet System Building.' Conflicts have been particularly endemic and severe around the issue of water quality. See Tarr, *The Search for the Ultimate Sink*.
[24] Biemond, 'Vraagstukken,' G.54.
[25] Waalewijn, *Achter de bres*, 81.
[26] Disco and Van den Ende, 'Strong, Invincible Arguments?'
[27] Knippenberg, 'Dutch Nation-building.' Hans Brinker is neither an historical nor a mythological figure, but a character in an American children's tale written by Mary Mapes Dodge in 1865. However, to appease disappointed tourists, the town of Spaarndam (near Haarlem) nonetheless erected a monument to the apocryphal Hans on its sea-dike. It shows him saving the countryside by, of course, sticking his finger in the dike to stop the leak before it could form a huge gap.
[28] Disco and Van der Vleuten, 'The Politics of Wet System Building.'
[29] Beck, *Risk Society*.

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