Mapping the Marine Clay Landscapes of the Wadden Sea Coast

Towards An Inter-European Historic Landscape Character Assessment

Internship rapport

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3rd March 2014, Leeuwarden

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Concluding rapport of an internship undertaken at the Rijksdienst voor het Cultureel Erfgoed (Cultural Heritage Agency) from 11th November 2013 - 11th February 2014
## Contents

1 Introduction  
1.1 Research Purpose  
1.2 State of the Art  
1.3 Research Area and Research Method  
1.4 Landscape Categorisation  
1.5 Structure of paper  

2 Geomorphological History of the Dutch, German and West Danish Coasts  
2.1 Colonisation and Cultivation of the Clay Marshes  
2.2 Landscape Character Assessment  

3 Process of creating the GIS map of the Cultural Marine Clay Landscapes of the Wadden Sea Coast  

Conclusion  

Bibliography  

Appendix  

A) GIS-based map of the cultural old, young marine clay landscapes and the land reclamation polders (17th - 20th century).  

B) Detailed GIS-based map of distinct cultural landscape regions within the GIS map of marine clay landscapes.
1 Introduction

1.1 Research purpose

Recently the Cultural Heritage Agency was tasked by the Ministry of Infrastructure and Environment to produce a map of the (cultural) landscapes of The Netherlands in a broader perspective. This meant making a map of the ‘Dutch’ landscapes at an international scale (following them into bordering countries). A GIS map of these landscapes was needed for the formulation of the new National Plan on Infrastructure and Landscape (Rijksstructuurvisie).

North-Western Europe was chosen as the basis of this new GIS map since it shows all the major rivers that flow into the North Sea. By being the main source of erosion and sedimentation they are responsible for the creation of the Holocene landscape.

The physical-geographical layer was produced fairly quickly by combining several European based GIS maps i.e. LANMAP2 for soil and topography and a NASA Digital Elevation Model map for the terrain. The Cultural perspective form the current point of attention – how did man shape and change the landscape?

The Holocene cultural landscapes have been divided (see legend v. 1.3) into clay and peat areas. The focus of this paper will be on the marine clay areas along the Wadden Sea Coast of the Netherlands, Germany and Denmark.

1.2 State of the art

In 2001 the book ‘Ongonnen Verleden’ was published in which a national overview was given of the cultural landscapes of the Netherlands. The Rijksdienst voor het Cultureel Erfgoed/Cultural Heritage Agency had performed this research for the Government of the Netherlands. GIS map published of cultural landscapes of The Netherlands.

In 2001 the first internationally organized research project, Lancewad, into the Wadden Sea region began? The goal of this project was to research the natural and cultural importance of this region by pulling together experts from all three neighboring countries, The Netherlands, Germany and Denmark. Ultimately the Wadden Sea was proclaimed World Heritage in 2009. This only included the natural area or only 66% of the region (chosen/demarcated on the basis of natural criteria). The Landsewad project is however still active in the sense that a Cultural Atlas is being uploaded onto the site in which every sub-region of the Wadden Sea Coast is being characterized, this means that by clicking on the sub-region the characterization (borders, geographical elements i.e. rivers) of the region and its landscape can be consulted.

Carrying on the German tradition of always studying the area as one culturally connected region, Dirk Meier in 2006 published a book on the development of the landscape all along the coast. The Belvedere project which was based on this publication finally designated twenty national landscapes for their unique and Netherlands? cultural heritage values. Both studies were used as basis for the publication Erfgoedbalans which appeared in 2009, this publication focused on the archeology, monuments and cultural landscape of the Netherlands. In this overview of the landscape heritage of the Netherlands the landscape types and reclamation history were discussed. The reclamation history was further categorized by historical reclamation patterns, soil use, and types of field system.

In 2013 an atlas of the Schleswig-Holstein region by Dirk Meier was published which provided some of the base maps for this paper. In 2001 this author had published a paper which gave an excellent overview of the embankment history of Schleswig-Holstein. Historic-geographical qualities of landscapes given in Ontgonnen Verleden,
description of every province.
In 2007 a Cultural Atlas of the landscapes of Denmark’s Wadden Sea coast was published as part of the Lancewad plan.6 In 2012 a follow-up was made with the publication of a national plan for the landscapes along the coast with many maps depicting Land use, tourism, development and a Landscape Characterisation (Nationalplan 2013-18).7
In 2011 the project of mapping the cultural landscapes of Northwestern Europe was given to the Cultural Heritage Agency. Although a rough draft of the cultural landscapes could be completed for The Netherlands, the cultural marine clay landscapes of Germany and Denmark are blank spaces on the map. In order to complete this project research is required on all cultural landscape types and a GIS based typology or character map supplied. These GIS maps of the typologies will be merged with the available knowledge of the Dutch landscapes in order to complete the Landscapes of Northwestern Europe map. The project is scheduled to be complete in 2018.

1.3 Research area and research method

1.3.1 Borders of research area

Most of the area of research can be found in the Wadden Sea region. The Wadden Sea has been described as reaching from Blavast Huk in Denmark to Den Helder in The Netherlands.
To be more specific the research area is comprised of the northern coast comprised of marine clay deposits of The Netherlands, Germany and Denmark. These include the northern most point of Noord-Holland (roughly an area surrounding the town Den Helder) and the northern coasts of the provinces Fryslân and Groningen.
The clay-landscapes of this region are located between the Varde Å river delta and the en-diked clay lands surrounding Den Helder at the most northern point of the Dutch province North-Holland. The research area ceases at the borders of the marine clay deposits, any moors or high aeolian sand deposits will not be included in this paper.

1.3.2 Project scale(s)

The GIS map of North-Western Europe developed by the Cultural History Agency has a scale of 1:100.000 The research area covered int his paper and subsequent GIS map of the cultural landscapes of this area will therefore have the same scale.
This however poses a few problems concerning the combination of international and national maps. All three countries have produced soil maps and geomorphological maps of different scales. In addition to this no easily available soil map exists for Germany, so the European Soil Database was used to create a 1:100.000.000 scale of the clay soils of all three coasts but primarily for those of Germany and The Netherlands. This functions as a base layer for the claylands of the Wadden Sea coast.

1.4 Landscape Categorisation

1.4.1 In the research area three landscape types have been defined:

Old claylands or polders
Young claylands or polders
Landscape reclamation polders or droogmakerijen

6 Jensen, L. and Lauenborg, M., Vadehavet Kulturarvatlas, 2007
The border of the old marches is defined by dikes, as are those of the young polders. The young polders border in some cases directly with the sea but in most case a sizeable stretch of salt marsh forms a buffer between the coastal dike and the Wadden Sea. The salt marsh has not been included in the GIS map since the border of the polders are strictly based on the presence of a dike. Since the sea still floods the saltmarshes regularly it would require a different project definition to include these as ‘Cultural landscapes’. The definition of these boundaries and their inclusion in the GIS map of Northwestern Europe, an overview of related literature and a Landscape Character Assessment for the whole region including the Dutch old and young polders are the main topics of this paper.

1.4.2 Characteristics which form landscape character definition

Natural characteristics which form definition:
Abiotic:
   Physical Geography
   Geomorphology

Biotic:
   Vegetation (Tree cover and pattern)
   Soil

Anthropogenic/Cultural:
   Cultural landscape characteristics which form definition:
   Settlement (Town/Village) Types
   Settlement Pattern
   Settlement Density
   Land Use
   Reclamation History
   Toponymy
   Topographical location
   Field system
   Open/Closed landscape
   Population Density

1.5 Structure of paper

A geomorphological history of the coasts of the Netherlands, Germany and Denmark will be followed by a brief cultural history of the sea clay areas. This will lead to the Landscape Character Assessment of the Cultural Landscapes ending with a conclusion and overview of literature. This paper forms a supplement to the GIS map of the old and young sea clay landscapes and accompanying Landscape Character Assessment.
The natural formation of the Wadden Sea coast has been largely influenced by the tidal movements and rising sea level. Fluctuating sea levels were caused by climatic shifts between cold and warm periods which created transgressional and regressive phases in the sea coverage of land so that during the ice ages the water level was much lower than during the warm periods.\(^8\) It is estimated that in the last ice age Weichsel the sea level was 100 meters lower than the current level. This means that in the ice ages a lot more land was available to man than in the warm periods. Changes in climatic conditions continue to influence the level of the Wadden Sea to the present day. Due to the rising sea level, starting at the end of the last Ice Age (roughly 10,000 years ago), the coastline of the Wadden Sea has constantly been shifting South. At this time England was connected to mainland Europe and the coasts of The Netherlands, Germany and Denmark extended far further to the North than the present day. The sea level began to rise circa 9000 B.C. and it is estimated that between 7000 and 4000 B.C. this rise comprised about 120 meters. By 6,500 B.C. the sea had reached the current shore line.\(^9\)

In 5000 B.C. the English Channel flooded, this is thought to have instituted a change in the direction of the tide, which now ran parallel to the coast facilitating the creation of sandbanks and barrier islands.\(^10\)

The force of the tide varies in the Wadden Sea, being strongest in the Helligoland Bight and weaker towards the coasts of Denmark and The Netherlands. As a result a long line of sand barriers could be formed off the Dutch and Danish shoreline but not in the Helligoland Bight.\(^11\)

These phases can be clearly made out in the stratigraphy of the soils along the entire coast (see fig. 1). The first phase of transgression deposited maritime clay sediments on the Pleistocene soils which covered organic matter with a thick layer of clay, effectively sealing it off from oxygen, thus allowing only partial decay of the organic materials. This process resulted

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\(^8\) Behre, K-E., 1987, p. 12
\(^9\) Ibid., p. 12
\(^10\) Marrewijk, Dré van (et al.), 2001 p.33
\(^11\) Ibid., p. 33
in the creation of a wetland landscape. With the next regression plants would recolonise the soil and would then become submerged with the next transgression. Regular continuations of this cycle throughout the early Holocene period causing a predominantly clayland landscape to form with peat sub layers. By about 1500 B.C. these peatlands had reached their maximum extent along the Wadden Sea coast (see fig. 2).\(^\text{12}\)

When man started to reclaim the peat lands they started an oxidation process whereby the peat was exposed to oxygen and started to subside. Eventually this would lead to the continuous flooding of the northern coast of The Netherlands and Germany, with the land now lying beneath sea level, and the need for better water management in the form of dikes, canalisation and sluices arose.

2.1 Colonisation and cultivation of the clay marshes

**Man starts to inhabit the North Sea marshes**

One of the conclusions to the Lancwad project was that if you could characterize the Wadden Sea region it would be to say that it was one of diversity. The cultural landscapes stretching from Den Helder to Ribe are just that; diverse, unique and a physical record of man's interaction with the sea in this region of Europe. How and where a man built his settlements and defenses was always in a response to or because of the behaviour of that natural element, the sea. In no other region of the world is this relationship between nature and culture more deeply engraved or expressed in the landscape. Even the particular nature of its tides is expressed in the name the different nations living along its shores gave this area; Waddenzee (Dutch), Wattenmeer (German) and Vadehavet (Danish). All three point to the intertidal nature of the sea, which causes a large stretch of the seabed to be exposed twice a day. When this happens the tidal flats, barring the deeper gullies, are dry or shallow enough to be waded through, explaining the use of Wad, Watt and Vade in the hydronym.\(^\text{13}\)

The sea clay regions of the Wadden Sea coast also share terminology between the three countries. Whilst they are called the *zeekleigebieden* in Dutch the Germans and Danes both refer to them as marshes (respectively Nordseemarschen and Marsk). In these sea clay marshes man made mounds with individual farmsteads and villages first dominated the landscape whilst dikes, pump stations, roads, farmfields and old farmhouses further determined the structure of the landscape.\(^\text{14}\) How this came about forms the core of the Landscape Character Assessment in sub chapter 2.5.

Man first settled in the salt-marches (mainly in the province of Noord-Holland in The Netherlands) during the Bronze Age (2000-1000 BC).\(^\text{15}\) These settlements were located on natural high spots in the landscape. By circa 800 BC these settlements in Noord-Holland were abandoned due to the rising level of the sea which caused the development of large peaty swamps in this region.\(^\text{16}\) Two hundred years later the first settlements (on high ground in the salt-marshes) appeared in the provinces of Fryslân and Groningen.\(^\text{17}\) Because of habitation the level of the soil beneath the house rose over time due to waste deposits.\(^\text{18}\) In the 4th/5th centuries the settlements on the German coast were largely abandoned, including some on the Dutch Wadden Sea coast, when the Jutes, Angles and Saxons invaded England.\(^\text{19}\) In Germany the settlements slowly are reinhabited and circa 700 A.D. the second phase of mound building began.\(^\text{20}\) The creeks and gullies crossing these marshes and the tidal flats pro-

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\(^{12}\) Speelman, H. (et al.), 2009, p.42

\(^{13}\) Abrahamse, J., Bemelman, M., Hillenga, M., (eds.), 2005, p.14

\(^{14}\) Ibid.

\(^{15}\) Bauer, E., Fischer, L., Kühn, H.J., Maluck, M., & Meier, D., 2001, p. 228

\(^{16}\) Ibid.

\(^{17}\) Ibid.

\(^{18}\) Behre, K.-E., 1987, p. 42


\(^{20}\) Behre, K.-E., 1987, p. 42
vided natural drainage channels for the farm fields. However, due to progressive sea level rise and the subsidence of the ground due to oxidation of the peat soils, the need for higher ground quickly became apparent. To answer this need man began to artificially raise the ground beneath his farm by use of sods and manure. In the provinces Fryslân and Groningen and the German coast mounds were constructed in Roman and Mediaeval times on the high ridges of the salt marshes. This line of mounds can still be seen in the present landscape. The older mounds lie scattered throughout the landscape. This is the case along the entire coast including Denmark (in the Tønder Marsk region). At this time, and especially in the 9th century A.D., the first wave of Frysian immigrants arrived in East and North Frisia in Germany (respectively Ostfriesland and Nordfriesland). Many mounds in these areas date from that time. Another migration wave of the same peoples would occur in the Late Middle Ages when the Frisians once again immigrated to the same regions, especially Eiderstedt, where they employed their highly developed technique of dike building.

In the province of Fryslân various towns developed in the mound region such as Leeuwarden and Dokkum. The former developed on three mounds which were gradually annexed, along the river Ee. These towns later joined the Hanze League along with several others (i.e. Stavoren and Bolsward) on the coast of the Zuiderzee (now the Ijsselmeer).

The first dikes and the old polders

Not surprisingly the diking projects have been split (at least by the Dutch and Germans) into two categories. One concerns the old claylands (respectively oude zeekleipolders/Alte Marsch), the other concerns the new claylands (jonge zeekleipolders/Junge Marsch). The characterisation of these two polder types is based on the settlement or cultivation history of these marshes. Winding roads (built on top of old dikes) and canals characterise the old marsh, with most of the settlements being located on mounds or along the dikes. This is because man, when first reclaiming or settling in the marsh, adapted his settlement pattern to the natural landscape. Existing channels were used to drain the land and naturally high areas in the landscape were colonised, in this case the levees of creeks and rivers. The old polders are dated between 1000-c.1550 A.D.22

Dike building started in the 11th century but developed and intensified during the 12th century with the coming of the monks in Westergo. The technique was very soon exported along the entire coast although it was never practiced in Denmark until the 16th century. The first dikes were called ring dikes, referring to the fact that it was usually built by the inhabitants around a group of farm mounds or a village. Later, under supervision and/or by work of the monks, these ring dikes grew until they formed one long continuous dike surrounding a region or area. The most famous is the Penjumer Gouden Halsbân dating from the 11th century in the west part of the province of Fryslân made up of amalgamated ring dikes. Amalgamated ring dikes can also be found in the region of Niedersachsen in Germany.

Aggressive diking projects started in the 13th century, when large sections of the Middelzee started to silt up, and resulted in the complete reclamation of the Middelzee during the course of the centuries. Today the location of many settlements in Fryslân can only be explained by reconstructing the shores of the Middlezee. Many profited by the access this sea provided to trade routes and when it did eventually silt up some settlements kept their access to the North Sea via canals (i.e. Sneek and Leeuwarden).

The practice of embanking silt deposits continued with the latest projects being undertaken in Denmark in the 20th century. Since the Middle Ages this process has been a constant development along the coast and is a defin-

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22 These dates were used for the GIS-based map of the marine polders and are based strictly on the date of dikes and not on the age of the settlements, since these are far older.
ing practice in and of the landscape. Land reclaimed by one of these undertakings is called a *polder* in The Nether-
lands but like many other practices along the coast it has names in other countries as well; Kog in Denmark,
Koog in Schleswig-Holstein and Groden in Niedersachsen.

In the Schleswig-Holstein region the Eiderstedt peninsular is one of the most notable old *polder* regions. Tran-
gressions of the sea formed the Suderhever tidal channel which divided Eiderstedt into two islands: Utholm and
Everschop. Due to reclamation of pieces of the Suderhever tidal channel in the Middle Ages these two islands
were reconnected in 1241 A.D. yet this reunion did not last long.\(^3\) Storm surges created the tidal stream Fallstief,
which cut the isle of Westerhever off from Utholm in the 14\(^{th}\) century A.D. and it had to be temporarily aban-
doned. A remnant of this tidal stream is the Tumlauer Bucht. Further reclamation projects were started after the
All Saints Flood 1436 A.D. and Westerhever was eventually connected to Everschop.\(^4\) Only in 1489 A.D. was it possible to reconnect Eiderstedt to the mainland by embanking the Dammkoog. However, the second bad flood of 1634 A.D. caused much land loss, especially in the Lundenbergharde area of North-
eastern Eiderstedt.\(^5\)

**Lost landscapes: Floods of the Middle and Late Middle Ages**

Throughout the history of the Wadden Sea region man has suffered from floods ruining his crops and killing
men and livestock, sometimes in great numbers. When studying the floods that had such a lasting effect on the
landscape cause and effect can be noticed. At the time of the Medieval Warm period the sea level rose causing a
spate of severe floods. After the Medieval period the temperatures dropped due to a small ice age. Diking proj-
ccts can be seen to drop.\(^6\) Another spate of bad flooding in the late Renaissance was recorded at the end of this
short ice age, when the temperatures started to rise. Floods that are documented occurred in 1164, 1219, 1287,
1330, 1362, 1374, 1421, 1436, 1509, 1511, 1532, 1570, 1634, 1686, 1717, 1825 and 1962.\(^7\)

The floods of 1362 and 1634 were particularly destructive and were responsible for the loss of much land in both the Dollart and Jadebu-
sen areas. Later diking projects carried out in the 16\(^{th}\) century were able to partially reclaim some of the land in these areas, which are
very fertile, but it is till not possible to reclaim parts of the flooded regions. Dikes in these
districts (especially in the Dollart area) form a
characteristic fan shape in the landscape.

**The young polders and droognakernijen**

If the features that characterize old *polders* are winding roads and dikes, which were a result of the small scale of reclamation dictated by the employed methods of the time, young
*polders* are characterized by long straight roads.

\(^{23}\) Meier, D. (et al.), 2013, p. 35
\(^{24}\) Ibid., p. 33, 97
\(^{25}\) Ibid., pp. 104-112
\(^{26}\) Ibid., p. 24
\(^{27}\) Abrahamse, J., Bemelman, M., Hillenga, M., (eds.), 2005, p.34
and dikes made possible by the large scale reclamations enabled by new technological developments. All young
polders date from after 1500 A.D. because during the Renaissance new techniques of draining the low lying areas
were developed and implemented. Roads and drainage ditches no longer followed the courses of the creeks and
gullies in the landscape. Instead, large portions of new land was reclaimed by building a dike and pumping the
water out using mills (droogmakerijen) or by building low dikes in the salt-marshes, letting the silt build up be-
hind them and then embanking and cultivating this newly acquired land. Although the polders are called young if they date from after 1500, the droogmakerijen were only technically
possible after 1612, when the first successful use of the technique was a fact after the drainage of the Beemster
Polder. In this polder the roads were laid out in a grid pattern and the farmhouses are located along the roads.
After this first implementation of water being pumped out of an endiked piece of land (or lake) by means of mills
many more droogmakerijen were created in The Netherlands and Germany.

As mentioned above, roads and waterways in the young polders also follow a straight pattern with farm-
houses positioned along the roads or at cross-roads. This pattern could be implemented because a large
piece of land was reclaimed in one process unlike the ring dike formation of the old clay landscapes. The
young clay landscapes are located at a greater altitude than the old clay landscapes because the latter sub-
sided due to the underlying peat oxidation process. Arable farming is thus possible on the young clay but
not on the old, where livestock farming dominates.

In the Dutch province of Frieslân the reclamation pro-
cess of the silted up Middelzee, that had been ongoing
since the high Middle Ages, was concluded with the
area known as Het Bildt, where large young polders
were reclaimed along the Frisian coast. After this recla-
mation there have been no newly added polders.
On the Dutch-German border, in the province of
Groningen, the area known as the Dollart (‘Dolle
aarde’) was lost during the floods of the Middle Ages
Nevertheless, since the 1500’s reclamation projects
have been undertaken in this region with the recla-
mation process having left an easily identifiable fan
shaped pattern in the landscape on both the German
and Dutch sides of the border. The Leybucht and
Harlebucht in Niedersachsen also form easily ideni-
fiable areas of late reclamation projects due to the
obvious shapes of their polders.

Large reclamation projects were still ongoing in
Germany in the first half of the 20th century. When
the National Socialists came to power in Germany in
1933 large reclamation projects were planned for the
Niedersachsen coast. Two polders were reclaimed in
the period 1933-1935, namely the Adolf Hitler Koog (28

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Fig. 4 Map by Kuhn of the embankment history of
Schleswig-Holstein. Notice the polders of Eiderstedt, The GIS
polygons of eiderstedt were based n this map.

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Ehlers, J., 1988, p. 260
now the Dieksander Koog) and Hermann-Göring-Koog (now the Tümmlauer Koog). Both were costly projects costing respectively 4.000.000 and 2.400.000 Reichsmark. Reasons for land reclamation in this period were no longer economically based, as was the case in the past. Two reasons were used for this land reclamation; the first was to create jobs and the second to create Lebensraum or Erweiterung des Lebensraum (expansion of the living space or area). More money was spent on coastal protection and land reclamation between 1933-1935 than the previous decades of the twentieth century.

On the Eiderstedt peninsular land reclamation was intensified during this period as well. The polders Tümmlauer Koog 1933-35, Ulvesbuler Koog 1934/35, the Finkhaushalligkoog 1934-36 and the Nordheverkoog 1935-37 all added to the amount of land available.

In Dithmarshen the reclamation went on until the latter part of the 20th century. The Speicherkoog is the youngest polder dating to 1978.

Denmark, in comparison with the Dutch and German coasts, started land reclamation projects at a much later date: the Tønder Marsk was embanked only in the 16th century. Subsequent endikements of the marine claylands only occurred in the 20th century. Here the young polders are easily identifiable by the the Danish word for polder (Kog) in the toponymy. Considering the unique position that Denmark takes in this research (possessing the only stretch of Wadden Sea coast almost exclusively composed of young polders) it is important to pay some attention to the characteristic elements of its polders.

The Danish marsken are located along the western coast of Denmark at the mouths of the rivers Varde, Sneum Å, Kongen, Ribe Å, Rejsby Å, Brede Å, and Vidå. In the South, the border of Denmark and Schleswig-Holstein runs through the middle of the Tøndermarsken. The only polders to contain dwelling mounds are those of the Ballummarsken and Tøndermarsken, these mounds generally date to the Medieval period. Together with fishing villages along the coast these mounds form the most important early settlement types in the polders. The earliest dike built in the Danish marshes the Højer-Rudbøl-Lægan-Greelsbøl dike built in 1556 also runs through the Tønder Marsk.

31 Ibid.
32 Ibid.
33 Ehlers, J., 1988, p. 276
35 Jensen, L. and Lauenborg, M., 2007, p. 48
Mostly livestock farming with agriculture only being practiced in the Ballum marshes (cultivated crop and grass-lands). Scattered farms in the Tøndermarsk and planned nucleated farmsteads throughout the rest of the kogs.

During the Middle Ages people moved from the Geest or high sand plateau down into the marshes. As seen in other parts of the coast they built dwelling mounds to protect themselves from the sea. The Tønder marsh is the oldest inhabited Danish *polder* landscape with many dwelling mounds located in it. Of these, the village of Misthusum is the northern most dwelling mound village in Denmark, consisting of 8 artificial mounds. In the Middle Ages a summer dike was built to protect Misthusum from the summer floods though in the 18th century Misthusum was flooded by winter floods and the population moved onto the higher lying Geest. The river Vidå was still navigable and used for transport. After this first embankment project the *polders* Gammes Frederikskog (1692), Rudbøl Kog (1715), Ny Frederikskog (1861) and Margrethe Kog in 1982 followed.36

Fields located behind the Højer-Rudbøl-Lægan-Grelsbøl dike show the characteristic irregular Mediaeval pattern. In front of the dike, in the younger *polders*, the field system is regular with straight drainage ditches and canals, reflective of the large scale reclamation projects.

**Emigration and Tourism: 19th and 20th century development**

Throughout the early 19th century the island communities of the region had suffered from the continental blockade implemented by the English during the Napoleonic Wars as they were cut off from mainland harbours. Additionally, problems arose because the islands could not support the communities agriculturally speaking and big trawlers operating from the mainland towards the end of the 19th century made living off fishing impossible. This led to much emmigration throughout the 19th and 20th centuries.

Sea-side resorts, started in the 18th century, drew tourists to the Wadden Sea islands, both in The Netherlands and Germany. The resort on Norderney was founded in 1797 followed by those on Wangerooge 1804, Spiekeroog 1809, Wyk auf Föhr 1819, Langeoog 1830, Juist 1840, Borkum 1850, Nes (Ameland) 1854, Westerland (Sylt) 1857, Schiermonnikoog 1866, Wittdün (Amrum) 1890, De Koog (Texel) 1896, Lakolk (Rømø) 1898.37 Tourism halted abruptly in the first World War when bunkers were built on the islands, though it started to recover at a slow rate after the war. With the outbreak of the Second World War tourism suffered again. After the war’s termination and with an improved connection to the mainland tourism in the islands increased.38 Today, tourism remains one of the main sources of income for all Wadden Sea islands.

2.2 Historic Landscape Character Assessment

**Old marine clay *polders***

Old marine clay *polders* are located in land and border mostly on the peat landscapes but in some cases, like Denmark, on the sand dominated soils. These *polders* are used predominantly for livestock breeding and meadow land along the entire coast. This is because they lie well below sea level and are therefore very moist. Since they were found in this condition and the first inhabitants drained them using the available water channels there are no straight canals or roads. The roads lie on top of old dikes throughout the landscape and the parcellation pattern is that of irregularly shaped rectangular or square fields. Canals wind and twist through the landscape and the trees are planted along the roads or are clustered around the farmhouses to form a buffer from the wind. Riverbanks were the first parts of this landscape to be settled and the original settlements on the riverbanks is where the dwelling mounds were eventually built. In most cases these dwelling mounds went on to become villages and can be recognised by their radial pattern (houses grouped around and radiating from a central point).

37 Ehlers, J., 1988, p. 215
38 Ibid.
The soil is usually acidic clay known as *verzuurde kleibodem/knipklei* in Dutch and *Brackmarsch or Kleimarsch* in German. It is best used for grazing cattle, especially when it contains iron deposits in the clay layers. Farmhouses and labourers cottages are located in ribbon villages along the dikes or up against the dikes but farmhouses can also be irregularly dispersed throughout the landscape, sometimes lying on their own dwelling mound. The dwelling mounds are dispersed throughout the landscape or are located along winding dikes or roads. Most of these lie between 1.0 –NAP and 1.0 m +NAP.39 The old *polders* lie at 1.5 m -NAP to 0.5 m +NAP.40

**Young marine clay polders**

Young sea-clay areas date from about the 16th century. Younger *polders* exist that were embanked much later but still belong to this typology. They are made up of permeable soils (relatively light limestone containing soil that is known in Germany as *Seemarsch* or *Kalkmarsch* and in The Netherlands as *zwavelbodem*) and are ideal for agriculture.41 Generally speaking, the fields show a regulated pattern and the parcellation is usually bigger than that of the old clay lands with the young *polders* lying at 0 to 2.0m +NAP. This greater height is what makes them more suitable for crops than the older *polders* and is caused by the embankment history of the young *polders*: they were originally the salt marshes that accumulated along the coast due to (artificially encouraged) sedimentation. When the layer of sediment was considered to be sufficiently above sea level the marsh was embanked and the sea had no further influence on the land. Another reason is that of the oxidation of the peat layers located under the old clay layers. Through this process of oxidation the old clay regions have subsided even further below sea level causing a greater difference in height between the two *polder* types. The farmhouses are dispersed along dikes, roads and canals whilst the villages are located near tidal harbours or crossroads.42

**Land reclamation polders 17th - 20th century**

These *polders* or *droogmakerijen* are mostly composed of clay soils in the province of North Holland in The Netherlands and the region of Niedersachsen in Germany. Those of the Dutch province of Friesland are composed of peat soils. These polders all date from after 1612, the year in which the first succesfull employment of the method of creating this type of polder was carried out. It concerned the Beemster polder in the province of North-Holland where water mills were used to pump the water out of the embanked lake into a set of canals dug for this purpose.

**3 Process of creating the GIS map of the Cultural Marine Clay Landscapes of the Wadden Sea Coast**

The process of the production of the GIS based map of the old marine clay *polders*, young *polders*, 17th - 20th century land reclamation *polders* (*droogmakerijen*) was intricate. In any research straddling more than one (national) border difficulties are almost always encountered, with

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39 Marrewijk, Dré van (et al.), 2001, p. 22
40 Ibid., p. 22
41 Ibid.
42 Ibid.
the most simple example being that of language. In the case of my research area this difference in language had consequences for the terminology used in this paper, the most obvious example being the term \textit{polder} which, whilst being the same in all the Dutch provinces, changed per region in Germany (\textit{Polder}, \textit{Gröde} and \textit{Koog}). In Denmark a \textit{polder} is known as a \textit{Kog}.

To map the old \textit{polders} of The Netherlands the Geomorphological map of The Netherlands was used, being 1 : 50 000 in scale it is a very detailed map and the difference between old and young clay deposits was relatively easy to extract from it. A satelite image layer was used as a base layer on top of which the geomorphological layer was projected and made transparent so that the dikes could be traced. This was important because the dikes form the border between the old and young clay polygons. The detail of the geomorphological map, whilst being extremely detailed, is not based on dikes but on soils so the polygons of the GIS map of the Cultural Marine Clay Landscapes of the Wadden Sea Coast do not match the border between soil types exactly but were based on the dikes of the \textit{polders}. In the province of North-Holland however, the oldest dikes and history of land reclamation had to be first researched before the map could be made.\textsuperscript{43} Dating the dikes could be done easily using existing literature and the oldest dike(s) were seen to be forming one continuous dike called the \textit{Westfrieseomringdijk}. It encompasses an area in the northern part of the province and the land located within the dike is the only old clay region located in the province. All the dikes incorporated in the \textit{Westfrieseomringdijk} date from between the 11\textsuperscript{th} and 13\textsuperscript{th} century, hence the old \textit{polder} typology.

The most important young clay polder lies in the extreme North known as the \textit{‘Kop van Noord-Holland}. All other marine clay polders were drained with the help of windmills after the first successful use of this method when creating the Beemster \textit{polder} in 1612. For the mapping of the \textit{‘droogmakerijen} a map made by dr. Dirk Meier was used.\textsuperscript{44} A satelite image was also employed to be able to trace the polygons of the \textit{polders} accurately. These could be identified by the pattern of their drainage canals (which encircle the \textit{polder}).

For the mapping of the German \textit{polders} the European Soil Database map was used as a base map. Since the scale is 1 000 000 the borders between the young and old were almost by default incorrect. Like the Dutch polygons those representing the old and young \textit{polders} in Germany had to be traced using satellite imagery based on the dikes. In order to locate the correct dikes a \textit{polder} map was used for Niedersachsen. This map included the dates of the \textit{polders}, the year in which they were reclaimed and sometimes the year in which the dikes were built (see fig. 4). Additionally, a map of the field pattern of the entire Wadden Sea coast was used to locate the exact border between the irregular shaped field pattern of the old \textit{polders} and the planned field pattern of the young \textit{polders} (where all fields in a \textit{polder} have the same orientation).

The maps included in the book \textit{‘Der Küstenatlas} formed the basis for the old and young \textit{polders} of Schleswig-Holstein, in

\begin{flushright}
\textsuperscript{43} Meier, D., 2013, p. 19
\textsuperscript{44} Ibid., p. 19
\end{flushright}
particular Dithmarschen. Dr. Meier also provided the border (based on dikes) between the Junge and Alte Marschen. In some cases such as in Dithmarschen near the town of Wesselburen the old’s dike is not easy to spot having been destroyed in several places. The border between the old and young clay landscape was then based on the difference between the parcellation structure of the land. In the old polders this consists of irregular blocks whilst the landscape in the young polders consists of rectangular fields, straight roads, dikes and canals.

Nordfriesland in the north of Schleswig-Holstein was based on a map of Dirk Meier, which in turn was based on a map by Kühn. These polders differed the most from the European Soil Database (see fig. 5). Taking Dithmarschen as an example the border between the the Junge and Alte Marsch differs on all three of the maps employed. For example, the dwelling mound village of Wesselburen located in the North of Dithmarschen is situated from top to bottom in the young polder, old polder and young polder. The final typology was based on the central figure (map by Meier, based on the dike of 1559). This example shows that that the European Database as well as the geomorphological map of Germany can not be taken for granted as representing the true picture of the reclamation history of the Wadden Sea coast and therefore should be used with caution.

Another example is that of Nordfriesland. If the polders had been based on the European Database the whole of Nordfriesland would be considered old marine clay landscape. This would be entirely incorrect as large portions of the coastal area of the region were only embanked in the 16th century.

An unintentional result of the making of this map was that it is now possible to reconstruct the old coast line of the Wadden Sea Coast by selecting only the old marine clay landscape in GIS, which will show the reclaimed coastal areas dated before the 17th century.

Denmark’s polders were based on the newest geomorphological map of Denmark (1:50 000) which -like that of The Netherlands- is extremely detailed. Most of the polders in Denmark date from the 17th century or later and are subsequently young marine clay polders, only the polders in the Tondernmarsken date from the 16th century and are therefore classed as old polders. The border between these and the later polders is formed by the Højer-Rudbol-Lægan-Grelsbøl dike.

Since the borders of the old and young polders are based dikes they are very

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45 Ibid., p. 16
46 Ibid., p.16
48 Kühn, H.J., 1992, p.19
accurate. However, when comparing the map to national or even regional maps the dates used for the division of the young and old polders must be taken into consideration. Comparing the GIS-based map to geomorphological or even soil maps will result in differences since these were found to differ greatly to the age of the dikes and thus the polders.

Fig. 9 Example of the method used to create the GIS-map of the clay landscapes. An overlay was created using the European Soil Database (transparent view) and the satellite image of Europe. The region of Dithmarschen is shown here. The red dot symbolises the village of Wesselburen, see fig. 8.
Conclusion

To conclude, the entire Wadden Sea coast shares almost precisely the same geomorphological history. Although there are many unique practices, traditions and dialects or languages that create regional diversities the landscape can be divided into three distinct characters. The resulting GIS map, which was based on the research put forward in this rapport, not only gives us a complete image of the old and young marine clay landscapes along the entire Wadden Sea coast but also the pre-1600 coastline. Land lost in the violent floods of the Middle Ages and especially the 17th century is highlighted by the shape or other characteristics such as road, dike and settlement patterns of the polders in the Dollart, Jadebusen and Nordfriesland's Halligen islands. Also the Leybucht and Harlebucht in Niedersachsen show major reclamation projects undertaken in early modern times.

By creating a GIS map of the cultural landscapes of Northwestern Europe it has become easier to compare the land mass (young polders) gained throughout the centuries between all three countries; Germany, The Netherlands and Denmark. The scale of the map allowed the inclusion of all the land reclamation polders including the smaller ones of Friesland and Niedersachsen.

As the borders of the polders are based on dikes they are very accurate and can be easily identified and plotted on other maps or used as a layer in conjunction with other maps in GIS. This allows various organisation in The Netherlands, Germany and Denmark to quickly compare their maps of the polders with this GIS map.
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Images
Front page (clockwise);

Fig. 1: Kulturarvatlas, 2007,
Fig. 2: Marencic, H., and De Vlas, J. (eds.), Geomorphology, Wadden Sea Ecosystem No. 25, Thematic rapport no. 9, CWSS, 2009, pp. 17-20.
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Fig. 6: Detail of European Soil Database, 1:1.000.000, 1999.
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Fig. 8: From top to bottom; Detail of the European Soil Database (1999), Map of Dithmarschen by Dirk Meier (Der Küstenatlas, 2013, p. 16), Detail of the Bodenübersichtskarte of Germany, Bundesanstalt für Geowissenschaft und Rohstoffe in Zusammenarbeit mit den Staatlichen Geologischen Diensten der Bundesrepublik Deutschland (2009).
Appendix A

Sea clay landscapes: Cultural Landscape Type

- Landscape reclamation polders
- Older marine clay polders
- Younger marine clay polders
Sea clay landscapes: **Historic Landscape Character**

- Altes Land Fruit Orchard Landscape
- Dwelling-mound pasture landscape
- Halligen-unembanked islands
- Land reclamation polders
- Younger marine clay arable polders