Learning by doing or expert knowledge? Technological innovations in dike-building in Coastal Flanders (13th-18th century AD).

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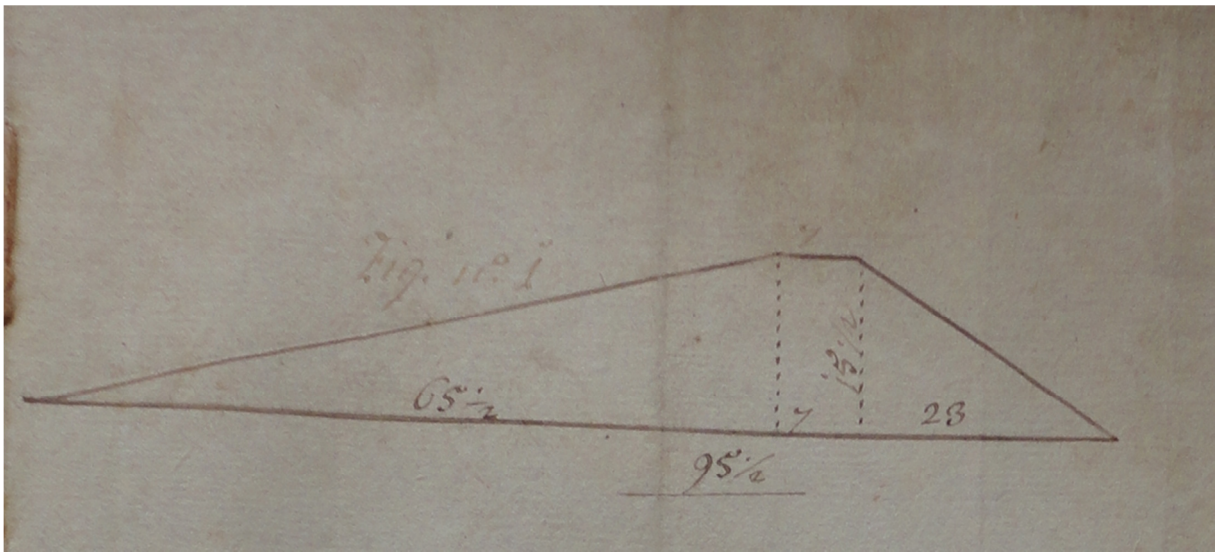
1. Introduction: a 1783 embankment.

In Early Modern Europe, embankment of polders and drainage of wetlands were high status activities, even among the highest nobility of Europe. This painting was commissioned around 1784 by the blind duke of Arenberg, Louis Englebert (1750-1820) and shows us in unusual detail the embankment works on his so-called New Arenberg-polder on the left-bank of the river Scheldt near Antwerp.

- The painting reveals some of the charcteristics of late 18th century dike-building:

- we see the main dike being built, with a steep land-side and a more gentle sea-side



- To the sea-side a so-called ‘karreveld’ or ‘earth-extractment place’ is constructed, protected by a smaller dike (the achterkade).

- the most difficult part is left to the last: the closing of the tidal channels that crisscrossed the area.

- Essential labour-tools were the wheel-barrow (probably with boards that could be removed), the spade, foot planks, a sort of sledge to carry earth, and flat-bottomed ships which can travel easily through the mudflats.

- sods were cut on the higher places of the saltmarsh, and intended to reinforce the dike.

- We also see some details which are not that evident: normally embankment projects embank raised saltmarshes (rijpe schorren), which were no longer flooded during normal floods and could easily be converted to agricultural land. Here, we see that not only saltmarshes but also a good deal of mudflats were embanked.

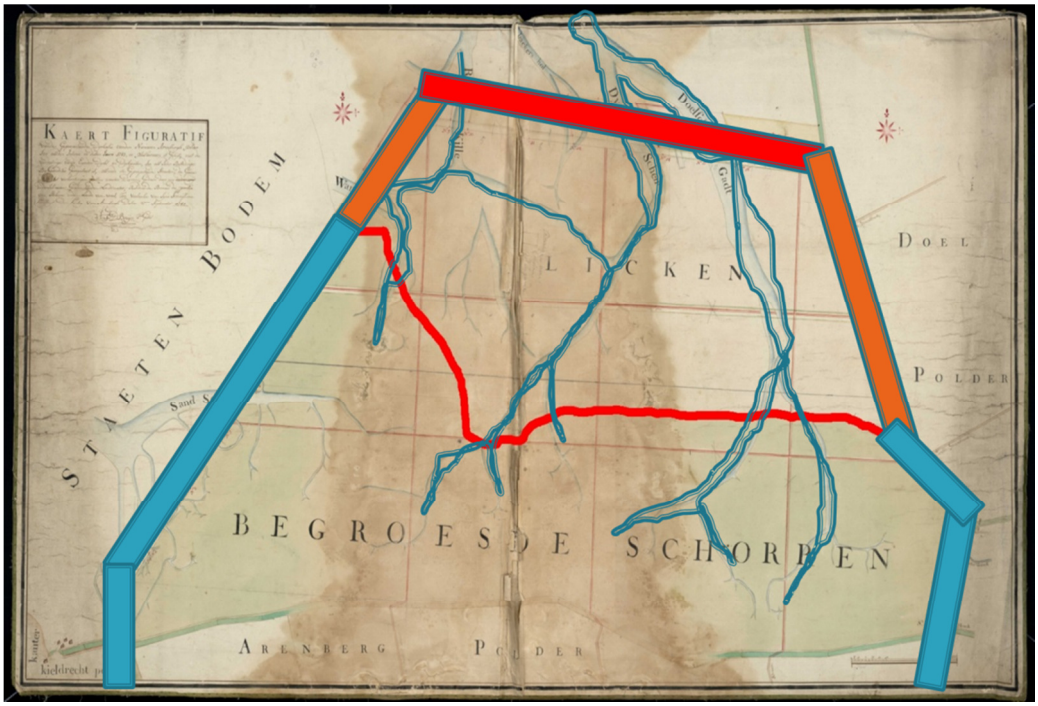


Figure: map of Nieuw-Arenberg, showing that the new dike encompassed both 'schorren' (raised saltmarshes – with the dike in blue, and 'slicken' (mudflats – with the dike in red).

- finally we also got an idea of the organisation of dike labour in the late 18th century. The large groups of workers, the systematic organization, the presence of soldiers to control the labourers, and the food provisioning system (including the only women on the painting) give us the impression of an army-like organization, which certainly pleased the duke of Arenberg. We'll come back on this point to.

2. **Historiography:** dike building is not exactly the type of object favoured by science and technology studies

Dike construction apparently uses simple technology, with slow and gradual change; not the kind of technology that reshaped the material conditions of living, comparable to the spread of electricity or sanitation in the 19th century 'networked' city (and linked to the disciplining of society and the rise of domesticity and the modern self-reflexive individual) (often inspired by Latour and Foucault). The basic evolution discerned in literature, mostly based on archaeological evidence, is from steep and low medieval dikes to more gently sloping, higher and much more massive dikes in the early modern period.

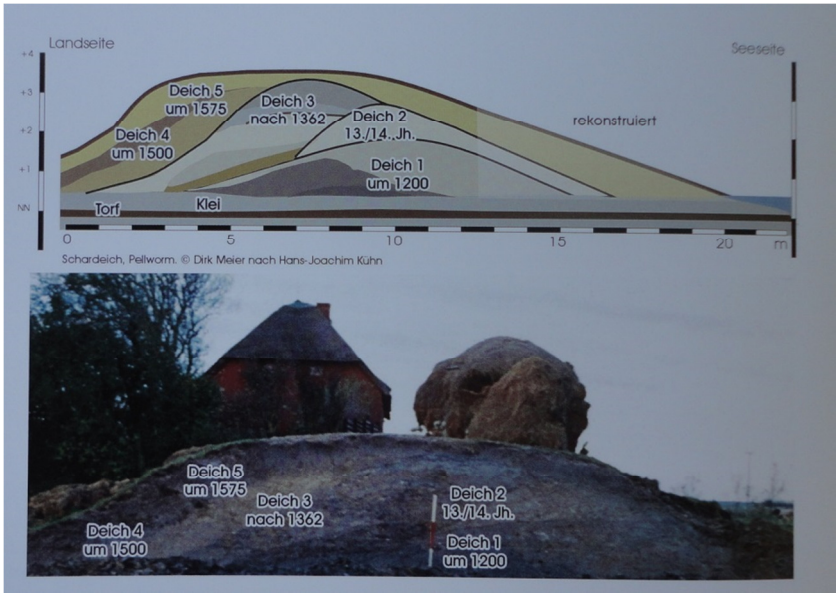


Figure: dike profiles on the island of Pellworm (Schlesiwg-Holstein) Meier et al. 2013

19th century engineers and 20th century historians alike applauded the tendency towards standardization, and government control which first appeared in the late 18th century in the Dutch Republic, with the introduction of a technical service for water management within the Ministry of internal affairs (the predecessor of Rijkswaterstaat, 1798) (see the synthesis by Van de Ven 2003).

On the other hand, for coastal societies this was 'capital technology', part of 'large technological systems', making the difference between life and death, and an essential feature of coastal landscape and life, and a locus of political power.

As such, a long-term analysis of dike building might shed new light on some essential features of pre-modern technological evolution.

- The rise of experts?
- standardization?
- commodification?
- disenchantment / demystification?
- technology as a tool to control nature ?
- the evolution of intrinsic versus added value ?

The history of dike building also cannot be properly understood without the evolution of coastal agriculture. From the medieval into the 19th century, coastal agriculture saw a decrease in the importance of wetland activities and a radical simplification of nature (as Donald Worster calls it), in focusing on the production of a limited set of (agricultural) products, and dismissing other activities.

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3. Our argument: we will show how embankment knowledge was gradually transferred from being a part of agriculture, to both groups of (self-declared) experts held in high esteem and a self-declared workforce.

- Implements played a role in this process, both implements that were introduced, and implements that disappeared (the horse).
- As we will see however, it was not so much the technology of dike building in itself that changed, but rather the control of this technology became more exclusive. Especially in the 16th and the second half of the 18th century, there was an appetite for technological innovation in dike building, but these innovations cannot be

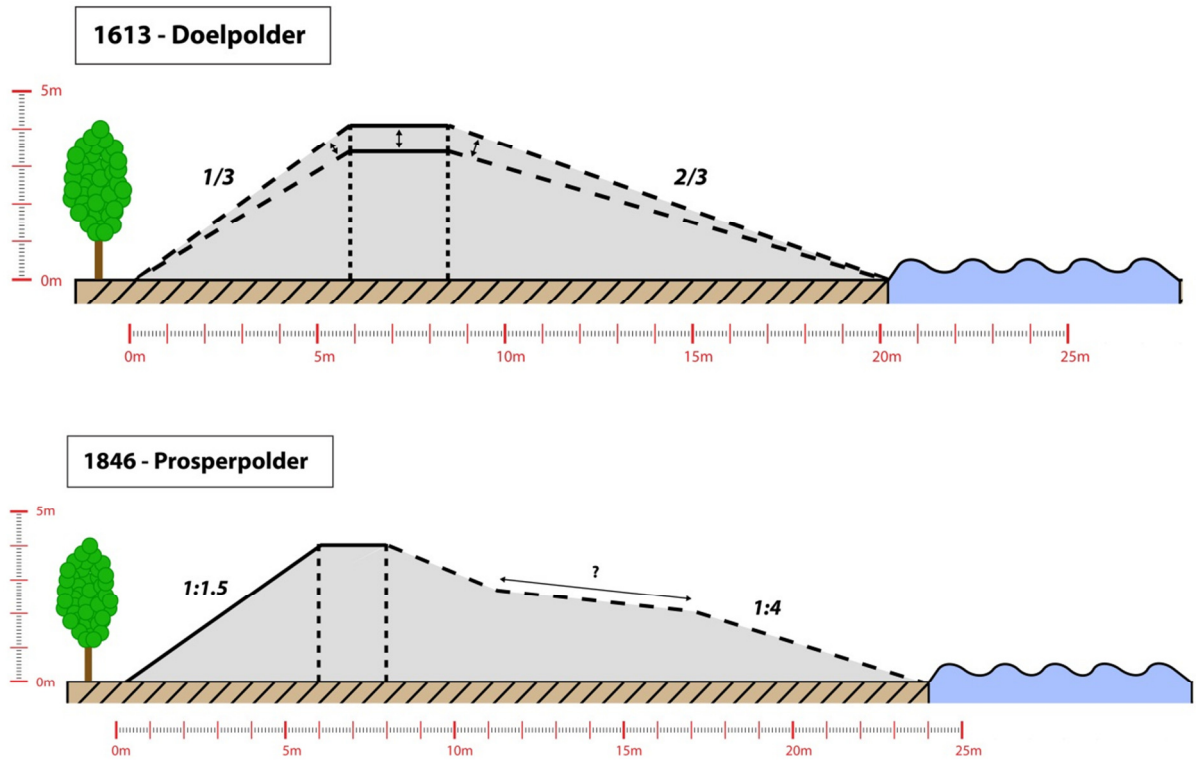
understood without taking into account broader shifts in the reorganization of dike labour.

- The result of this process was a gradual dissociation of the dike from both the rural economy *and* the coastal environment, in which it functioned.

- The consequence of our point of view arly modern or even 19th century dikes cannot be cannot be considered inherently 'superior' or 'more effective' than their more localized predecessors. They just corresponded to different realities, both in the organization of their construction, their ambition for technological control over the wetland environment, and the rural economy they served.

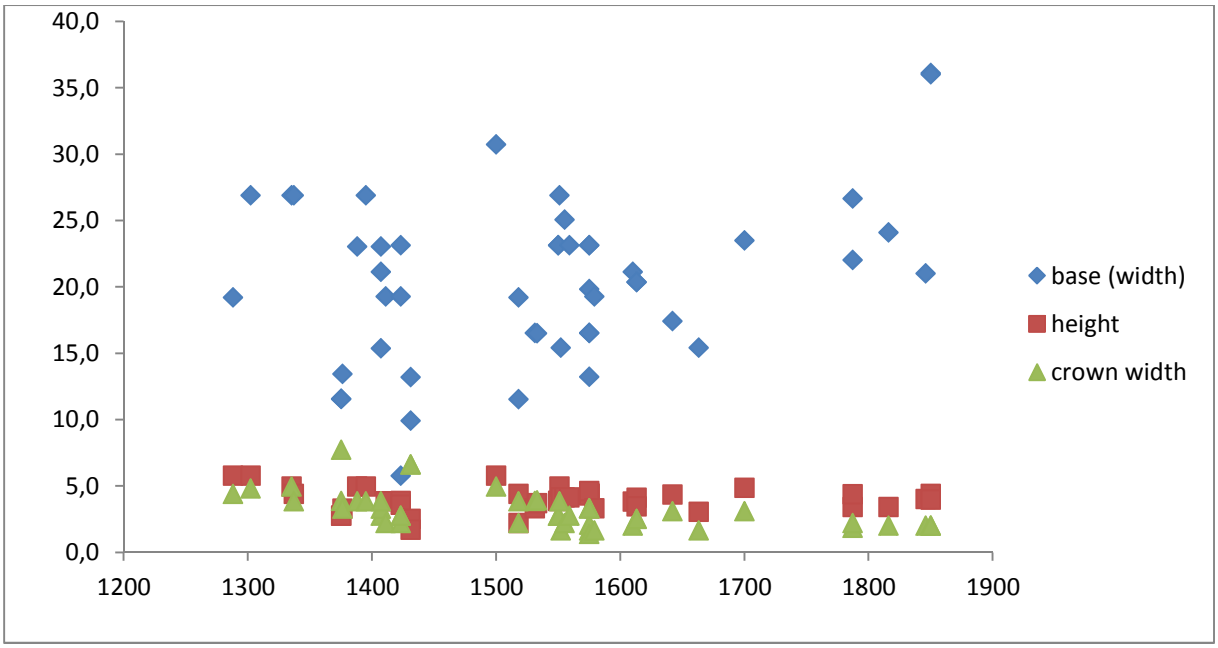
- The rest of this presentation uses two sets of data. On the one hand, we use 49 dike profiles from all over coastal Flanders, allowing us to present an quick overview of 5 centuries of dike building, according to historical sources. Secondly, we have examined more in detail data on one specific area, the Waasland polder area, on the left bank on the river Scheldt, where a beautiful sequence of dikes has been preserved ranging from the 16th century to the early 20th century, with several medieval predecessors hidden in the rich polder clay.

Waasland polder dikes: 1613 dike of Doel to the left and 1846 dike of Prosperpolder to the right

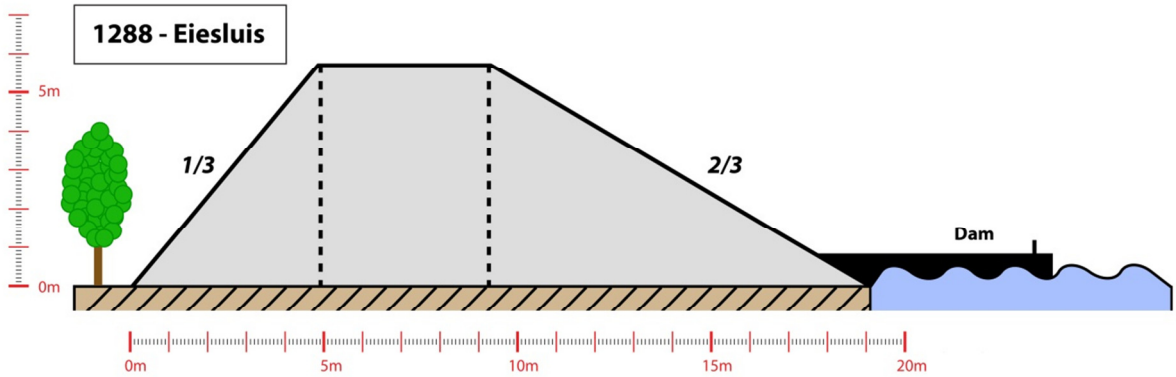


4. Bigger, higher, heavier? Dike dimensions from 1280 to 1850 AD.

Based on historical evidence, mainly instructions for the construction of new dikes, and some surveys of existing dikes, we could reconstruct so far the dimensions of 49 dikes built between 1288 and 1850 along the Flemish coast and the Western Scheldt Estuary.

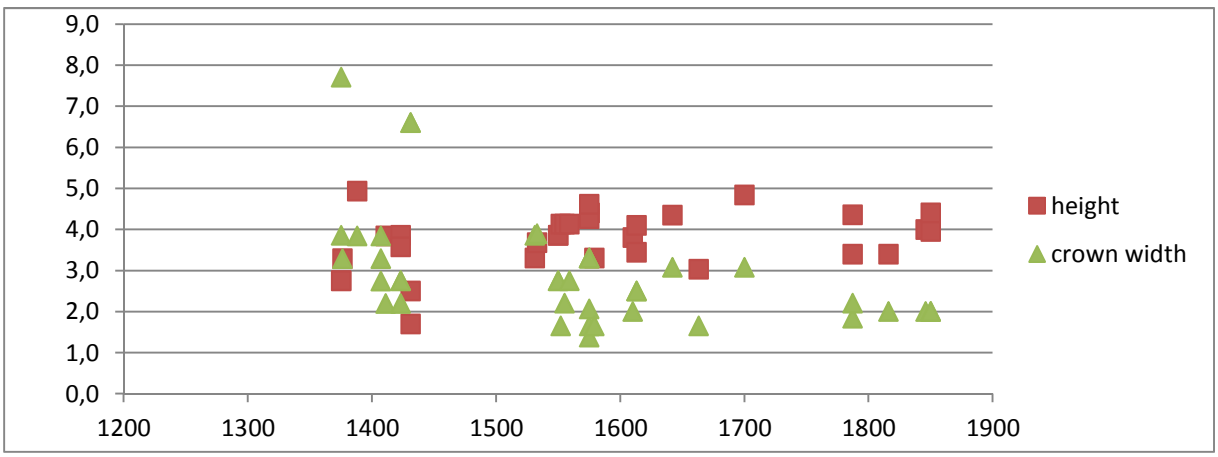


Notwithstanding a slow but steady rise in sea-level (8 centimeter per century?), and a much more pronounced rise in regional water levels in the Scheldt Estuary, there was no general tendency towards higher dikes.



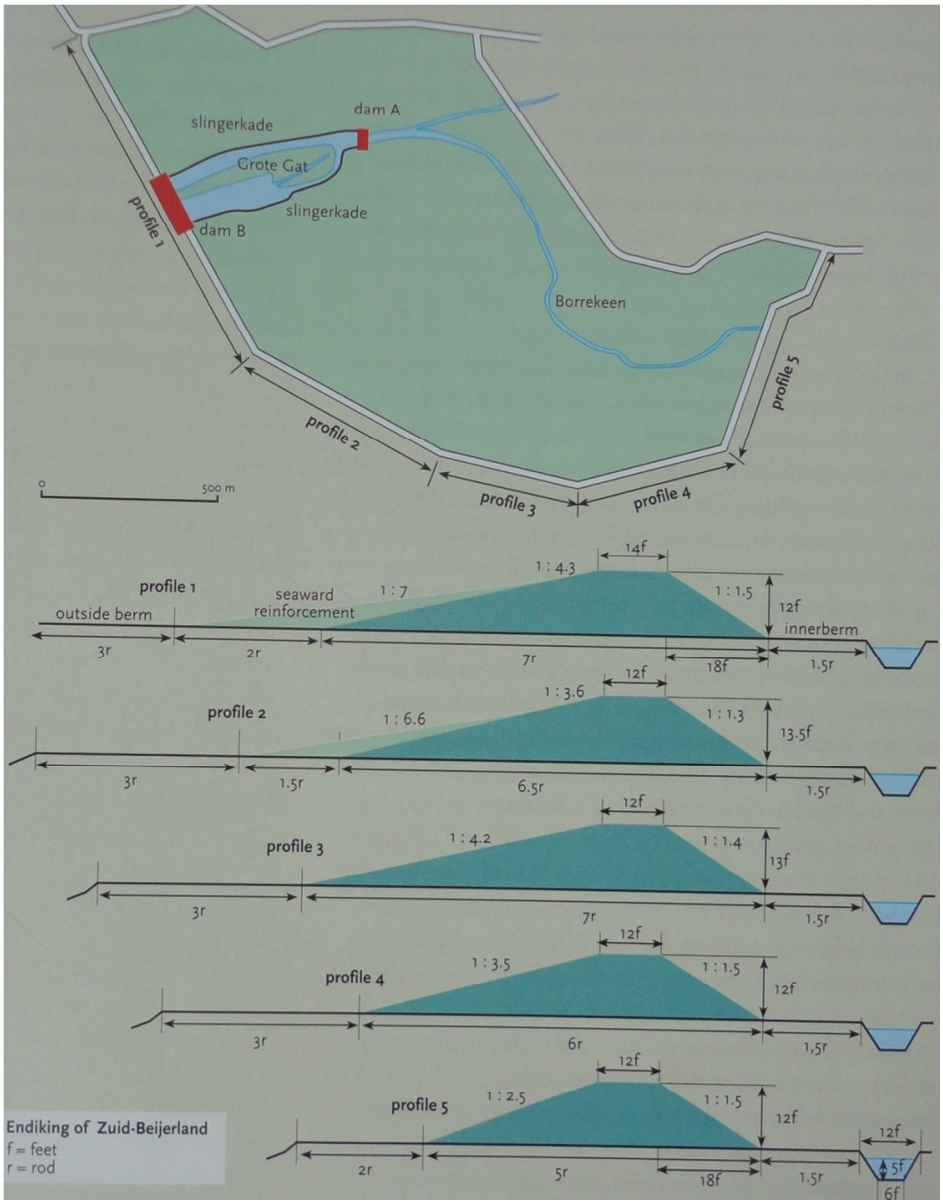
Heavy medieval dike: Eiesluis (Heist) 1288

To a certain extent, our evidence is misleading, because a lot of medieval dikes were constructed along the North Sea coast, where higher dikes were necessary, but even when concentrating solely on the Western-Scheldt area, we see that both around 1400 and around 1800 dikes of four meter height were built, that is four meters above the surrounding land (compared to modern ordnance datum, medieval dike levels were of course lower, as they were built on lower lands, whereas early modern dikes were built on newly sedimented land, which had kept pace with sea level rise. Before 1800 dike heights were based on local ground levels, not absolute heights, based on water levels. Only systematic sounding of water depths, starting in the (late-) 18th century, and the uniformisation of water levels in the early 19th century would allow to construct dikes of similar absolute heights, e.g. Fischer, Wassernot, 46).



- We do see other changes however: the range and variation in dike dimensions declined: medieval dikes could be very high and wide, but they also could be very tiny. A certain tendency towards standardization appears. The variation in medieval dikes can be linked to their purpose, and their adaptation to local environmental and social conditions. Whereas some dikes had to offer secure protection to settlements and arable land, others could do with a lower level of flood protection, as houses remained concentrated on higher lands. In the early modern period dikes invariably served the permanent 100% protection of land aimed at arable farming and settlement. Nevertheless, even 17th and 18th century dikes were not of strictly uniform dimensions: a weaker subsoil for instance often necessitated a higher and wider dike, as a higher degree of subsidence was expected[1]:

[1] Cfr. Embankment Nieuw Arenberg 1784, foto 3866: questions on the opportunity of uniformity. Cfr. Van de Ven, p. 137. Zuid-Beijerland (still much more variation in dike sizes!!!).



Dike profiles Zuid-Beijerland 1631 (Van de Ven, 137).

- What disappeared was the tradition of medieval dikes with very wide crowns: around 1400 we still see some dikes of about 7 meters width at the top, which were no doubt used for transport, even with horse and cart.
- By diminishing the crown width, and extending the base of the dike, the slope could become more gentle. However, it's a common misunderstanding that medieval dikes were too steep.[2] Medieval dikes in Flanders were no walls, and Flanders also did not see the multiplication of vertical 'Stackdeiche', which multiplied in the North of the

[2] Kühn, Sieben Thesen, 1992: "*Schier unausrottbar scheindt die Behauptung zu sein, die frühen Deiche seien steil profiliert gewesen und hätten schon deshalb den mittelalterlichen und frühneuzeitlichen Sturmfluten nicht standhalten könen"*

Netherlands in the 15th and 16th century, but they were nevertheless steeper than their early modern successors. In 1375 for instance two new dikes in the Waasland area had sea-side slopes of 1:1 and 1:8 respectively, which was certainly steep, but on the other hand, in 1423 we already find a new dike in nearby Saaftinghe constructed with a sea-side slope of 1:3,5. 17th and 18th century new polder dikes in the region usually had slopes of 1:3 to 1:4 as well. [3]

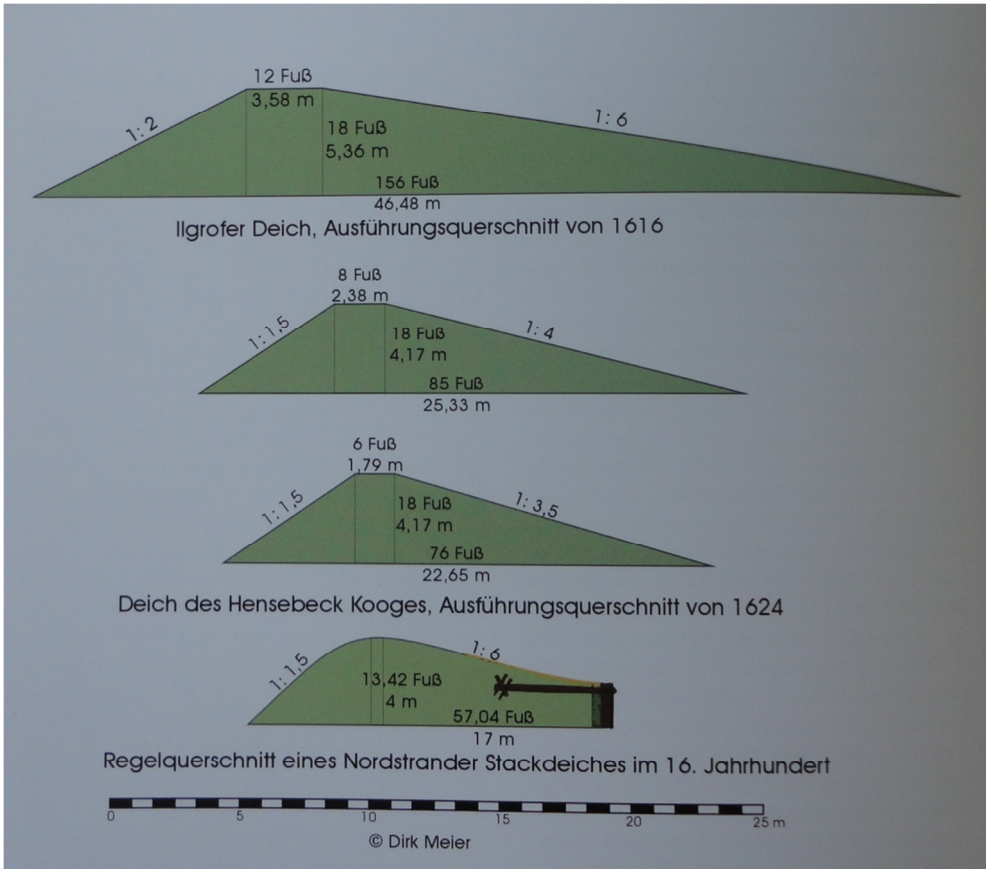


Figure: 16th and 17th century dike profiles in Nordstrand (North-Frisia, Schleswig-Holstein, Meier et al. 2013): no straightforward evolution towards higher, bigger and less steep neither.

5. The materiality of a dike

Dikes are much more than just large humps of earth. The preferred material for the body of the dike was fat clay, with a good fixation, although no strict prohibitions on sand were

[3] Eventueel nog uitwerken met BUITENBERM als vernieuwing, cfr. Prosperpolder en Bauwens and de Kraker.

issued for the inner part of the dike: only the cover of the dike body was obligatory made from either arable land (*'corenaarde'*) or clay, with an increase in thickness from two, to three, four or even five feet in the sixteenth century.[4] The primary material (clay or sand) was basically considered a free one: as much as possible it was to be taken outside the future dike, where future sediment disposal would refill the pits dug (which however not always happened). The cost of dike building was the labour cost of digging and transporting this earth, and constructing a dike from it. In the latter century, we see an increasing attempt to **calculate and rationalize the 'volume'** of the dike body and the amount of work it represented. Sixteenth century sources increasingly mention a specific unit for the volume of earth in a dike, which was used to contract works, the 'schacht', defined as one square *roede* (rod), one feet thick (about 4 m³).[5]

The use of a uniform unit of volume allows us to calculate labour productivity in dike work from the 16th to the 19th century.

Dike	**wage**	**wage/m³**	**day wage unskilled[6]**	**M³ PER DAY**
Andries Vierlingh, c. 1570[7]	3,5 stuiver/schacht	0,875 stuiver	4,4 stuiver	5,03
Paardenschor 1663	12,5 stuiver/schacht	3,125 stuiver	15 stuiver	4,80
Prosperpolder 1846	30-45 centimes/m³	30-45 centimes	140 centimes	3,11-4,67

16th and 17th century dike labourers needed to transport 5 m³ of earth a day to earn a day wage, 19th century dike labourers in the Prosperpolder about 4 m³. Apparently, no big increase in labour productivity could be reached in dike work, which however must be linked to the technological and environmental of dike building (see below).

[4] Kadzand 1500: two feet; Axel-ambacht 1515: four feet; Ostend: five feet; Doel 1567: three feet.
[5] The thickness of a 'schacht' is not entirely clear: the 16th century Dike expert Vierlingh (de Hullu and Verhoeven 105) assumes 6 thumbs (about 0,26 cm) for sods. But as he admits, other count a thickness of one foot (cfr. Beekman, Dijk en waterschapsrecht). Probably the 'schacht' of sods was different than the 'schacht' of earth. Using Ghent measures, we calculate a Schacht of earth at 4,08 m³ and a Schacht of sods at 2,26 m³
[6] Vandenbroeke, Werkinstrumenten
[7] Vierlingh, pp. 105-106. Vierlingh however speaks of sods.

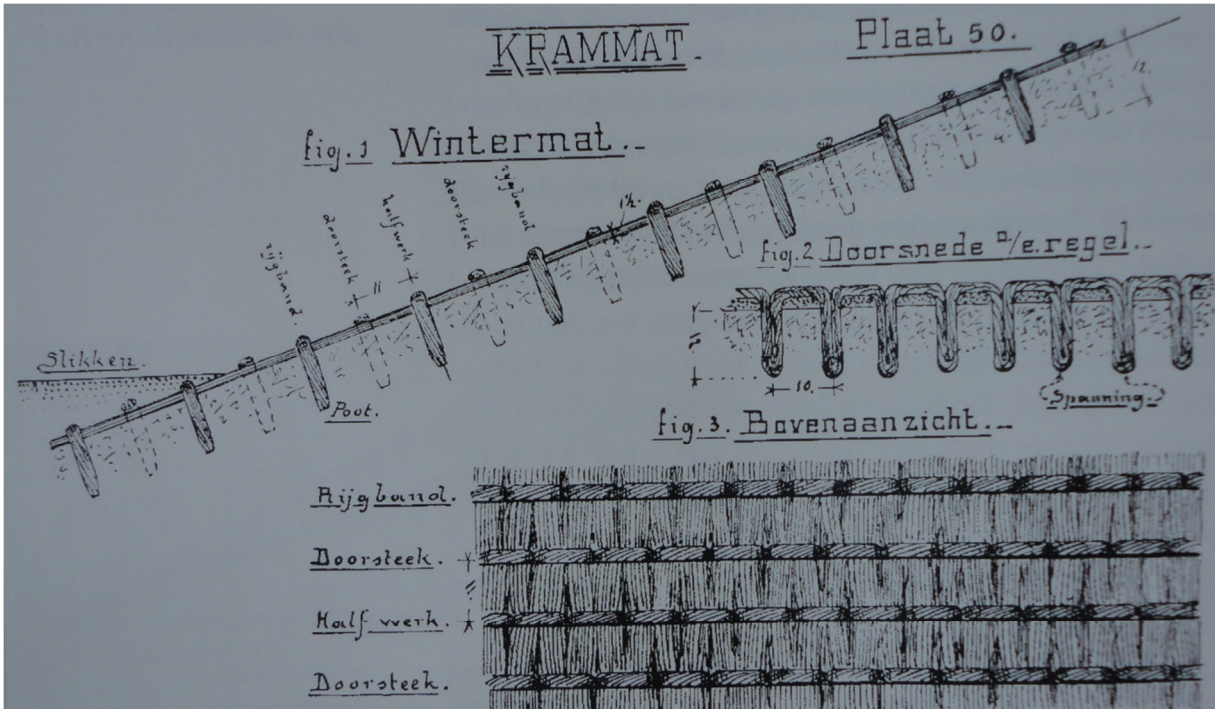
Compared to early modern ones, medieval instructions were less explicit on the body of the dike, but often more explicit on the land where the earth was dug. Fourteenth and fifteenth century prescriptions, contain detailed instructions on the so-called 'Karrevelden', where the earth was dug. These must be well developed, no closer than about 7 meters from the dike, in rectangular pits separated by dams.[8] The 18th century New-Arenbergpainting also shows us a pit, but this was a rather irregular, messy pit.

From the 14th century onwards, the body of the dike was covered by two coats, the first one of gras sods, about 6 thumbs or fifteenth centimeter thick, which should root in the body of the dike. The second one received more attention, these were the **fascine** or **osier** works. The most common (and cheapest) kind of fascine was a **carpet of straw (less rush)**, which was common in coastal Flanders, at least from the second half of the 14th century onwards[9].

[8] See 1388 Oude Yevene (a barm every 5 rods): "Ende de vorseide zeedijc wesende zesse roeden met aerden belopen, achtiene voeten hooch, viertiene voeten breet, boven de tweedeel vander laghe vanden dike ter zeewaert ende tardendeel te landewaert met twee roeden barems tenden voete vanden dike ter zeewaert ende met eere roede barems te landewaert ende datmen de tweedeel vanden weercke soude nemen ten zeewaert ende tdardendeel te landewaert ende dattie dijcpitte ter zeewaert lanc sullen wesen achte roeden ende viere roeden te landewaert, ende dat men telken vive roeden soude laten eenen veldam (blanco) roeden breet of der boven ende datmen den vorseiden liedijc maken soude vive roeden breet met aerden belopen zeventiene voeten hooch ende twalef voeten boven breet met baremme ende veldamme ghelijc den andren ende met alsulken laghen alst voorseit es ende datmen daer of tweerc nemen soude ghelijc den andren ende datmen de tweedeel van desen voorseider weercke bereet hebben soude tusschier ende Sinte Jansdach eerstcommende ende vulmaect te sine te Sinte Baefmesse daer naest commende,

[9] Rk. Eiesluis 1375-76: *"Item van ghelie daer de aerm mede ghecramt was ende den voet van den niewen dike: .. Summa van den stroe XII s. C over C II s. groten, summa pec.: 50 lb"*; rk. 1376-77: *"Item stroo ghepoot tusschen den ostende van den niewen dike ende den poortcruce van Blankenbreghe: ... Summa van den stroye: XVIIIm VIc, elc ondert VI groten, summa pec: 186 lb"*; rk. Blankenbergse 1377-78: *"Item van gloye daer die dijc mede ghecrammet was: IXc gloys over thondert: XXII grote, summa in ghelde: 33 lb."*; rk. Noord-over-de-Lieve/Lapscheure 1400-01: *"Item Michiel f. Clais ende Jan f. Ghisselins vanden zeedijcke te verstekene ende te aerdene daert nood was ende ghecrammed te houdene met glooye tote meye int jaer ons Heeren M IIIIc ende een, coste: 8 s. groten"*.

Dike with straw cover around 1900 (Westkapelle, Zeeland)



Fascine work: carpet of straw (Van Breen 1920)

Bundles of straw were attached to the dike by claws of straw (sometimes wood), using specific implements: **fascine forks** or **fascine spades.** In the 16th century up to three bundles each feet (27 cm) were used, which gave a very tight cover.

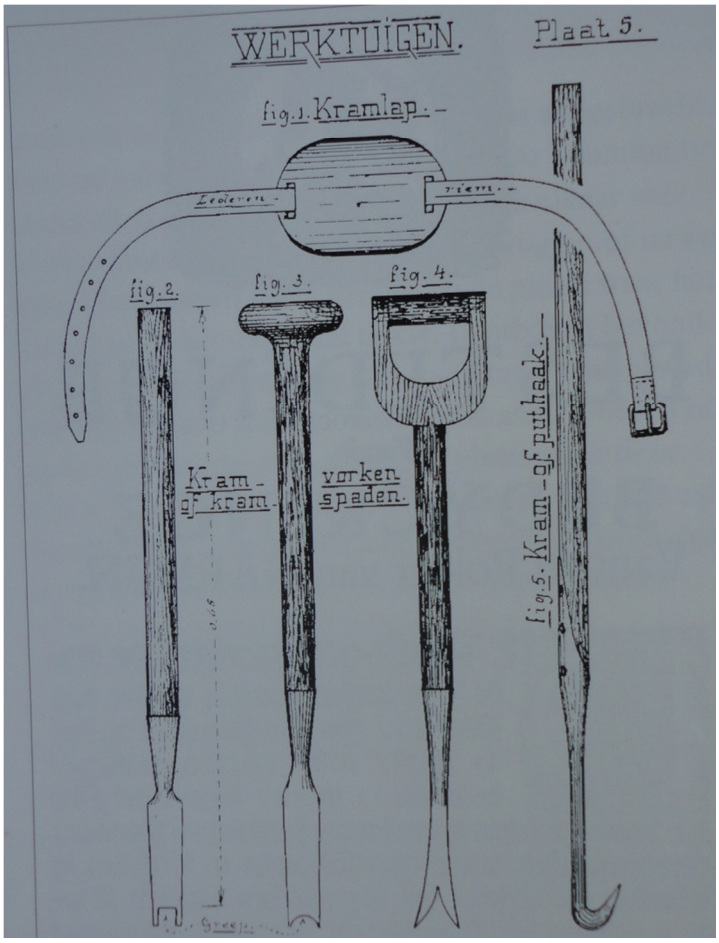


Figure: Fascine forks (Van Breen 1920)

Fascine work did not exceed 5% of the total cost of a dike, but needed to be replaced every year, hence being a recurrent rather than a one-time cost. In the 15th century fascine work was outsourced to the general contractor who build the dike.[10] By the 16th century, fascine workers had developed to a specific profession ('crammers'), which were higher skilled and better paid than dike labourers.[11]

Labourers	wage (groten / day)
dike labourer (man)	6 to 9
dike labourer (woman)	3 to 6

[10] E.g. Bentille 1423

[11] E.g. 1552/3: Aernoudt van Craeyenbrouck met zijne medehelpers hebben ghenomen deerste bestedincghen van oosten inne volghende ende naer tverclaers vander voorwaerde XXXIII roeden te II lb. VIII s. Groten de roede, LXXIX lb. IIII s. Groten, hier af gheminck vandien voor tcrame dat hemlieden mede besteit was te doenen ende nu anders beraden zoo dat zijt niet ghedaen en hebben IIII lb. Groten dus blijft: 75 lb. 4 s. Groten; 1568/5: Betaelt Joos vander Loo crammer II lb. X s. Groten over tcrammen van LXXV roeden dicx up tvinderlinck ende anden dijck tusschen tambacht ende der stede van Blanckenberghe te VIII d. Groten vande viercante roede, compt per ordonnantie: onderteeckent Boels: 2 lb. 10 s. Groten

dike worker (man) - night	12 to 18 (36)
fascine/osier work	18 to 24
fascine/osier work (master)	36
Supervisors	12 to 20

Wages paid for dike construction in Saaftinge/Kieldrecht 1530-31 (De Kraker 1993: 34)

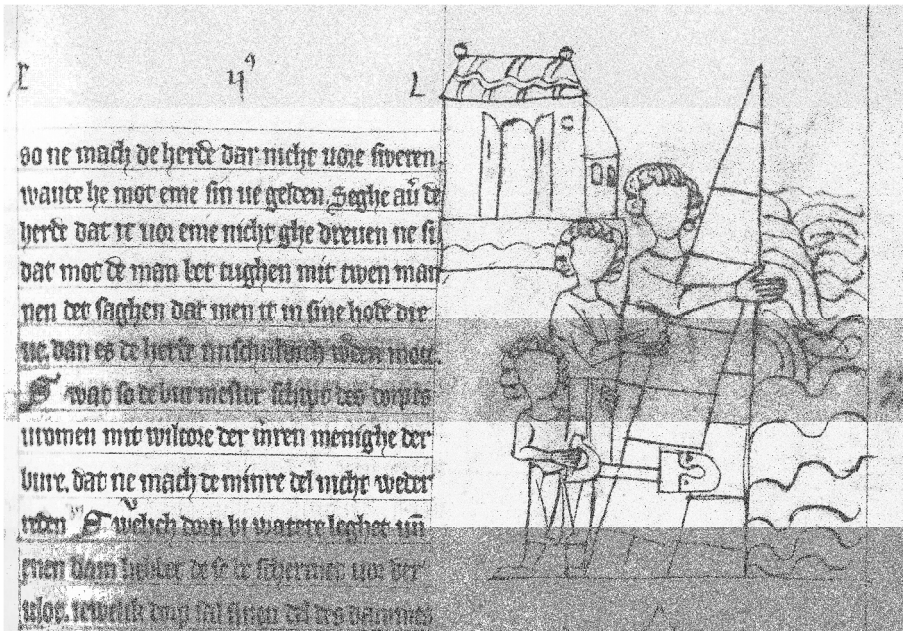
In the early modern period, straw carpets were considered the most basic dike cover, and other types of flood defense developed, which were much more capital intensive: groynes and dams of osier, sometimes filled of stone. In our Waasland test-case, such capital-intensive techniques remained rare however: the focus remained on the solidity of the dike body, and earthworks remained the most important part of dike construction:

Type of cost	**Total cost (B. Francs)**
administration	7130
earthworks	898330
earthworks: boatsmen	49994
earthworks: gazonnement (sods)	17953
earthworks: taluteurs	8814
equipment	36638
experts	16110
food & fuel	9766
ironworks	5739
osier-works	28963
rest	91
stoneworks	12238
woodwork	24835
Total	**1116600**

Figure: total cost of the Prosperpolder-embankment (1846).

6. Changing implements: the horse versus the wheel-barrow.

Whereas the oldest instrument for dike-labour is the half-ironed spade (which offers the perfect cohesion of clay[12]), already depicted in this famous 1336 manuscript of the Sachsenspiegel:



by the early modern period, a whole range of very specific diking tools had developed, like the already mentioned fascine forks, hammers to fix the sods, or long spikes to move the planks used to drive wheelbarrows (**figures).**

It's easy to see an evolution towards ongoing professionalization and specialization of dike labour. However, changes in implements cannot be understood without taking into account both the **organization of labour** and the **environmental context.** We can distinguish three different technics:

- The oldest historical sources (late 13th and early 14th century), in a period of high population density, and low wages, a distinction is made between *spade-workers* and

[12] Kühn, Deichbau, 57.

buttiers, which carried earth (porters), maybe in a *pannier,* a sack or on a board. Spade-workers received twice the wage of porters, and the latter might have include a considerable number of women.[13]

- From the 1360s onwards, we again find two categories: the spade-workers, and the horses with *browetten* or carts. People with horse and cart earn twice the wage of a spade-workers.[14] Interestingly, the *butte,* the implement to carry earth was no longer mentioned after the 1370's.
- Almost simultaneously, in the 1370's however, a second instrument appeared: the *pipegale* or wheelbarrow, which was used by the spade-workers to carry earth.[15] The wheel-barrow is no invention of the 14th century, it's frequently depicted on 13th century European miniatures, however its spread and use in Europe remains somewhat enigmatic. Dike work might have played a role in its geographic spread: in northern Germany, the introduction of the wheel-barrow is still attributed to the Dutch dike-expert Rollwaghen in his embankment works in Eiderstedt in the early 17th century.[16] In coastal Flanders, wheelbarrows were standard equipment of dike work in the 15th and 16th century, but so where horses and carts.[17] In fact, horse and chart on the one hand and the wheelbarrow on the other developed on two complementary, but also competitive models of dike construction.

  The 16th century dike expert Andries Vierlingh preferred horse and cart over the wheelbarrow: through their weight they consolidated the body of the dike.[18] The **choice between horse/cart and wheelbarrow** is more than just a matter of

[13] E.g. Account Blankenbergse Watering 1304. 24 d. for spadelieden versus 12 d. for buttiers. Géén paarden???
[14] 1366/4: Dit zijnze die ghedijc hebben tusschen Riquaerd Clais Colins ende Beyds weghe: in den eersten met paerden...(90 personen), summa dierum: Xic LXXXVIII d. , summa pec: 660 lb; dit zijn die spadelieden: (95 personen), summa dierum: IXc XXXVI d. Pro die V inghelsche, summa pec: 260 lb.; 1373/2: -Clais Cloosterman met eere merie met eere boerwete: XII groten; 1376/1: metter spade ende metten butte
[15] 1378/1: dit sijn die goene die ghewrocht hebben met paerden ende met buerwetten omme die dune of te donee vander sluis VIII roeden lanc VI roeden breed ende XXVIII voete diep: (5 personen, elk met I of twee paarden), summa vanden daghe: Iic IIIIxx XVIII daghen, over den dach XII groten, summa in ghelde: 596 lb.
- Dit zijn die goene die ghewrocht hebben met spaden ende met pipegalen ende die bloot makeden die sluus: (56 personen), summa van den daghen: IIIIc IX daghen over den dach V groten, summa in ghelde: 340 lb. 16 s. 8 d.
[16] Fischer, 51; Kühn, Deichbau, 59-63
[17] Cfr. instructions on standard dike equipment issued by the Habsburg government 1511: *zulcke quantiteyt ende ghetal van goeden gleye, hurden, rusen, crimsstaken ende oic van pipegalen, spaeden, houten, hameren*
[18] 'Carrewerck is het beste werck': Vierlingh, Tractaet, p. 344 and 334: *de eerde oft spijse bij de peerden oft karren soo hart wort in malcanderen getreden ende gesloten wort, datse soo taij valt ende wort dattet waeter daer op niet winnen en mach'.*

efficiency. *Labourers* did not own horses, coastal farmers did. Horses demanded food and water. Wheelbarrows demanded just human muscular power, and so the success of the wheel-barrow has been linked to the spread of wage-labour in dike-work.[19] Horses and carts also could bring in earth from further places, whereas wheelbarrows usually brought in earth from limited distances, right in front of the dike. There also were *environmental differences*: horses and carts could only be used in dryer lands, they could not work in tidal mudflats. If the embankment took place in wet conditions, the wheelbarrow on planks was the only tool that could be used, supplemented by flat-bottomed ships to supply earth.

In our early modern Waasland-embankments, the wheelbarrow eventually proved victorious. Large embankments like the Nieuw-Arenbergpolder in 1783 or the Prosperpolder in 1846 hardly used horses. From an environmental point of view, these dike constructions took place not on dry saltmarshes, but on tidal mudflats, where horses and carts would be useless. From the point of labour organization, both embankments were mainly based on the employment of an undifferentiated mass of labourers, up to 1000 or 1500 at a time. Their main instruments, were wheelbarrows, planks to ride these on, and spades.

7. Dike masters and the rule of experts.

To understand changes in the use of technology, we have to take into account changes in the labour organization of dike work. Over the long run, we could speak of the rise and decline of the independent dike master.

- Medieval embankments (mostly) emanated from local communities, using local labour and resources. Either dike repairs or constructions of new dikes in front of existing ones, were realized locally. Dike work was seasonal work, that fitted in the seasonal cycle of agricultural work **(figure Van Dam).** Dike workers brought with them their instruments (spades, carrying tools and horses) which were implements

[19] Kuhn, Deichbau, 59-63.

used in agriculture. Typically, the construction of a huge dike north of Bruges in 1288 was spread over five years. Each year 600 rods or 2,3 kilometers of dike would be constructed from May till August.[20] At first the evolution of dike work followed the evolution of the coastal economy: massive cheap labour around 1300, more horses in the second half of the 14th and the 15th century.

- In the early modern period, the link of dike labour with the local farming community was gradually disrupted. In the 15th and 16th century local communities started to lose both their property rights on the land in front of existing dikes. Coastal farming was more and more based on large commercial tenant farms, employing huge amounts of horses (the average Waasland-polder farm had about 7 horses in 1696)[21], but as we have seen the horse disappeared from dike construction in the same region.

- Instead we see from the later 14th century onwards, the rise of the independent dike-master professional. Already in 1379 dike masters from Zeeland were invited by the count of Flanders to supervise dike works in the North of Flanders.[22] Independent 'dikers' or 'dike masters' spread in the 15th and 16th century. They sometimes but not always brought with them horses[23], and employed small teams of labourers (mostly ten to 12). Large dike constructions were usually allotted in small sections of 10 to 20 rods (35 to 70 meters), and prohibitions to contract for more than one section were issued, favoring the smaller, independent masters.

- The geographic range of dike masters increased: whereas in the 1530's dike contractors in the Waasland area still came from the wider region, in the 1610's

[20] Eiesluis 1288.
[21] Horse census of 1696, Doel.
[22] 1379: Gillis f. Pieters ende Symoen f. Clais, bede van Zeland, elc over hem selven ende scolden quite minen here van Vlaendren, zinen commissarissen vander dycage van Ysendike ende zijn ghemene land van Vlaendren ende alle andre wiere quitance of toebehoord, van alden eesschen, sculden ende calangen die zij hemlieden in enegher manieren eesschen of calengieren souden moghen als van hare beder dienste die zij daden als meesters metgaders andre in de vorsiede dycage
[23] Blankenbergse watering 1567*: Betaelt Gheeraert de Hondt III lb. Groten ter cause ende over tdijcken met een paert upden dijck ende tvinderlinck XX daeghen te III s. Groten sdaechs compt per ordonnantie onderteeckent Boels: 3 lb. Groten*

many of them came from clusters of villages in South-Holland (Korendijk, Puttershoek, Heinenoord) or North-Brabant (Zwijndrecht, Oud-Gastel, Steenbergen) more than 100 kilometers away **(FIGURES).** Dike labour became a specialization of specific villages, mostly situated not in the agricultural core of coastal farming, but rather on the edge of the coastal plain, in the region. In the 16th century Wachtebeke in Flanders was such a village, in the 19th century Sliedrecht in South-Holland developed was the most important village of dike labourers in the Netherlands.[24]

- Whereas medieval dike masters were widely respected, starting in the 16th century dike masters and their workforce alike were increasingly stereotyped as lazy, disrespectful, drinking too much, and treacherous.[25] In the specifications for the construction of a new dike in Doel in 1567 it was mentioned that contractors and dikers should respect a physical distance of 2 rods (7 meters) when the administrators of the project inspected the work.[26]

- The mass of labourers employed in dike work increasingly frightened the noblemen and honest citizens investing in embankment works. They were horrified by the strikes organised by the former in pursuit of higher wages. Evidence for such strikes in the Waasland Polder region was found in winter 1570[27] and during both the embankment projects of the dukes of Arenberg in 1783 and 1847. To counter this unrest, military force was called: every major dike construction project in the early seventeenth century, the investors hired private soldiers (‘*hellebaerdiers’*), in the 18th and 19th century soldiers from nearby garrisons were sent.

[24] Hollanders en het water, 124-125.
[25] Ordonnance of Emperor Charles V 25th of January 1531: “*ende zoo tot onser kennesse gecommen zy dat de dyckers ende wercklieden daer toe nyet wercken en willen, ten zy datme hem gheeft thienne, elve, twaelf groooten Vlaems sdaechs, nyet tegenstaende dat winter es ende zy niet boven de zeven off acht uuyren sdaechs en wercken, ende zomwylen myn, alst reghent ende quaet weder es, dat zy ooick jn haer wercken zeere ongeregelt zyn ende uut fortse ende dreygementen ghelt van den meesters ende andere diese te wercke stellen hebben willen”*; Cfr. Matelé in the early 18th century: ‘deughenieten, bottericken, leugenaersen dronckaers’ (De Vleesschauwer, p. 227)
[26] Included in Vierlingh, Tractaet van dijckagie.
[27] De Kraker 1997, 106-107.

- In 17th century construction works, dike-masters seemed to lose a lot of their financial independence as well. In the Doel-embankment of 1613-14, many contractors each contracted small pieces of dike, but a large share of their earnings was directly paid to a limited number of so-called *zoetelaers,* who provided the catering and part of the equipment (including wheel-barrows according to Andries Vierlingh in the 16th century). Dikemasters could only receive full payment, if their *'soetelaer'* declared that all his costs had been paid.

- In the 18th century, large contractors replaced the independent dike master. In 1783 the duke of Arenberg insisted on allotting his new dike in smaller parts (14 or 16 instead of 7 for a dike of about 1400 rods (more than 5 kilometer) – still considerably more than the average allotment in the 16th century) out of real or pretended paternalistic feelings - *'voulant favoriser d'autant que possible ses propres sujets'* - but ended up with two general contractors.

- Dike masters were no longer seen as the real experts. In 1531, it was the bailiff of Oude Tonghe in South-Holland who was invited to advice on dike construction in the Waasland.[28] In the early modern period, the experts were people active in the administration of polders, often larger landowners themselves, like Andries Vierlingh in the 16th century. Land surveyors like Jan Matelé in the early 18th century could also develop into dike-experts. To prepare his 1783 embankment, the duke of Arenberg took the advice of Philippe-François Lippens[29], who called himself *"expert en ouvrages hydrauliques"* and also actively invested himself in embankment operations. When duke Prosper-Luis of Arenberg commissioned his grand Polder in the 1840s he was assisted by engineers: a Dutch one – Abram Caland – and a Belgian one, J. Wolters, 'ingénieur faisant fonctions d'ingénieur en chef des ponts et chaussées'.

- This new generation of experts loved new types of science to estabilish its position. Already in the 16th century, Vierlingh mocked colleagues who did new to use a pair of

[28] De Kraker, 1993, p. 44.
[29] J. De Smet, 'Philippe-François Lippens', *handelingen Sint-Guthago, X, 5, 1968.*

compasses to orient a dike.[30] But especially from the second half of the 18th century dike construction saw an appetite for 'science', with for instance in the 1770's contests organised by regional academies of science on hydraulic questions, including dike constructions (**Figure: Kool Blokland, p. 156).** Many of the new solutions were capital intensive, and they took long to spread in the actual practice. Determining height using water levels was known in the late 15th century[31], but in the practice of dike construction the height of a dike was still expressed in relation to the local ground level in the late 18th century. We have the impression that experiments with capital-intensive stone covers and osier-works were mostly embraced in the 16th and again in the second half of the 18th century, by new groups of specialists, often with central government support. Both private investors in embankment and professional dike labourers had little to win by such capital-intensive techniques. In the mean while experiments and scientific techniques however did help to enhance the position of experts in the financially attractive world of dike construction works.

8. To Conclude.

Using the example of dike construction in Coastal Flanders, between the 13th and the 19th century, we tried to demonstrate the intimate link between technological change on the one hand, and the evolving environmental and social context on the other. The development of dike construction is not just a story of incremental technological development in response to environmental challenges, as it has often been conceived. 18th or 19th century dikes were not superior to their medieval counterparts and nor or those of 21st century. They just correspond to different realities.

We could differentiate between several socio-technical 'assemblages' (*agencements* as Latour and Callon call them), configurations of tools, products, matter (earth, straw…) and man. Both tools (the spade, the wheelbarrow, the fascine fork…) and their products (the type of dike) are inscribed with knowledge and power, and continue to exert their influence

[30] Vierlingh, Tractaet, p. 49
[31] De Kraker, 1997, p. 221.

on whoever is involved with them, well beyond their construction. In this view, the medieval dike is a flexible one in line with a flexible environment, the product of a collective enterprise of anyone who could move earth (both men and women), reproducing the ideas and practices of an agricultural society. Through permanent maintenance and collective use (as a road for instance), the dike was strongly embedded in the rural community. The (early) modern one is a more standardized one, its solidity expressing mastership over an environment that was uncertain, built through labour that was commoditized, and increasingly proletarian, working standard units of earth in standard periods of time. For the local population the dike is an instrument of power beyond their control, and to a large extent taboo, as it could no longer be accessed.

Of course, these are rude generalisations. As we have tried to show in this paper the historic transitions in dike construction were much more complex and permanently moving on the interface of agricultural practice, evolving labour markets and knowledge systems. When studied in their social context, the study of implements can be extremely useful to uncover this evolution.