

INTERACTION BETWEEN DUTCH FLOOD PROTECTION AND URBANISATION

B. Stalenberg¹, J.K. Vrijling²

ABSTRACT: In the Dutch Delta several types of flood defences can be found. The coastline is mainly protected with dunes, the rural areas in the river landscape with dikes and the urban areas with fixed structures. The question is do connections exist between the changes of flood protection throughout the years and the urban development, and if this is the case what kind of interaction do they have.

For this research ten Dutch cities have been studied that are located along the different Rhine branches. The relevant Water Boards were contacted to obtain information about the current and historical flood protection. Simultaneously the urban history of each city has been studied as well.

The results of this analysis show that urbanisation and flood protection are indeed linked to each other. For instance, many settlements were founded on the natural sand dunes along the rivers. The river course contributed to a positive living climate. In return the urban developments created conditions and opportunities for flood protection of these cities.

Keywords: flood protection, urbanisation, historical development, Dutch river cities, the Netherlands

INTRODUCTION

Four large rivers have their estuary in the Netherlands, namely the Ems, Scheldt, Meuse and Rhine (Brinke, ten 2005). The Netherlands has been shaped by these rivers with its tributaries and by the North Sea. This shaping process was among other things caused by the erosion and sedimentation processes (Ven, van de and Driessen 1995). The Ems and the Scheldt discharge into tidal basins on the national borders. Only the Meuse and Rhine flow through the lowlands (Brinke ten 2005). River water flows from the Dutch borders at Lobith (Rhine) and Eijsden (Meuse) towards the North Sea. The Rhine branches off into the IJssel, Neder-Rhine, Lek, Waal and Merwede. In this perspective the Netherlands can be seen as a delta area. About 25 percent of the Netherlands is below mean sea level (MSL). This level equals the Dutch level called NAP which is used as reference for height measurements (Ven van de 1993). Without flood protection about 65 percent of the Netherlands will be inundated which indicates that flood protection is essential. A wide range of flood defences protects the Dutch landscape against floods from the rivers and from the North Sea.

The Dutch coastline is mainly protected with dunes. Nonetheless the coastal erosion endangers the strength of the dunes. Groins were built to tackle this erosion problem. More recently nourishment of sand beach and front dune has been applied to compensate for the loss of sand dune due to erosion. At some locations where it

was not possible to maintain the dunes, they were replaced by sea dikes (Louisse and Verhagen 1990). The rural areas in the river landscape are protected with dikes. In the tenth century the first dikes were built. Thereafter the dike system has been extended and improved considerably (Ven, van de 1993). In urban areas a different development stands out. Sand dunes near the river bed were used for settlements. In time more settlements were built and expanded which resulted in a decrease of the flood plains (Smits, Havinga et al.). Nowadays most dikes have disappeared in these urban areas. The cities are protected with fixed structures.

OBJECTIVE

River cities display different types of fixed structures for flood protection. A quick scan of several cities in the Netherlands show that every city has its own history and typology in flood protection and its own historical urban development. The question is do connections exist between the changes of flood protection throughout the years and the urban development? If this is the case the next question is also relevant: how is flood protection connected to urban development? The objective is therefore formulated as: investigate the possible interaction between flood protection and urbanisation of the Dutch river landscape.

¹ ir. B. Stalenberg, TU Delft, P.O. Box 5048, 2600 GA Delft, THE NETHERLANDS

² prof. drs. ir. J.K. Vrijling, TU Delft, P.O. Box 5048, 2600 GA Delft, THE NETHERLANDS

RESEARCH APPROACH

For this research ten Dutch cities have been studied that are located along the different Rhine branches: Kampen, Zutphen, Deventer, Doesburg, Arnhem, Nijmegen, Tiel, Zaltbommel, Dordrecht and Zwijndrecht. The relevant Water Boards were contacted to obtain information about the current and historical flood protection. Additional information about the general history of floods was sought in historical books. Simultaneously the urban history of each city has been studied by visiting the city's libraries and regional archives. The obtained information has been compared with each other in order to find interactions between flood protection and urbanisation of the Dutch river landscape.

URBANISATION OF THE DUTCH RIVER LANDSCAPE

Early settlements (600 BC – 1000 AD)

Around 800 the Netherlands was on average a thinly populated area. However the region of the large rivers was more densely populated (Ven, van de 1993). In the marshy delta small settlements were founded on natural sand dunes and levees along the rivers. The lower laying areas were used as meadows. Examples of such early settlements are Arnhem and Nijmegen. Both locations were attractive due to natural high grounds that provided natural protection against floods. The low laying areas with peat were uninhabited for a long time. Only since the eleventh century this area has been slowly colonised through the creation of the forerunner of the polder (Ven, van de and Driessen 1995).

High and Late Middle Ages (1000 – 1500)

In the High Middle Ages several cities grew. This urban development was due to the increased commercial activity so the self-supporting rural population could concentrate on agricultural production for a market economy. Urban commercial settlements came into existence. These sprang up spontaneously at intersections of trade routes. Some cities remained very small and even disappeared, whereas others survived and expanded (Ven, van de 1993). Via two cities along the IJssel, Deventer and Kampen, the exchange of goods took place between the Baltic area, Flanders and the regions along the Rhine. In the county of Holland only the city Dordrecht was of international importance (Ven, van de 1993).

Several cities along the IJssel and Waal, such as Kampen and Tiel, joined the Hanseatic League. At first this league was meant for merchants which traded over sea, but later on it was transformed into a city league. The welfare, induced by trading activities, was mirrored in public works which were built in the Hanseatic cities (Heslinga, de Klerk et al. 1985). For example, in the first half of the fourteenth century the old wooden fortification in Kampen was replaced by a stone one. Also several cities expanded, like Zutphen and Dordrecht. To facilitate the trading activities the cities had built quay walls along the river shores that were improved in the following decades. For instance in Deventer a primitive quay was already present in 1339. In 1545 the wooden quay was replaced by a quay-wall made out of bricks. Parts of this quay are still present and functioning.

The achieved prosperity did have a negative side effect. More protection was needed against local bandits and enemies from other counties. The solution was to build or to improve the fortifications in order to protect the city centre and expansions. In most cases the city expansions were premature and large open spaces could be found within the bulwarks of the Dutch cities (Nicholas 1971). The population of the cities Deventer and Kampen stayed below ten thousand inhabitants in the period between 1250 and 1600 (Ven, van de 1993). In the fifteenth century the prosperity declined in the cities along the IJssel. Due to the St.-Elisabeth flood of 1421 the distribution of the discharge altered for the Rhine branches (Mierlo, van -). The result was a higher discharge at the Waal and a reduced discharge at the IJssel which silted up in the following years. The economic position in Nijmegen declined as well. Cities like Dordrecht took advantage of this development. Trade was shifting towards the cities in Holland.

Early Modern Period (1500 – 1800)

From the sixteenth century onwards a more structured approach was taken to protect the Dutch lowlands. In those days the inhabitants had to cope with foreign enemies such as the Spanish oppressors. Landscape features were used in the defence system. Several fortified cities were connecting a number of natural defence lines (Will 2003). Especially water was used as a defence during military operations. Cities were firstly protected by a fortification but secondly the river water was used to flood the land up to the fortification. The local residents lived within the city walls and no building outside the bulwarks was allowed. Only loading and offloading of the ships happened outside the city



Figure 1: Historical map of Kampen (Blaeu 1652)

walls. A nice illustration of a bulwarked city is the historical map of Kampen (Figure 1).

Nineteenth and twentieth century

During the last two centuries the population of the Netherlands has grown by about 750 percent. This huge increase can be ascribed to several factors: high birth rates, low mortality rates and a positive balance of migration. High birth rates were, among other things, the result of urbanisation (Ven, van de 1993). Furthermore cities grew significant due to several agricultural crisis that drove the population towards the city. This led to a new problem (Hoogenberk 1980). Several cities such as Nijmegen and Arnhem were suffering from the spatial limitation of the fortification. Many cities built new houses on every empty spot they could find without much planning or structure. In 1874 the Fortification Act was proclaimed that regulated which fortifications had to be maintained and strengthened, and which fortifications could be taken down (Will 2003). Cities in the river landscape were officially allowed to demolish their fortification. Many cities, such as Nijmegen and Arnhem, took this opportunity to give their city a new impulse. The waterfronts became appealing. Beautiful avenues and incredibly rich manor houses for the more wealthy residents were built. In Deventer those stately manors are nowadays marked as monuments. These activities did however not improve the living circumstances for the labourers. Only the wealthy inhabitants profited of this development (Hoogenberk 1980).

Since 1950 the river cities have grown substantially. A result was that in 2000 the cities covered a much larger area than in 1950. At first the expansion was needed to cope with the population growth, but soon there were many additional houses required. Less people lived together in one house. At the same time the houses

became bigger and the number of rooms per house increased (Ven, van de 1993). During recent decades the tendency for river cities is to further embrace water in their urban development plans. For instance harbour areas are re-developed into new dwelling areas, such as in Dordrecht (Hooimeijer, Meyer et al. 2005).

FLOOD PROTECTION OF THE DUTCH RIVER LANDSCAPE

Ancient times (600 BC - 500 AD)

Due to the morphological behaviour of rivers, sand dunes were formed on both sides of the river. (Boo de and Middelkoop 1999). Because of their height they were very popular for settlements so many cities were founded on these sand dunes. The sand dunes were not giving that much protection and settlements were regularly flooded. Nevertheless it was still better than living elsewhere. The sand dunes can be seen as the first protection against floods and as the forerunner of the currently known dike. Still some sand dunes are part of the currently used flood protection system.

Middle Ages (500 - 1500)

In the river areas with clay the oldest dikes were built in the tenth century. These early flood defences were local structures, upstream of the villages (Boo, de and Middelkoop 1999). Quays were constructed transverse to the river and were meant to block the water flowing from upstream settlements (see Figure 2). A lot of floods occurred around 1200. The water level at the IJssel rose which can be explained by deforestation in Germany. Around 1300 a closed dike system was established (Ven, van de and Driessen 1995). However, this establishment did not mean that the cities were free from floods. Many dikes were still too low and too weak for a full protection of the area. Every winter this resulted in an inundated hinterland (Ven, van de and Driessen 1995). In areas with peat another development can be seen. Around 800 AD this part of the Netherlands was still nearly uninhabited. Settlements were founded since the eleventh century (Ven, van de and Driessen 1995). When the first water boards were created in the twelfth and thirteenth centuries the process of systematic enclosing the river within dikes began and with it the formation of polders. By 1450, the great rivers had been more or less completely diked (Boo, de and Middelkoop 1999).

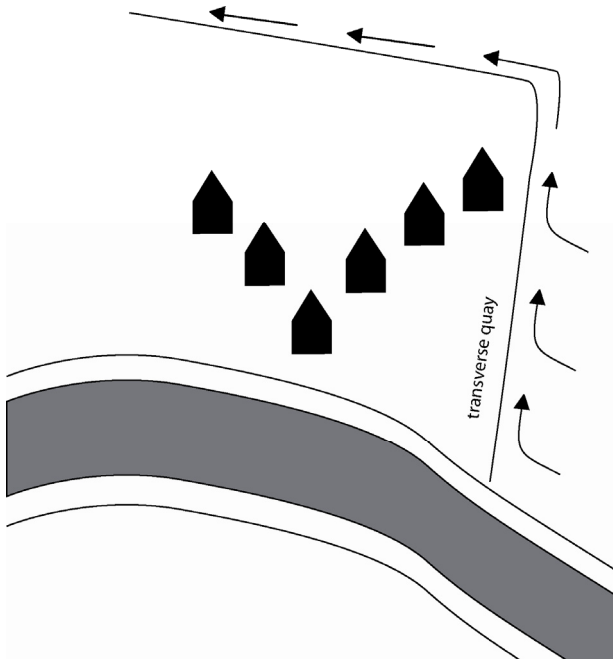


Figure 2: Transverse quays protected the villages against water from more upstream situated lands. (Hooimeijer, Meyer et al. 2005)

The natural sand dunes and dikes were used for flood protection for a long time but with the construction of the fortifications these sandbanks (temporarily) lost this function. The fortification was built in such a way that the land outside the bulwarks could be inundated to protect the settlements against hostile attacks. These structures had to block water. The fortification could therefore also function as a primary flood defence.

The construction of quays and dikes was not the only activity concerning flood protection. At some cities the course of the river was altered. For example, in the fourteenth century the course of the IJssel was altered at Zutphen due to the rising risk of flooding in the southern part of the city. In Arnhem an opposite development is seen. Arnhem was not located directly at the Rhine. Therefore a new bed closer to the city was dug in 1531. Nonetheless the riverbed altered in the following years and new plans were made to shift the bed again. However these plans were not executed because at that time the river was seen as a danger to the city.

Nineteenth century

As mentioned before, the Fortification Act was proclaimed in 1874 (Will 2003). This Fortification Act only looked at the safety aspect and not at the aspect of flood protection. Yet the bulwarks were crucial for flood protection in some cities which resulted in preservation of those bulwarks. This was for instance the case in Kampen and Tiel (see Figure 3). In other cities such as Deventer the fortification was taken down which

induced the restoration of the original sand dune as flood protection whereas in other cities the quay wall was very suitable for flood protection usage too. This can be seen in for instance Arnhem and Zutphen.

Twentieth century

Due to several city expansions many flood plains were lost and more bottlenecks occurred. The IJssel had free play for a very long time. Only at the end of the fifties the IJssel has been diked. The inconvenience of the uncontrolled inundation was not tolerated anymore and the government decided to dike the IJssel. The flood plains were reduced drastically and the water level rose. These developments caused degradation of the safety of the hinterland. Improvement of the flood defences were necessary. The Water Boards strengthened the dikes in rural areas. In urban areas these improvements were done in cooperation with the Municipalities and local residents. This cooperation was necessary due to different interests in these river cities.

Change in safety approach

Until the beginning of the twentieth century dike improvements were made after each breach. The standard that was used in those improvements was the previous occurred high water level. Dikes were designed for the worst-known-scenario with 0,5 m freeboard. The severe floods of 1926 and 1953 showed that these improvements were not enough to prevent floods. After the flood of 1926 the government already got doubts about the followed policy but after the flood of 1953 it became clear that a different approach was needed. The Delta Commission advised to implement a new system of protection that was based on chances. The Dutch Delta was divided into dike ring areas. The safety level differed per dike ring, depending on the population density and the economic value in a dike ring. In the river landscape a safety level of 1/1.250 is used (Ministry of Transport; Public Works and Water Management; DG Water). This implies that the area can be protected for a flooding event which has a chance of occurrence of 1/2.50 per year in the current situation. This new approach has resulted in a lot of improvement activities in the river cities. In Zutphen a solution was chosen to heighten the quay with a short sheet pile in combination with stop logs. The sheet pile was covered with stones of granite at the land side. In Tiel the Water Board and Municipality chose to improve the fortification and built several new flexible structures. As can be seen from the previous two examples this new safety approach has resulted in a wide range of applied structures.

Flood Protection Act

In 1996 the Flood Protection Act was adopted. With this legislation it became compulsory to test the flood defences every five years. Every flood defence has to answer the going hydraulic boundary conditions. The hydraulic boundary conditions are those water levels and waves that have to be blocked safely by the flood defence. These conditions change due to alterations in climate and morphology, and therefore have to be set every five years (Ministry of Transport; Public Works and Water Management; DG Water). This new legislation led to more improvements. For instance, the flood defence in Deventer answered the hydraulic boundary conditions of 1996. However, the normative discharge of 2001 was increased due to for instance heavy rainfall. This led to the improvement of the flood protection in Deventer. If this trend holds more improvements are inevitable in the future.

INTERACTION BETWEEN URBANISATION AND FLOOD PROTECTION

The development of the Netherlands can be described as a continuous dialogue between the powers of water and those of mankind. Protection against floods as well as the usage of water characterizes the Netherlands and its residents (Hooimeijer, Meyer et al. 2005). Transport was mainly done via the rivers so river crossings were a favourable spot for new settlements. One could say that the rivers in the Dutch Delta created positive boundary conditions for settlements in this marshy area. In the river landscape the natural sand dunes were located high enough to give some protection against floods. This was however not enough to prevent flooding. This resulted in the construction of better protection such as dikes and quays. These protections were sufficient enough to allow city expansions which were induced by the increasing trading activities. Due to the increased prosperity also protection was needed against bandits and enemies from other counties. The reaction of this thread was to build or improve fortifications. These fortifications had a positive side effect as they could also be used for flood protection. This is a nice example showing that urban development creates conditions and opportunities for flood protection.

There seems to be no visible effect of flooding on the population density. On the contrary, despite of the frequently occurring floodings the population in the river landscape grew faster than elsewhere in the Netherlands in the period 1795-1815 (Ven, van de and Driessen 1995). Until the end of the nineteenth century the fortified cities were not allowed to build outside the fortifications. Several cities were desperately in need of

more space in the nineteenth century. The proclamation of the Fortification Act brought relief. Many cities were officially allowed to take down the fortification. This led to the restoration of the former flood defences in many river cities. At the same time a lot of city expansions were carried out. These expansions interfered with the spatial need for flood protection. The other functions within the city demanded too much space in order to develop properly.

After the change in safety approach it became clear that many river cities were not protected sufficiently and improvements were needed. This was however very difficult to accomplish due to the claim of other functions, such as living and recreational activities, during the last decades. The solution to this problem was sought in every city individually. The local residents also had a say in the chosen structures. For example in many cities they did not want to lose their view looking onto the river. These boundary conditions and demands led to a set of different solutions in each river city. For instance in Kampen the Water Board and the Municipality choose to follow the original fortification line as much as possible and made houses part of the flood protection system. In Nijmegen they are thinking in the opposite direction. At this moment some buildings are part of the flood defence and the Water Board wishes to place these structures inside the flood defence by building other types of structures such as valve structures.

Looking at the currently executed improvements and projects concerning flood protection improvements a trend is noticeable. Water Boards and Municipalities are trying to combine flood protection with other functions. Cities wish to be protected against floods more than ever but this must not affect the quality of the designed waterfront. The flood defences are integrated in the current urban design and the nuisance is being minimised during normal circumstances. This is for instance the case in Nijmegen. At this moment a mixture of different structures are used. Fronts of restaurants in combination with stop logs, fronts of dwellings and quays. The Municipality is using this improvement to give their waterfront a new impulse. New structures for flood protection are integrated in the waterfront. The structures are monofunctional, such as valve structures and quay walls, but through their usage they contribute to the new waterfront.

CONCLUSION

This research shows that urbanisation and flood protection are closely linked to each other. For instance, many settlements were founded on natural sand



Figure 3: Current flood defence in Tiel.

dunes. The river course contributed to a positive living climate. In return urban developments created conditions and opportunities for flood protection of these cities.

As from the end of the nineteenth century a less harmonic development can be found. After the proclamation of the Fortification Act city expansions took place on a large scale. These expansions interfered with the spatial need for flood protection thus caused lack of space to improve the flood defences. Moreover the local residents also had a say in the chosen structures. These boundary conditions and demands led to a set of different flood protection solutions in each river city.

FUTURE DEVELOPMENTS

As mentioned before a trend is noticeable to integrate flood defence structures with the urban design of waterfronts. The question is if this development is a fruitful one. At this moment every five years a new set of boundary conditions is set to which the flood defences have to answer. If improvement is needed this is done in relation to that set of boundary conditions. If the boundary conditions change in a negative way the flood defence has to be altered again. This has direct consequences for the waterfront. Another approach in design and improvement of flood protection can bring relieve. Adjusting designs on a small scale every five years can be replaced by creating designs with a larger bandwidth. This means that a slight change in the boundary conditions will not automatically lead to improvements of the flood defence. Of course this may not lead to degradation of the waterfront. A solution is to really integrate the function of flood protection with other functions in multifunctional structures. Through this new way of building the flood defence is no longer seen as an obstacle but is integrated in every day life. At this moment research is executed at the Delft University of Technology to examine this approach more thoroughly.

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