

At some points in time the area was also a theatre of war during which a strategy of flooding was applied which also adversely affected the landscape. Therefore the main research question of this paper is to investigate how much of the flooding events have natural causes and how many are a result of man's interference? As the list of flooding events in the area is too long, the focus will be on the major 16th century flooding events, three special cases from the 17th and 18th century and the two major flooding events of the mid-20th century.

2 Background

Since 1000 AD local communities – at that time still living on low dwelling mounds – began to build low dikes in the archipelago of the mouths of the rivers Meuse, Eastern and Western Scheldt. Gradually small islands were extended and some were joined into even bigger ones by dikes and dams. Many centuries later islands such as Schouwen and Duiveland, but also Goeree and Overflakkee became bigger islands. On every island settlements were founded and on the major islands towns rose.

This coastal area was attractive for settlement because of its natural resources. The clay soil was very fertile and suitable for arable farming and where areas remained under the influence of the tides there was sheep farming (Verhulst, 1995, p. 64–76). As the process of land reclamation was well underway, local communities were joined by big investors such as feudal lords, monasteries and hospitals located in towns such as Ghent and Bruges. As the medieval period ended, land reclamation and dike building were in fact carried out by mainly big investors (de Kraker, 2011a, b). Their main task was to maintain the dikes in order to keep out the outside water and to maintain a network of ditches with a sluice in order to discharge the polders of fresh water on the inside. Long-term water discharge of polders meant a gradual drop in surface level, because of the thick layer of peat in the subsoil that compacted at several locations.

Next to farming these thick peat layers were also a second major natural resource of the archipelago. Large peatbogs had formed since 5000 BC in a fresh water environ-

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ment protected from the North Sea by a system of coastal barriers on one hand, while on the other hand the ground water table slowly rose corresponding to a slowly rising sea level. The flow of water through the rivers Scheldt and Meuse contributed very much to the growing of the peatbog area (Baeteman, 2013; Weerts, 2013). After the 3rd century AD peat growth was interrupted by large scale flooding. This affected the peat in two ways. At some places it was removed and new clay depositing occurred, in most places however, peat was penetrated by sea water and covered by a fresh clay layer. Peat could therefore be used for two purposes: fuel and salt extraction (de Kraker et al., 2008). At the end of the medieval period some twenty towns were very active in making salt from peat, employing thousands of workers (de Kraker, 2007). It meant that in vast areas peat was cut and therefore the original surface level of the old polders dropped (Borger, 1992; van Dam, 2001). In spite of regulations forbidding entrepreneurs to cut peat in polders too close to dikes, the process of land subsidence could not be stopped. The alternative was to cut peat at low tide in saltmarsh or flooded areas.

On the one hand the sea had contributed much to building the landscape of the archipelago in terms of clay soils and salt in the peat layers, on the other hand it also had its downside. Contemporaries building dikes could determine how high and how broad its base had to be, still storm events building up towards gale force 8–9 Beaufort or even storm force 10–11 Beaufort, could not be foreseen. As the wind turned to NW and coincided with New Moon or Full Moon, water levels could be pushed up to a level of more than 0.5 m above the highest dike levels causing flooding. Top levels of dikes varied from 3.85–4.95 m (Van de Ven, 1993; De Kraker, 2005). As the water of the North Sea was not only funnelled into the southern North Sea but further upstream into the mouths of the rivers Meuse, Eastern and Western and Scheldt, polders lying at the far end needed to have higher dikes than those located at the river mouths.

It was not until the mid-19th century that it became possible to foresee how the weather would turn and how high water levels could actually reach. From that period onwards hydraulic engineers regularly monitored and measured top levels of all the

dikes in the area and made plans to improve on them. Making plans is one thing, but imposing them on all the so called free polders, which were completely autonomous, was another. Generally the administration of such polders chose to govern their polder and maintain their dikes at the cheapest price, rather than spending “spoil” money on raising top levels of dikes mainly aimed at pleasing the tax paying landowners. This radically changed after the major flooding of 1953.

3 Materials and methods

This paper builds on ongoing multi-disciplinary research into how the landscape of the study area has changed during the recent five centuries. This consists of extensive research of documentary evidence which can be subdivided into the following categories. Documents that relate to landownership and land use, such as manorial accounts of which monasteries and nobility are most important. Accounts of the maintenance of sea defence such as dykes, dunes and sluices which were controlled by the many water boards in the area. If preserved each single polder had to keep an annual account of dyke maintenance. Also correspondence of various stake holders in flooded areas and local administrations and provincial governments are of interest and historical maps made after flooding events. All of this documentary evidence provides information on flooding events and specific details about how, where and when flooding happened, what was the extent of the damage and how this could be repaired. For some flooding events (1715 and more recent ones) specific damage assessment reports were made. Next to historical geographical research also archaeological information is used of specific locations, features and even settlements which disappeared shortly after a flooding event and were buried under new clay deposits. In this respect aerial survey proved to be very useful too where the focus was on crops marks. Finally geological maps (1 : 50 000) were used along with the digital elevation model of the Netherlands (Actueel Hoogtebestand Nederland). In particular the old soil maps with cross-sections

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of subsoil layers of Holocene peat proved to be very useful clearly pointing at locations where new tidal channels had removed peat or had not affected the old layer at all.

The general literature about flooding events in the Netherlands mainly focusses on the 1953 event and its aftermath as far as the SW Netherlands is concerned and the 1916 event as far as the Dutch provinces of Holland, Utrecht, Gelderland and Overijssel, surrounding the former Zuiderzee are concerned. The 1953 event became the onset of the many Delta Works carried out here and the 1916 event became the onset of the closure of the former Zuiderzee and large scale land reclamation in the area. Most of the studies focussed on hydraulic engineering aspects (an de Ven, 1993), some on the human suffering and the initial causes of the event (Slager, 2003). The 1953 flooding was also the start of a broad scientific research programme of historic flooding events caused by storm surges and river flooding 7th century AD – 1700 (Gottschalk, 1971, 1975 and 1977). Many case studies of the history of small polder areas published by small water boards located in the coastal areas of Holland and Zeeland, which were about to merge into larger ones, also deal with much detailed information on single flooding events (Kool-Blokland, 2003; de Kraker et al., 2000; van Tielhof et al., 2006). Recently there is also a focus on flooding within the framework of climate change (all extreme weather events) both in coastal and river areas and the perception of flooding events by contemporaries from the past (Bosch, 2010; van Dam, 2012; de Kraker, 2013).

4 Flooding events, 1500–2000

4.1 General

The major flooding events in the research area referred to as storm surges are well known. Gottschalk (1971, 1975, 1977) has studied these events by using chronicles and related documents which enabled her to make a distinction between fact and fiction (Table 1). If we include the occasions on which parts of the area flooded at other

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1584. In July 1586 another inundation was caused near Axel (Fig. 2 no 5 area B), but this did not serve to relieve Ghent anymore which was already dominated by the Spanish (de Kraker, 1997, 335–337). The carefully chosen places to make breaches in the seawall or to simply take out a wooden sluice had a devastating impact on the landscape, but this strategy completely missed its directly anticipated goals. Bruges, Ghent and Antwerp were subdued by the Spanish in the course of 1584 and 1585, leaving the rebel side empty handed. The impact of these flooding events on the landscape were without precedent, because even secondary dikes (dikes in second line) were also affected, finally flooding about 2/3 of the late medieval landscape. The flooded zone also isolated the area from its historical hinterland, from which money usually came and decisions were made for repairs. From the rebel side all possible money for repairs went to the military and was not spent on newly conquered areas of which control remained uncertain. As the area became a frontier between the two warring parties, there was no rush to carry out fast repairs. Besides, nobody could survive in the flooded area. In fact the vast flooded land, which separated the warring parties, was gradually considered to be a rather practical solution to avoid any kind of hostile engagement in the field.

If there was no eagerness to reclaim the flooded land, what happened to it? The military took even further control of the flooded polders by building earthen fortresses at strategic points. These were built both by the Spanish and the rebels leading to the development of a chain of fortresses or Spanish line of defence and a rebel chain of fortresses or Dutch line of defence. Over the next two centuries these defence lines, after 1648 taken over completely by the Dutch Republic, became the blue print for further land reclamation.

Another major impact on the landscape as a result of these strategic inundations was the start of a new process of erosion and deposition. At places where dike breaches were caused deep new channels were formed which slowly developed into new large creeks (the Otheense Kreek, Hellegat and Vlaamse Kreek). As the process of reclaiming these areas started very late, most of the minor creeks had already silted up again yielding new rich clays soils for arable land. Silting up also occurred in areas which had

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been overexploited during the late medieval period, which had caused large scale subsidence of surface level, leaving behind a new thick clay layer. At most places where the late medieval landscape had been overexploited a thick new clay layer covered all remnants of buildings, roads and ditches. Also medieval villages were abandoned and finally lost (Hontenisse, Aendijcke, Beostenblijje and Othene). Some of these villages have never been found, others are under the new deposits in some recently reclaimed polders.

Closely related to the long duration of the strategic flooding events and the gradual reclamation of land afterwards is the deep impact on the population. As the original inhabitants had to abandon the flooded lands, gradually new inhabitants settled again, but this time mostly coming from the Dutch Republic, mainly being of protestant belief and speaking with a slightly different tongue.

It needs to be said that in the province of North Brabant the area of Bergen op Zoom and its vicinity and some adjacent polders further to the north east also experienced strategic flooding of which the first happened in 1584 east of the town. Polders and villages disappeared. It was not until about 1700 that most areas were gradually being recovered again, this time without villages (Kluiving et al., 2006).

4.4 Flooding 1682–1715 compared

Another flooding event occurred on 26 January 1682 during which about half of the area of Dutch northern Flanders was submerged, while on the other islands of the archipelago and parts of North Brabant the area flooded ranged from 10 up to 25% (Fig. 3). The following extended quote summarizes what happened around Antwerp³.

“On the 26 January 1682 there was a big tempest with a high flood and according to the word that came from Antwerp this was never seen nor heard of before. Because of the extreme violence caused by this flood water flowing into polders of Kallo where about all of the polders drowned as far as the fort Vlaamsche Hoofd located on the left

³Kortrijk Municipal Library (Belgium), ms. 175.

bank of the river Schelt. Only those polders having strong dikes such as the Beverenpolder, Verrebroek and around were spared. It was a real deluge because everywhere there were dead bodies of people and dead animals floating and a lot of grain, household goods, stables and even entire barns in such large numbers that it was hard to describe it all. Damage was estimated to run in the millions and thousands of people were ruined.

Officials inspecting the broken dikes and going into the flooded lands saw and heard numerous people who had taken refuge on the rooftops of their houses, barns and stables. They could only get down safely if they were rounded up by rowing boats and barges. But most of them were too frightened because they feared the small boats would be shipwrecked as the storm that caused all of this lasted for several days. Therefore it was feared that most would not resist any longer such conditions and would eventually starve. The floodwaters also entered the town of Antwerp where it caused large scale damage to merchant and warehouses of which a lot would be bankrupted.

The floodwater also came into the main church of Antwerp. Here thumb stones were uplifted, and graves collapsed. In the cemetery of fortress called Vlaamse Hoofd dead bodies were lifted from their graves and floated towards the main gate of the fortress. Here the floodwaters washed a hole in the pavement of about sixty feet long making its way to the gate on the interior which was ruined. Then the water made its way towards the church of the fortress making the situation very dangerous.”

Also the fortified town of Hulst was badly flooded. Along the North Sea coast of Flanders several areas were flooded too⁴. Although reports of the event from several areas hit in Zeeland were sent to the provincial capital Middelburg, mostly begging for assistance, no general relief was given. Initially all areas had to rely on themselves to make their land dry again. Soon afterwards the provincial government advised some polder boards to raise the top levels of their dikes and the commander of Hulst took many measures to strengthen the town.

⁴State Archive Bruges (Belgium), Vrije van Brugge, no. 106.

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The next flooding occurring on 3 March 1715 was not as devastating as the 1682 one. Many people in 1715 still remembered the flood that happened 33 years ago (de Kraker, 2013). In general the same polders were hit again, but waters did not penetrate that deeply into the hinterland as they did in 1682. Also the town of Hulst remained dry, because of the measures it had taken. In terms of flooded area it hardly surpass 10 % and in terms of casualties the 1715 flooding was hardly a serious one, except on the islands of Goeree and Overflakkee where some polders had to be abandoned for some years.

4.5 Strategic flooding events of the 17th and 18th centuries

In both the Dutch part of northern Flanders and the area north of Bergen-op-Zoom a long area consisting of creeks and salt marshes was not given out for reclamation. Some already reclaimed neighbouring areas could be given back to the sea through the opening of sluices or by making breaches into seawalls again.

In 1672 when the French army marched into Flanders, also threatening the Dutch part, commanders of garrisons opened sluices at several locations (Table 1). One such event took place near Sas van Gent, where a large new polder (reclaimed in 1652) was given up and flooded⁵. Also further to the east polders were flooded. Some were drained as soon as hostilities were over, others flooded again in 1682 (see above).

In the course of the 18th century and after another threat from the French an ingenious network of sluices and channels was developed in order to generate flooding within a few days. From Liefkenshoek (northwest of Antwerp) as far west as Sluice a long area could serve as a water barrier. Water had to reach 40 to 60 cm, which did not allow guns to be dragged through such a flooded land nor the use of boats, while foot soldiers could easily be stopped.

At the start, strategic flooding events mainly used sea water, but by the end of the 18th century fresh water could also be used, by simply leaving sluices closed. This last

⁵State Archive Ghent (Belgium) Boudelo abbey, no. 2657.

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(October–March) and more in particular two days after New or Full Moon. The impact of the event depended on many circumstantial and additional conditions, which will briefly be discussed.

5 One of the conditions of large scale flooding during a storm surge was the long duration combined with strong winds. During the 1953 storm surge, wind force hardly surpassed 9 Beaufort, but the surge lasted for more than two successive high tides (Hickey, 2001). After the first high tide which was already dangerously high, the following ebb tide also remained high, which consequently caused the second high tide to be higher than the first high tide. Also the flooding event of 1530 is known for its extreme
10 high level. Some contemporaries spoke of a two feet or even a beer barrel's height above the top level of some dikes, which meant that water level was more than half a metre higher than top levels of dikes at the time. Because each polder or water board maintained its own standards for top level height, it is hard to generalise flood level back in 1530. More likely big waves were pushed over the dikes during gusts of strong
15 wind, which led water to affect the landside slope of dikes which were more brittle than the extra defended gentle slopes on the seaward side. If this went on for hours dikes could collapse from the landward side very easily. Such kinds of dike destruction were widely observed in 1953 in the SW Netherlands again. Once such collapsing started, the top level slid down like a very local landslide making a hole in the dike through
20 which water could penetrate into polders making deep erosive gaps.

Flooding during a storm surge could also occur if two or more extreme weather events happened within a short time span. The 1421–1424 Elisabethan floods (Leenders, 2009), 1509–1511, the 1530–1532 and January–February 1552 storm surges all came in pairs. Areas hit during the first storm surge were either not given enough
25 time for repairs to be carried out or dikes that had already been repaired properly still proved to be too weak and therefore collapsed again as the second surge hit the area. At this point there is a great amount of resemblance between communities hit by two successive years of crop failure and communities hit by two successive flooding events (Campbell, 2010). In both cases resilience is put to the highest test, usually meaning

that contemporaries could not cope well with such extremes reoccurring in fast succession.

The opposite is also true. This is the case of the 1682 flooding which seems to have come out of the blue, being the second extreme event of its kind in the area during the
5 entire 17th century. As the first flooding occurred on Easter Monday 1606, nobody in 1682 had any recollection of that early flood which most likely had made water boards less vigilant leading to neglect of extra maintenance of dikes. The 1682 flood also hit major trade centres such as Antwerp and Flushing inflicting damage to stocks and other properties. For the region of Zeeuws-Vlaanderen it should be noted that the vastness
10 of the flooded area must have partly contributed to the strategic flooding that occurred barely a decade ago. Not all of the flooded area had been properly recovered, while some flooded polders were left disputed, because landowners did not want to pay for all the drainage costs themselves. The 1715 flooding demonstrates that some extra measures taken since 1682 paid off, but not everywhere (de Kraker, 2013). It should be
15 noted that the storm surges, such as the 1715 one, happening during the day time, did not come as such surprise as the 1682 one did. Compared to other 18th century storm events and storm surges the 1715 flooding event must be considered as being the major flooding event of its century in the SW Netherlands (Baart et al., 2011; Demarée and Muir-Wood, 2008; Pfister et al., 2010).

20 The 1953 flooding event in the SW Netherlands, compared to the other flooding events is special in many ways. It is not only the extremely high water level reached on 1 February which generally is considered to be its main cause. It happened at a time period most people could have still remembered the 1906 flooding, which was a rather small scale event not having caused large scale flooding and not having caused a large
25 human toll at all. There are more factors to be considered. One of them being the failure to raise top levels of dikes regularly up to a level of 6 m as it was ordered by Rijkswaterstaat. So it was common knowledge that dikes were too low. At places where top levels had been raised this was carried out by building concrete walls (Muralt walls) on top of the dike which were fastened into the topsoil. Because of the wave action

and the sheer volume of water these concrete walls were simply pushed over the dikes during the storm surge. The extent of the flooding was also very much caused by the slow response of officials of local water boards. As the flooding happened on Sunday morning many people were attending church service or were still sound asleep after an exciting Saturday night. At the same time it clearly exposed the weakness of the water board organisation, consisting of about 300 water boards all having to decide which measures had to be taken to prevent that one dramatic flooding event. The large scale material damage and the high human toll were also largely caused by the weak buildings in the flooded area not being able to withstand the impact of the incoming tide. So many having taken refuge on rooftops (compare 1682) still did not make it because their houses collapsed. Most had to wait and endure the cold until relief came, which during the first days consisted of many fishing boats and other vessels, while only two helicopters were available.

5.2 Strategic flooding

Looking at the second category of flooding events, caused by the military and occurring during warfare or prior to the threat of an enemy invasion, demonstrates that especially the flooding during the Eighty Year's War stands out as a major event. As the rebel side asked experts of the local water boards to advise on the locations where breaches should be made, this guaranteed the largest possible extent of such a flooding. The initial intention was having water in polder areas standing two feet high. This prevented the use of flat bottomed barges and made it impossible to drag heavy artillery through the area. As the flooding in some areas remained too limited it was soon ordered to also make breaches in secondary dikes lying more inland, so that water could penetrate as deeply as possible into the area. As there was no backup plan for repairs after hostilities, no dikes were repaired ('t Hart, 2014, 105–107). Moreover soon the flooded area became part of a strategic line of defence. From then onwards reclamation of flooded land could only be carried out with a special permit of the government who first asked the advice of the military. The long duration of the war (1568–1648) and

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the incorporation of the flooded areas into further warfare had profound consequences for the landscape. Large and deep new tidal channels formed, such as Saeftingher Gat, Hellegat, Braakman and Havengat in Zeeuws-Vlaanderen, clearing old medieval settlements and other structures on the one hand. Floodwaters used the old ditches and canals to finally fill the areas where large scale subsidence of surface level had taken place by cutting peat for fuel and salt making. On the other hand a thick new clay layer was deposited at most places. At places designated as strategic inundation areas the process of depositing could go on until the end of the 18th century. Here the level of the salt marshes had already become so high that the strategy of flooding had become inefficient and therefore completely outdated.

Another consequence of this kind of flooding on the landscape was that salt water had a devastating effect on crops during the first few years. Because strategic flooding events were carried out in the common interest, therefore no compensation was paid to farmers. It was not until the end of the 18th century that the view on strategic flooding began to change. Instead of using sea water, fresh water could also be used. This led to the building of special sluices, inundation sluices, that were able to store the fresh water in the polder areas (Fig. 5). However, there was only one major problem. If an enemy army attacked by surprise, there was not enough time for a fresh water inundation to reach a level of two feet in polders. This took some weeks and was almost completely dependent on rainfall. Intensively spying on the enemy could provide information far in advance and as a result of this flooding could already be set in motion. In 1784/5 strategic flooding proved to be completely unnecessary because no enemy force came to the area. The outcome was a growing opposition against this weapon of war.

The strategic flooding events of the Second World War show two faces. The Nazi flooding of parts of Zeeland Flanders with fresh water and the islands of Schouwen-Duveland, Tholen and St. Philipsland with sea water were caused far in advance of a possible allied attack. This way there was time enough for the water to rise to the level aimed at. Moreover weak locations could be re-enforced properly. Being purely defensive these flooding events did not stop the allied from marching north, only slowed

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them down. The allied strategic flooding of the former island of Walcheren in 1944 was carried out within a day, allowing sea water to flood 70% of the island. It proved to be very effective. The Nazis immediately surrendered the island to the allied forces and then repairs could begin. Gaps were closed and dikes rebuilt and re-enforced. Meanwhile the flooding of the island was the main cause to carry out a major land re-allotment and land consolidation in the years after. This meant that by 1953 this area in the SW Netherlands had already been changed to meet the demands of modern times, including its sea walls, from which it benefitted very much during the storm surge that year when only a small strip in the east of the island was flooded.

5.3 Comparison and the wider scope

Comparing the two categories of flooding events (storm surges and warfare) it needs to be said that the human factor plays a major role in both. Strategic flooding events are caused by man, but water as a natural feature should finish the job by pushing into areas making them inaccessible. Flooding events during storm surge do have an important natural component which as such could be very devastating, but much depends on the vigilance and resilience of man in preventing this from happening or to limit damage as much as possible. Five centuries of flooding events in the SW Netherlands have made it clear how vital the role played by man is to have an influence on the kind, extent and the duration of flooding. Since 1953 his role has been the dominant factor in the prevention of further flooding events in the area and still is. Needless to say that this dominance also has its drawbacks, which, however, are not the subject of this paper.

A comparison between the coastal flooding events in the SW Netherlands and flooding in more upstream river areas demonstrates both the similarities and the differences. Upstream river areas and the lower river basins not being under tidal influence tend to flood at times of extreme rainfall, peak discharge caused by sudden thaw setting in, ice blocking or a combination of such events occurring. None of these factors plays a role of any significance in the tidal inlets of rivers. There have only been two events of ice

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playing a role in coastal areas. In both cases a lengthy period of frost caused sluices to become jammed. After having been defrosted, the sluice doors could function again. The large scale strategic flooding events in the Dutch river between 1672 and 1795 were caused by partly piercing the river dikes at some place. Especially during the French War of 1672–1678 it caused large scale flooding in Central Holland and Utrecht which rendered areas out of agrarian use for some years. At that time this Old Dutch Water Line proved to be effective. Later on it was to be extended further south and east in later centuries (New Dutch Water line) with additional strategic flooding areas around the rivers Lower Rhine and IJssel. None of these ever achieved their ultimate goals.

Looking at the flooding events in the SW Netherlands, 1500–2000 and putting them in a much wider European scope of flooding events, it becomes clear that there is a much longer tradition of researching flooding events in the Netherlands. This is especially due to the fact of the vulnerability of the Dutch landscape to both coastal and river flooding. It is low lying with large parts below sea level and three major rivers (Rhine, Meuse and Scheldt) form a kind of delta near the North Sea. Dyke building along with other coastal defences and the embedding of many water boards has been the response to flooding in the past, it still is in the present and will be far into the future. Regarding this long tradition and the very nature of the Dutch landscape, the use of flooding as part of a military strategy sounds very logical. Flooding events outside the Netherlands have begun to get special attention since climate change has caused some major river flooding in various parts of Europe in the past few decades (Glaser et al., 2004; Brázdil et al., 2012). In terms of causes and consequences there are differences with flooding events in the Netherlands. The most important cause of recent flooding across Europe are extreme rainfall events, even in summer, while in Dutch coastal flooding, storm surges and gale storms play a major role. In river areas across Europe, such as Central Europe (River Danube (Kiss et 2013; Rohr, 2013), River Rhine (Wetter et al., 2011) and River Elbe) most damage is caused in river towns, while in the Netherlands mostly rural areas were hit. Finally the response to flooding in the

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Netherlands is a large scale project which gives more room for rivers to run through densely populated areas and to store large amounts of water of which some aspects go back to the early 19th century. Across Europe such projects are just beginning to develop. Studies on flooding events across Europe therefore began to focus on flooding events of the past, unravelling patterns, how people responded to the events and what measures they took. Having studied that, the challenge is how to deal with present and future flooding in a generally highly urbanised environment, which is completely different from the landscapes of the past.

6 Conclusion

This paper set out to explore how natural the flooding events of the last five centuries in the SW Netherlands were. These flooding events have been classified into two groups: flooding events caused by storm surges and flooding events occurring during warfare. The multiple century overview of the events has demonstrated that the first category has an initial natural cause, being meteorological in terms of severe gale force Beaufort 8–11 coinciding with New and Full Moon and human intervention in terms of vigilance and resilience. As no flooding event caused during storm surge is alike, the extent of the flooding and the damage caused depended a great deal on the duration, wind force, time of day or night and the weather condition at that particular date. Moreover the human response to each such flooding event also differs a great deal, depending on how often such flooding events occurred during a life time, how fast a second flooding happened, the organization of the local water boards, the state of maintenance of dikes, while sometimes much depended on the individual measures people were willing to take. The second group of flooding events occurring during warfare are man-made, either caused by fresh water or – as was the case before 1800 in the SW Netherlands – by sea water. The strategic flooding during the Eighty Year's War failed to facilitate the rebel offensive to free the besieged towns of Ghent, Bruges and Antwerp. The strategic flooding of later centuries failed as a defensive strategy to stop the French armies from

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invading the area. Although the strategic flooding during the Second World War did not help the Nazis from stopping the allied march, it did help the allies in liberating parts of the SW Netherlands before the winter 1944/45 began.

The impact of flooding events caused during storm surges and those happening during warfare is different. In terms of extent of flooding and devastation, the strategic flooding events of 1584–1586 and 1621 had the biggest impact on the landscape, so did the 1953 flooding caused during a storm surge.

References

- Baart, F., Bakker, M. A. J., van Dongeren, A., den Heijer, C., van Heteren, S., Smit, M. W. J., van Koningsveld, M., and Pool, A.: Using 18th century storm-surge data from the Dutch Coast to improve the confidence in flood-risk estimates, *Nat. Hazards Earth Syst. Sci.*, 11, 2791–2801, doi:10.5194/nhess-11-2791-2011, 2011.
- Baeteman, C.: History of research and state of the art of the Holocene depositional history of the Belgian coastal plain, in: *Landscapes or Seascapes? The History of the Coastal Environment in the North Sea Area Reconsidered*, edited by: Thoen, E., Borger, G. J., de Kraker, A. M. J., Soens, T., Tys, D., Vervaet, L., and Weerts, H., *Corn Publication Series, Comparative Rural History of the North Sea Area*, 13 Brepols Gent, 11–30, 2013.
- Borger, G. J.: Draining–digging–dredging; the creation of a new landscape in the peat areas of the Low Countries, fens and bogs in the Netherlands: vegetation, history, nutrient dynamics and conservation, *Geobotany*, 18, 131–171, 1992.
- Bosch, T.: Changing societies produce changing rivers, *Managing the Rhine in Germany and Holland in a changing environment, 1770–1850*, in: *A History of Water. Series II Volume 2: Rivers and Society: from Early Civilizations to Modern Times*, edited by: Tvedt, T. and Coopey, R., London/New York, 263–286, I.B. Tauris, 2010.
- Brázdil, R., Kundzewicz, Z. W., Benito, G., Demarée, G., Macdonald, N., and Roald, L. A.: Historical floods in Europe in the Past Millennium, in: *Changes in Flood Risk in Europe*, edited by: Kundzewicz, Z. W., IAHS Special Publication 10, IAHS Press and CRC Press/Balkema, Wallingford, 121–166, 2012.

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- Campbell, B. M. S.: Nature as historical protagonist: environment and society in pre-industrial England, *Econ. Hist. Rev.*, 63, 281–314, 2010.
- de Kraker, A. M. J.: Landschap uit Balans, de Invloed van de Natuur, de Economie en de Politiek op de Ontwikkeling van het Landschap in de Vier Ambachten en het Land van Saeftinghe Tussen 1488 en 1609, Matrijs, Utrecht, 1997.
- de Kraker, A. M. J.: Modernization of dike maintenance and coastal management in the Meuse-Schelde-Delta, 1500–1900, in: *Kulturlandschaft Marsch. Natur * Geschichte * Gegenwart. Vorträge anlässlich des Symposiums in Oldenburg vom 3. bis 5. Juni 2004*, edited by: Fansa, M., Isensee-Verlag Oldenburg, Oldenburg, 146–161, 2005.
- de Kraker, A. M. J.: De centra van zoutproductie in Brabant, Vlaanderen en Zeeland tussen 1400 en 1600, in: *Veen–Vis–Zout Landschappelijke Dynamiek in de Zuidwestelijke Delta van de Lage Landen Geoarchaeological and Bioarchaeological Studies 8*, edited by: de Kraker, A. M. J. and Borger, G. J., Vrije Universiteit Amsterdam, 81–113, 2007.
- de Kraker, A. M. J.: Sustainable coastal management, past, present and future or how to deal with the tides, *Water History*, 3, 145–164, 2011a.
- de Kraker, A. M. J.: De Rol van de Cisterciënzerabdijen in het Kust- en het Waterbeheer in Noordoost-Vlaanderen Tijdens de 15de–16de Eeuw, *Novi Monasterii. Jaarboek Abdijmuseum Ten Duinen 1138*, 11, 75–84, 2011b.
- de Kraker, A. M. J.: Two floods compared, perception of and Response to the 1682 and 1715 flooding disasters in the low countries, in: *Forces of Nature and Cultural Responses*, edited by: Pfeifer, N. and Pfeifer, K., Springer Verlag, Dordrecht, 287–302, 2013.
- de Kraker, A. M. J. de and Bauwens, W. E. M.: Polders en Waterschappen in het Hulsterambacht. De geschiedenis van Zeedijken, Vooroever, Binnenwater, Wegen en van de Bestuurlijke Organisatie van de Waterschappen in het Voormalige Hulsterambacht Tussen 1600 en 1999, *Kloosterzande*, 2000.
- de Kraker, A., de Koning, D., and Wielinga, R.: Making salt the medieval way, *Experimentelle Archäologie in Europa, Bilanz 2008*, Heft 7, European Association for the Advancement of Archaeology by Experiment, Oldenburg, 75–90, 2008.
- Demarée, G. R. and Muir-Wood, R.: De “Grote Storm van December 1703” in de Lage Landen – een stormachtige periode in de Spaanse Successieoorlog, in: *Jaarboek voor Ecologische Geschiedenis 2008*, edited by: De Kraker, A. M. J. and van der Windt, H. J., *Klimaat en Atmosfeer in Beweging*, Ghent, Academia Press, 33–54, 2009.

- Essink, K. (Ed.): *Stormvloed 1509, Geschiedenis van de Dollard*, Stichting Verdrongen Geschiedenis, Groningen, 2013.
- Glaser, R. and Strangl, H.: Climate and floods in Central Europe since AD 10000: data, methods, results and consequences, *Surv. Geophys.*, 25, 485–510, 2004.
- Gottschalk, M. K. E.: Storm surges and river floods in the Netherlands, Vol. 3, Van Gorcum & Comp., N. V. Assen, 1971–1977.
- Groenveld, S., Leeuwenberg, H. L. P., Mout, M. E. H. N., and Zappey, W. M. (Eds.): *De Tachtigjarige Oorlog. Opstand en Consolidatie in de Nederlanden (ca. 1560–1650)*, Walburg Pers, Zutphen, 2008.
- Hickey, K. R.: The storm of 31 January to 1 February 1953 and its impact on Scotland, *Scott. Geogr. J.*, 117, 283–295, 2001.
- Kiss, A. and Laslovszky, J.: 14th–16th century Danube floods and long-term water-level changes in archaeological and sedimentary evidence in the western and central Carpathian Basin: an overview with documentary comparison, *J. Environ. Geogr.*, 6, 1–11, 2013.
- Kluiwing, S. J., Brand, N., and Borger, G. J. (Eds.): *De West-Brabantse Delta: een Verdrongen Landschap Vormgeven*, *Geoarchaeological and Bioarchaeological Studies 7*, Institute for Geoarchaeology and Bioarchaeology, Amsterdam, 2006.
- Kool-Blokland, J. L.: *De Rand van't Land. Waterschapsgeschiedenis van Schouwen Duiveland. Werken Uitgegeven Door het Koninklijk Zeeuws Genootschap der Wetenschappen*, no 13, Middelburg, 2003.
- Slager, K.: *De Ramp, Een Reconstructie van de Watersnood van 1953*, Uitgeverij Atlas, Amsterdam, Antwerp, 2003.
- Leenders, K.: “Die inundacie ende inbreck van onsen Grooten Waert”. De verdrinking van de Grote Waard, in: “Nijet dan water ende wolcken”. De Onderzoekscmissie Naar de Aanwassen in de Verdrongen Waard (1521–1523), edited by: Wikaart, V., *Stichting Zuidelijk Historisch Contract Tilburg*, Tilburg, 65–74, 2009.
- Pfister, C., Garnier, E., Alcoforado, M.-J., Wheeler, D., Luterbacher, J., Nunes, M. F., and Taborda, J. P.: The meteorological framework and the cultural memory of three severe winter storms in early eighteenth-century Europe, *Climatic Change*, 101, 281–310, 2010.
- Rohr, C.: Floods of the Upper Danube River and its tributaries and their impact on urban economies (c. 1350–1600): the examples of the towns of Krems/Stein and Wels (Austria), *Environ. Hist.*, 19, 133–148, 2013.

- 't Hart, M.: *The Dutch Wars of Independence, Warfare and Commerce in the Netherlands, 1570–1680*, Routledge, London/New York, 2014.
- van Dam, Petra, J. E. M.: *Sinking Peat Bogs, Environmental Change in Holland, 1350–1550*, *Environ. Hist.*, 6, 32–46, 2001.
- 5 van Dam, P. J. E. M.: *Denken over natuurrampen, overstromingen en de amfibische cultuur*, *Tijdschrift voor Waterstaatsgeschiedenis*, 1 and 2 June/December, 1–10, 2012.
- van der Ham, G.: *Zeeland, 1940–1945*, Waanders, Zwolle, 1990.
- van de Spek, A. J. F.: *Tidal asymmetry and long-term evolution of Holocene tidal basins in the Netherlands: simulation of palaeo-tides in the Schelde estuary*, *Mar. Geol.*, 141, 71–90, 10 1997.
- van de Ven, P. G. (Ed.): *Man-Made Lowlands, History of Water Management and Land Reclamation in the Netherlands*, Uitgeverij, Matrijs Utrecht, 1993.
- van Tielhof, M. and van Dam, P. J. E. M.: *Waterstaat in Stedenland, het Hoogheemraadschap van Rijnland voor 1857*, Uitgeverij, Matrijs Utrecht, 2006.
- 15 Verhulst, A.: *Landschap en Landbouw in Middeleeuws Vlaanderen*, Brussels Gemeentekrediet, Gemeente Krediet, 1995.
- Weerts, H.: *Holocene sea-level change, sedimentation, coastal change and palaeogeography in the southern North Sea lowland. A 2012 geological literature overview*, in: *Landscapes or Seascapes? The History of the Coastal Environment in the North Sea Area Reconsidered*, edited by: Thoen, E., Borger, G. J., de Kraker, A. M. J., Soens, T., Tys, D., Vervaet, L., and 20 Weerts, H., Corn Publication Series, Comparative Rural History of the North Sea Area, 13 Brepols Gent, 145–176, 2013.
- Wetter, O., Pfister, C., Weingartner, R., Luterbacher, J., Reist, T., and Trösch, J.: *The largest floods in the High Rhine basin since 1268 assessed from documentary and instrumental evidence*, *Hydrolog. Sci. J.*, 56, 733–758, 2011.
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Table 1a. The number of flooding events caused during storm surges in Zeeland-Flanders and elsewhere in Zeeland, 1500–2000.

Flooding caused by storm surges					
Year	Old Style	New Style	Year	Old Style	New Style
1014	28 Sep	2 Oct	1488	25 Dec	3 Jan 1498
1042	2 Nov	6 Nov	1491	14 Sep	23 Sep
1134	2 Oct	7 Oct	1493	no exact date	
1248	28 Dec	3 Jan 1249	1497	no exact date	
1262	28 Jan	3 Feb	1502	16 Oct	26 Oct
1268	28 Jan	3 Feb	1509	26 Sep	5 Oct
1288	14–17 Dec	20–23 Dec	1511	14 Dec	24 Dec
1330	24 Dec	31 Dec	1516	26 Dec	5 Jan 1517
1334	23 Nov	30 Nov	1530	5 Nov	15 Nov
1341	no exact date		1532	2 Nov	12 Nov
1357	24 Dec	31 Dec	1552	13 Jan	23 Jan
1374	9 Oct	16 Oct	1552	15 Feb	25 Feb
1375	8–10 Oct	16–18 Oct	1570	2 Nov	12 Nov
1394	21 Jan	29 Jan	1606		27 Mar
1398	no exact date		1609		18 Feb
1404	19 Nov	28 Nov	1671		22 Sep
1409	10 Feb	19 Feb	1682		26 Sep
1421	19 Nov	28 Nov	1683		18 Feb
1424	19 Nov	28 Nov	1695		Jan
1436	31 Oct–1 Nov	9–10 Nov	1715		2 Mar
1446	10 Apr	19 Apr	1717		25 Dec
1449	22 Mar	31 Mar	1808		
1468	21 Oct	30 Oct	1809		
1472	5 Oct	14 Oct	1906		2 Mar
1477	27 Sep	6 Oct	1953		1 Feb

1462

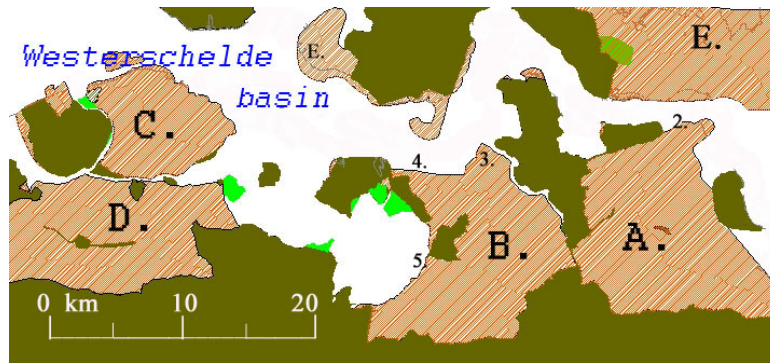


Figure 2. Strategic flooding during the Eighty Year's War (1568–1648) in Zeeuws-Vlaanderen. (A.) Flooded in February 1584 at no 2., (B.) area flooded in July 1584 and the southern area flooded in July 1586 at no 5. (C.) Area flooded in 1584. (D.) Area flooded in 1584, then reclaimed again and flooded again in 1621–1622. (E.) Areas flooded during storm surges, 1530, 1532 and 1570.

1465

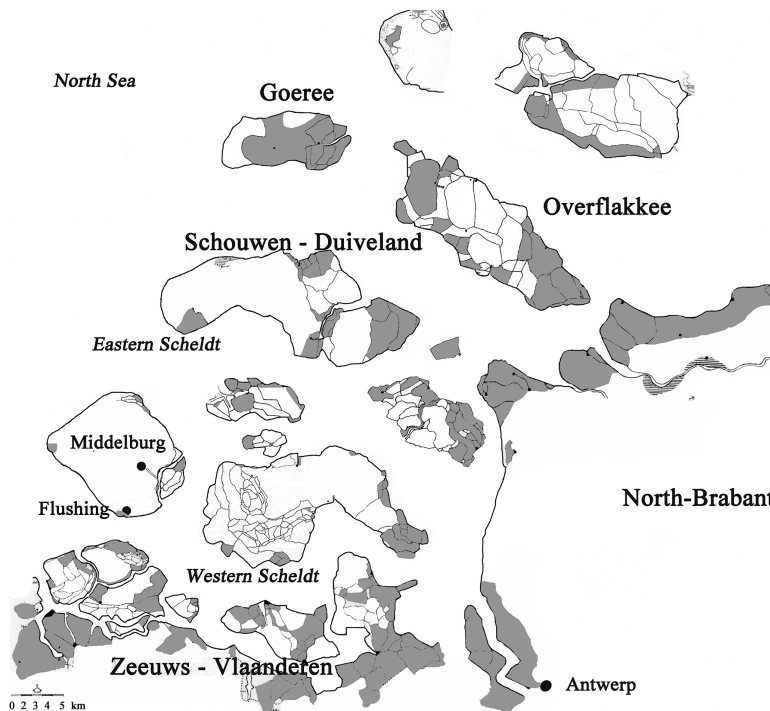


Figure 3. Reconstruction of the flooded areas (shaded) on the main islands and in the western part of North-Brabant during the storm surge of 26 January 1682 (Gottschalk, 1977).

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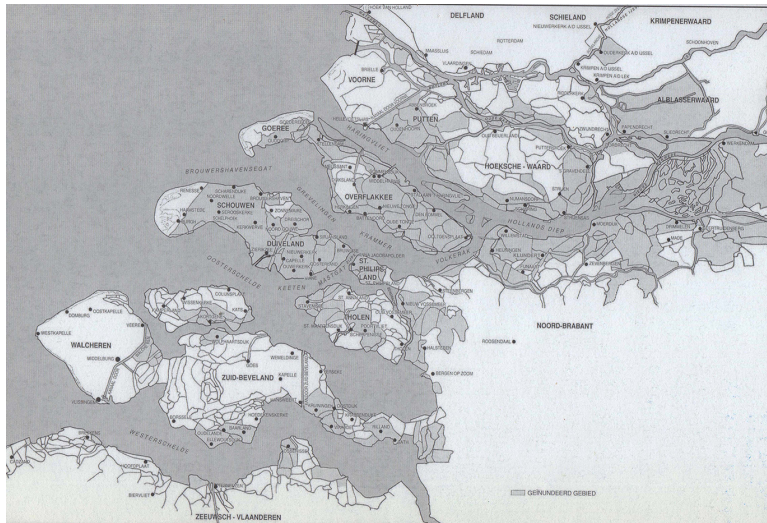


Figure 4. Reconstruction of the flooded areas (shaded) in Zeeland, parts of the provinces of South Holland and North Brabant during the storm surge of 1 February 1953.

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Figure 5. Land side of an inundation sluice, built in 1789 by the Estates General of the Dutch Republic at Zwartenhoek (51°15' N and 3°51' E). Notice the double groove in the protruding parts in which beams could be installed. As the space in between the beams could be filled with earth, this construction was strong enough to prevent the fresh water from flowing seaward. After some weeks water in polders could reach a level of some decimeters. As soon as the threat of war disappeared, beams and earth were removed again (photo, Nellie de Kraker).

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