Evolution of the dune ecosystem in Flanders during the Middle Ages : anthropogenic factors versus sea level change theory [1]

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Little is left of the Older Dunes of the Flemish coast. Is this due to the influence of the sea and climate changes, or was it the influence of man that played a major role in this evolution ? It appears that the latter has been the case.

INTRODUCTION

On the eve of the Great Reclamation Period (11th – 13th century), the Flemish lowlands were protected from the sea by a high and wide range of dunes, which was completely overgrown, wooded even, and which consequently formed a solid natural barrier. Storm surge dikes along the coastline were not required in those days. The slow process of creation and decay of the Flemish coastal dunes in the historical age has until now always been explained in Belgium on the basis of purely physical elements. The repeated transgression phases, or periods of rising sea levels, were believed to have caused the various prolonged floods of the Flemish lowlands. In the light of a contradictory vision with regard to the Dutch coastal dunes (Jelgersma and De Jong, 1970), and the results of more detailed historical research (Augustyn, 1992) we have raised the question as to what extent human activity has contributed to the destruction of the Flemish dune ecosystem, and as to whether it is still possible to sustain the theory about early and full medieval transgression phases (Dunkerque II and III) for the Flemish region. We found that in the Flemish region sea walls that ran parallel to the shoreline had to be constructed only in the early part of the 14th century. The damage to the dune environment became even more pronounced in the course of the 14th century, until eventually, on November 19, 1404, a north-westerly storm, known as the first Saint Elisabeth Flood, almost completely destroyed this chain of dunes, leaving only a small stretch of dunes on the Flemish West Coast. Can we attribute this destruction to a rising of the sea level in the late medieval period ? By examining the records of that time we were able to determine a number of anthropogenic factors. Consequently, a confrontation of the historical archives with the geological and climatological literature was inevitable. For periods of rises and drops of the sea level are caused by a warming and cooling of the climate, and consequently they are the result of purely physical factors when we consider the past.

It was only in the sixties that realistic and more scientifically reliable curves of the rise of the sea level could be drawn up by means of the radiocarbon method. Jelgersma, a researcher at the Dutch National Geological Department (Jelgersma, 1961) was a pioneer in this field of research. Since O. van de Plassche's geological study (1982) on the Dutch coastal region, it is widely accepted in international scientific circles that, on a global level, the sea level has only slightly risen since the Subatlanticum, i.e. the climatological period in which we are living at the moment (since about 2300 years ago) (Devoy, 1987 ; Tooley and Shennan, 1987 ; - a theory which has been corroborated by research on the American coasts : Van de Plassche, 1991).

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[1] The present article is a slighty modified English version of "De evolutie van het duinecosysteem in Vlaanderen in de Middeleeuwen: antropogene factoren versus zeespiegelrijzingstheorie" , which was published in 'Historisch-Geografisch Tijdschrift', 13 (1), 1995, p. 9-19.

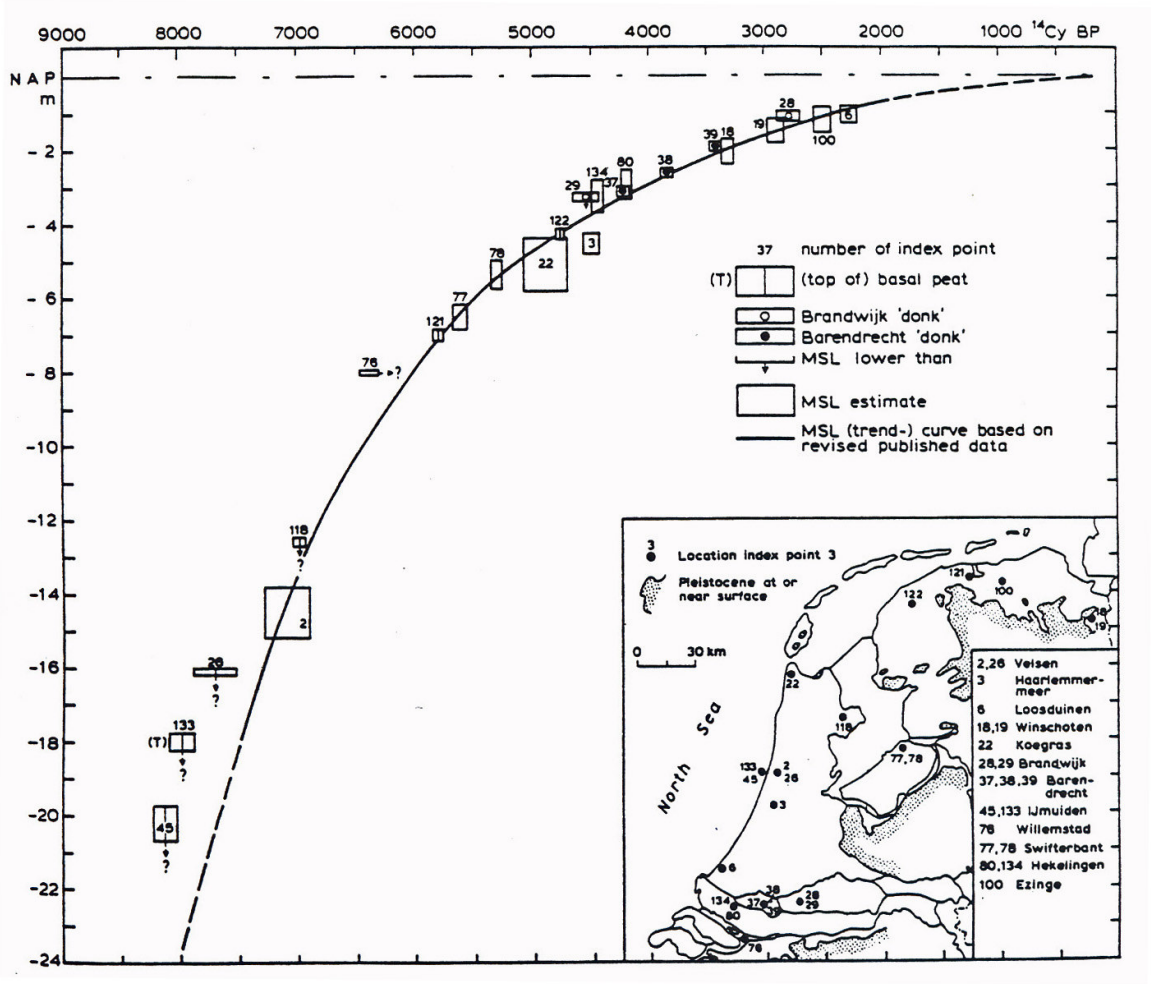

Figure 1: Relative sea-level rise curve of the National Geological Department of the Netherlands, projected on the basis of the combined data on sea-level rise by Jelgersma (1961) and Van de Plassche (1982).

However, this does not alter the fact that the marine transgression phase theory was still used to explain the destruction of the dunes and the clay deposition in the Flemish coastal area in the post-Roman era. The modest start of this trend dates back to the 19th century. In 1877-1878 J. Gosselet and H. Rigaux were the first to conceive the idea of a post-Roman marine transgression phase that lasted until the end of the 8th century: *" Le golfe marin des Flandres ne date que de la fin de la domination romaine… (le littoral de la Flandre) où on ne rencontre aucun nom appartenant à la langue gauloise ou romaine… le golfe était déjà comblé vers 800*". This concept was adopted by the Lille-based professor R. Blanchard in his famous work "*La Flandre*", which was published in 1906, and in which he stated that the Flemish coastal plain was transformed during this period into a wadden area ("*les wadden flamands*").

Furthermore, this original geological theory, which was applied in the early fifties to classify the clay strata in the Northwest European Plain, was finally transformed during that same period – within the context of the devastating effect which the 1953 storm surge had on the population of the Netherlands - into an internationally accepted climate theory by J.P. Bakker in 1958, under the influence of J . Bennema's study "*Holocene movements of land and sea-level in the coastal area of the Netherlands*", published in 1954. Within this context we recall an influential study published in 1972-1977 by H.H. Lamb, titled "*Climate : Present, Past*

and Future", and the more recent work by J.M. Grove (1988) on the hypothetical Little Ice Age of the New Era. Until recently climatologists believed that a study of the past would lead us to the origins of a number of climatological phenomena that could point to a natural warming of the atmosphere and a global melting of the glaciers since the late 19th century.

However, since then there has been a growing dissonance from climatologists and ecologists. Alarming information on the effects of air pollution, and of CO^2 emissions in particular, have increasingly convinced scientists all over the world that the so-called Greenhouse Effect may possibly constitute a greater danger for climate changes in the near future. (Berger, 1988; Billen, 1991; Roqueplo, 1993). Therefore it is not surprising that the historical-climatological research into the Little Ice Age which is supposed to have preceded the present 'naturally' warmer period was dug up again. This eventually resulted in a more balanced view and a scepticism among scientists about the existence of that period! (Bradley and Jones, 1992).

Nevertheless, as far as the Northwest European Plain is concerned, this hardly affected the geological foundations, i.e. the transgression phase theory (formulated by Gosselet and Rigaux, in 1877, and pursued by Blanchard in 1906 until the dike construction period). The transgression phase theory still has an appeal to scientists studying the history of development of the Northwest European Plain in the Middle Ages and it has led to various economic explanatory models according to which the role of man and society is subordinate to the natural elements (Van der Linden, 1955, reprint 1980; Verhulst, 1995).

The thesis that anthropogenic factors lie at the origin of significant alterations to the landscape of the coastal plains and constitute an increased risk of encroachments of the sea has been expounded in a number of significant historical-geographical studies published in the Netherlands (Borger, 1975 and 1988; Henderikx, 1986; Stol, 1981 and 1990; Dekker, 1988). Unfortunately we find that the only work that found its way into international literature is an outdated English historical-geographical synthesis on The Netherlands by Lambert (1978, reprinted in 1985). Within this context specific research was carried out on the French coastal areas, the results of which were rather limited due to the absence of early and relevant records (Beck and Delort, 1993). We did not find any evidence either of maritime transgressions on the Flemish coast (as a result of climate warming) in the historical era. In the course of our research, however, we were confronted with several irreversible human interventions in the dune ecosystem since the Great Reclamation Period (especially from the 12th century onwards) , which, eventually, in the Late Middle Ages, led to a considerable loss of dune area and land and to irreversible hydrographic changes in the course of the Zwin and Western Scheldt (Augustyn, 1992).

WERE THERE ANY OLD (= PREHISTORIC) DUNES LEFT IN FLANDERS IN THE EARLY MIDDLE AGES ?

Although, in contrast with the Netherlands, few relicts of prehistoric Older dunes remained in Flanders (Depuydt, 1972), we can state fairly confidently that they remained intact until the Great Reclamation Period and that they functioned as a natural sea wall for the hinterland which was not yet protected by any dikes. For, the young and unstable drift-sand dunes, which, in spite of the encroaching mass tourism, can still be found in some areas along the Flemish coast are an inadequate defence against the recurrent storm surges, as a result

which it is unlikely that there was any human activity in the coastal plain prior to the land reclamation period and the construction of an unbroken network of sea walls.

Yet a limited number of sources indicates that the Flemish coastal plain was indeed inhabited before that period, i.e. during the Early and Full Middle Ages. However, the earliest references to that effect (late 8th/early 9th century) cannot provide any evidence for the fact that the coastal plains stood clear of the water after a maritime transgression, in this case the Dunkerque-II transgression phase. On the contrary, these records provide exceptionally early proof of human activity in the coastal plain in the Early Middle Ages. Well-documented are the two extensive early medieval sheep farms or *bercariae* on Testerep, which was presumably the original name of a *shire* belonging to the 'Brugse Vrije', an administrative entity within the county of Flanders, limited by Ostend and Westend (which Blanchard mistakenly saw as an offshore island and which he used to support his sand coast regularisation theory), which were donated to the Saint Peter's Abbey of Ghent in the 10th century and which were large enough to allow this abbey to keep a flock of 900 sheep. However, several official records from that period provide evidence of the fact that there were many more. Several references to earnings from *lana* (wool) and *bercariae* in the coastal plains, found in the oldest remaining accounts of the county of Flanders, the so-called "Great Brief" , dated 1187, support that theory.

The toponymy of the Flemish coastal plain, an aspect of research in which hardly anybody had been interested considering the prevalence of the Dunkerque-II transgression theory, can also make a valuable contribution to the study of habitation of the coastal plain. The browsing through M. Gysseling's "*Toponymisch Woordenboek*" (Toponymic Dictionary) (in which only the toponyms mentioned in the charters are included up to 1226) yields a considerable number of names of Merovingian/Carolingian settlements (with suffix on *in(g)a(s)*, *ingahaim* and *sali*), scattered all over the Flemish coastal plain, from the north of France to Zealand Flanders : *Hundigehem, Oudinghesela* (Dunkerque), *Adenckerka* (Adinkerke), *Loringa* (Koksijde), *Latfinga* (Leffinge), *Onengem* (Snaaskerke), *Fortheringe* (Klemskerke), *Flessingehem* (Vlissegem), *Vertinga* (Wenduine), *Hadiggalant* (Meetkerke), *Utinga* (Sint-Pieters op de Dijk), *Ridsela, Dodesela* (Dudzele), *Grifningas* (Westkapelle), *Michem* (Oostkerke), *Hennekingwerve* (Aardenburg), *Stodingrewech, Cumbingascura* (Oostburg), *Pelechem* (IJzendijke), *Pakenge* (Biervliet). We can and we need to do further research in this domain. For instance, we have learned from more recent documents that a *Vackersele* and *Casinghem* must be situated in the present-day Nieuwmunster, *Garlinghem* and *Ghijsele* in Lissewege, *Spietsela* and *Scueringhe* in Zuienkerke, *Lopinghe* on the isle of Wulpen. Although it is still not possible to date the toponyms from the Early Middle Ages precisely – it is generally assumed that the Merovingian-Carolingian settlements were established between the sixth and the ninth century -, they are undeniably indications of the fact that the coastal region was inhabited in the Early Middle Ages, before the dike construction period.

The only explanation for this habitation of the coastal region is that the area must have been protected by a high, broad and stable dune range that acted as a sea wall, or, in other words, the Older dunes. This view, which we will support and substantiate below by means of historical data, is much more in keeping with the latest views on the evolution of the coastline and dunes in the Netherlands and the north of Germany (Müller-Wille, 1988), from which the Flemish coastal area cannot be dissociated. It also conflicts with the popular notion (conceived by Blanchard) that Bruges was originally situated by the sea. As we will demonstrate later on, it is very likely that it was only from the 12th century onwards that the people inhabiting the northwest European Plain had the hydraulic know-how to keep the coastal ports from silting up.

THE CULTIVATION OF THE DUNE AREA DURING THE GREAT RECLAMATION PERIOD (12TH-13TH CENTURY)

The destruction of the range of dunes, which was several kilometres wide, high, overgrown and even wooded, only began in the Great Reclamation Period, especially from the 12th century onwards, since more land had to be cultivated as a result of the changing political and economic circumstances and the growth of the population. Various factors led to a slow but irreversible degradation of the dunes from the 12th century onwards, to the extent that in the beginning of the 14th century seawalls had to be built in some locations to take over the protective function of the dunes. Furthermore, violent north-westerly storms got a grip on the dune landscape and precipitated the irreversible degradation of the dune landscape until, by the late 14th/early 15th century, little more was left but the small unstable drift-sand dunes we still know today.

The harbour construction and urbanisation activity in the dunes, which took place on a major scale since the second half of the 12th century, involved deforestation and levelling of the dunes, to use the literal description of a number of charters of foundation issued by the county. Let us cite a paragraph of the charter of Lombardzijde (1276) : *eussiens* [countess Margaret of Constantinople] *dounei masures partie es dunes u il ont maisonnei* (I have donated parcels of dune land on which they have built their houses). The town infrastructure was conceived by the Count of Flanders according to a draughtboard pattern, which is typical of the towns erected in the late medieval period. Only in Nieuwpoort has this draughtboard pattern remained intact.

Between 1163 and 1168 Count Philip of the Alsace founded the seaport towns of Nieuwpoort, Dunkerque, Gravelines, Calais and Mardick in the Flemish dunes, and possibly also the submerged town of Waterdunen on the isle of Wulpen, Biervliet on the Braakman, and Damme and Sluis in the Zwin region. Countess Margaret of Constantinople pursued this policy in the 13th century and founded Lombardzijde, the vanished town Nieuwe Yde in the Ijzer estuary, and Ostend and Blankenberge between 1246 and 1267.

Why was it necessary to build new ports in Flanders during the 12th and 13th century ? For there were plenty of other flourishing inland ports, such as Bruges, Ghent, Veurne, Diksmuide and Aardenburg. In this context we can formulate a number of different hypotheses, but it is most likely that the decision of the Flemish counts to erect these ports was prompted by financial motives. We may assume that they tried to shift the increasing harbour traffic to ports they founded themselves, with the intention of levying new tolls and excises.

The construction of coastal ports on the North Sea coast, which was subject to large tidal movements, only became possible when the impoldering of the hinterland became economically viable. This statement probably calls for some explanation. The sovereign '*wateringen*' or coastal polders were not exclusively reclaimed for supplying food to the growing population ; the drainage of fresh water from the polders by means of canal systems and sluices leading towards the new coastal ports also created a 'drainage basin effect', which

was necessary to keep the (artificially dug) harbour channel open. For it is a well-known hydraulic principle that the supply of fresh water counteracts the sedimentation of (salty) minerals carried along by the sea during high tide, and that, in addition, it creates a more stable balance between the duration of high and low tide, which makes it possible to keep coastal ports open (Van Mierlo, 1926). This implies that this principle was known in our regions as early as the 12th century, whereas the oldest record explicitly referring to this principle only dates back to the 16th century. The text describes the situation of the port of Middelburg on the isle of Walcheren : in 1549 they constructed a "*speuyer… om de voirs. haven te schueren ende zuveren opdat deselve myet en vervuyle metten slycke die de vloet van de zee daerinne dagelycx bringt*" (a sluice to wear away and clean the afore-mentioned harbour so that it is not polluted with silt deposited by the sea every day during high tide), as we can read in a document drawn up by the Secret Council. The application of the drainage basin effect in Flanders is described in many documents during the Modern Age ; time and again new plans were drawn up to reconstruct and improve the sluice systems, especially in Ostend and Nieuwpoort, two coastal ports which often suffered from an insufficient supply of fresh water, as a result of which sandbanks formed in the harbour channel.

However, as a result of the levelling of the dunes to build the ports, the latter were extremely vulnerable and threatened in the event of a storm tide. Ostend, the largest Flemish coastal port soon suffered the consequences of this disastrous human intervention. A century after the foundation of the town, during the Saint Clemens Flood of 1334, all frontal dunes were washed away and the church was moved from the seaside to the centre of the town, which indicates that part of the town was abandoned to the waves. Not even sixty years later, during the Saint Vincent Flood of 1393, the town was flooded again. A charter reveals that the Ostend town magistrate was given about 17 acres of dune land belonging to the count, for the reconstruction of the church and the submerged part of the city and the reconstruction of the harbour. During the Saint Elisabeth Flood of 1424, the sea again recaptured part of the town of Ostend, which meant that in a period of about 200 years' time the church, and consequently the areas situated on the coastline, had to be moved inland three times. This implies that in the 16th century, little remained of the original 13th century town as we can see on the map drawn by Jacob Van Deventer, and today it is completely submerged in the sea.

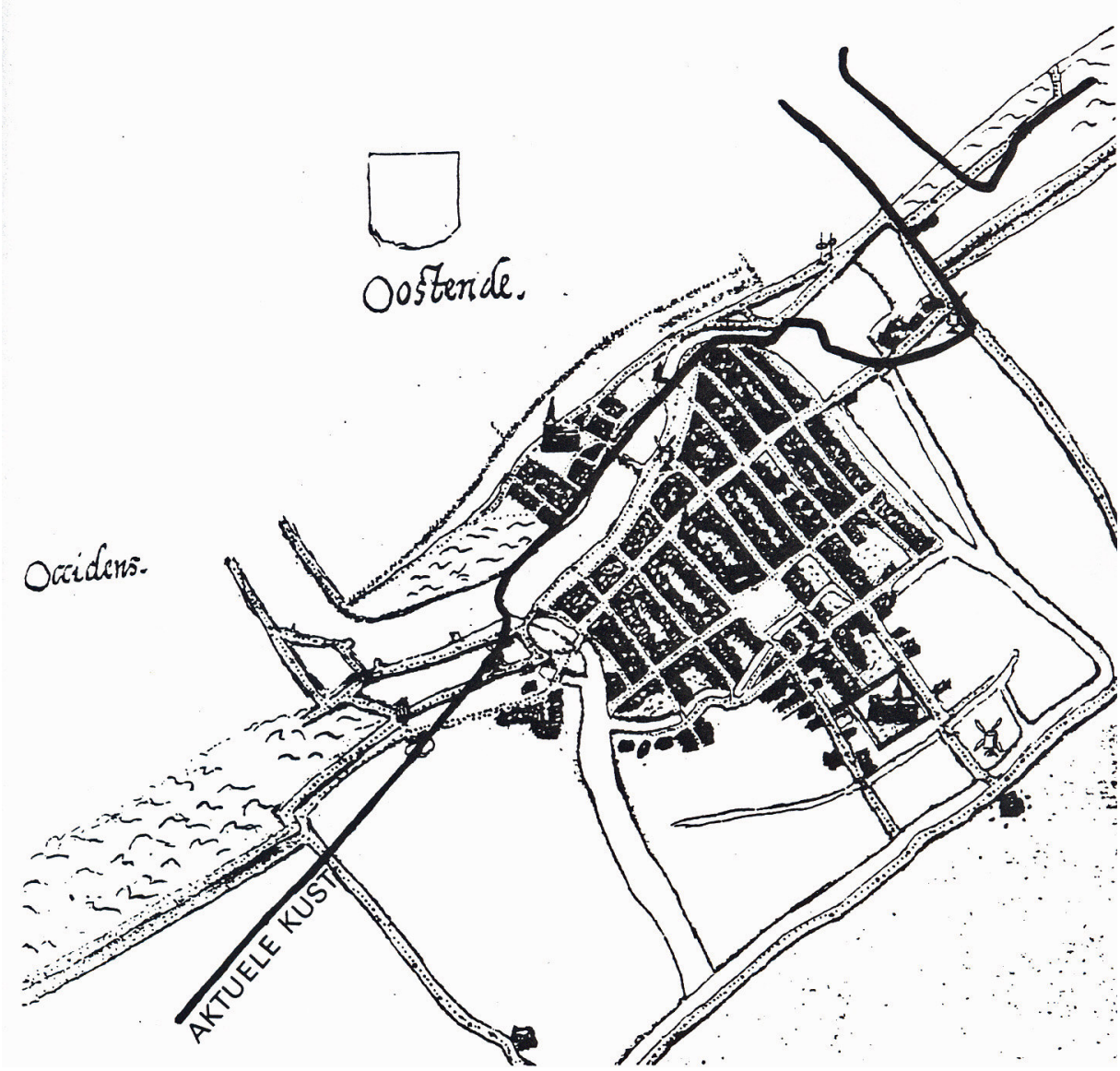

Figure 2: Town plan of Ostend by Jacob van Deventer dating from the middle of the 16th century.

___ is the current coastline. Note the remnants of the medieval town, which remained after the storm surge of 1393, with the port entrance located on the west side of the town, which was later moved to the east side. Note also the draughtboard street pattern of the section that was constructed in 1395.

The town of Blankenberge met with the same disastrous fate. It was also swept by the storm surge of 1334 and the church was moved to the inland village of Uitkerke. After the storm surge of 1424 the town magistrate was afraid that some houses would be located outside the dikes. As we learn from the town's accounts, he conceived a plan to construct a seawall across the town and to abandon the houses located in front of the seawall to the sea because of the dips and hollows that had formed in the dunes ("*daelen ende nederinghen inden dunen").*

Obviously neither the ports nor the road infrastructure they brought in their wake were able to destroy the entire Flemish range of dunes that acted as a seawall. The main hazard that marked the destruction of the Older dunes since the Great Reclamation Period was the almost total conversion of the dunes from a natural landscape into a man-made landscape, mainly intended for breeding cattle. As a result of the reclamation of the Flemish coastal plain, the large landowners, abbeys and local landlords moved their cattle farms or *bercariae* either to

the Flemish peat- or moorlands, or to the dunes which they leased from the count of Flanders. Furthermore, a count's account dated 1187 reveals that in the course of the 12th century not only sheep but also cattle grazed on the dunelands due to the growing demand for meat, butter and leather in the towns and cities. This grazing of the dunelands, numerous references of which we have found in ancient records such as the archives of the abbey of Ter Duinen in Koksijde – which in 1128 acquired a large stretch of duneland for stock breeding "*ad pascua suarum bestiarum"* (cattle, horses and sheep), indicates that also on the Flemish coast, the Older dunes were still intact on the eve of the Great Reclamation Period. For only a dune range that has gradually formed since prehistoric times has a thick humus layer which allows the development of grassland, shrubs and trees and which retains rainwater, which is the drinking water cattle needs to survive. (Firbas et al., 1959).

We dispose of exceptional information on the medieval dune vegetation in the Flemish region, which tells us that the dunes were covered with *nemora* (woodland), *virgulta* (brushwood), *spinas* (sea buckthorn) and *runcos* (bramble bushes). The fact that people were aware of the risk which such an extensive grazing of the dune range posed to the sea barrier function of the dunes, is demonstrated by the strict dune regulation which was implemented during that period and the creation of a special service installed by the count and headed by a *opperduunherder* (chief dune keeper) to enforce these regulations. However, by the end of the 13th century, these regulations were no longer applied very strictly. Due to the ostentatious concentration of power of the counts of Flanders and the resultant need for more financial resources, they sought to increase their *extraordinaris* earnings, inter alia by optimally exploiting their domains, which also included the dunelands. Subleasing the dunes, which resulted in overgrazing, was allowed, and fines for not replanting and for cutting shrubs and trees were no longer imposed. The oldest known Flemish seawall that runs parallel to the dunes is the inner dike of Heist, which was constructed in 1302. This indicates that in some locations the dunes had lost their sea barrier function and were subject to sand-drifts as a result of this short-sighted policy.

THE DESTRUCTION OF THE DUNES IN THE LATE MEDIEVAL PERIOD (14TH/15TH CENTURY)

As a result of the deteriorated economic situation and the violent civil wars that swept through Flanders during the 14th century, the management of dunes and dikes was completely disordered. After the Ghent Revolt (1379-1385) the economic recession in Flanders had reached an all-time low and there were no resources to carry out even the most urgent dune replanting and seawall repairs. Hence, it is not surprising that the inhabitants of the coastal region feared an imminent disaster at the end of the 14th century. Apart from inland sand-drift on a major scale ("*vloghe vanden zande"*), which cannot be attributed to a physical-geographical ' regularisation mechanism', as Blanchard postulated in 1906, nor to any climatic factors (stronger and more frequent northwesters and/or a rise of the sea level), the people of that era were aware of the imminent danger of the bursting of dikes and flooding of the surrounding land, as we learn from the Flemish literature of that period ("*waren de diken in aventuren van te brekene ende te verdrinkene al 't lant daeromtrent"* (1387). The afore-mentioned economic and political factors also provide a possible explanation for the different evolution of the coastal landscape in the Netherlands (which was much less urbanised, was subjected to much less economic interference by the authorities and was characterised by a more politically stable climate) where the Older dunes were largely preserved (Jelgersma and De Jong, 1970).

In Flanders the predicted catastrophe held off until the violent north-westerly storm of 19 November 1404, the Saint Elisabeth Flood. During this storm surge the dunes and polders were flooded up to 3 Flemish miles or about 15 kilometres inland, as we can read in Jacobus Meyerus's chronicle. Although this chronicle dates from 1561, more than 150 years after the disaster, Meyerus provides reliable information on this storm surge : in Meyerus's time the ruins of the villages that were submerged during the flood of 1404 still surfaced at low tide ("*cujus etiam nunc agnoscuntur vestigia"*) ! Meyerus's account of the facts is corroborated by a reliable administrative document, i.e. the direct tax adjustment of the so-called Transport of Flanders of 1408, which was needed because several taxable square kilometres op polder land had been yielded to the sea and a number of villages were submerged, i.e. Vijfhuize and Schaerte before the coast of Knokke, De Panne before the coast of Heist, Harendijke before the coast of Wenduine and Vogeldijk before the coast of De Haan on the Flemish east coast. On the Flemish west coast the damage caused by the storm surge must also have been substantial and is assumed to be the cause of hydrographical alterations to the Ijzer estuary (Casaer, 1993).

LOSS OF DUNES AND LAND IN THE WESTERN SCHELDT ESTUARY : FLOODING OF THE ISLE OF WULPEN

The Western Scheldt estuary was the region where most land was lost to the sea, since here the north-westerly storm swept across the land from two sides. The large isle of Wulpen, situated off Cadzand, with its five parishes Avenkerke, Briele, Remboudsdorpe, Oostende-Sint Precatus and Westende-Sint Lambertus, submerged in the sea. This island used to have a port called Waterdunen, although it had probably been abandoned to the sea after the Saint

Clemens Flood of 1334, which, as we already described above, also ravaged the towns of Ostend and Blankenberge. During that flood the dune range on the isle of Wulpen had been severely damaged, as a result of which the isle completely flooded in 1404, whereas the much smaller island of Cadzand, which had only one parish and which was situated under the lee of the isle of Wulpen, was largely spared during that storm surge.

Wulpen can be accurately reconstructed by means of a map drawn around 1547 by the well-known 16th-century cartographer Frans van de Velde, in combination with the account of the demarcation of this island in 1290 by order of the Saint Bavo abbey of Ghent, which possessed ecclesiastical rights in four of the five parishes on the island. Frans van de Velde may, of course, have drawn his map on the basis of these or other surveys. However, it is more likely that he reconstructed the isle of Wulpen on the basis of the visible *vestigia* (ruins) of this island. Yet , we may wonder why, 150 years after the abandonment of this island to the sea, it was still possible to trace its contours ?

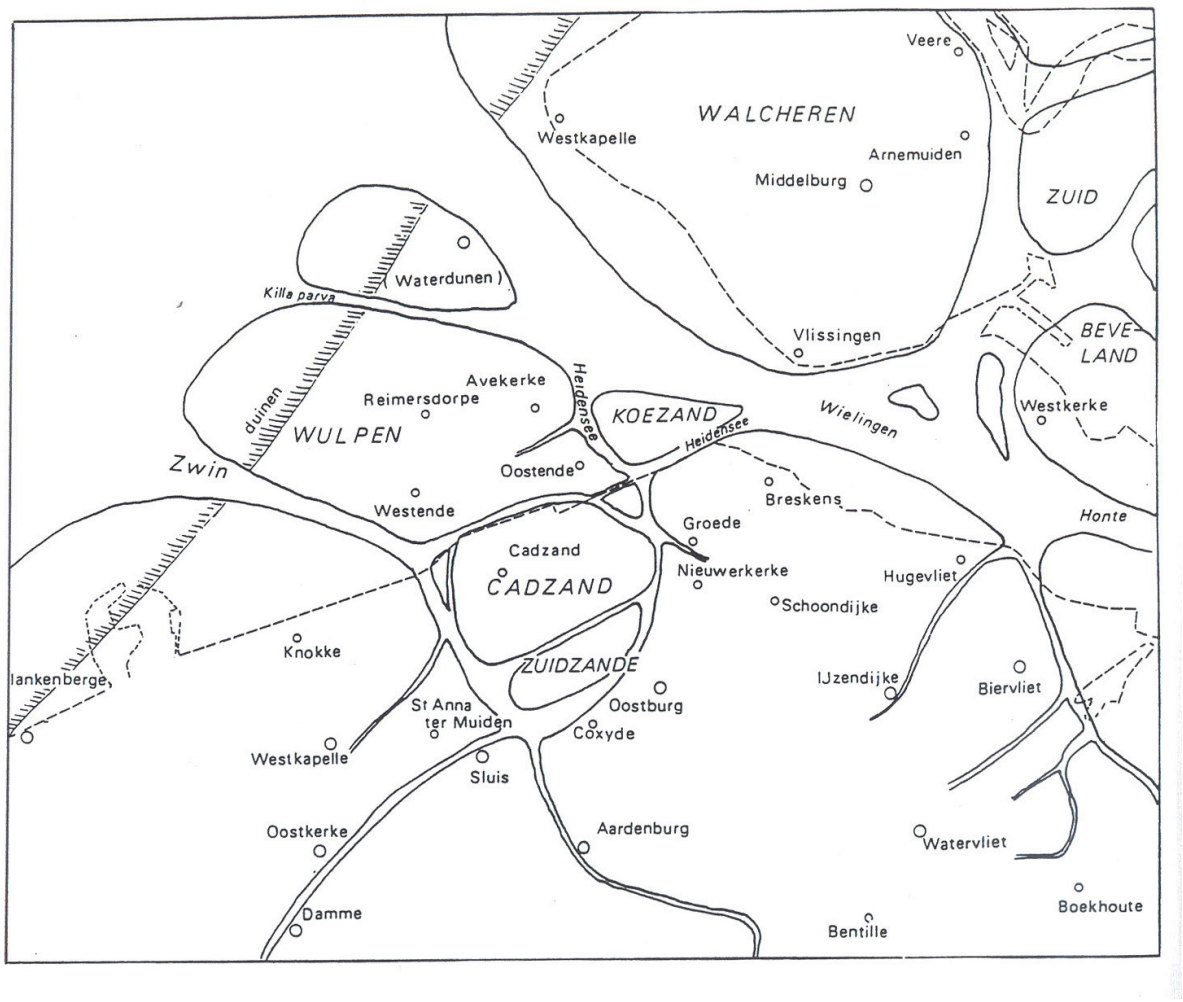

Figure 3: Reconstruction map of the Scheldt delta north of Bruges circa 1300 by cartographer Frans Van de Velde, middle of the 16th century , projected by ourselves onto a topographic map.

------ is the current coastline.

First of all, we should bear in mind that yielding land to the sea was a much slower process than we generally assume. Furthermore, the location of the submerged villages in the Braakman (Zealand Flanders) during the 1488 storm surge was still precisely known in the 16th century and was charted by Frans van de Velde and studied by Gottschalk (1958).

Moreover, during the Ancien Régime it was strictly forbidden to pull down and remove materials of useful navigation beacons such as church towers rising above the water surface ("*te breken eenighe zeemarcken van torens, kercken oft baken resterende van der inundatie…noch oock te vervoeren eenighe steenen oft materialen vandien up verbuerte vanden lijve"*) (Decree of 1685), since such ruins allowed the ships to detect and sail round dangerous 'obstacles'. Two ships did run aground on the isle of Wulpen during the storm of 2 February 1408 : a Genoa caravel and a hulk from Lisbon. When the storm died down the wreckage and washed up goods were transferred from Wulpen to Cadzand by means of carts (!). In 1412, a "*mote"* on the isle of Wulpen appears to be inhabited by some poor folk and the reclaiming of Wulpen started in 1418. However, this reclamation did not extend beyond two polders northeast of Cadzand, which would persist throughout the entire period of the Ancien Régime and would only be abandoned to the sea after the storm surge of 1808.

THE CONSEQUENCES OF THE ABANDONMENT OF THE ISLE OF WULPEN IN 1404 FOR THE NAVIGATION ROUTES TO BRUGES AND ANTWERP

Why was the isle of Wulpen not completely reclaimed ? After all, the economic side effect was detrimental, especially to the city of Bruges. The yielding of land in the Zwin estuary, which was the navigation route to Bruges, soon led to the silting up of this water course. In this context we must bear in mind that the route from the Zwin to the sea was about 15 kilometres longer before the storm surge of 1404. The estuary mouth was originally much wider and allowed a much larger volume of water, and consequently the tidal flow rate was much higher before 1404, which resulted in the erosion of the water course. The silting up of the Zwin area grew worse due to the fact that the barrier bars on which the submerged dunes had formed, started to develop into sand banks which were drawn into the new Zwin estuary by the tidal flow.

We believe that the abandonment of Wulpen to the sea is mainly due to two factors : first of all there is the deteriorated economic situation of the region, which lasted until the first two decades of the 15th century, and secondly there was the trouble with the English. Troop movements and arsons at the coast ("*aen den zeecant")* continued until 1410. To hold off the threat of war, the sovereign had stockades constructed at Sluis, in the Zwin area, which contributed to the land accretion. It was not until 1420 that Philip the Good leased out these accretions, which by then had developed into salt marshes, to the citizens of Bruges and allowed them to carry out excavations in the Zwin area, which had locally become so shallow that the sailing vessels could no longer reach the city of Bruges unless there was a spring tide. In fact, at that time the hydrographic situation could no longer be reversed. The hydraulic operations that have been carried out since then, particularly in the tidal basin that had formed, called 'Het Zwarte Gat' (the black hole), and through which part of the Zwin water was drained off, were all in vain. This was one of the reasons why Bruges failed to develop into a prominent international market during the 15th and the beginning of the 16th century and was superseded by Antwerp, which managed to capitalise on the colonial trade (Brulez, 1970).

Antwerp turned the abandonment of the isle of Wulpen in 1404 to its advantage. The mouth of the Western Scheldt estuary became wider, which resulted in a bigger water volume and a higher flow rate in this coastal inlet, which allowed ships with a deeper draught (like caravels and galleons) to reach Antwerp via the much shorter Western Scheldt route instead of via the Eastern Scheldt.

The above is borne out by C. Calvete de Esterella's account of Philip the Second's tour of the Netherlands in 1558, during which he also visited the city of Bruges : "*Cette ville [Bruges] était jadis l'entrepôt de tout l'Europe et l'une des quatre grands marchés du continent… mais à la suite des guerres et des séditions du peuple contre ses chefs et ses gouverneurs, le commerce transporta son siège et ses foires à Anvers où le flux de l'Escaut lui offre bien plus de commodités… Bruges ne conserva que le trafic des laines qui y fait affluer surtout les Espagnols"* .

CONCLUSION

The purpose of the present article is to demonstrate that the disruption process of the original coastal ecosystem of the so-called Older dunes on the Flemish coast only started during the Great Reclamation Period as a result of anthropogenic factors, until, with the exception of a small stretch on the West Coast, it was completely destroyed in the 14th and the beginning of the 15th century. Since that period, seawalls were constructed to shore up the newly formed Younger Dunes which consisted of loose sand and which have been subject to inland sand-drifts throughout the Modern Age. No connection was found between the abandonment of land and dunes and marine transgression phases, or climatologically warmer periods, and therefore we support the views of Gottschalk (1971-1977), who questioned the existence of these medium-term climate waves on the basis of her historical study of storm surges.

Today, the social relevance of what we call anthropogenic climatology, the most recent branch of scientific ecology, is acknowledged more and more. This discipline is supported by physical and chemical scientists who have been publishing measurement data on the projected anthropogenic climate changes as a result of the by now universally known Greenhouse effect since the eighties.

As becomes clear from the preceding study of the evolution of the Flemish dune ecosystem, this does not imply that historical-climatological research has lost its function entirely. On the contrary, further research in this field remains necessary and may provide additional data to negate the largely hypothetical physical-climatological theory which is quite persistent. And we are not the only ones to take that view. (see, for instance, the introduction in Beck and Delort, 1993).

However, nobody probably realises that this physical-climatological theory about medium-term waves of rises and drops in the sea level caused by periods of warming and cooling of the climate in the course of history, is based on a small article on the Flemish coastal plain, which was published in the "*Annales de la Société géologique du Nord*" in 1877-1878. Most climatologists are not aware of the fact that this theory was only introduced in the fifites in Belgium and the Netherlands, on the basis of Blanchard's work "*La Flandre*", which was published in 1906, nor are they aware of the importance of the articles by Bakker for the world-wide propagation of this theory. In this respect we specifically recall the famous meteorologist Lamb, who, in his numerous publications in the seventies and eighties, made the existence of these climate waves widely known, inter alia by quantifying a selection of storm surge disasters in Northwest Europe, which he saw as "*major storm surges"*. However, in his interpretation of these *major storm surges* he failed to consider the possible

anthropogenic factors, which did play an important role, as can be demonstrated on the basis of the singular and highly relevant records of the Flemish coastal plain. This fact had already been established for the Netherlands in the studies on the abandonment of the 'Grote Waard' after the storm surge of 1421 (Stol, 1981) and of Zuid-Beveland during the successive storm surges of 1530 and 1532 (Dekker, 1988). The extent of these storm surge disasters and the possibly permanent loss of land they brought in their wake, were to a large extent also due to economic and political factors.

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