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Understanding the cultural historical value of the Wadden Sea region. The co-evolution of environment and society in the Wadden Sea area in the Holocene up until early modern times (11,700 BC–1800 AD): An outline

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ABSTRACT

The Wadden region is a cultural landscape of exceptional *cultural historical* value. The present article describes in qualitative terms how the cultural landscape of the Wadden Sea region came about through the complex interaction of people and nature. Human impact on this region has occurred in stages, with changes in the way of life, technology, the organisation of labour and the use of natural and fossil fuels playing a key role. With each stage, the impact of people on the natural environment increased exponentially, bringing with it each time a combination of intended and unintended outcomes. Although technological or organisational innovations meant that people were sometimes successful at overcoming these effects, at other times they were not.

1. Introduction

The Wadden Sea is generally regarded as a complex of 'natural, large-scale, intertidal ecosystems where natural processes continue to function largely undisturbed'.[1] Hence the status of world heritage site granted to about 66% of the region on the basis of *natural* criteria. The larger Wadden region – an area of dyked salt marshes and reclaimed coastal peat bogs – is viewed as a cultural landscape of exceptional *cultural historical* value (Vollmer et al., 2001). This appraisal is supported by a recent study comparing the Wadden Sea region with 15 other coastal wetlands containing visible human adaptations to the environment in the form of embankments, dykes, canals, polders, etc. (Essex County Council, 2010). Judged by a range of criteria,[2] the Wadden Sea region has emerged as one of the highest value areas, surpassing sites like the Po delta (Italy), Mont St-Michel and its bay (France), Romney Marsh (United Kingdom), the Sundarbans (Bangladesh and India), the Thames estuary (United Kingdom) and the Camargue (France). The present article describes in qualitative terms how the cultural landscape of the Wadden Sea region came about through the complex interaction of people and nature (Meier, 2006, 2011, 2012).

2. The post-Pleistocene development of the Wadden Sea area

When the Holocene began 11,700 years ago, the Wadden Sea region did not yet exist. The later coastal area of the northern Netherlands, Germany and southern Denmark was still part of a vast plain, the greater part of which was formed during the Pleistocene (Gaffney et al., 2007). This glacial landscape was literally the foundation for the changes described in this article. It was here during the Holocene that metres-thick layers of sand and clay were deposited and extensive layers of peat were formed.[3] The rising sea level was the major driving force behind these changes. Following a rapid rise in temperature within in a short space of time 11,700 years ago, the lowlands filled with meltwaters from the northern polar ice caps over a period of 6,000 years, to roughly the level of the present-day coastline of the southern North Sea.

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[1] http://whc.unesco.org/en/list/1314.

[2] The criteria are time depth, integrity of the cultural landscape, level of archaeological and documentary evidence, degree of adaptation of the natural environment, associative cultural significance, extent of cultural landscape, and authenticity.

[3] The Holocene coastal area of Northwest Europe between Calais and Esbjerg comprises almost 40,000 km^2.

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And yet the sudden climate warming and subsequent *absolute* rise in sea level was only one factor that led to the drowning of the area. This is because, with the exception of some minor fluctuations following the temperature surge, the climate did not become substantially warmer after the beginning of the Holocene. The melting of the polar ice caps of North America and Scandinavia lasted several thousand years but came to a halt about 6,000 years ago. From that time on, the volumes of new ice formed each year kept pace with the melting ice. The fact that the sea level in the southern North Sea region nevertheless continued to rise – albeit at a much lower rate – was therefore attributable to other causes. During the Holocene, plate tectonics, isostasy (Vink et al., 2007) and peat consolidation and oxidation as a result of drainage were responsible for continual soil subsidence in the Netherlands–German–Danish coastal area and hence for the *relative* rise in sea level (Kiden et al., 2008). However, there were marked regional differences in the way these three effects operated in combination.

It was the absolute and relative sea level rise (Behre, 1999, 2003, 2004; Bungenstock and Weerts, 2009: Baeteman et al., 2011) that determined the location of the southern North Sea coastline, which shifted mainly southeastwards during the first half of the Holocene. In around 6,400 BC, at a height of about 23–25 m below present-day mean sea level, the sea reached the more elevated boulder clay landscape that ran from the northern Netherlands in the southwest to Schleswig–Holstein and Denmark in the northeast. The low-lying parts of the northern Netherlands, northern Germany and southern Denmark were inundated via the basins of various rivers - the Boorne, Hunze, Fivel, Eems, Jade, Weser, Elbe, Eider and Treene. In the submerged areas, the sharp decline in absolute sea level rise created a shallow sea with mud flats, which was dominated by tides. A combination of factors specific to each area – the supply of sediment, the horizontal and vertical space for deposition and the character of the transport mechanism involved – determined how these areas evolved (Beets et al., 1994; Beets and Van der Spek, 2000; Ehlers, 1988; Hoffman, 2004; Hoffman et al., 2007; Kiden et al., 2002; Vos, 1999; Vos and van Kesteren, 2000). The presence of sand sources, the tidal amplitude, the tidal volume of the tidal basins and the location of protecting sand banks are therefore relevant to the study of the development of the Wadden area. This 'process-based' model is extremely useful for research into this coastal area of the Netherlands, Germany and Denmark because it allows us to describe the considerable variation in landscape change across the various subregions.[4]

The chief source of sediment in the Wadden Sea region was not the rivers discharging into it but primarily the coastal sea bed itself. As a result of currents and wave action, the sea churned up sand and other particles from the sea bed and transported them to the coast and the tidal basins behind them. This sedimentation from the sea can be seen in the sand banks along the coast. The tidal basins behind them were less turbulent, allowing particles that were finer than sand to settle. Both sand and clay are found in these environments. The tidal basins usually shifted landward as sea levels continued to rise. However, as the pace of sea level rise decreased, a different effect began to occur from 4,000 BC onward: the coastline stopped shifting in a southward and eastward direction. This was because in various areas the accumulation of sediment from the sea and rivers was able to keep pace for the first time with the drop in surface level. Despite the continuing sea level rise, the coast silted up, became more elevated, stopped moving eastward or southward and in some instances became closed to the sea. At times when sand deposition along the coast moved faster than surface subsidence, the coast was even extended seawards.

In the first millennia of the Holocene, the rising sea level caused an associated rise in the groundwater table in the still dry hinterland. This process was intensified in low-lying areas by the supply of seepage water from higher sandy grounds, which raised the water table to ground level near the coast, creating marshes and causing peat to form. In about 7,000 BC the first coastal marshes with reed peat developed in the lowest parts of the large river valleys. With the sea level rising still further, the coastal peat bogs moved further landward as sea water flooded the coastal peatland with increasing frequency, leaving behind a marine clay deposit overlaying the peat. In some places this process was repeated one or more times, creating different peat layers in the subsoil of the salt marsh area. This process came to an end in most river basins in the Wadden Sea as a result of a sharp decline in sea level rise. In regions like Belgium and the western Netherlands, where the coast was completely closed to the sea, the tidal basins became entirely covered with a thick deposit of peat. The coastal belts of reed peat were bounded on the landward side by an expansive area of peat bog and peat moor, which eventually covered a sizeable portion of the Pleistocene hinterland. This peat was formed in stream valleys and higher areas as a result of high groundwater tables and poor drainage.

3. Early holocene occupation: hunting and gathering and early farming in a drowning landscape (11,700 BP–600 BC)

Between 9,000 and 5,500 BC the sea level rose very rapidly – by as much as 60–75 cm per century – and sizeable tracts of land were drowned.[5] Climate change also brought substantial changes to the natural environment. Until the beginning of the Holocene, the present-day Netherlands–German–Danish coastal area was still part of an enormous open steppe with wind-borne sands. Subsequently, this landscape gradually gave way to woods, first a pine and birch forest, later a mixed deciduous forest of oak and lime. It formed the territory of small groups of wandering, Mesolithic hunters, fishers and gatherers.

By about 5,500 BC the sea level had risen to 6–8 m below present mean sea level. The lowest lying Pleistocene valleys and sandy areas in the Netherlands–German coastal region were transformed into large tidal basins. These were often bounded by sand banks or islands that lay several kilometres off the present-day coastline. The landscape behind the sand banks or islands was fairly similar to the present-day Wadden. At that time, however, the sea level was still rising an average of about 40–50 cm per century and sedimentation in the low-lying central parts of the basins could not keep pace. So, unlike the present-day Wadden Sea, the tidal basins were drowned and often shifted inland. The higher edges of the basins were transformed into a tidal landscape with tidal gullies, intertidal sand and mudflats, and salt marshes. The neighbouring reed peat area rose to a height of about 5–6 m below present mean sea level. The fact that the ground level did not subside everywhere at the same rate led to substantial regional variation.

The progressive drowning of the Netherlands–German–Danish coastal area came to an end in around 3,850 BC. Although the sea level continued to rise, the mainland rose at much the same rate

[4] The model used should be considered more complex in comparison to the traditional 'transgression and regression-model' which only focusses on sea-level rise. See Bazelmans et al., 2011a, b for an overview of the paleogeographical development of the Netherlands during the Holocene in ten A4-size maps (maps made by P. Vos (TNO/Deltares)).

[5] The rate makes one wonder whether this has been perceptible to the people at the time.

through sand and clay deposition. In Belgium and the western Netherlands, the coastline became closed off from the sea but in the northern Netherlands and in the German and Danish coastal areas it has remained open to this day. Extensive areas of peatland appeared everywhere inland. Hunting, fishing and gathering were no longer the primary food sources for the people living there. The fifth millennium BC saw a gradual and fairly lengthy transition to agriculture and livestock rearing, which formed part of the diverse cultural traditions, some of them exclusive to coastal dwellers (Behre, 2008; Fokkens, 1998; Meier, 2006).

Between 3,500 and 2,500 BC, the rise in sea level fell from 30–40 cm to 20–30 cm per century as the North American and Northern European icecaps had almost completely melted. Coastal soil subsidence, which varied from place to place, was now the key factor in the relative rise in sea levels. This was one of the reasons for the rise of intensified differences in coastal development between Belgium and the western Netherlands on the one hand and the northern Netherlands and Germany on the other. In the latter area, the sea continued to flood the coast because of a greater relative drop in surface level. The tidal basins here often became even larger, which meant that the coastline of the northern Netherlands and Germany remained open, unlike that of Belgium and the western Netherlands. Wadden islands were located here throughout the Holocene, separated by large tidal inlets. A not insignificant factor in this regard is that the prevailing westerlies brought much more wave-driven sand to the coasts of Belgium and the western Netherlands (crosswise to the prevailing wind) than to those of the northern Netherlands and Lower Saxony (parallel to the prevailing wind). There were also major regional differences in the availability of sediment on the coastal sea bed. In the western Netherlands this greater supply of sand from the sea was further supplemented with sand transported to the sea via the Rhine and to a lesser extent the Meuse.

Because the coastline remained open in the northern Netherlands and Germany, storm surges and tidal action always had a major impact.[6] The open tidal area – with islands and tidal inlets off the coast – continued in existence here, with accretion occurring only along the edges of the tidal basins. Here the peat extended in a seaward direction, overlaying the tidal deposits. However, the large-scale accretion and progressive peat formation on top of the old sand that occurred in the western Netherlands did not occur here. The position of the Wadden islands at this time is uncertain. We do know that in the Netherlands and Lower Saxony they were situated slightly north of the present-day Wadden islands, and that in Schleswig-Holstein and southern Denmark they occupied roughly their present positions. Immediately inland, the stream valleys filled increasingly with peat, which led to further deterioration in the drainage of the Pleistocene hinterland. As a result, the 'inland' peat bogs continued to expand. Although these conditions do not of themselves seem favourable for habitation (an increasingly large area was made up of marsh-like peat), people managed to survive surprisingly well on sand banks, tidal channel belts (Strahl, 2005) and in the coastal Pleistocene hinterland, and sometimes – as in West Friesland (North Holland) – even in a well-protected salt marsh area (IJzereef, 1981). Habitation occurred in places where a certain amount of land was available, with the population density increasing over time in these habitable areas. During much of prehistory, farmers tended to live in scattered farmsteads. Later, the farms were sometimes situated closer together and in some areas, such as on the West-Frisian creek ridges, it became more common to live in small hamlets. Around these hamlets, the land was divided into plots by means of ditches. Farmyards contained a variety of ancillary buildings, such as granaries for storing the harvest. Byre houses – a combination of dwelling and byre – provided shelter under one and the same roof for both people and livestock (Roymans, 1999).

With the exception of sand banks, the larger islands (e.g. Woltering, 2000 for Texel) and the coastal Pleistocene hinterland, the Wadden Sea region initially offered few opportunities for habitation. But the deceleration in sea level rise made the area less susceptible to flooding, creating ever larger areas of salt marsh with alluvial ridges. These slightly elevated ridges were the first to be colonised. During the early Iron Age people from the Pleistocene hinterland began to explore the possibility of living in the salt marshes themselves. They were probably already familiar with the area because they had used it as temporary grazing for their cattle (van Gijn and Waterbolk, 1984; van der Waals, 1987). They built small dwelling mounds (or rather platforms) by stacking salt marsh sods – an enterprise that would have been possible with limited technological resources and with small family groups or neighbours working together. These mounds gradually developed into proper dwelling mounds (or terps), eventually creating an extensive terp landscape (Figs. 1–3).

4. Tribal communities and their dwelling mounds (600 BC–800 AD): adapting to a rich tidal environment

In the first century AD Pliny the Elder described the Greater and Lesser Chauci inhabiting the Lower Saxon coastal area as *misera gens* (wretched people) because of what he perceived as the extreme environmental conditions in which they lived (*Naturalis Historiae* XVI, I, 3; Plinius, 2004). However, the coastal landscape was a much pleasanter place than Pliny would have us believe (Meier, 2004; Vos and Knol, 2005; Vos and de Langen, 2008). In the first place, salt marshes in a temperate climatic zone have an exceptional biomass production, which can be put to good use by human society through grazing by cattle and sheep (van Zeist, 1974, 333). Archaeological research has demonstrated this clearly in various ways (Bazelmans et al., 2011a, b). Houses with byres (Zimmermann, 1999), some of them quite large, have been found on dwelling mounds. Studies have also revealed the presence of large volumes of waste containing cattle bones, and at times large quantities of dung. In the second place, flooding posed little threat to people living on mounds or terps in the undyked salt marshes. Thanks to the large tidal storage capacity of the extensive mudflats and salt marshes, the water level was relatively low, even at extremely high water. In the third and last place, the salt marsh area was also part of a maritime landscape, with opportunities for trading links overseas (Meier, 2009; Westerdahl, 1992, 2007). In other words, the building of terps represents a successful, safe and productive adaptation to a very special environment.

Colonists chose the highest points in the salt marsh for their first settlements, in particular the ridges on the seaward edges. Habitation started there when a new salt marsh ridge was being formed on the seaward side, protecting the new settlement. Combined archaeological and geological research over the last two decades has shown that habitation began when the salt marsh ridges attained the height of a middle marsh. A middle marsh is defined as a marsh that is flooded dozens of times a year, not only during winter storm floods, but also during high spring tides in summer. This suggests that it was not possible to live directly *on* the salt marsh surface, in a so-called *Flachsiedlung*, and that the living area needed to be raised at the very outset. In our view most evidence for *Flachsiedlungen* must be re-interpreted as features in the salt marsh around a house on a small platform. Flooding and

[6] Because of lack of space we do not discuss the influence of the substantial differences in tidal amplitudes along the Wadden Sea coast.

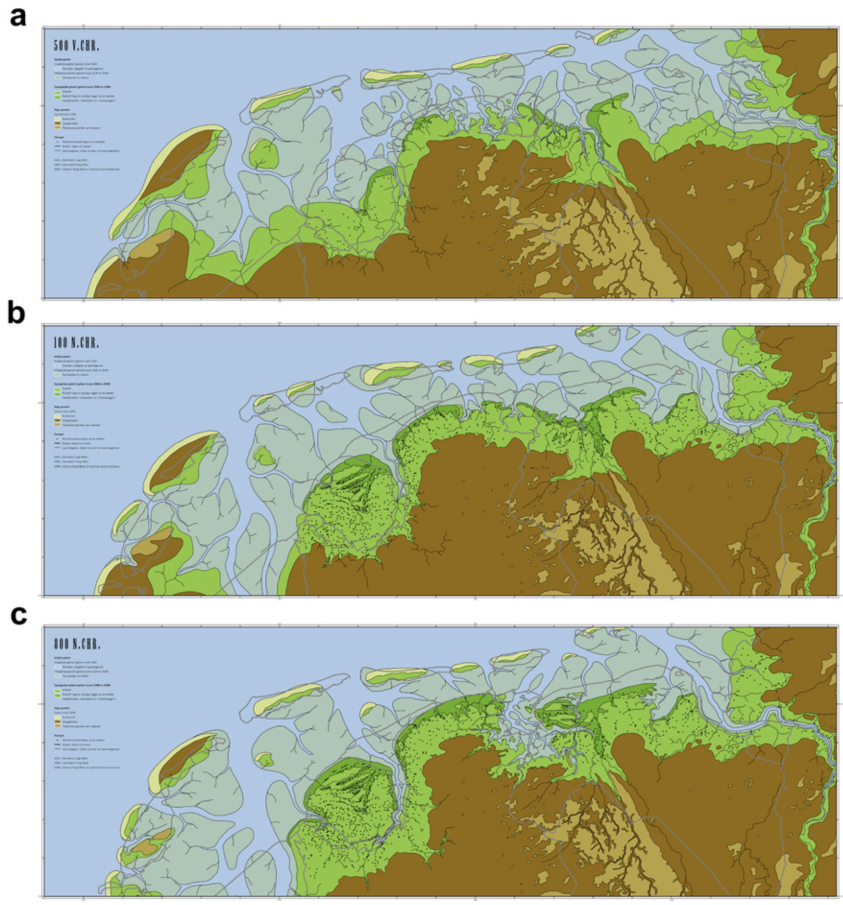

Fig. 1. Palaeogeographical development of the northern Netherlands, (a) 500 BC, (b) 100 AD and (C) 800 AD. dots represent dwelling mounds (grey, mud flats; green, salt marsh; dark green, high sandy salt marsh; brown, peat bog).

sedimentation continued during habitation, as is often evident at the sides of terps.

The core of early dwelling mounds was usually made up of arbitrarily placed salt marsh sods. Dung was also used, although there is regional variation here – it is hardly ever encountered in terps in northwestern Friesland, for example. Platforms were consolidated with a broad lining of horizontally placed sods, and ditches were dug to drain the area around them. During habitation, people adjusted to the continuing flooding and sedimentation by raising and expanding their living area when necessary. Platforms

Fig. 2. Niehove, large dwelling mound in the Dutch province of Groningen (photo Cultural Heritage Agency, Amersfoort).

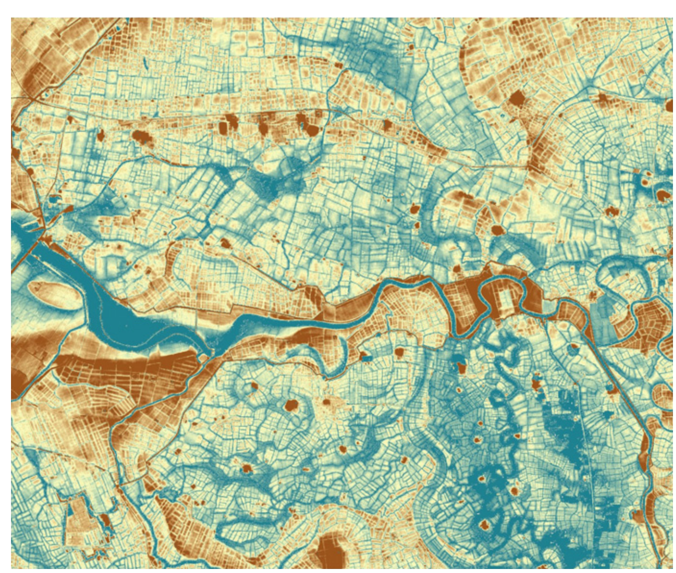

Fig. 3. Digital elevation model of the dwelling mound area northwest of the Dutch city of Groningen. In the middle the valley of the river Reitdiep (www.ahn.nl).

were initially only slightly larger than the houses built on them. A wide area around the settlements was used regularly for all kinds of activities, with ditches and features such as pits found there. Following the initial colonisation, house platforms were extended and raised (Fig. 4). Sometimes individual platforms were joined together to form a larger terp. With the passing of time, there emerged a varied pattern of larger village terps, hamlets on smaller terps and house terps (Fig. 5).

One of the most vexing questions within terp archaeology is whether the landscape allowed for arable farming. The brackish soil, the sea wind and the risk of flooding during germination and growth are not favourable conditions for the growing of crops (Wijnen, 1999). Experiments on the unprotected salt marsh have shown that it is possible to grow some crops on the sandy clays of the highest parts of the salt marsh, after the spring rains have washed away the salt (van Zeist et al., 1976; Bottema et al., 1980; Körber-Grohne, 1992). Nevertheless, these experiments have highlighted the many risks involved; there was no certainty that all the effort would result in a usable harvest. Still, macrofossil remains in excavations of barley (*Hordeum vulgare* ssp. *vulgare*), field mustard (*Brassica rapa*), gold-of-pleasure (*Camelina sativa*), field bean (*Vicia faba*), flax (*Linum usitatissimum*) and even emmerwheat (*Triticum turgidum* ssp. dicoccon) show that at least some arable farming was practiced, and that circumstances were possibly less harsh than we imagine on the basis of present salt marsh conditions. However, even though it could be argued that conditions on the salt marsh were more favourable for arable farming than they are today (because of the much larger water storage capacity of the pre-dyked salt marsh), it would seem that a more reliable kind of arable farming was required. Excavations conducted in several terps in the northwestern part of Friesland in the 1990s have found parts of small, late Iron Age and Roman Iron Age dykes (Bazelmans, 2005).[7] It was established that the dykes made of salt marsh sods were built on the middle salt marsh, possibly on a salt marsh ridge, bordering on a young, low marsh on the seaward side (Fig. 6) (Nieuwhof, 2006). Evidence suggests the dykes were probably used to protect arable fields. Such fields would have to be surrounded by a dyke on all sides, with a water outlet to drain the area during the summer season. Calculations show that the building and gradual *extension* of these dykes could be carried out in family groups or together with neighbours. In other words, no form of 'central authority' would have been required.

There is no evidence that hunting, fishing or collecting shellfish were major occupations for the inhabitants of the prehistoric salt marsh. The bones of wild animals (including birds, fish, and shellfish) constitute only a small portion of the abundant animal bones found in terps.[8] During the pre-Roman and Roman Iron Age, human occupation did not pose a direct threat to animal populations, as was the case from the Late Middle Ages.

Cattle grazing on the salt marsh vegetation may have had a more profound impact on the environment. The fairly large herds were probably kept inside at night for safety reasons and to facilitate dung collection. Except during times of flooding, they grazed the salt marshes during the day in summer and winter (Nieuwhof and Woldring, 2008). Archaeobotanical evidence shows that in some areas the diversity of the flora did not decline during habitation, indicating that the area did not suffer from heavy grazing.

Fig. 4. Excavation of the dwelling mound of Süderbusenwurth (Ditmarschen, Germany). Complex and rich settlement strategraphy from the Roman Iron Age (photo Dirk Meier).

Elsewhere, heavy grazing probably did cause a reduction in the number of plant species (Woldring and Kleine, 2008). Burning the previous year's plant remains, which may have been practised in some or many areas (Exaltus and Kortekaas, 2008), must have had an impact on the vegetation, although it is difficult to gauge precisely what this was. It is conceivable that burning resulted in a concentration of nutrients in the soil, which encouraged certain plant species to grow more abundantly.

In some regions humans had a major impact on the evolution of the landscape. The former salt marshes of the Middelzee and the Lauwerszee became large tidal basins due to a combination of natural causes and human activity. One natural cause was the increasingly poor drainage of the salt marshes because of the ever higher salt marsh ridges that came to function as barriers for inland water. In Westergo in particular, the Middelzee served as a new outlet for the waters of the Boorne and other small rivers. However, the effect would probably have been fairly limited if it had not been exacerbated by human activity. There are indications, for the Middelzee area that exploitation of the seaward margins of the peat area bordering the salt marshes affected the landscape quite drastically. Draining and peat cutting from as early as the late pre-Roman Iron Age, together with salt extraction of sub-surface peat from the early Middle Ages, caused the peat surface to subside, so that these areas became affected by the tides. This caused an increase in tidal volume and enlarged the tidal channels, a self-reinforcing process that resulted in peat erosion, improved drainage and enlargement of the tidal inlet of both the Middelzee.[9]

Without going into greater detail here, we can say that the area permitted high population densities. Estimates for the Netherlands region of Middag/Humsterland, for example, have suggested an increase from three to four inhabitants per km^2 in the middle Iron Age to ca 15 in the late Iron Age, and then to ca 20 in the Roman period (Miedema, 1983). A rough extrapolation of this data yields an estimated population of about 30,000 to 40,000 inhabitants for the entire Netherlands terp area in the Late and Roman Iron Age – in other words, a fifth to a quarter of the present population. In the same period, the Pleistocene hinterland had population densities of only two to five inhabitants per km^2 (Roymans and Gerritsen,

[7] Other dykes or summer embankments – all from the middle Roman period - have since also been found in Wergea (Friesland, Zandboer, 2010), Jelsum (oral communication by J. Nicolay, RUG), Serooskerke (Netherlands) (Dijkstra and Zuidhoff, 2011, 67–71) and Raversijde (Pieters et al., 2008) and Stene (Belgium) (mentioned in Dijkstra and Zuidhoff, 2011).

[8] This is not the result of archaeological techniques for collecting data; birds and fish are rarely found at excavations were soil is being sieved.

[9] The same holds possibly true for the Lauwerszee.

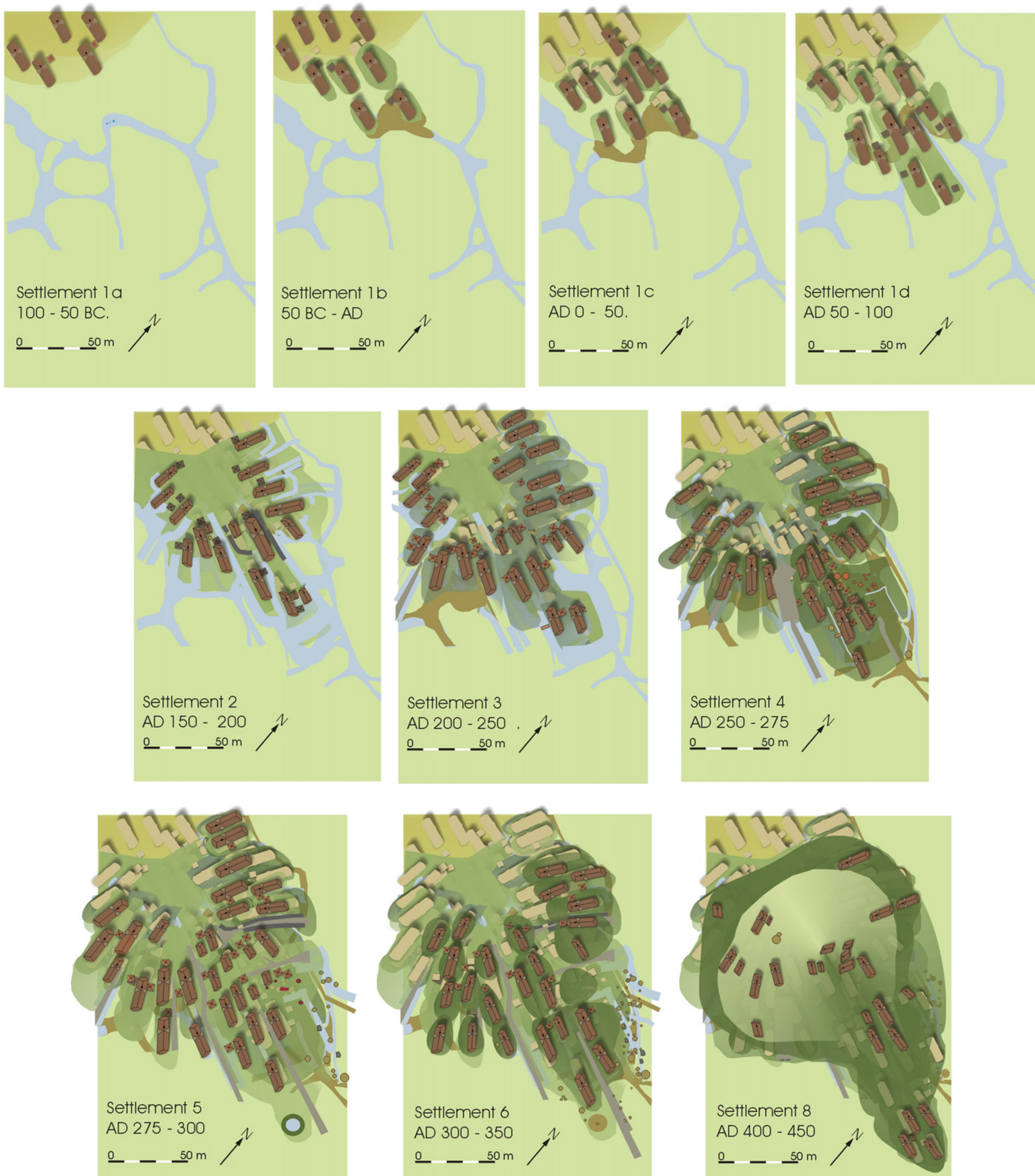

Fig. 5. Development of the dwelling mound of the German Feddersen Wierde, 100 BC–450 AD (Land Wursten).

2002). The difference between the coastal area and the hinterland can be traced back to the difference in biomass production. Whereas one cow per hectare can be grazed on salt marshes, at least 6 ha are required on sandy soils (Brinkkemper, 1991).

There are big differences in colonisation and population growth in the different subareas of the Wadden Sea region. On large islands (like Sylt, Föhr and Texel) and continuous sandy dune areas (as in the western Netherlands), there appears to have been almost

(a)

(b)

Fig. 6. Cross section (a) and overview (b) of a small dyke from the late Iron Age at the Frisian village of Peins (Groninger Instituut voor Archeologie, Groningen).

uninterrupted habitation from the Neolithic up until historical times. For the Pleistocene cores of Amrum, Sylt and Föhr this is however not certain; evidence is lacking for habitation here during the Migration Period and the 6th end 7th century.

Moreover, various levees of principal rivers that discharged into the Wadden Sea have a settlement history that sometimes stretches back to the Bronze Age. However, habitation in such places generally spanned just one or a few generations. With the exception of the North Holland area of West Friesland, settlement in the salt marsh regions did not really get off the ground until the early Iron Age, first in Friesland and Groningen. Settlement of the salt marshes was not a feature of the German coastal area until early Roman times and later. Salt marshes did not develop in the Danish area until much later and there is no evidence of habitation until the late Middle Ages. Most salt marsh areas that were inhabited in late prehistory or in Roman times show a steady population growth, and often the gradual emergence of a settlement hierarchy involving villages, hamlets and individual farmsteads.

It is clear that there were major disruptions to population and to settlement structure in the 4th to 6th centuries AD (Bazelmans, 2001; Gerrets, 1996; Nieuwhof, 2011). Although the precise causes are uncertain, they no doubt related to changes taking place within the Roman world (Erdrich, 2001a and 2001b; Hiddink, 1999). We should also not underestimate the impact of deteriorating drainage as a result of the formation of fairly high, closed salt marsh banks (Nieuwhof, 2011) and endemic inter-tribal warfare (Bazelmans, 2001). Some areas, such as Friesland in the 4th century and Land Wursten in the 6th century, probably became entirely depopulated. The exact dating of the major changes, the duration of the interruption in habitation and the dating of recolonisation varied enormously from one region to the next. The description and explanation of this variation should be a major subject for future research.

5. Being part of the Christian empire (800–1500 AD): large-scale embankments and reclamations of the tidal marshes and peatlands

From the end of the early Middle Ages, after many centuries of continual adaptation to the dynamics of the sea, the inhabitants of the Wadden Sea coastal region were increasingly successful at bending their unruly environment to their will. Controlling the external water – and later the internal water as well – was the critical factor here. Between roughly 800 and 1500, colonisation of the salt marshes was completed, large parts of the coastal area were dyked and the coastal peat bogs behind the salt marsh zone were converted into prosperous farmland. By these means, a predominantly natural landscape was transformed in the space of just a few centuries into a vast and varied cultural landscape (Fischer, 1997; Knottnerus, 2001; Behre, 2008; Meier, 2010).

Following the large-scale recolonisation of the salt marsh areas in the 5th to the 7th centuries (Knol, 1993) and the sharp rise in prosperity of the agrarian economy and trade during that time, the 8th century ushered in a new phase in the development of the international Wadden Sea region. The hitherto fairly autonomous Frisian coastal areas were incorporated into the hierarchical structure of the Frankish empire (734–785 AD), triggering substantial social changes that would ultimately be reflected in the medieval landscape (Gerberding, 1987; Heidinga, 1997). Firstly, the new Frankish authority acquired vast tracts of land in the Frisian coastal districts from the 8th to the 11th centuries, which were managed by prominent imperial abbeys like Echternach, Fulda, Werden, Corvey and Prüm. Later came the bishops, dukes and counts, who functioned as authorities representing the Frankish king. They ran their large estates under the manorial system, whereby dependent peasants were given land in a form of leasehold (Noomen, 1999, 2005).

A second key influence of the 'Francisation' process was the coming of Christianity, which had a profound impact on the daily lives, culture and world view of the coastal inhabitants.

By founding and promoting trade settlements such as Staveren, Leeuwarden, Groningen, Emden, Bremen, Hamburg, Ribe and Haithabu, by levying tolls and by minting coins, the new Frankish authority wielded its influence in countless ways on Frisian long-distance trade in luxury goods to the Baltic Sea region and Russia (Lebecq, 1983). Numerous trade settlements sprung up along river mouths and tidal gullies, often on elongated trading terps (Brandt, 1977, 1984, 1986, 1991; de Langen, 1992). Even more so than previously, the Wadden Sea region benefited from its location at the hub of the vast Frankish empire, Scandinavia and Eastern Europe (Meier, 2009). One of the main trade products was salt, which was produced at many places along the coast by burning salt turf. Large scale sheep-farming, cloth production, dying and trade had important impact on the landscape, by heightening the land-use pressure. The systematic exploitation of natural resources in the Middle Ages led to a considerable decline in biodiversity, which is attested in archaeological sources (Prummel and Heinrich, 2005).

Trade suffered greatly in the 9th and 10th centuries as a result of Viking raids from the north. To defend themselves, people constructed ringworks at various places along the coast and on the islands, including in Dithmarschen, on Sylt, on Föhr, near Itzehoe and Bremerhaven, on Texel and further down the Dutch and Belgian coast (van Heeringen et al., 1995).

The rapid population growth and great prosperity of the salt marshes in the early Middle Ages meant that any salt marsh banks suitable for habitation soon became fully populated, compelling early medieval coastal dwellers to explore new places to live and work (Knol, 1993; De Langen, 1992). These they found in three different landscapes of the Wadden Sea region: the salt marsh fringes, the peatland bordering salt marsh gullies, small rivers and drainage channels, and the inland peat moors. To begin with, from the 7th century onwards, they increasingly sought refuge in the salt marsh fringes, where the salt marsh passed from a thin layer of clay on peat to fairly elevated *sphagnum* bog zones. Colonists began to occupy and reclaim these new territories, starting from the southern fringes of the salt marsh and working their way into the coastal peat bogs, laying the foundation for the stripfield parcellations and elongated peat settlements that have become characteristic features of the medieval peatland (Fig. 7). Particularly in the Netherlands part of the Wadden region, these salt marsh fringes were probably already largely settled in the 9th century (de Langen, 2011), whereas in northern Germany colonisation of these areas probably did not occur until the 10th and 11th centuries (Meier, 2011; Groenendijk and Schwarz, 1991). As the peat consolidated and oxidized, the ground level of the reclaimed areas in the salt marsh fringes fell substantially and these areas often fell prey to the sea. Today, most of them lie buried beneath a layer of clay. The inhabitants were sometimes able to hold out under these conditions by erecting terps or by only living, working (e.g. producing salt) and grazing stock there in the summer months.

The reclamations of the early medieval salt marsh fringes anticipated the much grander scale colonisation and reclamation of the coastal and inland peat bogs that would take place from the late 9th and the 10th century (De Langen, 1992, 2011). As well as continuing to reclaim the fringes, growing numbers of colonists moved upstream, away from the coastal area to the tidal gullies, brooks and streams in order to systematically reclaim the peat bogs (through river reclamations). The first settlements – often in a long line parallel to a river – were built on the slopes of the peat domes, with ditches dug diagonally to the river for easy drainage. After the passage of time, oxidation and peat consolidation often lowered the ground level to such a degree that a new settlement had to be built further upward in the peat bogs. In the 10th and up until the 13th century, large tracts of peat bog and fenlands in the northern Netherlands and northern Germany were put into cultivation. These inland peat moors, which originally rose high above the level of the sea and salt marshes, sank many metres in just a few centuries, partly as a result of large-scale, anthropogenic soil subsidence. This led to major problems with the internal and external water in the later Middle Ages.

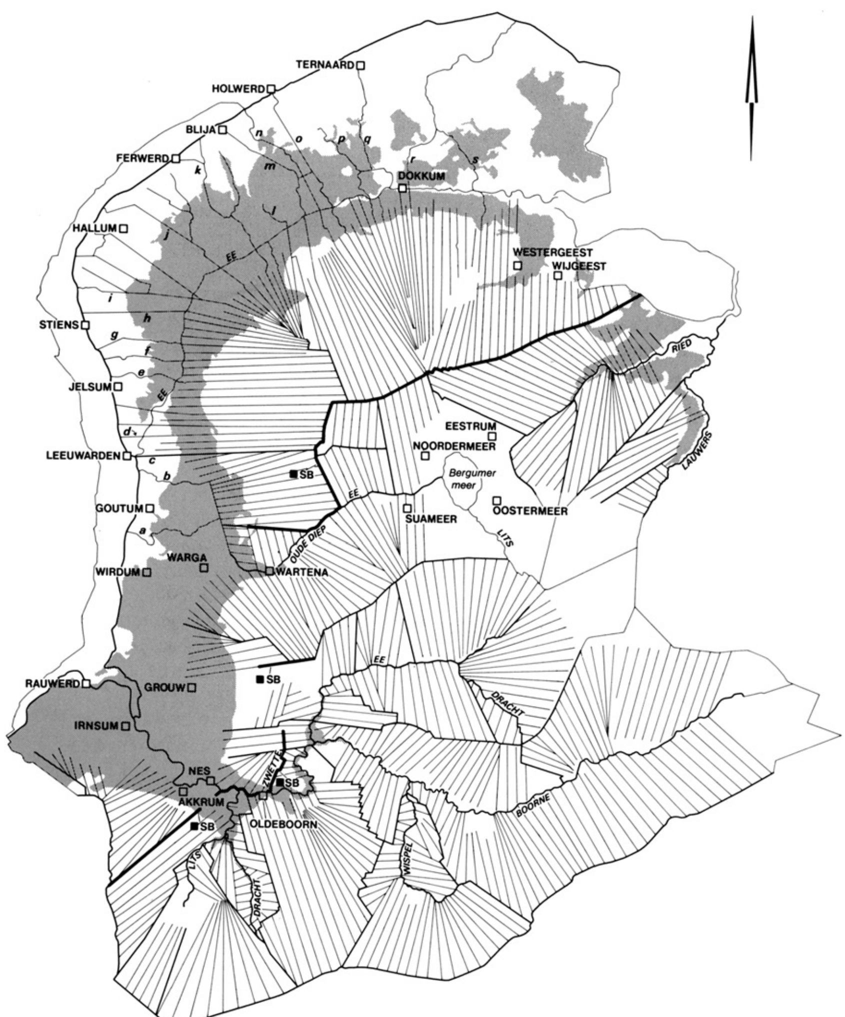

Fig. 7. Systems of medieval stripfield parcellations in the Frisian area of Oostergo in the peat bog area south and east of the marsh area which was inhabited since the Iron Age (De Langen, 1992).

Although the first low dykes had been built in the terp region in the first few centuries AD to protect the farmed land from flooding, it was not until the 11th century that somewhat larger dykes were erected in the Frisian coastal area. We know, for example, that the inhabitants of several terp villages in Westergo joined forces to construct a ring dyke measuring 1–1.5 m in height. These early ring-dyke polders are also called ‘mother’ polders (Rienks and Walther, 1954). They were gradually joined together, eventually forming a continuous ring dyke around the whole of Westergo in the 11th century. Continuous ring dykes were also built in other parts of Friesland and Groningen in about the 12th century (Kooper, 1939; Schroor and Meijering, 2007). In Lower Saxony and Schleswig-Holstein, such dykes date mainly from the 12th and 13th centuries (Kühn, 1989; Schmid, 1991; Behre and Van Lengen, 1995; Vollmer et al., 2001; Meier, 2001, 2005; Ey, 2007).

Also of great age are the river dykes which were built in Friesland around the 11th century along the Boorne, Ee and other rivers to protect the reclaimed peat landscapes (Rienks and Walther, 1954; de Langen, 2011). A start was also made in the 13th century on the ‘offensive dyking’ of silted-up tidal basins like those of the Marne, Middelzee, Fivel bay, Krümmhorn and the Eiderstedt area (Krämer, 1984). For the first time in the history of the Waddensea area, man started to regain land from the sea. Unembanked areas along the coast were stimulated to silt up between small brushwood embankments and were subsequently endiked. A great number of fertile new polders were reclaimed in this way (Fig. 8). The damming of tidal gullies and river mouths by means of dyke locks (Dutch *zijlen*, German *Siele*) was another important technique for controlling external water. Eventually, by about 1500, this led to a series of linked sea dykes along the Wadden coast, with tidal basins penetrating far inland in just a few places.

In many places dyke construction put an end to natural drainage of the land via tidal basins. Everywhere, new ditches had to be dug and the inhabitants of the new polders had to take charge of water management. In the 13th century, numerous water boards (Dutch *zijlvesten*, German *Köge* and *Sielachten*, Danish *kogen*) were created for this purpose in the coastal areas along the Wadden Sea.

Another significant outcome of the progressive dyking of the salt marshes was that this enabled settlements to be built on flat ground in the newly created polders. From the 13th–14th centuries onwards, numerous villages and an even larger number of individual farmsteads sprang up. The absence of floods meant that the surrounding farmland could now be exploited much more intensively. The flourishing agrarian economy and strong population growth of the 16th century accelerated this new inland occupation.

The extensive reclamations and dyke building in the coastal areas of the Wadden region also had negative consequences for the landscape. Up until the 12th–13th centuries, at times when water levels were extremely high, the sea had a very large storage capacity in the form of many hundreds of square kilometres of undyked salt marshes. Large-scale dyke construction meant that the salt marshes were no longer available for this purpose, and the water in the tidal basins was pushed up much higher than before. The dykes, which were still low at this time, were often not up the task. Besides, the large-scale reclamations and draining of the fenlands caused a considerable lowering of the surface level, which made them extremely vulnerable for sea incursions. From the late 12th to the early 16th century, there were innumerable major sea incursions in the Netherlands, German and Danish Wadden region, with disastrous consequences (Fig. 9). Examples are the floods in the Jadebusen, Dollard, Leybucht and the North-Frisian Uthlande (Knottnerus, 2001; Meier, 2004, 2012). Many marine clay polders were flooded, coastal villages disappeared, islands vanished or moved, and large tracts of peat bog were washed away. A further problem was that the ground level in the hinterland – in particular the reclaimed peatland – had fallen sharply as a consequence of oxidation and settling, making these areas highly vulnerable to flooding. A third factor may have been the large-scale salt harvesting in the coastal area, which created many depressions in the landscape. Thus the late medieval sea incursions were caused not so much by natural factors, but by anthropogenic ones. In the centuries that followed, the tidal inlets and basins that arose were largely embanked once again by means of offensive dyking. A small portion of the formerly flooded areas, particularly in the German Wadden Sea region, still lies outside the dykes, and traces of earlier settlements and cultural landscapes can regularly be seen on the mudflats (Heinze, 2000).

In the 12th and 13th centuries, the dominant role of distant authorities and landowners in the coastal Wadden Sea districts increasingly gave way to an ever smaller-scale political system of 40–50 small, autonomous coastal republics controlled largely by the local elite (often networks of noble families) (Van Lengen, 2003; Schmidt, 1975, 2005). That same period also saw the emergence of new consultation and decision-making structures for the purposes

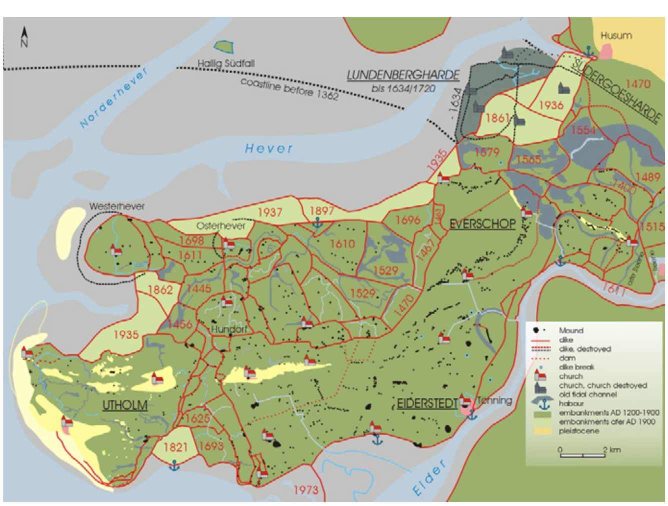

Fig. 8. The medieval and (early) modern embankment of the peninsula of Eiderstedt (design Dirk Meier).

Fig. 9. Drowned landscape of the North-Frisian Uthlande. Remains of a stack dike of the island of Strand, destroyed in 1634 (photo Dirk Meier).

of regulating water management, justice and defence (Frieswijk et al., 1999). These structures often proved rather unstable. Moreover, conflicts of interest arose in many areas between the various family networks, so much so that the late Middle Ages are known as a period of political disputes, feuds and vendettas. The region's cities were actively involved. It is no coincidence that the nobility erected local fortifications and castles, such as *borgen* and *stinswieren*, virtually throughout the Wadden Sea region (Noomen, 2009). These fortifications are restricted to the coastal landscapes of the northern Netherlands, Ostfrisia and the Elbe river mouth. However, they generally lack in the Wadden regions of Schleswig–Holstein and Denmark, probably because there was no large-scale brick production in these areas.

It was not only the local and regional nobility who enjoyed great prosperity during these few centuries. Monasteries also thrived in the region from the end of the 12th century. More than 200 monasteries sprang up in the coastal areas during the late Middle Ages, with about 15–25 percent of the land in their control (Mol, 1991). The monasteries wielded considerable influence on local society in many areas through the economic exploitation of farms (home farms and outfarms), dyke-building (Mol, 1992) through turf and clay extraction and through the requisite improvement in regional drainage. This period also saw the appearance of hundreds of new churches in the Wadden Sea region, in Romanesque, Romanesque Gothic and later also Gothic style. With their distinctive towers, these churches are prominent features of the landscape to this day. The construction of hundreds of village churches was not the consequence of reclamation but rather of more profound Christianization and the actions of local elites, trying to get more influence on their surroundings by founding private churches. The crusades had a lot of impact too, as the returning crusaders became acquainted with urban culture.

A third important development was the rise of towns and trade in the later Middle Ages. As a consequence of the emerging Baltic Sea trade and the formation of the large international Hanseatic League, cities like Ribe, Hamburg, Stade, Bremen, Groningen and Stavoren enjoyed immense prosperity from the 12th to the 14th centuries. Key factors here were the fast and efficient new types of ship, such as the Hanze kogge, the Frisian hulk, the *kraweel* and the Dutch *marsschip* (Brand, 2007; Meier, 2009).

6. The Wadden sea area as part of the early modern world system (1500–1800): agricultural and maritime innovation as triggers for prosperity

Even more so than the heyday of Frisian trade in the early Middle Ages, the early modern era – with its flourishing agricultural and maritime cultures – can be seen as the period of greatest economic prosperity for the Wadden region. From the 16th century, the regional economies increasingly became part of a world economy. The rapidly expanding economy of the Dutch Golden Age focused not only on European long-distance trade, but to an increasing degree on the newly discovered colonial areas of Asia and America (Wallerstein, 1974–1988). Grain and timber supply from the Baltic were key pillars of this economy. In the 16th and 17th centuries the coastal harbours and coastal zones of the Wadden region benefited enormously from their position as way stations between the towns of Holland and the Baltic (Roding & Heerma van Voss, 1997). Both the maritime and agricultural economies were given a significant boost (Westerdahl, 1992, 2007). The region's population rose sharply during this time, from an average of 15–25 inhabitants per km^2 in about 1500 AD to 30–50 inhabitants per km^2 in about 1800 AD. Although there was no need for major changes to the overall spatial structure of the landscape, many far-reaching adaptations and innovations were introduced to many landscape elements between 1500 and 1800 AD, changes that determine its appearance to this day (Knottnerus, 2001).

At the start of the 16th century, the Frisian coastal areas lost their political independence and were incorporated into larger, centrally controlled territorial states. In practice, because of the remoteness from centres of power, authority was usually delegated to officials, most of whom came from old noble families. For this reason the rural elite – noble owners of large estates and large gentlemen farmers – continued to exert a profound influence on local and regional governments, on the administration of justice and on water boards right up until the 19th century (Frieswijk et al., 1999). Together with the urban elite and leading figures in mercantile shipping (e.g. shipowners and ship commanders' families), they controlled a highly commercialised trade economy that was very successful in both the agricultural and maritime sectors. Compared with the more feudal societies in the interior, freedom and local and personal autonomy played an important role in this coastal society. In religious terms, the vast majority of the coastal areas converted to the Calvinist (Netherlands) and Lutheran (Germany) faiths, which were fairly tolerant of minorities (Knottnerus, 2001). Locally, more conservative, 'experiential' forms of Protestantism predominated, a phenomenon that can also be found in coastal regions elsewhere.

The flourishing maritime economy that developed in the Wadden Sea region from the 16th century onward led to many landscape changes, both large and small (Westerdahl, 1992, 2007). In the Wadden itself and on the islands, an increasingly fine network of shipping routes appeared, marked by beacons, lighthouses and buoys. And in the towns and villages along the coast, the growing importance of merchant shipping, inland shipping and fishing was expressed not just in a host of new commercial buildings, harbours and art works, but also in the spatial structure and architecture of the villages (e.g. market squares, fishing districts, trading and craftsmen quarters, grand streets with patrician mansions, new houses and churches in Renaissance, Baroque and Classical styles).

Although major flooding by seawater was much less frequent from the mid-16th century than in the late Middle Ages, countless hydraulic improvements were carried out in the Wadden Sea region between 1500 and 1800. These had three objectives: coastal defence, regulation of the internal water, and the advancement of inland shipping. Sea dykes along the coast were heightened and strengthened (Knottnerus, 2005a,b), new tidal harbours with locks were constructed and many new marine clay polders were dyked. Inland, the inhabitants dug a very fine network of waterways to allow the water to drain more easily from the peat and marine clay areas to the sea, and to vastly improve inland shipping. Many ships could now avoid the treacherous sea routes and instead travel long-distance routes inland. Almost every village in the marine clay and peat areas of the Netherlands and the eastern part of East Frisia were linked to this maritime network by means of canals and access channels. The maritime cultural landscape of the Wadden Sea region was therefore located not only along the coast but extended far inland as well. For the most part, inland ships such as tow barges carried agricultural products, turf and passengers. Significant innovations were also introduced to sea fishing in this period, with whaling beginning to flourish from the beginning of the 17th century. In the early modern period, the hunting of harbour seals, grey seals, dolphins and harbour porpoises was a further important source of additional income, particularly for island and coastal inhabitants.

In the period 1500–1800, a significant part of the Wadden region countryside was geared toward international export (Roding and Heerma van Voss, 1997). Thanks to economies of scale, intensification of production and new technologies, this coastal region developed to become one of the most successful agricultural areas in Europe. Many of the production systems that evolved were based on a closely interwoven network spanning different regions, each of which was responsible for its own link in the agricultural chain. One example is the flourishing international cattle trade of the 16th and 17th centuries. These animals were bred in Denmark, fattened in Northern Germany and the Netherlands, and then sold for meat in the cities of Holland (Westermann, 1979; Gijsbers, 1999). An important difference within the Wadden region was the integration in the von Thünian circles of the Dutch urban core: the western parts confined themselves largely to cattle-raising and dairy farming, the eastern parts, lying farther from the Dutch staple markets, exported cereals too. After about 1750 the whole area was transformed by an agricultural boom, caused by intensification of cereal growing and exports.

Also important was the large-scale hiring of migrant workers from Westphalia and Lower Saxony at haymaking and harvest time. The presence of a flourishing maritime culture was a vital precondition for the sharp rise in production in the early modern Wadden Sea region. This increasing prosperity was reflected in the landscape not just in the increasingly sophisticated network of inland waterways — restricted to the western part of the area - and new marine clay polders with their large-scale, rationalised plot divisions. We see it too in the new types of farmhouse (the three-aisled Frisian barn, the 'stolp' farmhouse and Gulfhaus) with their opulent residential sections and gardens, which were built by gentlemen farmers.

7. Conclusions

From a social evolutionairy point of view it is interesting to conclude that the coastal zone of the northern Netherlands, Germany and southwestern Denmark was a very rich environment in pre-modern times. In comparison to most transalpine areas population density and average settlement size seem to have been high during most periods of time and in most marsh areas. However, no complex political hierarchies above the tribal level did develop within the area. Possibly, the 'societal format' (Claessen, 2000) did not provide for the necessary preconditions: the total numbers of inhabitants was too low and resources too evenly distributed. In addition the area was difficult to control because it was more of an archipelago of dozens of societies then a continuous space of habitation. The changeover to the construction of embankements did not provide an incentive for political centralisation too (in contrast to developments within most others 'hydraulical societies' (cf. Wittfogel, 1957)). Dykes could be build, extended and maintained within relatively small communities. Relatively high population numbers, an indigenous 'prestige economy' centred on the establishment of a warrior's fame (and the capture of valuables like cattle) and the absence of a state monopoly on the use of violence did provide for a situation in which inter-tribal raiding and warfare were endemic. This came to a definitive end only at the beginning of the early modern era, as a result of conquest of the Wadden region by outside state powers.

Over the course of about two and half thousand years, humans became a significant geological factor through the successive use of manpower, animal power and wind power. The coming of the industrial revolution meant that fossil fuels could also be harnessed to make dramatic changes to the landscape. The widespread strengthening of existing dykes and the construction of new polders, dune dykes and dams would be unthinkable without the use of large ships, dredgers and excavators. The stench of exhaust gases rather than sweat became the distinctive odour of people's engagement with the landscape.

Despite the far-reaching modernisation of the Wadden landscape in the past 150 years, the many terps and dykes, together with the complex plot system, are evidence to this day of the long history of interaction between people and environment discussed here. This is what makes it one of the oldest and most complex cultural landscapes in Europe and the world today. It is not just the natural values of the region, as demonstrated by its world heritage status, that deserve preservation. The cultural historical values are important too. The traces of the region's millennia-long, often changeable history are not only valuable in themselves, as material for a historical narrative, but because they enable us to reflect on the region's present and future.

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