Terpen in
‘It Lege Midden’

Name: Miel Kanneworff.
Student number: S6128645.
Study: Cultural Geography, track Climate adaptation governance.
Faculty: Campus Fryslân.
Course: Master Thesis Cultural Geography.
Supervisor: Dr. K.A. (Karsten) Schulz.
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university of groningen
campus fryslân

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Abstract

Historically, terpen represent one of the earliest examples of people adapting the landscape to their own needs. In this study, the focus is on the Frisian region 'It Lege Midden', an area defined by its relationship with water. My first question will be 'What are the landscape characteristics of It Lege Midden'. It will look at the difficulties this area faces in relation to peat oxidation and salinization. Various studies have focused on implementing terp[1] constructions within the landscape. The projects range from enhancing climate resilience to managing dredged material. 'How can terp constructions be applied within the landscape?', my second question will look at the forms in which terpen can be constructed. Making infrastructure more climate-resilient is important for the future of Fryslân. Large fluctuations in temperature and precipitation can negatively affect the landscape and buildings. My third question 'What are the possibilities regarding national policies in It Lege Midden?' will look at policies related to fields such as water management, climate adaptation and ecology. These three questions will help to answer my research question: *'How can landscape alterations, such as terpen, prove successful in the climate adaptation of It Lege Midden?'* This research will look at the possibilities of incorporating elements of the cultural landscape within climate adaptation.

[1] Artificially built hills below a structure (singular: terp; plural: terpen).

1. Introduction

My research will focus on the research question: *'How can landscape alterations, such as terpen, prove successful in the climate adaptation of It Lege Midden?'* Terpen are historically used to protect buildings against flooding. Nevertheless, they have as well been implemented within modern infrastructure such as the Overdiepse polder. First my research will look at the sub-question 'What are the landscape characteristics of It Lege Midden'. The landscape of the region will be analysed, while looking at the main issues like peat oxidation, salinization and freshwater loss. In relation to this, terpen could help limit these negative effects. In the following question 'How can terp constructions be applied within the landscape?' the different forms of modern terpen will be discussed. What for design and material should be used for its construction? The function can also differ between water safety to storage of dredged material. The last sub-question, 'What are the possibilities regarding national policies in It Lege Midden?' looks at current policies focused on water management, climate adaptation and ecology. It will assess corresponding projects and look at the implementation of terpen.

The cultural landscape of Fryslân is influenced by its relationship with water. During the start of 500 B.C. terpen were already being constructed to protect the area from the effects of the sea. These structures were typically built in low-lying areas. During high tide, the elevation protected farmers and their livestock from flooding. The elevation helped to prevent the water from infiltrating inhabitants' houses and buildings. Initially, each building had its own elevated mound. Over time, these small mounds expanded and merged, forming larger hills where settlements grew. Some farmsteads built on an individual terp were called huisterpen[2]. In the early stages, many terpen had a dobbe[3], which was a place where soil was excavated from and used for the construction of the terpen. The dobbes became places where the livestock could access their water to drink or wash. In subsequent phases, due to the central position of many dobbes, they became places where churches were built. Deceased inhabitants were often buried on the terpen. Hence the terpen and dobbes became important in the formation of a communal identity[4].

Later, these terpen fell out of use with the construction of dikes. During the nineteenth century, these sites were even in danger of being excavated. The soil of the terpen, known as terpenaarde, was popular to cultivate the more barren areas. These terpen contained many artifacts which had accumulated during the centuries. During the excavation, many of these items were found and often sold. In the later phases of these excavations, the terpen became more and more a subject of academic study. Albert van Giffen initiated archaeological research on the terpen. In some instances, he purchased the area, so it could be studied with fewer time restrictions. This research was valuable in providing a more complete historical context of these structures. Due to the various excavations, many terpen have been partially or completely destroyed[5]. The impact of terpen can still be seen in many villages in Fryslân and Groningen, they usually form the core in many communities. So these structures remain integral to the regional identities of Fryslân and Groningen (where they are known as wierden). Many of these historic constructions have an official status as a national monument, while they contain many materials from a wide range of periods. They are also remnants of the dynamic landscape that Fryslân and Groningen once had. The terpen still live on as an example of

[2] Translation: House terpen.
[3] Naturally or artificially built hole, which became a pool of water not connected with other waterways and rivers (singular: dobbe; plural: dobbes).
[4] Rudolphie 2023, 27-29 and 35-36.
[5] Van Doesburg & Stöver 2018, 11-14.

living with the water for the early population of these provinces. It is an early example of how humans employed their own skill to control nature. In this study, the focus will be on their contemporary usage. The terpen can tell us about land use patterns of Fryslân and Groningen. They are not just only occurring in these two regions[6] (see figure 1). Terpen seem to have somewhat disappeared from our collective memory. Yet this form of water protection seemed to have been less invasive towards the natural water flow than our current dikes. Therefore, terpen could help us in reinventing our current water management and land use.

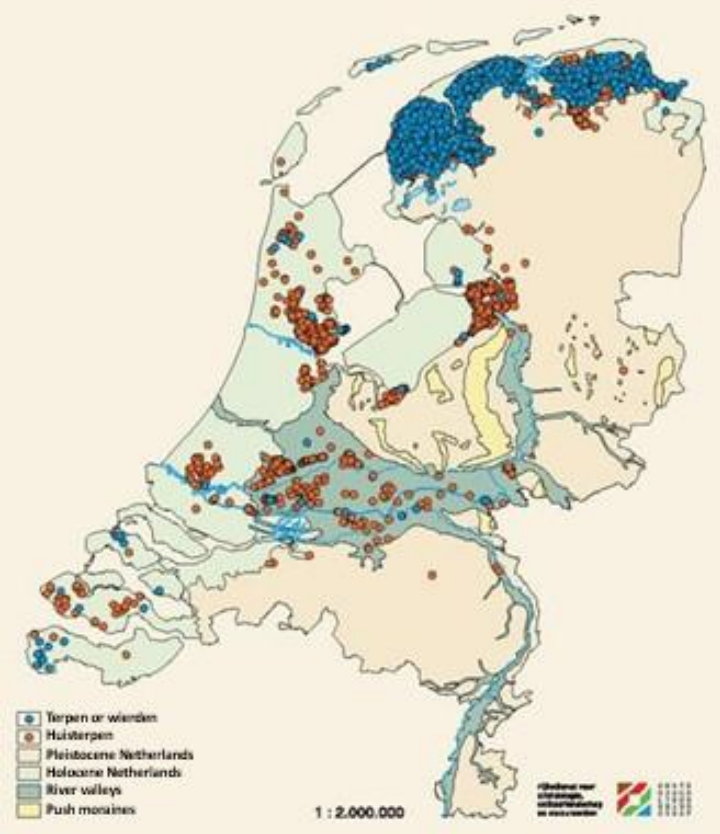


Figure 1: Map of the Netherlands with terpen.

'Terp fan de Takomst' is an artistic project located in the salt marshes near Blije. With the project, the residents wanted to reaffirm their connection with the sea and show the original function of terpen. The construction is circular with wooden columns installed. Two rings are incorporated within the construction. These rings symbolise the marriage between land and sea, and humankind and nature[7]. Peter Vos from Deltares and the Terpencentrum have worked together to make geological observations in the salt marsh area near the coast. Stone ridges, mound platforms, and settlements

[6] Not only found in Fryslân and Groningen, but in the northern part of Drenthe (Mars & Van der Sanden 2018, 3-14) terpen have been found. In Zeeland elevated hills were used during high tide (vliedbergen) (Van Heeringen et al. 2007, 11-20). In Gelderland there are examples of naturally and superficially hills being made and used (pollen) (Provinciale Staten van Gelderland 2014, 15-42). Moreover, specific areas such as Marken (Vervloet 1974, 5-9) and Kampen (Ufkes & Tuinstra 2012, 5) had terpen. Terpen can also be found outside the Netherlands in Belgium, North-Germany and West-Denmark (Nieuwhof 2018, 45-46).
[7] Arjaans 2022, 15-17.

in the clay-on-peat area are assessed in relation to palaeogeographical maps. Flooded coastal areas were desirable due to their openness and fertility. Nature was not the only dominant factor in the landscape. Humans appear to have a lasting impact on the climate, in a positive and negative sense. Both land reclamation and peat degradation are a result of human interference[8]. Experts have evaluated the possibilities of modern terp habitation. This would increase ground level of coastal areas with new sediment. It would require the organization of a floodplain, a creek system, sufficiently elevated terpen (to withstand extreme high tides), durable structure (clay and silt for firmness and cohesion), and low dikes (to serve as sediment traps). Community involvement in the planning, the construction, and the maintenance is essential[9]. In recent years, climate adaptation has received more attention in policymaking. This study will focus on constructing terpen as a sustainable answer for the changing Frisian landscape. Terpen have played a role in the history of Fryslân. They were built in areas known to be flooded during high tide. Thus, they are the earliest example of flood protection. It will try to bridge the gap between this form of cultural landscape with 'modern' climate governance.

Climate governance looks at tackling climate change[10]. Making people known with these risks is important. A participatory approach helps people become aware of these changes. Therefore, they grow to be more resilient. However, in certain areas we can also adapt the landscape to future changes. The climate in the Netherlands will show larger fluctuations in precipitation and temperature[11]. Making infrastructure more climate-resilient is as well important. This development is furthermore visible in other countries which are vulnerable to climate risks. Nature-based Solutions (NbS) is an approach to tackle climate change with socio-economic and environmental co-benefits[12]. Creating more space for the river or looking at alternative farming methods are both examples of this approach.

[8] De Langen et al. 2016, 56-57.
[9] Nieuwhof et al. 2019, 86-87.
[10] Gogoi & Harshita 2018, 1.
[11] Seneviratne et al. 2023, 1517-1520.
[12] United Nations Environment Programme 2020, 5-7.

1.1 Context and state of the art

1.1.1 Historic landscape of Fryslân

During the Pleistocene (370,000 to 10,000 years ago), sand ridges were created. During the Saalien glaciation, Fryslân was covered by an ice sheet. Push moraines and clay loam areas were created during this time. During this period, Fryslân was already visited by humans, and locations of regular habitation were established. Approximately 6,000 years ago, the first farmers settled in the area. In the Holocene, the climate became warmer and the sea level rose. The Frisian landscape can be divided into four parts:

1. Clay loam areas in the south and east.
2. Clay loam areas with coversand (connected with the 'Drents plateau').
3. Sea clay areas in the northwest.
4. Raised peatlands which were consisted of clay loam, coversand, and clay layers in the subsoil. Now due to land degradation It Lege Midden[13] it has become the lowest area of Fryslân (fen)[14].

During the Iron Age, terpen began to appear in the Frisian landscape. During this period, the geography of Fryslân consisted of Westergo and Oostergo, two regions divided by the Middelzee. Terpen were mostly constructed in the salt marshes connected with the Middelzee and the Waddenzee. It is unknown whether some of the earliest permanent settlements were constructed without artificial elevation. Places in Westergo and Oostergo became emporia during the 6th and 7th centuries A.D. By the 8th century, some emporia traded more directly with markets. In terpen regions, ditches were dug to protect the settlements against flooding. In the Roman period, small dikes were built to protect the arable land[15]. Due to siltation, the edges of Fryslân became inhabited by people who built their terpen in these newly formed areas. Around 900 A.D., the Middelzee became silted up.

During the Middle Ages, peat excavations started in Fryslân, which led to a decrease in groundwater levels. These excavations likely led to the creation of the first waterways. These waterways were probably used by communities for water level regulation, travel, and other purposes. Due to siltation and ground level decline, certain areas became increasingly affected by water hazards. Many experts argue that the construction of dikes began in the late 10th and 11th centuries A.D., although some suggest that the topic has not been sufficiently researched. In later periods, settlements began to focus more on craft industries (nijverheid) and trade instead of primarily agriculture. Churches also began to appear in many settlements. Many villages developed their specific layouts during this period[16].

[13]In English means 'The Lower Middle', while in Dutch 'Het Lage Midden'.

[14]De Bruijn et al. 2009, 13-20.

[15] Bazelmans et al. 1999, 54-61.

[16] De Bruijn et al. 2009, 21-38.

1.1.2 It Lege Midden

It Lege Midden is an area characterised by its fens. Around the eighteenth century, peat was excavated in the area (turfwinning), which changed the landscape drastically. The area became swampy, and its ground level decreased. The Alde Feanen is a testament to this period. This national park consists of swampy fen with various lakes and reed beds. After the eighteenth century, the 'wasteland' (woeste gronden) of It Lege Midden consisted of swamps, reed lands, petgatten (excavated peatlands), and lakes. Reclaimed peat areas were present within the landscape as zomer- and winterpolders[17]. In 1924, Heidemij and the Grontmij[18] started the NV De Drie Provinciën which began cultivating the land in the Fryske Wâlden and It Lege Midden. Areas were reclaimed, drained, paved, or fertilised for agriculture. The land became available for various sectors such as housing, agriculture, and industry. Consequently, many stakeholders are dependent on It Lege Midden for their livelihoods, while the area as well holds an important nature reserve, the Alde Feanen[19]. Due to the wet conditions and the vulnerable soil, peatlands are not very suitable for crop production. Thus, animal husbandry is more appropriate in these areas.

It Lege Midden is lower than the surrounding lands. As a results, it is sometimes referred to as the 'Bathtub of Fryslân'. Due to its peat composition, this area is vulnerable to fluctuations in humidity. In periods of drought, the peat can deteriorate, leading to a lowering of the ground level. Peat deterioration not only results in changing landscape, but it also contributes to greenhouse gases. When peat oxidation occurs, carbon dioxide is released. Also, nutrients are as well freed during this process, which leads to eutrophication[20]. Over the years, many publications have been released about the conservation of peat. Drainage is seen as one of the main drivers of peat deterioration. In the thesis 'Omgaan met verdwijnende veengronden', the peatlands of the Drents Overijsselse Delta is discussed. Ruben Beens debates the options of accepting, anticipating, and rewetting in relation to agriculture. He argues for new, alternative forms of farming, such as typha or sphagnum cultivation (wet agriculture). Beens urges rewetting measures to protect the peatlands from land subsidence. In areas with a peat layer less than 80 centimetres thick and where no capping is currently used, anticipation or rewetting seems to be less necessary[21]. In 'Shallow drainage of agricultural peatlands without land-use change: have your peat and eat it too', researchers analyse the rewetting of the areas. Increasing water levels did not show significant changes regarding eutrophication, vegetation diversity, or wetland-adapted species. The paper argues for both water level management and the reduction of intensive land use[22]. Landscape architect Peter de Ruyter has outlined different approaches in spatial planning that could prove successful regarding It Lege Midden. He advocates for nature-inclusive agriculture and an increase in hayfields[23]. In my interview with Peter de Ruyter (see annex), he explained that salinization is related to water management in the area. With drainage, the water levels are artificially lowered. Due to these low water levels, seawater can flow move into surface waters. As a result, the higher salinity levels can contaminate arable lands and

[17] Hosper 1997, 6.
[18] Organizations for the cultivation of wasteland.
[19] Wiersma 2021, 66-71.
[20] De Ruyter 2020, 51.
[21] Beens 2016, 63-86.
[22] Heuts et al. 2024, 2-9.
[23] De Ruyter 2012, 193-194.

freshwater surfaces[2425]. In ‘Vloeiend Landschap’ Peter de Ruyter discusses that the peat when wet can be poorly permeable for saltish and brackish water[26].

The Boarn runs through the area. This river has historical ties to the origin of the Middelzee (also called Boorndiep or Bordine). Over the centuries, this natural waterway has changed due to both natural and artificial processes. Landscape formation and human habitation have influenced the shape of the river. After the Last Glacial Period, the surroundings of the river transformed into peatland. Another major event was the construction of dikes, which altered the river’s course[27]. The Prinses Margrietkanaal passes as well through It Lege Midden. This canal is part of the larger Hoofdvaarweg Lemmer-Delfzijl, which connects the Prinses Margrietkanaal with the Eemskanaal and the Van Starkenborghkanaal. Around 1900, there was discussion about creating a single shipping route for the northern provinces. Some Frisian villages were already connected by canals, but a continuous waterway was realised in 1951[28]. This canal connects various Frisian lakes and is an important system for water transport. The canal has a length of around one kilometre and a width of approximately 30 metres. Due to the limited space within the canal system, the waterways can face difficulties draining water during periods of high fluctuation. In recent times, government bodies have focused on broadening river basins. They have shown considerable interest in spatial planning, with a renewed emphasis on water management. ‘Leven met Water’ was initiated by the national government to illustrate the Netherlands' historical and future relationship with water. Technical interventions such as aqueducts and floodgates play a prominent role in the water system[29]. In ‘Weerbaarder, Guller en Attractiever: Naar een nieuwe aanpak voor het veen in het Lage Midden van Fryslân’, landscape architects Peter de Ruyter and Paul Plambeck propose that more space for water can be achieved in three ways:

1. Creating space within the ‘Fryske Boezem’ (water system of lakes, canals, and waterways).
2. Increasing capacity within the creek system.
3. Making the water system more robust in reclaimed fens[30].

1.1.3 Peat terpen

In It Lege Midden, many terpen are located. These consist of large communal terpen and huisterpen. Many of these structures have unfortunately been destroyed or damaged. Visible traces can still be found beneath houses and other buildings. In the past, peat terpen existed in addition to those built in the marshlands. In the southwest of Groningen, archaeologist Albert van Giffen identified several peat terpen. These terpen could have a length of 10 to 40 metres and a height of 25 to 100 centimetres. The peat is usually found in a mixture of peat, sand, ash, and potsherds. They were found in eroded areas of the Pleistocene, which were, during that period, filled with peat. In the north, a large clayish body wedges to the south. This creates a clayish, earthy, peaty topsoil (moerige eerdlaag). Animal husbandry could be practised in the peatlands. Agriculture was as well possible for a few years, which meant peat was burned for nutrients. These nutrients were important for the

[24] De Ruyter 2012, 185-188.
[25] Ter Voorde & Velstra 2009, 5.
[26] De Ruyter 2020, 71.
[27] Timmerman Azn & Hoekstra 1980, 139-147.
[28] Baboeram et al. 2015, 8-15.
[29] Baboeram et al. 2015, 24-29.
[30] De Ruyter and Plambeck 2018, 16-19.

growth of crops. Stones and fishing net weights indicate that fishery was be practised. The terpen had footpaths, which connected them to each other. In later years, the population likely fled due to rising water levels[31]. In Onlanden (Drenthe), these terpen have also been found. Yet due to peat oxidation, these terpen can slowly disappear from the landscape[32]. In It Lege Midden, not much is known about possible peat terpen. Still, it is not unlikely that this large, low-lying peat area possessed them.

1.1.4 Modern terpen

Some studies have been conducted to examine whether terpen could be relevant within spatial planning. In the Overdiepse polder terpen were constructed as part of the 'Spiegelproject Overdiepse polder'. The essence of this project was to transform perceived threats into opportunities. Policymakers aimed to enhance safety by creating more space for water. Within this project, terpen were regarded as both technical and spatial interventions, and were considered the most cost-effective measure compared to dredging. Due to the presence of multiple landowners in the area, an integrated approach was adopted. In addition to terp construction, the project focused on the following aspects:

1. Relocating homes and businesses to newly constructed terpen along the levee.
2. Creating a spillway or an inlet and outlet structure to allow the polder to flood during extreme high-water events.
3. Excavating a former soil depot at the western tip of the polder, with the intention of reusing its material for terp construction.
4. Modifying the hydrological infrastructure, including relocating the polder's pumping station.
5. Designing the new layout so that the polder is not used for tidal inflow more than once every 25 years[33].

The Perkpolder followed a plan similar to that of the Overdiepse polder. Here, a floodplain was created. These became tidal zones where the sea could flow naturally, reducing wave pressure on the dike. Houses were built on an elevated ferry platform to protect them from flooding[34]. In earlier concepts, the area was to be raised to form a large terp for habitation[35].

In the project 'WINN – Terpen van Baggerspecie', the focus was on the possibility of constructing terpen using river dredged material, this is exposed during dredging activities. The terpen could be utilised in diverse ways. Five options were explored: green (refuge, nature reserve, and estate), red (residential and commercial use), orange (landmark), yellow (clay storage), and blue (shore protection)[36]. Terpen construction can be implemented in various ways, such as through concentrated sedimentation basins, underground bunkers, refillable geotubes, or filled terpen

[31] Klungel 1971, 188-197.
[32] De Moor et al. 2017, 5-7.
[33] Van Rooy & Slootweg 2003, 5-19.
[34] Van de Lageweg et al. 2019, 22-27.
[35] Rijkswaterstaat 2013, 1-2.
[36] Colin 2004, 7.

(omputterp). These methods provide greater structural stability or enable a dynamic creation process. The program examined public perception and legal frameworks related to terpen[37].

Terpen have been incorporated into housing projects. In Tusken de Fearten in Dokkum, a design inspired by the terp communities of Fryslân and Groningen was chosen. The houses are built on small islands or on terpen in grasslands (referred to as weide- and waterterp), functioning as a nature- and landscape-inclusive form of living[38]. The neighbourhood De Terpen, developed in Kampen, incorporates terpen in its design. These are connected to the farmstead terpen in the surrounding landscape and are approximately 1.50 to 2.00 metres high. The construction of the terpen contributes to a more rural atmosphere. Elements such as 'noaberschap[39]' appear to influence some design choices. Considerable attention is given to green spaces, with the inclusion of a fruit orchard and a farmyard[40]. De Terpen in Kampen seems to emphasise aesthetic value instead of climate adaptation. In Stadshagen seventeenth houses have been built on two terpen. Due to a neighbouring water buffer, the area can change into a peninsular when water levels are high[41].

In the area of Marken, similar concepts were applied by incorporating 'werfen[42]' into housing developments. The surrounding region includes places named Witte Werf, Grotewerf, Rozewerf, and Moeniswerf, and two corresponding werfen the Oostelijke and Westelijke Werf were constructed. These werfen reflect the cultural and urban landscape of Marken, where houses are traditionally built in clusters on artificial hills[43]. Although these werfen typically held a solitary position in the open landscape, the current project also considers the inclusion of a sports complex for the wider area. Due to its urban planning approach and emphasis on cultural heritage, these werfen are designated as part of the protected cityscape of Marken[44].

1.1.5 Administrative bodies of It Lege Midden

The size of It Lege Midden varies depending on interpretation. The broadest definition includes parts of De Fryske Marren, Súdwest-Fryslân, Leeuwarden, Heerenveen, Smallingerland, and Waadhoeke[45] (see figure 3). Others define the area more narrowly, focusing primarily on Boarnsterhim and parts of Leeuwarden (see figure 4).

The municipalities surrounding It Lege Midden have evolved over time. Two municipal reclassifications occurred during the 20th and 21st centuries. In 1984, the municipality of Boarnsterhim (see figure 2) was created through the merger of Idaarderadiel, Raarderhim, and Utingeradiel. This new municipality encompassed a large portion of It Lege Midden, along with part of Leeuwarden. Idaarderadiel and Utingeradiel were predominantly rural. Due to similarities in administrative structures and societal characteristics, the merger was approved. Idaarderadiel had a larger population, with approximately 8,500 inhabitants. Nevertheless, the decision to merge the three municipalities was not contested, given the generally positive response. The mayor and

[37] Colin et al. 2004, 19-24
[38] Gemeente Noardeast-Fryslân 2023, 5-12.
[39] Broad and active neighbourly help. Related to more small, rural areas where services are less accessible.
[40] Van Vliet 2020, 5-15.
[41] Stadshagen unknown date. Retrieved from https://stadshagen.nl/buurtschap/wierde/
[42] Marken denomination of terpen (singular: werf; plural: werven).
[43] Gemeente Waterland 2022, 9-12
[44] Vonk-Minke 2021, 3-12.
[45] It Lege Midden 2025. Retrieved from https://itlegemidden.nl/over-it-lege-midden/

alderman of Idaarderadiel stated that all three municipalities shared a similar rural character, political orientation, and resident mentality[46].

On 1 January 2014, Boarnsterhim was disbanded, and its territory was divided among the municipalities of Leeuwarden, Heerenveen, De Friese Meren, and Súdwest-Fryslân. This decision was made because the municipality no longer considered itself viable as an administrative body. Furthermore, it was classified as an Article 12 municipality, indicating long-term financial deficits[47]. As a result, the territory of It Lege Midden is now divided among multiple municipalities. Due to the unique landscape characteristics of the region, municipalities must exercise caution in planning and development activities within it.

Wetterskip Fryslân is the waterboard responsible for water management in It Lege Midden. In 2021, it released the Veenweideprogramma 2021–2030. This program analyses the Frisian wetlands, focusing on the causes and consequences of peat oxidation. It adopts an integrated approach and monitors the impacts of various interventions. The peatlands are viewed as a complex and data-scarce landscape. The program tracks land degradation, promotes alternative forms of agriculture, examines the rise in carbon emissions linked to peat oxidation, and provides guidelines on carbon management and land degradation[48].

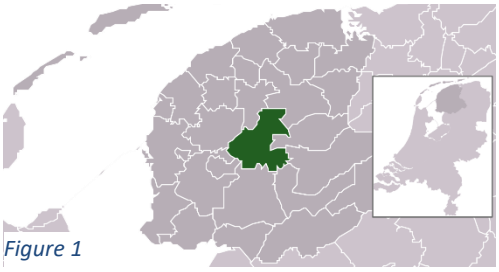


Figure 1

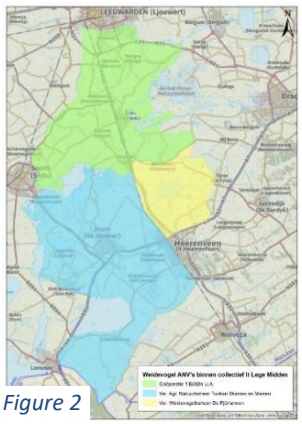


Figure 2

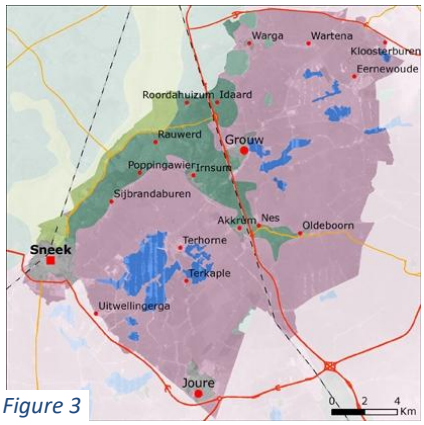


Figure 3

Figure 2: Former municipality of Boarnsterhim. Figure 3: The largest extension of the It Lege Midden (all coloured areas). Figure 4: Smaller extension of It Lege Midden.

[46] Staten-Generaal digitaal 1982, 21-22.

[47] Rekenkamer Leeuwarden 2015, 1-8.

[48] Provincie Fryslân and Wetterskip Fryslân 2020, 7-38

1.1.6 Academic context

Spatial planning is becoming more prominent role in water management. The program 'Ruimtelijke kwaliteit in waterveiligheidsbeheer[49]' (RuiKwa-LAB) functions as a quality circle involved in climate adaptation within spatial planning. This program focuses on 62 projects, each centred on comparative research or case studies. Provincial authorities, municipalities, and waterboards have also participated in several of these projects. The projects are particularly focused on spatial quality and explore solutions for high-water protection. RuiKwa-LAB collaborates with the Hoogwaterbeschermingsprogramma, and their efforts are especially targeted at dike reinforcement projects[5051].

The Deltaprogramma specialises in water management in the Netherlands. In 2024, it launched the project Leven met het Water, which examines current planning practices in relation to major events such as droughts, flooding, and salinization. The Deltaprogramma aims to make essential infrastructure more climate-resilient[52].

The Rudolf Agricola School is a community of scientists and stakeholders focused on interdisciplinary sustainability research, affiliated with the University of Groningen. One of their research groups, 'Logistics in the Sustainable Urban Landscape', examines challenges related to:

1. Assessing the Effectiveness of Innovative Solutions for Liveable Cities.
2. Facilitating Stakeholder Collaboration and Public Policy Development.
3. Ensuring Justice, Fairness, and Equity for Smaller Firms and Inhabitants.
4. Cultivating New Imaginaries for Last-Mile Logistics and City Life.
5. Enhancing Data-Driven Decision-Making and Knowledge Sharing[53].

In recent years, researchers and planners have shown increased interest in incorporating climate adaptation into spatial planning.

Several countries share landscapes similar to that of It Lege Midden and face comparable issues, such as peat oxidation. The International Peatland Society is a network of experts focused on peat and peatland management. Over the years, it has published various articles and organised numerous conferences. Its strategy aims at conserving peat and rehabilitating drained, degraded, or otherwise altered peatlands. The ecological significance of peatlands and their uses in agriculture, energy, and other sectors are also examined[54]. This demonstrates how international knowledge exchange can support global peatland preservation.

In 2010, the Vereniging Nederlands Cultuurlandschap declared Fryslân the most beautiful province in the Netherlands. The assessment considered ecology, biodiversity, historical features, and water quality. The province was especially praised for its bocage landscape[55]. The province boasts an

[49] Translation: Spatial quality in water safety management.
[50] Keijzer et al. 2023, 36-39.
[51] Restemeyer et al. 2024, 3-30.
[52] Postma and Schwandt 2024, 14-22
[53] Buys & Rauws 2024. Retrieved from https://www.rug.nl/rudolf-agricola-school/research/sustainable-landscapes-and-regions/logistics-in-the-sustainable-urban-landscape
[54] Clarke & Rieley 2019, 7-25.
[55] Terrain of mixed woodlands and pasture.

extensive network of ditches, hedgerows, and wooded banks[56]. Unsurprisingly, Fryslân has placed greater emphasis on the conservation and restoration of its cultural landscape. Through projects such as 'Herstel Cultuurlandschap', experts and local communities aim to protect and recover the Frisian cultural landscape[57].

1.2 Epistemology

1.2.1 Research method

The basis of this research is a combination of literature review and policy analysis. The literature review will examine existing sources on It Lege Midden as well as water management and spatial planning. The policy component will focus on current policies and expertise of researchers. This research primarily concentrates on climate adaptation.

Researchers in systematic review and meta-analysis Edward Purssell and Niall McCrae argue that 'systematic literature review is formed as a logical, linear process where each part is informed by that preceding it'. In this process, sub-questions can be posed. Each may follow a slightly different approach, but the general principles remain the same[58]. This study will address sub-questions to guide the overall research question, which will be answered with the help of literature and expert input.

Political scientist Eugene Bardach describes policy analysis as a social and political activity involving moral and intellectual responsibility for the quality of analytical work. However, policy analysis extends beyond this to include large numbers of citizens, professionals, and stakeholders in the decision-making process[59]. In this research the aim is to reflect on current policies in relation to my topic of interest.

[56] De Pijper. 2010. Retrieved from https://www.trouw.nl/nieuws/friesland-is-het-mooist-gebleven~b985c5af/
[57] It Lege Midden 2021. Retrieved from https://itlegemidden.nl/projecten/herstel-agrarisch-cultuurlandschap-fryslan-2021-2024/
[58] Purssell & McCrae 2020, 19-21.
[59] Bardach 2012, xv.

1.2.2 Frisian identity

During the late eighteenth and nineteenth centuries, a period marked by Romanticism, interest in national identities across Europe increased. Research during this period often focused on an area's language, culture, and society. In Fryslân, Frisian linguist and author Joast Hiddes Halbertsma was a significant figure in the development of Frisian cultural identity[60]. Frisian identity and its associated landscape are frequently connected in literature. For example, in 'Over het volkskarakter der Friezen' (On the group identity of the Frisians), Halbertsma describes the Frisian, and their landscape as follows:

'The Frisian of clay will never fully feel at home on these high grounds. He is a man of the water and the flat land without trees. His eye must be as free as his will and actions.[61]' (translation)

Some of the ideas associated with the Romantic era have been subject to later critique. The concept of 'Volksgeist', popularised by Georg Wilhelm Friedrich Hegel, has attracted criticism. Hegel emphasised the importance of world history in the self-actualisation of the universal spirit (Geist). In this process, the spirit is liberated, reaching a moment of alignment between self-consciousness and rationality. Hegel posited that states, tribes, and individuals each acquire a specific and fixed principle over time. Due to this rationale, certain societies were viewed as less developed and, therefore, subordinate[62]. In this context, Hegel appears to justify the negative consequences that this perspective could impose on so-called 'primitive' groups.

In recent years, interest in regional and local identities appears to have increased. The concept of indigenous knowledge has gained popularity. Anthropologist Brian Morris defines this as the way in which ordinary people relate to the natural world. He argues that the term 'indigenous' is not easily applicable to many European localities, given their emphasis on culturally shaped or urban landscapes[63]. Nevertheless, terpen are an example of the interaction between premodern human settlements and water. The inhabitants were shaped by the natural forces of water, and terpen served as protective structures against flooding. In later periods, this function became redundant with the construction of dikes. The notion of 'Local Solutions to Global Problems' has become a popular slogan in climate governance[64]. Glocalism is an important concept in the contemporary management of climate change, as it acknowledges both globalising and localising dynamics in social, political, and economic systems. Writer and international relations expert Xiaoyu Lu emphasises that local and global entities should be engaged in a continuous and interactive process of negotiation and renegotiation. He argues against a binary division between local and global structures. The local represents the contextual and everyday experience, rich in temporal and spatial detail, while the global reflects the broad, universal, and generalisable, often detached from specific places. Lu asserts that these two spheres are interconnected and mutually influential[65].

[60] De Jong 2009, 15-18.
[61] Wiersma 1938, 41.
[62] Leezenberg & De Vries. 2017, 163-169.
[63] Morris 2010, 1-2
[64] Frazetto & Frischknecht 2003, 553-555.
[65] Lu 2021, 36-38.

1.2.3 Research gap between cultural landscape and climate governance

Within this research, emphasis is placed on the value of the Frisian cultural landscape in relation to the more modern climate governance. Historical geographer Jelle Vervloet describes the cultural landscape as one that bears the imprint of human activity, having been transformed and adapted to human needs. These interventions have led to modifications of the natural landscape. Such human interferences alter the classification of the respective landscape[66]. The cultural landscape can be changed through various processes such as agriculture, infrastructure, and water management. The terpen were constructed to protect the area against the natural forces of water. The first terpen were primarily located in the salt marsh landscape along the coastlines of Groningen and Fryslân. In the salt marshes, the water was less active than in other areas. Due to the low water flow, terpen could be constructed and were not easily damaged by the sea. The construction of these structures changed the area's terrain drastically. Houses and churches were built on these hills to protect them from the unruly waters. Later, they were integrated into the nucleus of many villages and cities. They protected the inhabitants from flooding. In this research, terpen will be analysed in It Lege Midden to assess whether they can also prove beneficial[67].

In the master's thesis 'Van Blauwgrasland naar Uitgestrekte Raaigrasweide', Marten Braaksma discusses both the physical and cultural factors that shaped the current landscape. His theoretical framework focuses on the interaction between landscape, nature, and agriculture. All three play a role within the concept of 'historical ecology.' He argues that various changes have occurred within agriculture. While in the past there were clear differences between the winter- and zomerpolders[68] (binlân and bûtlan), during the winter the zomerpolders would be flooded and left alone, while in the summer they would dry and become accessible for cattle. In the winter, these zomerpolders played an important role for many other animals due to the abundance of food and space. With the extensive reclamation of wet areas and the adoption of more intensive agricultural techniques, biodiversity declined significantly around 1900. In recent years, there has been growing attention to nature-inclusive agriculture. Braaksma argues that farmers can look to the premodern cultural landscape for alternative farming techniques[69]. Thereby connecting historical land use and agriculture and contributing to a more sustainable process.

In addition to landscape design, this study will focus on climate governance. Climate governance addresses both mitigation and adaptation. Mitigation aims to reduce the effects of carbon and other greenhouse gases emissions or to remove carbon dioxide from the atmosphere. Adaptation addresses the effects of climate change and seeks to adjust relevant infrastructure and practices. Both forms of climate governance are influenced by their systems of federal governance[70]. In this study, climate adaptation will be the primary focus. The terpen are relevant within the field of climate governance. In current climate adaptation strategies, many researchers tend to prioritise grey infrastructure over more sustainable options. This study will look more into landscape changes. Through landscape alteration, this study aims to contribute to a more sustainable and secure water system. This research will explore the potential overlap between the cultural landscape and climate governance, focusing specifically on terpen and their potential in climate governance. At the same

[66] Vervloet 1986, 1-4.
[67] Wiersma & Nieuwhof 2018, 11-24.
[68] Reclaimed area.
[69] Braaksma 2019, 1-15 and 99-107
[70] Fenna et al. 2023, 1-2.

time, it aims to bridge the gap between the historical and cultural landscape and climate policy strategies (see figure 5).

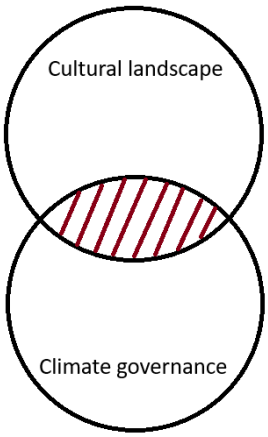


Figure 5: Cultural landscape and climate governance.

1.3 Aims and objectives

1.3.1 Overview

The aims and objectives of this research are not only to integrate cultural landscape elements within climate adaptation governance, but also to analyse the landscape of It Lege Midden and explore the integration of terpen within the area. Here, the practicalities of the region and the construction of terpen will be discussed. This study will examine the policy-making process and public collaboration regarding climate adaptation governance measures. During this research, current policies regarding water management, climate adaptation and ecology will be analysed. The focus will be on the central research question: *'How can landscape alterations, such as terpen, prove successful in the climate adaptation of It Lege Midden?'*

This research question will be addressed through three sub-questions:

1. What are the landscape characteristics of It Lege Midden?
2. How can terp constructions be applied within the landscape?
3. What are the possibilities regarding national policies in It Lege Midden?

1.3.2 Approach

This research will begin by addressing the sub-question, 'What are the landscape characteristics of It Lege Midden?' The aim is to analyse the region's landscape and assess the potential benefits of terp constructions in this specific area. It will therefore examine the characteristics of the landscape and its rivers. Issues such as peat oxidation and salinization will be discussed, alongside a description of the area and an exploration of the feasibility of constructing terpen.

The next sub-question, 'How can terp constructions be applied within the landscape?', will examine how terpen can be integrated into the landscape. It will consider the requirements for constructing terpen in the region, including their form and materials. Additionally, the function of terpen will be explored.

The following sub-question, 'What are the possibilities regarding national policies in It Lege Midden?', will evaluate current climate adaptation, water management and ecology policies. It will assess measures that have already been implemented, or should be, by analysing contemporary and recently amended policy acts. Policy documents from municipalities related to It Lege Midden, Wetterskip Fryslân, and the municipality of Leeuwarden will be considered.

These sub-questions will collectively contribute to answering the central research question: *'How can landscape alterations, such as terpen, prove successful in the climate adaptation of It Lege Midden?'* Through these sub-questions, this study will evaluate important issues such as landscape features, terp construction, policy, and public perception. These factors will inform the assessment of the success of terp implementation. An increasing number of experts support the idea of giving rivers more space to flood, which reduces sea drainage. This study will explore the potential of terpen in improving water management and mitigating water hazards.

1.4 Methods

The study's approach will follow a deductive research strategy. Deductive studies operate from the 'top down', beginning with theory and progressing through hypothesis and observation[71]. This research will focus on the construction of terpen in relation to climate adaptation. Although specific studies on this topic exist, this research will specifically examine the integration of terpen in It Lege Midden. This phase will primarily involve a literature review and landscape analysis. Once this stage is complete, the focus will shift to policy analysis. This stage will include an examination of policy programs. Projects whose tools relate to terpen will be researched. Then the process and findings will be further analysed.

The study will employ a qualitative research design. The goal of qualitative research is to investigate a particular social situation, event, role, group, or interaction. In this case, the focus will be on climate adaptation. Data collection will rely primarily on existing literature rather than data-gathering techniques. Furthermore, both the research process and its outcomes will be considered important. The likely outcome will involve a negotiation between the possibilities of spatial planning and the

[71] Soiferman 2010, 2-3.

limitations of climate adaptation governance, due to the involvement of various stakeholders and their diverse interests[72].

1.4.1 Methodological approach

A variety of research methods will be used, aligned with the research questions. For the first question, 'What are the landscape characteristics of It Lege Midden?', the study will focus on literature review. The three main objectives are: (1) to situate the research focus within the broader academic context, (2) to provide a critical review of relevant literature, and (3) to identify a gap that the research will address[73]. A number of articles have already been published on It Lege Midden, and many landscape researchers have shown interest in the area due to its uniqueness and challenges.

For the second question, 'How can terp constructions be applied within the landscape?', the focus will be on the spatial planning of such projects. Existing literature on similar endeavours will be reviewed. Correspondence or participation in formal or informal interviews with specialists may be pursued to gain technical insights into the topic.

For the third question, 'What are the possibilities regarding national policies in It Lege Midden?', the research will include a policy analysis. Specifically, programs focused on water management, climate adaptation and ecology will be examined. Furthermore, previous projects with terpen will be analysed. Their success has been the result of well-developed process. Expert input will be sought, particularly through interviews.

1.4.2 Ethical considerations

In this study, interviews were conducted with experts. This complements the literature review and policy analysis. My policy analysis is empirical and based on expert interviews.

I hereby declare that this thesis is an original work, produced solely by me. If I have borrowed information and ideas from other sources, I have explicitly mentioned this in the text and notes.

Leeuwarden, 09-06-2025

[72] Creswell 2009, 180-186.
[73] University of Leicester 2009, 1.

1.4.3 Anticipated dissemination and impact

The focal point of this research is the integration of elements of the historic cultural landscape within climate adaptation governance. By focusing on the use of terpen, this study will address sustainable water management and mitigating water hazards. While traditional water protection methods, such as dikes, provide immediate security in some areas. In It Lege Midden less obtrusive solutions may be necessary for success. With traditional land and water use harming the landscape, looking for alternatives is becoming more important. Through the construction of terpen, this study aims to enhance the safety, liveability, and biodiversity of It Lege Midden.

In recent years, increased attention has been given to the cultural landscape in Fryslân. Projects such as ‘Herstel Cultuurlandschap’ focus on revitalising historical agrarian landscapes to support biodiversity or serve as inspiration for Nature-based Solutions. This study will focus on traditional landscape modifications specifically, terpen in the context of climate adaptation. Particular emphasis will be placed on water management in Fryslân, with the aim of exploring new perspectives in this field.

2. What are the landscape characteristics of It Lege Midden?

2.1 Introduction

It Lege Midden is a vulnerable area of Fryslân due to its low-lying character. Many experts have advocated for rewetting the land. Draining the land results in the drying and deterioration of the peat. These effects accelerate land subsidence and drastically alter the landscape. The Fryske Boezem is an important component of water management in It Lege Midden. Over the years, various lakes and swamps have been drained and transformed into polders. These lower areas are dependent on human intervention such as pumping stations and are more susceptible to salinization. This chapter will focus on water management and provide an analysis of the peatlands, low-lying areas, and surface waters in It Lege Midden.

2.2 The Fryske Boezem

Water from the polders is transported via ditches into the Fryske Boezem. This system connects many different lakes, rivers, and waterways throughout the province of Fryslân and the Gaarkeuken area in Groningen. In the past, the water level fluctuated with the changing of the seasons. During the summer, the Boezem had a smaller water body (around 17,000 ha) than during the winter. Currently, the target level of the Boezem is set at -0.52 m NAP, indicating improved control over water management. The water system is crucial for many sectors, including nature and water quality, agriculture, water supply to Groningen, commercial shipping, and water recreation.

Some stakeholders, such as nature organisations, advocate for more flexible fluctuations, while others, such as farmers, prefer to maintain lower water levels. For more flexible fluctuations, it is important to note that much of the water infrastructure is not equipped to handle large influxes of water (for example aqueducts). With increasingly extreme weather conditions, such as droughts and heavy rainfall, it is essential that the water system is capable of retaining and storing water.

During the 16th century, the first polders were created in Fryslân. In It Lege Midden, the number of reclaimed areas increased considerably through these years. At the time, safety concerns related to water hazards were prioritised over the productive value of the reclaimed land. In subsequent centuries, the number of polders continued to grow. The reclamation was accomplished using windmills, amounting to 1,732 mills operating across 1,543 polders around 1881. The Boezem became responsible for storing water from the polders[74].

By 1952, 12 peat polders, 241 waterboards (functioning as storage basins), and 963 privately owned polders were dependent on the Fryske Boezem for drainage. The stabilization of the Boezem was achieved through improvements to natural discharge systems, the closure of the Lauwerszee (1969), and the construction of a second pumping station (the J.L. Hoogland pumping station). Additionally,

[74] Wetterskip Fryslân 2022, 4-25.

the transition from numerous smaller committees to a centralised provincial waterboard, Wetterskip Fryslân had a positive effect on water management related to the Fryske Boezem[75].

Figure 6 shows the changes in ground level and groundwater flow over time. In the past, these areas were saturated during the winter, while in the summer they dried due to evaporation and drainage into low-lying, dewatered areas. As a result of the land subsidence, artificial drainage has become necessary to keep the land dry during the summer (see figure 7)[76].

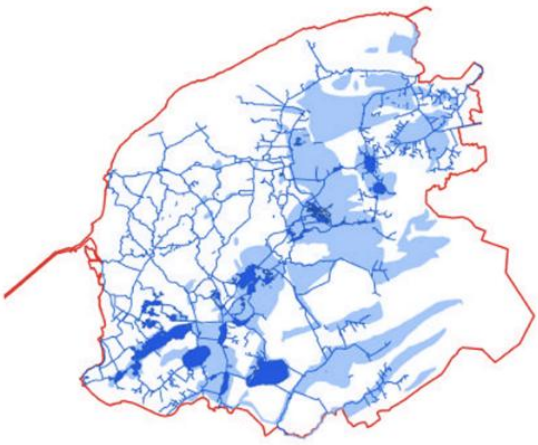


Figure 6: Fryske Boezem around 1876, the map shows the historic seasonal differences.

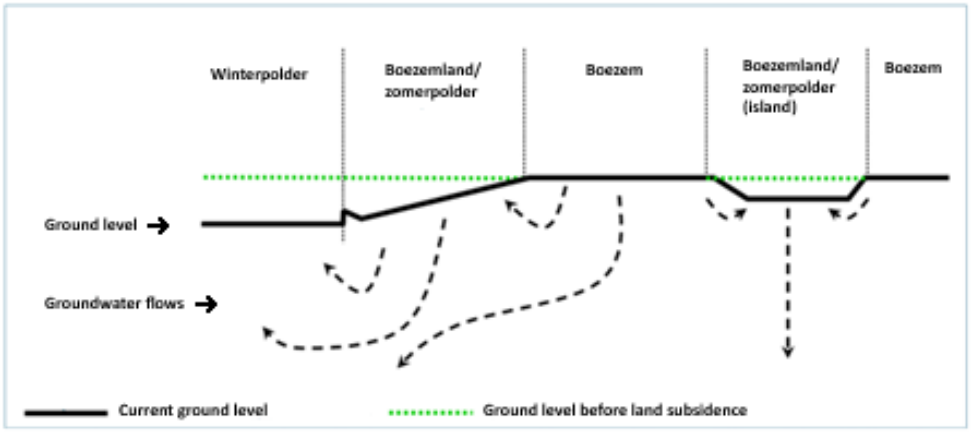


Figure 7: Schematic representation of ground level and groundwater flows in and around the basin in the current situation.

Many sectors have expressed concerns regarding the water level of the Boezem. Changes in water levels are rooted in the interactions among the natural, socio-economic, and institutional systems. The physical/natural system influences the socio-economic and institutional systems. Recreation and animal husbandry are possible due to the high quality of surface water. However, socio-economic

[75] Louman 2007, 491-509.
[76] Royal HaskoningDHV 2023, 26-28.

activities such as intensive farming can negatively impact the natural system, leading to peat deterioration and biodiversity loss[77].

Climate resilience has received increased attention in the policy-making process. Recent proposals by Wetterskip Fryslân aim to relieve pressure on the Frisian storage basin through several measures: disconnecting polders via new pumping stations, merging multiple polders (Greidhoeke) with a central discharge system through a new station, diverting discharge from De Lende and De Tsjonger under free fall to the IJsselmeer, eliminating dead-end storage basin canals, creating new intermediate storage basins with lower water levels and establishing controlled storage basins that can be locked during high water levels.

Other measures, which are also relevant to other parts of Fryslân, include:

1. Simplifying water system design by reducing the number of water level sections and pumping stations.
2. Reducing freshwater flushing for salinity control.
3. Decreasing the supply of fresh water to elevated sandy soils.
4. Conserving water on higher sandy soils.
5. Aligning design criteria and performance norms for water systems, particularly considering the degree of acceptable risk for functional operation (minimum system requirements and basic operational standards).
6. Introducing more flexible water level management, to be partially executed by land users themselves[78].

Sea level rise and significant fluctuations in precipitation may pose challenges to current water management strategies, potentially necessitating revised policy approaches for rivers and waterways.

2.3 Natura 2000

Natura 2000 is a European network of protected nature reserves. These areas are preserved due to their unique biodiversity of animals and plants. Many of the Frisian lakes and rivers are considered important ecological sites and have received the Natura 2000 designation. For example, the fens and lakes are important for species such as the *Limosa limosa* (black-tailed godwit), the *Spatula clypeata* (northern shoveler), and the *Gallinago gallinago* (common snipe). These animals typically forage and feed in wetlands. Insects such as damselflies and caddisflies also thrive in the fen, as they are dependent on water for breeding their larvae.

Due to the nutrient-rich atmosphere (eutrophication), the landscape is undergoing hydrosere succession[79]. This means that swampy and open waters are slowly transitioning into grassland and

[77] Hendriks et al. 2022, 11-13
[78] Wetterskip Fryslân 2018, 3-8.
[79] Plant succession of open water to climax woodlands.

forest. These ecological changes affect biodiversity, as many former species of plants and animals are unable to survive in the newly formed landscape and are therefore threatened[80].

Water quality is essential for maintaining a healthy and stable ecosystem. Currently, eutrophic levels have become more uniform, and both very eutrophic and non-eutrophic water bodies have largely disappeared. This loss of variability negatively impacts aquatic biodiversity. The growth of shoreline vegetation can help improve water quality, particularly as such vegetation thrives under high water levels. Hence seasonal water level fluctuation is considered a more favourable approach to maintaining water quality[81].

Many features of It Lege Midden are the result of human intervention. The creation of natural areas is often connected to cultural-historical activities, such as peat excavation, which produced swampy environments. The interplay between cultural and natural historical developments gives these areas their unique character[82]. In recent years, increasing attention has been paid to the cultural elements of the landscape, which are prominently present in these natural areas.

2.4 Landscape types and water management

It Lege Midden contains various landscapes: peat bogs and meadows, clay-on-peat, salt marsh plains and banks and stream valleys (see figure 8). Each landscape requires specific management practices, particularly regarding water levels. The geomorphological composition influences both vegetation and hydrological relationships. Peatlands are unsuitable for agriculture but can be used for animal husbandry. As the soil consists largely of plant remains, it remains soft and acts like a sponge, absorbing water.

In contrast, clay soils comprising smaller particles typical of tidal marshes retain water less effectively. Still due to their fertility, these tidal wetlands are well-suited for agriculture. The Drents Plateau, a higher region made up of push moraines (+10 to 20 m NAP), is composed of boulder clay overlain by coversand and peat. The elevation of this area exerts hydrological pressure on low-lying areas.

The varied landscapes of Fryslân add complexity to water management. Each land type requires specific attention. When water levels are low, clay soil can harden, but higher water levels may hinder agriculture. Conversely, peatlands need higher water levels for conservation purposes, although wet conditions can complicate farming.

Elevation is a critical factor in water management. Figure 9 illustrates the difference in ground and water levels between two areas: the left side of the road is significantly lower than the right, and the road serves as a barrier between the two fields. With the help of pumping stations, Wetterskip Fryslân can artificially maintain suitable water levels in each area. The low-lying nature of It Lege Midden presents significant challenges for the regional waterboard. The ‘Veenmobiel’ is a model used to represent current water management strategies (see figure 10). As It Lege Midden lies lower than surrounding regions, water naturally accumulates there. Through pumping stations, excess water is discharged into the sea or adjacent surface waters such as the IJsselmeer[83].

[80] Beltman et al. 2012, 385-388.
[81] Claassen 2008, 5-32.
[82] Hut & Wolf 2015, 8-15.
[83] Royal HaskoningDHV 2023, 18-39.

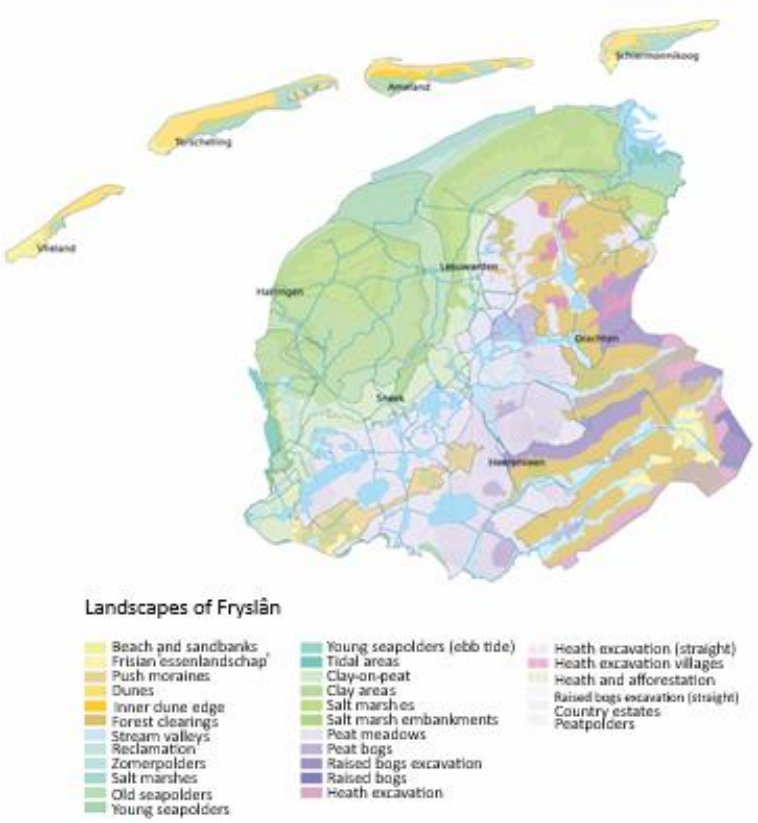


Figure 8: Map of Fryslân with its landscape types.


Figure 9: Image shows the difference in landscape and water levels (near the Alde Feanen).

Figure 10: Veenmobiel.

2.5 Low-lying areas

Fryslân contains several low-lying areas (−2 to −4 m NAP), many of which are polders. Reclamation was historically regarded as a risky endeavour, and to encourage development, the government exempted pioneers from taxes on lease value during the initial years. This policy led to the drainage of many lakes and wetlands[84].

The Veenpolders form a large cluster of reclaimed areas. These regions originated as peatlands, which were excavated in the 18th century, and they still exhibit the characteristic petgatten. In 1822, a regulation was introduced requiring that land be reclaimed once peat excavation ceased. Peat extraction remained common until the 20th century. The area features a thin peat layer overlying clayey sand and fine to medium sand[8586]. The most prominent polders in Súdwest-Fryslân are the Parregeastermar, Makkumer Mar, and Warkumermar. Prior to reclamation, these lakes were used for fishing. In 1876, the first steps toward drainage were undertaken using a steam engine, and by 1878, the reclamation of the three lakes was complete. The topsoil predominantly consists of a clay layer over peat, making the area relatively suitable for agriculture due to its clayey composition[87].

This study focuses on the polders located south of Leeuwarden. The landscape in these polders consists primarily of grassland, and their elevation ranges between −2.00 and −2.50 m NAP (see figure 11). These polders do vary in both land use and geomorphological characteristics. The top layer of Greate Wergeastermar consists of mostly clay (see figures 12 and 13), whereas Auke Hinsmar comprises over a small clay layer over peat (see figures 14 and 15). Presently, Greate Wergeastermar is used for farmland, while Auke Hinsmar serves as a nature reserve. Although many polders contain clayey soils, farmland in the region is still predominantly dedicated to animal husbandry or a combination of land uses.

Over time, numerous experts have raised concerns about salinization in these low-lying areas. Through seepage saltwater can affect both farmland and nature reserves with impact on vegetation

[84] Schroor 1989, 75.
[85] Raap 2022, 1-7.
[86] Van Kampen 2025. Retrieved from https://fryslansite.com/schema/html/veenpolders.htm
[87] Westerink 2010. Retrieved from https://noorderbreedte.nl/2010/03/31/hoogte-op-kleur-2/

and soil composition. Internal salinization is common in coastal and low-lying areas, particularly in polders and regions near pumping stations. These effects intensify with rising sea levels. Establishing freshwater buffers such as water reservoirs can help mitigate these issues, as freshwater is less dense than saltwater and can reduce the upward flow of saline groundwater[88]. Salinization in It Lege Midden is more connected to its water management than its low-lying character. With drainage water levels are kept low, which results in more seawater infiltrating fresh surface waters.

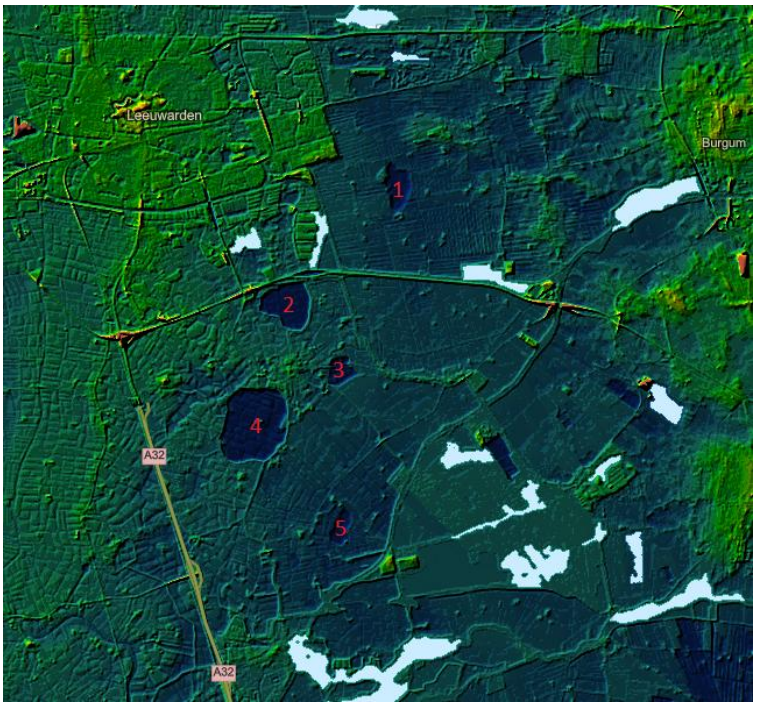
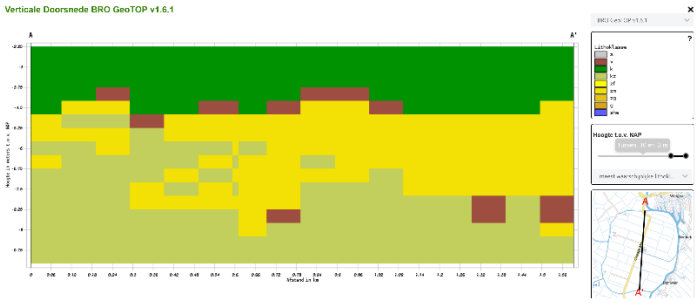


Figure 11: Low-lying areas (blueish colour) near Leeuwarden (1 t/m 5: 2.5.1-2.5.5)

[88] IPLO 2025. https://iplo.nl/thema/water/beheer-watersysteem/verzilting-oorzaken-gevolgen-maatregelen/



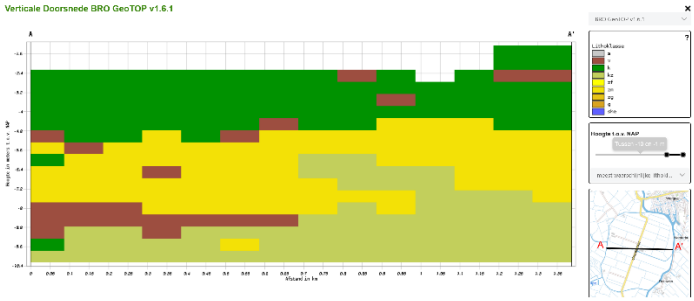
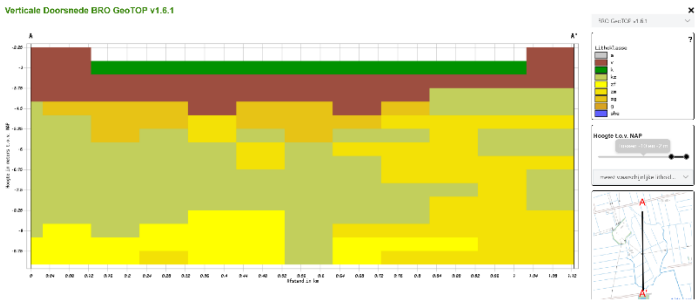


Figure 12 and 13: Presumable geomorphological data of the Greate Wergeastermar -10 till -2 metres NAP (green: clay, light green: clayish sand, brown: peat and yellow/orange: sand).



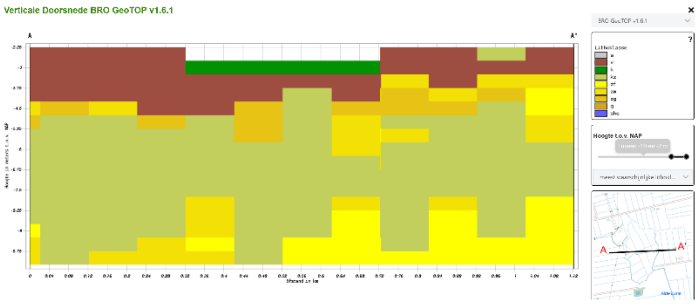


Figure 14 and 15: Presumable geomorphological data of Louwsmarpólder -10 till -2 metres NAP.

2.5.1 Louwsmarpólder

The Louwsmarpólder covers an area of 40 hectares. Four merchants from Makkum initiated the drainage of the former lake Louwsmar. The lake was reclaimed in 1780, only to be inundated again in 1784. In 1807, it was sold to a resident of Leeuwarden. In 1847/1848, the land was once more reclaimed[89]. Currently, the area is used as grassland by a certified organic farmer[9091].

2.5.2 Himpensermar

The Himpensermar spans 98 hectares. In 1773, three Frisians decided to reclaim the land, which was officially reclaimed in 1785[92]. The drainage employed a dike and ring canal, powered by windmills (wind energy). Recently, an electric pump system was installed to allow for more regular operation. Many of the land parcels are square rather than rectangular and are referred to as 'seis pûnsmiet[93]'. The term 'seize' is derived from this unit, and plots were often named according to their use, such as Bargehokseize (pig pen) or Koarnseize (barley) [94]. The former 'stelp' farmstead in the polder has been converted into a restaurant named Gasterij de Waldwei. The polder is open to birdwatching enthusiasts and has been granted municipal monument status.

2.5.3 De Lytse Mar

De Lytse Mar, besides known as the Jornahuystermeerpolderand covers approximately 25 hectares. The initiator of the reclamation was Wybren Franz van Jornahuys (1537–1623). His gravestone, originally located at the Nederlands Hervormde Kerk in Wergea, was later reused for a public toilet at a bridge in Wergea but was eventually preserved and placed as a monument in the polder. Historical maps show that two windmills were constructed for reclamation purposes in 1718. Two farmsteads were established in the polder and were owned by families bearing names linked to the Jornahuystermeerpolder[95], either by descent or through name adoption in 1811[96]. In 1634 it was partly drained. The environment of the polder was rich in lakes and water, but with the introduction of electric drainage, this changed[97]. Currently, the polder consists of grasslands and provides family accommodation for tourists[98].

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[89] De Brouwer 1958. *Encyclopedie van Friesland*.
[90] Boerderij Louwsmar unknown date. Retrieved from https://boerderijlouwsmar.nl/
[91] Schroor 1989, 77.
[92] Schroor 1989, 77.
[93] Dutch translation: Zes pondematen.
[94] Gasterij de Waldwei 2018. Retrieved from https://issuu.com/jipp_jobsinprintpromotion/docs/jipp_krant_gasterij_de_waldwei___he
[95] 'Jorna' or a derived name of 'Jurna'.
[96] Van der Kolk online unknown data. Retrieved from https://www.vanderkolkonline.nl/wijtgaard/
[97] Molen Database 2025. Retrieved from https://www.molendatabase.nl/molens/ten-bruggencate-nr-03083-a
[98] De Lytse Mar unknown date. Retrieved from https://www.friesland.nl/nl/locaties/2163514436/de-lytse-mar

2.5.4 Greate Wergeastermar

The Greate Wergeastermar, also called the Greate Mar, covers approximately 216 hectares and is one of the largest and oldest reclaimed areas in Fryslân. The reclamation was initiated by merchant Paulus Janszoon Kley from Amsterdam. A monument has been erected in his memory. Greate Mar 2, the oldest building in the polder, was constructed in 1680. Greate Mar 4 was built in 1876, and the remaining structures were erected in the 20th and 21st centuries. The Wergeaster Feart canal flows along the eastern side of the polder[99]. Here many farmers are engaged in animal husbandry.

2.5.5 Auke Hinnesmar

Auke Hinnesmar comprises approximately 26 hectares and was reclaimed in the late 19th century. The name is derived from Auke Hinnesz. According to 'Het Geslacht Wartena' by K. Terpstra, he was the son of Hinne Olfertsz, a farmer from Grou in 1580, where he worked on pastoral lands. He later resided at the 'Tjesmawier' farmstead. Today, the area has been designated a small nature reserve and is accessible to visitors seeking to enjoy the natural environment[100].

2.6 Benefits of the terpen

Groundwater and seepage water tend to collect itself in the low-lying areas. This water also comes from surrounding natural sites and higher areas. This transportation of water can result in the drying out of peatlands and surface waters. This means that the water management of these areas directly affects neighbouring landscape. Around the edges of peatlands which had *Potamogeton* (pondweed), *Sagittaria sagittifolia* (arrowhead) and *Stratiotes aloides* (watersoldiers), are repressed by *Phalaris arundinacea* (ribbon grass), *Glyceria maxima* (great manna grass) and *Hydrocharis morsus-ranae* (European frog-bit). This shows the geological development in these areas. The former peatlands are slowly transforming in sandy or in some cases clayey lands[101]. The construction of terpen together with a more dynamic water management could help in lessening the effects of peat oxidation, salinization and loss of freshwater.

[99] Schroor 1989, 73.
[100] Sytema 2002, 1-2.
[101] De Ruyter 2020, 51-65

2.7 Conclusion

The Frisian landscape is diverse in both landform and elevation, which complicates water management policy. The Fryske Boezem, a natural water system, has been significantly altered by human intervention. This has led to the reclamation of lakes and swamps, came to affect peat layers and demanded drainage infrastructure. The polders now serve various purposes, with some dedicated for agriculture and others more nature-inclusive objectives. Their water management is however connected with the neighbouring areas, water from higher areas and surface waters gathers in these low-lying areas. A change in water management could lessen the impact of peat oxidation, salinization and loss of freshwater. In recent years, increasing attention has been paid to the ecological value of the Boezem. Eutrophication is affecting the species richness in natural sites and water.

3. How to apply terp constructions within the landscape?

3.1 Introduction

Terpen can vary in form. They can be constructed using natural sediment or through artificial methods. Terpen serve to protect buildings from flooding, acting as a barrier against rising water. Moreover, terpen can be built using dredged material. Some experts have advocated for the construction of 'green terpen', which may offer ecological benefits to the area. The solution of terpen could contribute to environmental and socio-economic benefits (NbS). It is important to consider these objectives when looking at a given location.

3.2 Types of terpen

In the past, elevated dwellings have been found in many countries. However, terpen were specifically constructed in regions affected by high tides. Despite appearing isolated, these communities were in fact relatively open. During low tides, the inhabitants primarily engaged in agriculture and animal husbandry. Historically, terp construction was a continuous process. Figure 16 shows how historical terpen were incrementally elevated over time[102]. These terpen were constructed using sods[103], manure, sediment, and some waste materials. Contemporary terpen vary in construction and location. A terp can be built on the landward or seaward side of a dike, may have a gentle slope or steep sides, and can be used for residential, agricultural, or recreational purposes[104]. During floods, terpen can help reduce damage to buildings and communities. In certain areas, they are already being used for flood protection. Even though these communities seem to be secluded, they formed nevertheless an open society (see Annet Nieuwhof's interview in annex). During low tides the inhabitants focused mostly on agriculture and animal husbandry. Now terpen can differ in their construction, location and use. A terp can be built in the inner or outer areas of the dike, have a slope or steep form and be used for living, farming or recreation.

[102] Nieuwhof et al. 2019, 81-82.
[103] Sods consist of the topsoil (5-10 centimetres). In this layer the plants and roots are strongly presented.
[104] Van Akkerveeken et al. 2007, 30-33.

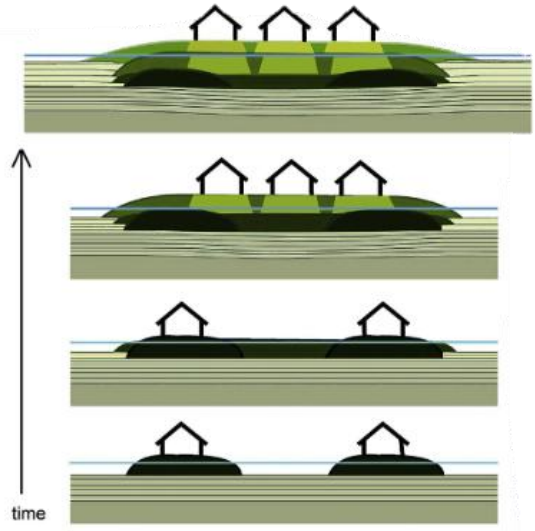

Figure 16: Terp habitation (from Iron Age till 11th century).

In Germany, terpen have been constructed in coastal areas. These newer terpen are built with sand, marine clay, and a layer of sods on top[105]. In the Overdiepse polder, local materials were predominantly used. The terpen there consist of multiple sand layers, each terp covering about 2 hectares and reaching six metres in height[106]. Terpen can also have different designs. The 'sludge ring' is a circular structure with two or three concentric rings. When river water fills the ring, sediment is deposited inside as the water drains out, gradually raising the land (concentrated sedimentation basin) (see figure 17). The underground bunker method uses a strong concrete foundation filled with soil. With refillable geotubes, two ramparts are placed on each side. The cavity is filled with geotubes or sacks packed with material. An advantage of using geotubes or sacks is improved drainage and greater stability. The filled terp technique uses sediment from (river) floodplains to raise land behind the winter dike (winterdijk). The excavated area in the floodplain will gradually fill with sediment over the following years[107].

[105] Arbouw 2020. Retrieved from https://www.volkskrant.nl/wetenschap/hogere-terpen-tegen-zeespiegelstijging-het-gebeurt-in-duitsland~b8c6fe3a/
[106] Brabantsedelta 2015. Retrieved from https://www.youtube.com/watch?v=oxK_6pkFCBU&list=PLuCaggWfJy8GyGaXyb1vtOe3i1SuC1MDb&index=3
[107] Colin et al. 2004, 20-24.

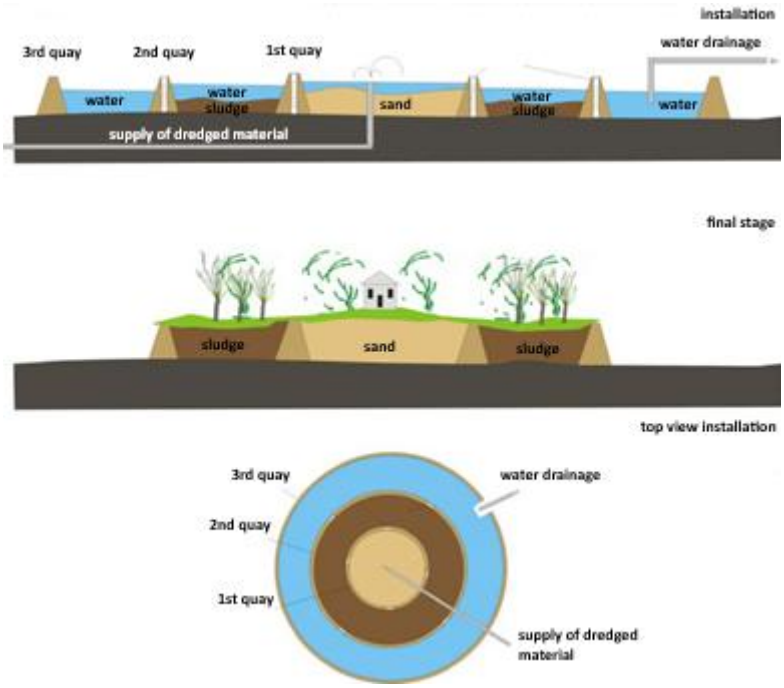

Figure 17: Sludge ring.

The use of dredged material for terp construction is as well an option. In 2005, WaterINNovatiebron (WINN) were trying discussing the construction of trial terpen using dredged material near rivers. This material must first be tested for contamination, and the project must be supported by local authorities and the public. These trial terpen are relatively small, covering around one hectare. Their purposes vary: some are integrated into larger nature parks, while others serve as recreational spaces[108]. Terpen may serve multiple functions such as residential, agricultural, ecological, or recreational.

For residential terpen, dredged material could be used. Such structures should be limited to individual homes or farmsteads and not be built in urban areas or open water bodies. They must comply with nature conservation policies. Inappropriate placement in surface waters can negatively affect water flow. Environmental studies student Rutger Veenstra has suggested that terpen are best constructed adjacent to a dike[109].

3.3 Climate-resilient terpen

Researchers Chris Jacobs and Eric Koomen, in their report on global spatial evaluation and safety strategies for the Netherlands by 2100, examined the potential for constructing terpen. In 'Nederland Omhoog', they explored the feasibility of building terpen in urban environments. These structures would be used for residential and commercial zones in the Netherlands, covering approximately 65,000 hectares. Additionally, the report analyses spatial planning scenarios focused on socio-economic trends, such as urban expansion, island creation, and coastal widening. The terp strategy is positively evaluated in terms of safe construction and landscape quality, as well as for the

[108] Rademakers 2004, 3-17.
[109] Veenstra 2007, 23-37 and 71-73.

international business climate and the physical living environment. It did receive negative evaluations concerning environmental, health, and safety (EHS) standards. Within regional communities, terpen may negatively impact the landscape quality and local identity[110].

Terpen have typically been examined in studies concerning climate-resilient housing or spatial planning. Integral system approach expert Anne Loes Nillesen and urban designer Mona zum Felde, argue that the effect of terpen is similar to building houses on stilts. In both cases, the structures raise the maximum water level that buildings can withstand. Modern terpen can protect houses from flooding, but their height must be determined during initial construction, as elevating them later is difficult. Building terpen moreover requires substantial investment, with benefits typically realised over the long term[111]. For residential terpen, a stable structure is essential for its prolonged use. This stability is best achieved using multiple sediment layers or robust construction techniques such as underground bunkers or geotubes. These structures are more resistant to extreme weather events and easier to maintain. Floor elevation for houses has been researched in other countries too. Inhabited areas prone to flooding have been analysed in terms of floor elevation. In many cases, such constructions are preferred due to their cost-effectiveness based on benefit-cost analyses. Still experts often rely on generalised building specifications, while the actual construction costs of elevation are highly specific. Thus, some researchers have provided more detailed data on elevation costs per building[112].

It is important to assess the surrounding landscape when constructing terpen. Besides water safety, creating more space for rivers or changing the water level are as well important to address. Furthermore, terpen can play a role besides the construction of dikes, pumping stations, etc. Using low dams can additionally work as a sedimentation trap, here the area is being elevated by sediment deposition. As a result, the raised terrain becomes less vulnerable to flooding.

3.4 Dredged terpen

Dredging involves removing sand, silt, and other layers from the waterbed, as well as land reclamation and surface water clearance. Dredge refers to the accumulated material such as sand, silt, and debris deposited in rivers. Dredging is vital to prevent obstructions to shipping (see figure 18). However, this dredged material must be stored. Creating small terpen (approximately one hectare) can benefit wildlife by providing breeding grounds. For plants, changes in relief offer more opportunities for diverse species to grow, thereby creating a more varied landscape[113].

[110] Jacobs & Koomen 2008, 2-18.
[111] Nillesen & Zum Felde 2022, 16-18.
[112] Taghinezhad et al. 2021, 1-2 and 11.
[113] Wetterskip Fryslân 2025. Retrieved from https://www.wetterskipfryslan.nl/kaarten/baggerkaart

Figure 18: The dredging activities in the area below Leeuwarden (top-left corner).

Waterbeds typically contain both natural and artificial waste. Items such as bicycles, plastics, rubble, and car tyres are considered foreign objects, which complicate dredging operations and pollute water bodies (with substances like metals, oil, and polycyclic aromatic hydrocarbons). Hence careful examination of the water basin is essential[114]. In the Netherlands various locations have been appointed for the storing of contaminated material, so-called baggerdepots (see figure 19). In Klompenwaard, an area was analysed where river dredged material was deposited. This snuffelterp (examination terp) was assessed for soil contamination. The cover layer (0 to 1.5 metres deep) showed slightly elevated metal concentrations. Still the study found out that the polluted material would likely not significantly contaminate surrounding soil or groundwater[115].

Figure 19: Example of baggerdepot near Hollandsch Diep and nature reserve Sassenplaat.

[114] Bolleboom & Van Etten 2005, 5-6 and 41-42
[115] Van Rijsbergen 2006, 1-8.

In a study at Broekpolder, vegetation growth on dredged soil was examined. Experts from the Instituut voor Bos- en Natuuronderzoek[116] studied the vegetation's response to contaminated dredge material. The study found that growth rates for many plant species such as *Fraxinus* (ash) and *Acer* (maple) were unaffected, except for *Quercus* (oak) which was slightly reduced and *Populus* (poplar) which was moderately reduced. Elevated pH or calcium carbonate ($CaCO_3$) levels in the dredge were identified as likely causes of this reduction. Spontaneous vegetation was dominated by *Urtica dioica* (stinging nettle), although in rare cases, rural species like *Chamaenerion angustifolium* (fireweed) appeared[117]. The findings demonstrate that dredged material can be used in natural areas, provided the vegetation is suited to the soil conditions, thus optimising the natural habitat.

In recent years, attention to de-eutrophication (verschraling) has increased. Projects aimed at reducing phosphate and nitrogen levels in natural habitats have expanded. Eutrophic areas often display less biodiversity. De Leijen, a lake in Fryslân measuring 300 hectares, was one such site. Specific measures were implemented to combat eutrophication and silting, including efforts to reduce nutrient loads and wind-induced sedimentation while improving water clarity. Interventions included IBAs[118], rainwater decoupling systems[119], the creation of a purification marsh, channel dredging, and fish population management[120]. To address wind movement, islands and rows of posts (palenrij) were constructed. To enhance water clarity, hydrophytes (aquatic plants) and *Dreissena polymorpha* (zebra mussels) were introduced. These efforts appear to have improved water quality, though organism growth varied, with noticeable improvement primarily in fish populations[121]. Dredging can partly help in reducing eutrophication. With it limiting the amount of nutrients in rivers.

Some projects aim to alter surface levels by removing eutrophic soil, thus allowing a wider variety of plants to thrive[122]. The removed soil may be repurposed to construct terpen, creating a mosaic of eutrophic and non-eutrophic zones in the landscape. Terpen can serve as refuges that support rare species, thereby enhancing biodiversity.

3.5 Implementation

In the past, proposals to submerge polders such as the Himpensermar for recreational use in Fryslân were discussed. These proposals would have drastically altered the landscape and water management but were never realised. Recently, the Himpensermar was designated for water storage by Wetterskip Fryslân. During periods of extreme rainfall, the polder can store excess water[123]. Adapting the Himpensermar for water storage required significant infrastructure changes, including elevating the neighbouring dike and constructing new pumping stations and dams (see figure 20).

[116] Institute for Forestry and Nature Research
[117] Peeters & Van den Berg 1998, 5-28.
[118] Individuele Behandeling van Afvalwater. English translation: onsite sewage facility.
[119] Prevents rainwater from draining in the sewers.
[120] Reducing the amount of the *Abramis brama* (common bream, Dutch translation: brasem), these fish habits eutrophic waters. 'Verbraseming' is the situation when there are few water plants in the riverbed and the water becomes blurred by algae. In this situation the number of northern pikes plumet. Therefore, creating a situation where the number of common breams grow (Paternotte 2007, 28).
[121] De la Haye et al. 2012, 28-31.
[122] Hendriks et al. 1985, 8-12.
[123] Wetterskip Fryslân 2025. Retrieved from https://www.wetterskipfryslan.nl/projecten/polder-himpensermar-inrichting-als-waterberging

Other Frisian polders have as well been used as washlands[124]. Hence the areas can prove successful in reducing desiccation during warm periods, while being stored water during wet. In previous years, the practice of 'ontpolderen[125]' has faced significant opposition most notably in the case of the Hedwigepolder, which many residents viewed as a symbol of regional resilience against flooding. Public and media opposition led to delays and criticism of inundation plans[126]. However, this tool may be necessary to reduce the effects of weather extremes.

In the future, maintaining low water levels may prove challenging due to peat oxidation and salinization. This will necessitate more flexible water management systems. Draining such areas could become expensive in terms of land subsidence and operational costs (pumping). Therefore, policymakers must critically assess low-lying areas.

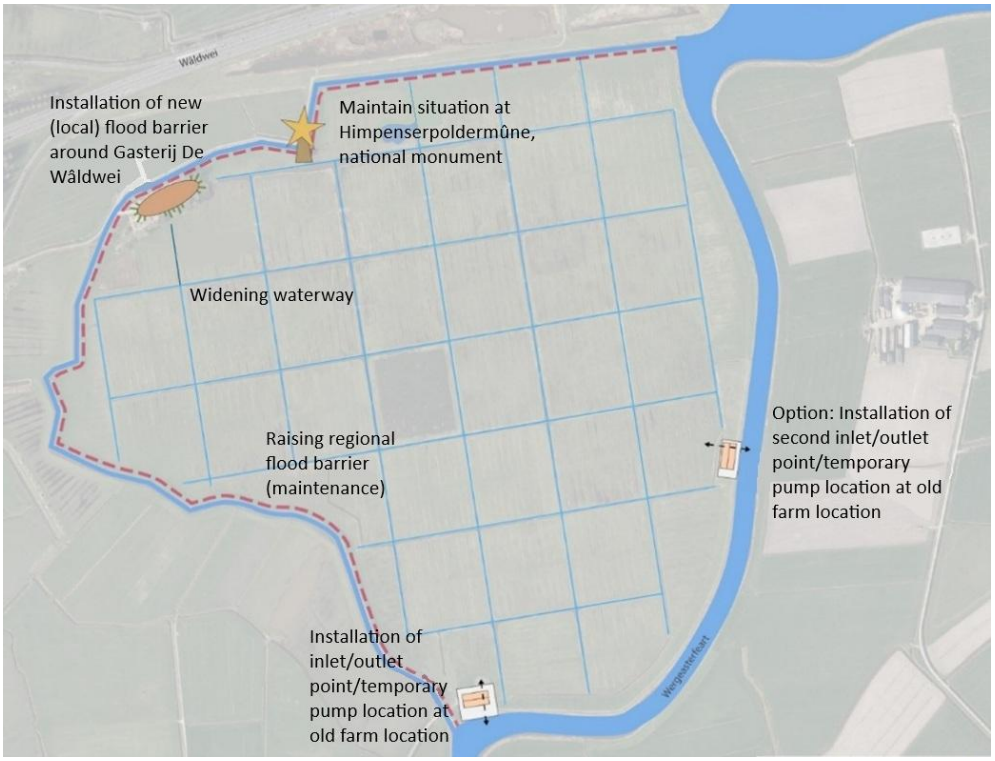

Figure 20: The changes in the Himpensermar (elevating the dikes and construction of pumping stations and dams).

For more effective water management, it is important to consider low-lying areas. As Peter de Ruyter discussed, the focus should be on retaining water instead of draining it (see annex). Water naturally flows to low-lying areas, resulting in the drying out of higher elevations. Maintaining a higher water level in these low-lying areas during winter can limit peat deterioration. During the summer the water level will naturally be lower, making the area suitable for animal husbandry. Pursuing a more natural, rather than artificial, approach to water management can reduce peat deterioration.

[124] Wetterskip Fryslân 2024. Retrieved from https://www.wetterskipfryslan.nl/news/update-4-januari-we-zetten-zeven-retentiepolders-in
[125] De-reclamation.
[126] Van Tilburg 2010, 91-100.

Therefore, looking for a more seasonal waterflow. It will as well lessen the inflow of saltish water to surface waters.

Using solid structures can be quite expensive. Choosing local earth for the construction of terpen appears to be the easiest and cheapest solution. In certain areas due to the existing peat layer on top, this would require careful organization. This could be done by removing sandy layers below the surface. In addition, river shores could be considered, as deposition and removal of sediment occurs frequently in these areas (see Peter de Ruyter's interview in annex). In areas where the peat layer has been significantly altered a lot, sediment near the surface can be used (see figure 21). With dredged material smaller terpen can be constructed. So, to create a new solution in dealing with excess amount and making the rivers more navigable.

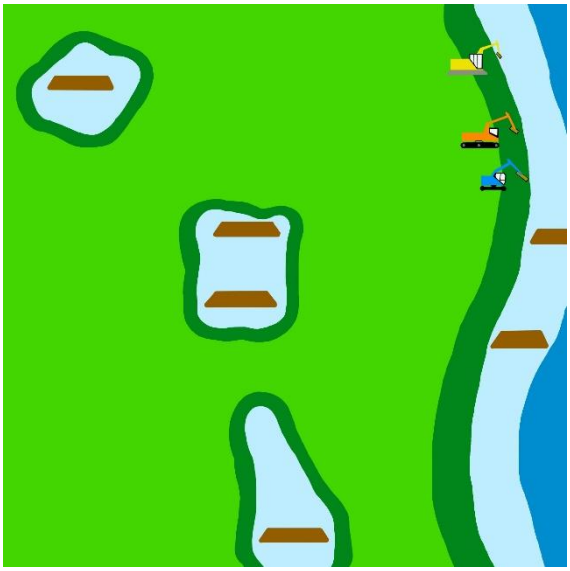

Figure 21: Sketch of terpen in low-lying areas[127].

The polders near Leeuwarden differ in land use. Some, like the Louwsmarpólder, De Lytse Mar, and Greate Wergeastermar, contain residential buildings. Agriculture is primarily practiced in the Louwsmarpólder and Greate Wergeastermar, making these areas suitable for safety terpen. Such terpen could be constructed using local sediments (sand and clay) from nearby waterways or using hard structures such as geotubes or concrete. If dredged material is used in inhabited areas, its composition must be carefully assessed. Elevating existing homes using terpen is a complex task that may necessitate the demolition of existing structures. Thus, evaluating building value and related factors is essential. The Himpensermar, De Lytse Mar, and Auke Hinnesmar are less agriculturally active and are used more for natural and recreational purposes. In these areas, the ecological approach is more suitable. It can help limit the slipping up of rivers and eutrophication. A cover layer can prevent environmental harm from contaminated materials. Overall, terpen can benefit current landscape with its contribution to water safety and ecology.

[127] Inspired by Peter de Ruyter's ideas.

3.6 Conclusion

The various types of terpen demonstrate the diversity of landscape modifications they can facilitate. Their functions can focus on water safety, typically relying on large artificial structures such as the underground bunker or terpen built with sediment layers. Some types also allow for land elevation (sedimentation). Green terpen can as well offer a solution in certain areas. These can prevent waterway obstruction and serve as natural habitats. It is essential to conduct a thorough landscape and land-use analysis before implementation, to select the most suitable option for the specific area.

4. What are the possibilities regarding national policies in It Lege Midden?

4.1 Introduction

In recent years, policies related to climate adaptation have increased significantly. Through national and regional programs, attention has been given to extreme weather. Urban and rural areas must be adapted to the increasing fluctuations in temperature and precipitation. Terpen can help to make Fryslân more climate-resilient. The Overdiepse polder and the WINN terpen are both related to national policy. It is important to assess these two cases in relation to the possibility of terpen in It Lege Midden.

4.2 National level

From 2006 to 2015, the program 'Ruimte voor de Rivier' was implemented, focusing on creating more space for rivers to flow, aiming to prevent flood hazards in urban areas near water[128]. In 2025, a new program, 'Ruimte voor de Rivier 2.0', was launched, which aims to make river areas more resilient for the future. It focuses on: 1. Water drainage, 2. Freshwater availability, 3. Water quality, 4. Navigability and 5. Regional economic development[129].

The 'Nationaal Water Programma 2022–2027' outlines the current national water policy. The government has identified three main objectives:

1. A safe and climate-resilient delta
2. A competitive, sustainable, and circular delta
3. A clean and healthy delta with high-quality nature

The policy aims to establish a safe and climate-adapted delta capable of withstanding extreme weather events such as floods and droughts. Freshwater facilities should become more resilient. Creating water buffers can make the delta more robust. The strategy focuses on using water sparingly, retaining it, and distributing it more efficiently. Freshwater availability is essential for agriculture, nature, historic green spaces, industry, and transportation. The government promotes the development of a cleaner and ecologically healthy delta by encouraging reduced dumping and the restoration of water biodiversity[130].

In 2016, the government developed the 'Nationale Klimaatadaptatie-strategie'. This program addressed climate adaptation in various sectors, including water and spatial planning, nature, agriculture, horticulture and fisheries, health, recreation and tourism, infrastructure (road, rail, water, and aviation), energy, IT and telecommunications, and security particularly in relation to a warmer, wetter, and drier climate, as well as sea level rise. The strategy analysed effects such as occupational heat stress, infrastructure failure, crop damage, changing climate zones (flora and

[128] Room for the River 2012, 4-11.
[129] Ruimte voor de Rivier 2.0 2025. Retrieved from https://www.ruimtevoorderivier.nl/over-ruimte-voor-de-rivier
[130] Rijksoverheid 2022, 3-7.

fauna), increases in infections and allergies, and cumulative (multi-sectoral) damage[131]. In 2023, the 'Nationaal Uitvoeringsprogramma' was established, calling for more sustainable water management and climate-resilient infrastructure[132].

In 2008, the Netherlands, in cooperation with other European countries, launched the program 'Kwaliteit voor Later', aiming to improve the chemical and ecological quality of surface water and the quality and quantity of groundwater. The program emphasises eutrophication. High nutrient concentrations can harm biodiversity in water by causing excessive algae growth, which negatively affects species richness, making it accessible only to a limited number of organisms. These effects are exacerbated by climate change through increased temperatures, precipitation, and photosynthesis. This program was established to maintain healthy water quality and prevent pollution[133].

4.3 Provincial and local level

In Fryslân has Wetterskip Fryslân raised awareness on potential issues relating to its water management. In 'Waterbeheerprogramma 2022-2027' the waterboard discuss the many challenges the province faces. Topics such as water management, safety, sufficiency, cleanliness and climate challenges are all discussed[134]. Attention to climate adaptation has moreover increased over the years. In 'Fryslân Klimaatbestendig 2050+', the potential risks to the water system and landscapes of Fryslân are discussed. The province highlights concerns such as the decline in freshwater resources, soil degradation, and loss of biodiversity. The approach varies between subregions. In vital sandy areas, more effort is placed on water retention. In peatlands, peat oxidation is being halted. In low-lying clay areas near the sea, freshwater lenses can be constructed, while in urban environments, buildings are becoming more climate-resilient[135].'Herstelprogramma Biodiversiteit Fryslân' has been started to educate the public about biodiversity restoration. It focused on protecting and restoring the natural habitats of vulnerable species[136].

Water management in Leeuwarden is affected by climate effects. Therefore, the municipality has taken steps towards climate adaptation. Within the city, the focus is on water storage, heat stress, and drought. The city's infrastructure is being made more resilient to extreme weather events[137]. More broadly, the municipality emphasises water, soil, and biodiversity. This low-lying region, situated between the high sandy areas of Appelscha and the sea dike, faces challenges due to land subsidence and sea level rise. Salinization may become a significant issue, which would damage water, soil, and biodiversity, ultimately affecting multiple sectors, including agriculture and nature[138]. Furthermore, Leeuwarden has started two programs related to ecology, 'Uitvoeringsprogramma Biodiversiteit: Ruimte voor de natuur 2025-2027' and Uitvoeringsprogramma Vergroening 2025-2035'. The first one focuses on policymaking connected with nature, promotes nature inclusive approaches within the municipality, aims to connect green and blue structures and enhance

[131] Rijksoverheid 2016, 3-6.
[132] Rijksoverheid 2023, 4-9.
[133] Cleij et al. 2008, 143-182.
[134] Wetterskip Fryslân 2022, 5-50.
[135] Wetterskip Fryslân et al. 2023, 1-10.
[136] IVN Friesland unknown date. Retrieved from https://www.ivn.nl/provincies/friesland/herstelprogramma-biodiversiteit-fryslan/
[137] Leusink et al. 2020, 5-23.
[138] Westhuis en partners 2024, 6-22.

education and communication[139]. The second program looks at the ecological structure of the municipality and aims to improve urban planning[140].

4.4 Water safety

Floor elevation of houses has already been implemented in various countries that are prone to flooding. In Indonesia, floor elevation is considered cost-effective. In vulnerable coastal areas, sea level rise, land subsidence, and extreme rainfall pose serious challenges[141]. In Thailand, urbanisation has led to migration to other areas, many of which are at increased flood risk. Thus, digital models are used to assess potential dangers and evaluate the feasibility of built-up expansion in these regions[142].

Many countries are increasing efforts to make buildings more climate-resilient. The terpen in the Overdiepse polder represent one of the most well-known examples of floor elevation in the Netherlands (see figure 22). This project began as part of the national program Ruimte voor de Rivier, which focused on water safety in river areas. It is furthermore recognised for facilitating intensive cooperation among partners such as waterboards, provincial authorities, municipalities, nature organizations, and sand and gravel producers[143]. During the process, the area was repurposed with the construction of newly built farmsteads on terpen and the lowering of river dikes. During high tide the Overdiepse polder will be flooded, this will happen only in exceptional cases (1:25 years) (see figure 23)[144]. Not only in the Overdiepse polder terpen were built but in the Noordwaard too. Here a similar project was launched in connection with Ruimte voor de Rivier. Here not only terpen were built, but also quays, dikes, roads, pumping mills and wind pumps[145].

Figure 22: Terpen plan in Overdiepse polder.

[139] Reitsma et al. 2025, 11-23.
[140] Gemeente Leeuwarden 2024, 21-32.
[141] Juarni & Belgawan 2013, 1-10.
[142] Littidej & Buasri 2019, 1-3.
[143] Rijkswaterstaat unknown date. Retrieved from https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/maatregelen-om-overstromingen-te-voorkomen/ruimte-voor-de-rivieren
[144] Roth & Winnubst 2010, 52-63.
[145] Bielars et al. 2012, 7.


Figure 23: Overdiepse polder before and during flooding.

In my interview with Simon Hofstra, project manager of the Overdiepse polder, it was the government's intention to create a water storage basin with a side channel. The farmers in the area formed a residents' association. Although they could not stop the implementation of the program, they proposed an alternative plan: the construction of terpen. Several farmers chose to remain, others to relocate, and some were undecided. The Spiegelproject Overdiepse polder demonstrates the favorable cost-benefit analysis of terp construction. The project as well received strong support from residents[146]. The government accepted the farmers' proposal (see Simon Hofstra's interview in annex). Director of NederLandBovenWater, Peter van Rooy, emphasises the importance of collaboration between different stakeholders and residents. In his book 'Overdiepse polder: Vijftien jaar overheidsparticipatie', he discusses public engagement and key lessons in communication (see Peter van Rooy's interview in annex).

4.5 Dredging

Dredging is a crucial activity that prevents rivers and waterways from becoming obstructed, thereby ensuring navigability. However, it is essential to carefully assess the soil quality of the waterbed. With the 'Handreiking Beoordelen Waterbodems', the government provided guidelines for evaluating dredged material, which can contain various metals and non-organic substances. For public health, it is essential to evaluate the safety of dredged material. In certain instances, human contact must be strictly avoided. From an ecological standpoint, dredging can impact nutrient levels in the riverbed, thereby affecting food availability for aquatic organisms. Furthermore, eutrophication, an excess of nutrients, can harm biodiversity. Some projects have aimed at reducing eutrophication and have been implemented under the European Water Framework Directive, which focuses on protecting water bodies[147].

Eutrophication has been observed in the Fryske Boezem. Wetterskip Fryslân has reported significant changes in water quality. Due to eutrophication, the extent and quality of shore vegetation have declined. Certain experts advocate for a more natural water level regime. Although the waterboard argues that this approach is rarely sufficient and that other factors such as steep banks and an

[146] Van Rooy & Slootweg 2003, 5-12.
[147] Hin et al. 2010, 5-6 and 11-46.

overabundance of the *Cypriniformes* (whitefish) play a role. Additional measures must further be considered[148]. Dredging could be evaluated as a potential method to reduce eutrophication and create more variety in its feeding ground.

The WINN began with a public idea competition to generate creative solutions for managing dredged material from rivers and waterways. Public perception of dredging and disposal varies. In the IJmeer, respondents questioned the necessity of dredging and the availability of alternatives. Many supported the removal of contaminated material, acknowledging it as necessary for navigability, despite concerns over deposition. The deposit of the dredge is a topic which is much debated. With many residents arguing that IJmeer should be exempt from dredge disposal due to their area's activities, clean water, nature and history[149]. In the coastal area of Noord-Holland similar research was done. Here people seemed as well critical on the deposition of the dredge material. There was scepticism regarding the relocation of dredged material, with some doubting its long-term containment. Effective public communication is essential for informed decision-making.

Regarding terp construction by WINN, public responses are mixed. Some emphasise the cultural heritage of terpen as high-ground refuges for cattle and advocate for preserving the authentic landscape. It is important that terpen do not dominate the landscape. If they are constructed too large or become overly numerous, negative reactions have been observed. While many respondents supported farmsteads on terpen, other uses such as recreation were seen as artificial or excessive[150]. The intended function of terpen is also of significant consideration. Nevertheless, the ideas of WINN were not put into practice (personal communication). These dredged terpen are seen by some as more of a temporary solution (see Peter de Ruyter's interview in annex).

The examination terp in Klompenwaard serves as a model for terpen constructed from dredged material (see figure 24 and 25). The project investigated the effects of polluted soil on groundwater, soil quality, and crop cultivation, as well as the social aspects of its implementation. Residents and tourists frequently visit the area). Most respondents were unaware of changes and felt the terp fit well within the landscape. The new terp was considered non-disruptive and accessible to livestock during high tides. Although few respondents knew the material was contaminated, many still supported the initiative. The project highlighted the importance of communication and residents' perceptions of landscape features, tranquillity, and familiarity with the process. Informal communication channels were preferred over formal ones, and residents expressed interest in the dredged material, in respect due to their trust in contractors[151].

[148] Claassen 2008, 24-32.
[149] Stolp & Van Vliet 1996, 39-42.
[150] Flinterman & Van Konijnenburg 2004, 7-11, 20-26 and 41-43.
[151] Manders 2006, 11-34.

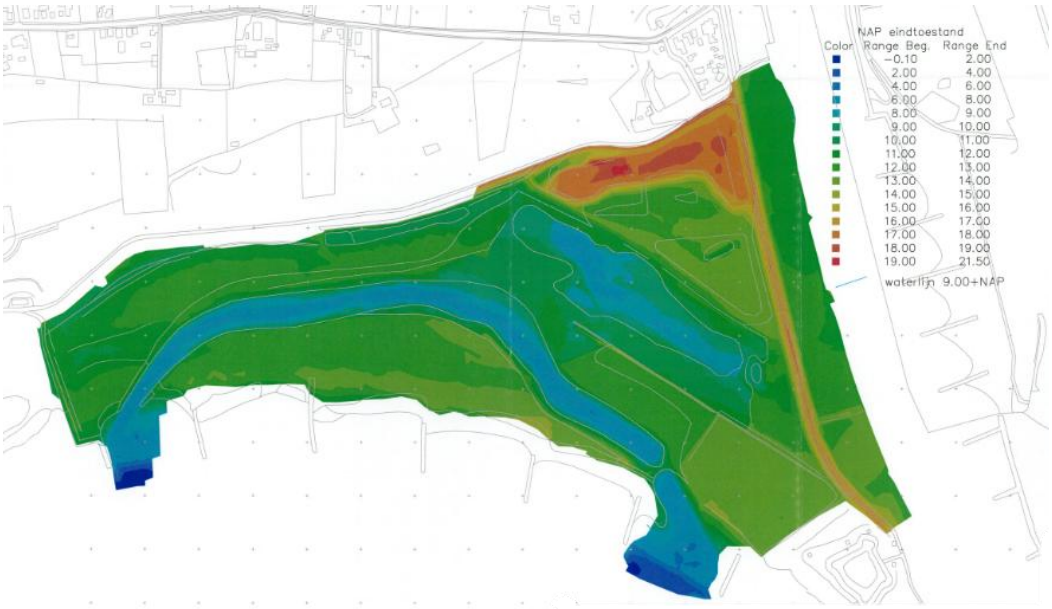

Figure 24: Shows the height difference of the Klompenwaard (blue: lowest and red: highest). The high-lying areas likely contain polluted material.

Figure 25: Examination terp in Klompenwaard.

4.6 Terpen in It Lege Midden

In the case of terpen in It Lege Midden, the experience of the Overdiepse polder demonstrates the importance of involving the public in policymaking. Initially, the plan required all farmers to leave the polder. The residents' alternative terpen plan illustrates the value of participatory processes, where policymakers and the public collaborate.

The Klompenwaard study further highlights how researchers' perspectives can differ from public perception. Terpen are generally not seen as intrusive in the landscape. Despite limited awareness of contamination, many still support dredge-based terp projects. Communication plays a critical role in building trust. Residents value informal communication for addressing their concerns.

For my study in It Lege Midden, it is essential to inform the public about ongoing developments. Residents can contribute valuable insights in assessing both current conditions and future plans. Experts, in turn, can clarify policy goals and environmental issues. Public perspectives may differ from expert assessments. Some changes are perceived as painless, while others provoke concern. Peter van Rooy and Simon Hofstra, both agree that terpen can be implemented in more areas. This would likely be in low-lying or vulnerable places. Its implementation may present challenges, as terpen can become isolated during flooding. Therefore, consideration should be given to the spatial lay-out of the area.

4.8 Conclusion

The implementation of terpen is connected to various policy frameworks. In It Lege Midden, this study focuses on climate adaptation, as flooding is expected to become more frequent. In previous decades, terpen have been constructed as part of different initiatives. The Overdiepse polder project, for example, was linked to the Ruimte voor de Rivier program, aimed at increasing flood resilience. The WINN research group explored the use of dredged material to construct terpen. Dredging is crucial for navigability, yet generates significant volumes of material. Terpen offer a sustainable solution for its reuse. In both cases, collaboration between policymakers and the public was central. Public information and engagement are essential components, as community input can enhance the quality and acceptance of such projects.

5. Discussion

'*How can landscape alterations, such as terpen prove successful in the climate adaptation of It Lege Midden?*'

Many issues which It Lege Midden faces is related to its water management. Peat deterioration and salinization are both examples of poor water management. Water seems to gather in the low-lying areas of the landscape. Hence water can travel from the higher areas into the lower. Consequently, drying out these places and harming the peat layers. In addition, this process results in the loss of freshwater due to drainage. Due to intensive draining salinization can also occur more frequently in the Fryske Boezem. The Boezem is of importance for the region, as various sectors are dependent on favourable water conditions. Salinization can increase the salinity levels of the water. Making the water management more robust could lessen these harmful effects. This could lead to a more seasonal instead of fixed water level. During the winter they protect buildings against water hazard, while in the summer the surrounding land can be used for farming. Terpen could play to a role within this new landscape.

In most cases climate adaptation requires a long-term strategy. Thus, the implementation of terpen is part of a continuous process. The polders are characterised by grasslands. Their uses vary: some are designated as natural sites, while others are predominantly used for animal husbandry. The construction of terpen will require coordination. Solid structures such as underground bunkers or filled terpen can be chosen, although the most accessible option would be the use of local material. Dredging is an essential practice for maintaining river navigability. Construction can positively contribute to issues such as water safety and ecology. Green terpen can be applied in areas with small human interference. Material can be contaminated, although a protective layer can shield it. This does mean that terpen are alluring spots for animals to live on.

In previous decades, terpen have been incorporated into various policies. The Overdiepse polder was part of the Ruimte voor de Rivier program, while the Klompenwaard was evaluated by the research group WINN. With the Overdiepse polder, its implementation helps reduce pressure when river levels are too high. This step required landscape changes, such as lowering river dikes. This does require drastic changes in the spatial planning and can make people hesitant. With using dredged material similar reactions arose. Still the Klompenwaard shows that public responses to these terpen can also be positive. These structures can acquire a role in the existing landscape. During terp implementation, the relationship between policymakers and residents is important for the project's success. Public feedback can help refine the plans. This solution for dredged material is temporary and not applicable in every area.

The municipality of Leeuwarden has emphasised the importance of climate adaptation in its policies. Effects of heat stress are being addressed in its urban planning, while locations such as Himpensermar are designated as water storage areas. In some places a different water management policy can have instrumental effect for its region. While with dredging, large amounts of dredged material are still being removed from the waterbed. Hence the use of terpen appears to be a viable option in these cases. They can be considered as a solution for It Lege Midden, alongside other measures such as the creation of floodplains and the construction of flood barriers.

6. Conclusion

Climate adaptation has gained attention. With fluctuations in weather extremes, it is important to innovate our current infrastructure. This means we must look critically at our current water organization and land use. In this process, experts can look at the environmental and socio-economic co-benefits of changes within these fields. A participatory approach is important in this regard. The collaboration between policymakers and public is important.

It Lege Midden is an area that faces numerous challenges. These issues stem from its unique, low-lying landscape. Peat oxidation, salinization and loss of freshwater is affecting the landscape and industries. The low-lying areas are also linked with the water flow. In these areas, changes in water management could contribute to systemic change. Previous studies conducted in the Overdiepse polder and Klompenwaard have demonstrated the potential of building terpen. Terpen can support the development of a more climate-resilient landscape. However, they can as well help address issues in other areas, such as the surplus of dredged material. In this way, terpen enhance the area's navigability while the dredged material can be used for green solutions. Therefore, terpen will contribute to positive change within Fryslân's ever changing landscape. Within the policy-making process it is important to look for support and input from inhabitants. With both case studies many residents seem much easier to accept these changes once being informed and listened to.

In It Lege Midden terpen could help us in thinking differently towards water management and land use. In the past these structures helped to protect buildings, while water can flow naturally. With dikes and reclamation, the landscape became more subservient to human's needs. This has resulted in negative consequences for the peatlands and water system. Thus, elements of the premodern cultural landscape can help us rethink our current water management and land use, while creating new possibilities for dealing with weather extremes.

Annex

Annet Nieuwhof's interview

Professor archaeology and specialist in the landscape and habitation history of the terpen and wierden region of Groningen and Friesland.

1. *De ophoging van de terpen ontstond deels door het weggooien van afvalresten. Hiernaast groeiden de terpen ook door middel van sedimentatie. Hoe substantieel was sedimentatie voor de groei? Is dit ook makkelijk terug te vinden als archeologen? (Interviewer)*

Dat klopt niet, terpen groeiden door opzettelijk ophoging: het aanbrengen van ophogingslagen die konden bestaan plaggen gestoken uit kwelderafzettingen/sediment (daar zit waarschijnlijk het misverstand) of uit mestlagen. Ook een beetje afval maar dat is verwaarloosbaar. (Annet Nieuwhof)

2. *In de meeste stukken lees je dat terpen in kweldergebieden verschenen, die bescherming boden tijdens hoogtij. Zijn jullie echter ook gebieden die buiten dit patroon vallen?*

Er zijn elders ook wel verhoogde woonplaatsen, bv tells in het Midden-Oosten. Maar dat zijn geen terpen, ze waren niet verhoogd om te beschermen tegen hoog water.

3. *Hoe leefden de mensen? Was dit voornamelijk jacht, veeteelt en Crustacea (schelpdieren)? Of kon er op sommige plekken ook aan landbouw gedaan worden?*

Ze leefden voornamelijk van veeteelt en akkerbouw. Jacht, visvangst en schelpdieren speelden geen grote rol. Daar heb ik veel over geschreven, even zoeken op mijn Academiapagina (Dagelijks leven op ...).

4. *De levensverwachting van de terpbewoners was niet hoog. Waarom besloten vroegere bewoners er toch op te blijven?*

De levensverwachting was nergens hoog in die tijd.

5. *Leefden de terpbewoners een open of gesloten leven van de buitenwereld (contacten, handel, etc.)?*

Open (met nadruk) (zie *Identiteit en samenleving* op mijn Academiapagina).

6. *Hoe kan je de groepsidentiteit van de terpbewoners het best beschrijven?*

Dit is een erg complex onderwerp dat zich niet zomaar in een zin laat samenvatten. Niet als Friezen waarschijnlijk (met nadruk).

English version

1. *The elevation of the terpen arose partly through the disposal of waste remains. In addition, the terpen also grew through sedimentation. How substantial was sedimentation for growth? Is this also easy for archaeologists to find? (Interviewer)*

That's not true, terpen grew by deliberate raising: the application of embankments that could consist of sods cut from salt marsh deposits/sediment (that's probably where the misunderstanding lies) or from dung layers. Also, some waste but negligible. (Annet Nieuwhof)

2. *In most papers you read that terpen appeared in salt marsh areas, providing protection during high tides. However, do you include areas outside this pattern?*

There are elevated habitations elsewhere, such as the tells in the Middle East. But those are not terpen, they were not elevated to protect against high tides.

3. *How did people live? Was it mainly hunting, animal husbandry and Crustacea (shellfish)? Or could they also do agriculture in some places?*

They lived mainly from cattle breeding and arable farming. Hunting, fishing and *Crustacea* (shellfish) did not play a big role. I have written a lot about that, just search on my Academia page (Daily life at....).

4. *The life expectancy of terpen dwellers was not high. Why did former inhabitants decide to stay on it anyway?*

Life expectancy was not high anywhere at that time.

5. *Did terpen dwellers live an open or closed life from the outside world (contacts, trade, etc.)?*

Open (expressly) (see Identity and society on me Academia page).

6. *How can you best describe the terpen dwellers' group identity?*

This is a very complex subject that cannot be summed up in one sentence. Not like Frisians probably (expressly).

Simon Hofstra's interview

Project manager of Overdiepse polder

1. *Hoe kwam het idee op om terpen te gebruiken bij de Overdiepse polder? Waren jullie ook bekend met de historische achtergrond van terpen? (Interviewer)*

De boeren in de polder hebben zich georganiseerd in een bewonersvereniging toen ze hoorden dat Rijkswaterstaat de polder wilde omvormen tot ene waterbergingsgebied met een nevengeul er

doorheen. Ze wilden niet weg, maar realiseerden zich ook dat ze een dergelijk groot plan van de overheid (Ruimte voor de rivier) niet konden tegenhouden. Daarom hebben ze zelf een plan met terpen bedacht waardoor een deel van de boeren zou kunnen blijven boeren. Ze hebben eerst onderling ene anonieme enquête om te inventariseerden wat de 17 boeren/bewoners van de polder hiervan zouden vinden: 1/3 wilde wel blijven op terpen, een derde wilde wel elders opnieuw beginnen, een derde wist het nog niet. Dat vonden ze voldoende basis om met de overheid in gesprek te gaan en over hun plan in onderhandeling te gaan. Dit is uiteindelijk het winnende ontwerp geworden wat is uitgevoerd. En natuurlijk waren we bekend met het eeuwenoude concept van terpen. Anders hadden we ze ook niet zo genoemd. (Simon Hofstra)

2. *Door het verlagen van de dijken ontstond er een overstromingsgebied waar sediment kan worden afgezet. Is er sprake van landverhoging in het gebied naar de aanleg?*

De polder is nog nooit onder water geweest. De dijk is verlaagd met drie meter, tot een hoogte waarop hij theoretisch een keer in de 25 jaar onder water loopt. Het is niet de verwachting dat er veel sediment in de polder zal achterblijven.

3. *De toepassing van terpen bij de Overdiepse polder werd gezien als een iets unieks. Denkt u echter dat het gebruik van terpen in wel meer gebieden mogelijk is (lage delen)? Hoe kijkt u naar toekomstig gebruik van terpen (klimaat adaptatie)?*

Ik denk dat op veel meer plekken terpen een goede oplossing kan zijn, soms beter dan dijken. Het probleem is wel dat de woningen/bedrijven op terpen ook bij overstroming bereikbaar blijven. Dat is bij Overdiepse polder opgelost door de terpen tegen de nieuwe hoge dijk aan te leggen, zodat de boerderijen altijd bereikbaar zijn en hun melk ook kunnen afvoeren als de polder onder water staat.

4. *De terpen van Overdiepse polder zijn vooral gericht op veiligheid en ruimte voor de rivier. Hoe kijkt u naar een bredere toepasbaarheid van terpen (natuur, recreatie, etc.)? En naar vergelijkbare projecten zoals de groene terpen van WINN (waterinnovatie programma)?*

Andere toepassingen zijn natuurlijk ook mogelijk. De groene terpen van WINN ken ik niet.

5. *Wat zijn de reacties van de omwonenden (voor en na de bouw)? En de reacties van de bewoners (positief en negatief)?*

De bewoners zijn er uiteindelijk materieel gezien allemaal beter van geworden. Het sociale proces is wel moeilijk geweest omdat ze op een gegeven moment concurrenten van elkaar werden voor een plek op de terpen en bij de verdeling/aankoop van de grond die vrijkwam nadat een deel was vertrokken, maar nu is dat wel weer redelijk glad gestreken en is iedereen tevreden.

6. *Hoeveel bedraagt het onderhoud van de terpen? Moet er vaak aan de terpen gewerkt worden?*

De terpen zijn eigendom van de boeren en die onderhouden dat zelf. Daar heeft de overheid geen onderhoud aan. De terpen zijn ontworpen om 100 jaar bestand te zijn tegen (stijgende) zeespiegel en waterhoogtes van rivieren.

English version

1. *How did the idea of using terpen at the Overdiepse polder come about? Were you also familiar with the historical background of terpen? (Interviewer)*

The farmers in the polder organised themselves into a residents' association when they heard that Rijkswaterstaat wanted to turn the polder into a water storage area with a side channel through it. They did not want to leave, but also realised they could not stop such a big plan by the government (Ruimte voor de Rivier). So they devised a plan with terpen that would allow some of the farmers to continue farming. They first conducted an anonymous survey among themselves to take stock of what the 17 farmers/residents of the polder would think about this: 1/3 wanted to stay on terpen, a third wanted to start over elsewhere, a third didn't know yet. They felt this was sufficient basis to engage with the government and negotiate their plan. This eventually became the winning design which was implemented. And of course we were familiar with the age-old concept of terpen. Otherwise, we wouldn't have called them that either. (Simon Hofstra)

2. *Lowering the dykes created a flood plain where sediment could be deposited. Is there any land elevation in the area towards construction?*

The polder has never been flooded. The dyke has been lowered by three metres, to a height at which it theoretically floods once every 25 years. It is not expected that much sediment will remain in the polder.

3. *The use of terpen at the Overdiepse polder was seen as something unique. However, do you think the use of terpen is possible in more areas (lowlands)? How do you view future use of terpen (climate adaptation)?*

I think terpen can be a good solution in many more places, sometimes better than dykes. The problem is that the houses/farms on terpen should remain accessible even when flooding occurs. This was solved at Overdiepse polder by constructing the terpen against the new high dike, so that the farms are always accessible and can export their milk even when the polder is flooded.

4. *The terpen of Overdiepse polder are mainly aimed at safety and space for the river. How do you look at a wider applicability of terpen (nature, recreation, etc.)? And to similar projects such as WINN's green terpen (water innovation program)?*

Other applications are of course also possible. I am not familiar with WINN's green terpen.

5. *What are the reactions of residents (before and after construction)? And the residents' reactions (positive and negative)?*

The residents all benefited materially in the end. The social process has been difficult because at one point they kept competitors from each other for a place on the terpen and in the division/purchase of the land that became available after some had left, but now that has been fairly smoothed out and everyone is happy.

6. *How much is the maintenance of the terpen? Do the terpen require frequent work?*

The terpen belong to the farmers and they maintain them themselves. The government does not maintain them. The terpen are designed to withstand (rising) sea levels and river water levels for 100 years.

Peter van Rooy's interview

Director of NederLandBovenWater and important contact for the residents of the Overdiepse polder

1. *Hoe kijkt u naar de toepassing van terpen? Denkt u dat de aanpak in meerdere gebieden mogelijk is?* (Interviewer)

Goed toepasbaar in laaggelegen of kwetsbare gebieden. (Peter van Rooy)

2. *Het project is bekend doordat er verschillende partijen aan meededen. Wat waren de grootste voor- en nadelen van dit principe?*

Zonder medewerking van alle cruciale partijen lukt het niet. We hebben hier geen Trump of Poetin.

3. *Het terpen plan was een initiatief van de bewoners. Waaruit kwam dit plan voort? Wat wilden de bewoners vooral bewaren voor toekomstige generaties?*

Staat aan begin van boek ('Overdiepse polder: Vijftien jaar overheidsparticipatie').

3. *Lokale contacten zijn van groot belang bij deze projecten. U zegt dat hier intensief aan gewerkt moet worden (niet één informatieavond). Wat is hierbij volgens u het beste middel om het publiek te betrekken (contactavonden, open dagen, lezingen, etc.)?*

Een op een gesprekken door een schakelpersoon (was mijn rol 15 jaar lang) die groot netwerk kan aanboren.

4. *Niet iedereen kon blijven op de Overdiepse polder. Maakte dit nog veel reacties los?*

Alras tekenden zich blijvers, wijkers en twijfelaars af. Gaandeweg steeds duidelijker. Geen gedoe geweest.

5. *Waren de omwonenden en bewoners tevreden over het resultaat? Kwam het overeen met hun verwachtingen? Wat merkten de boeren van de veranderingen op?*

Grote waardering in en om de polder. Inmiddels meer dan 10.000 bezoekers uit binnen- en buitenland. Voor blijvende boeren ideale oplossing.

6. *In uitzonderlijke gevallen kan de Overdiepse polder onder water komen te staan. Hoe wordt deze mogelijkheid kenbaar gemaakt aan omwonenden en reizigers?*

Bij extreem snel stijgend waterpeil in Oude Maas krijgen boeren oproep vee op terp te houden. Dan kan polder nodig zijn om waterstand in Maas af te toppen.

English version

1. *How do you view the application of terpen? Do you think the approach is possible in several areas? (Interviewer)*

Well applicable in low-lying or vulnerable areas. (Peter van Rooy)

2. *The project is well known because several parties participated in it. What were the main advantages and disadvantages of this principle?*

Without cooperation from all crucial parties, it will not succeed. We don't have Trump or Putin here.

3. *The terpen plan was an initiative of the residents. From what did this plan emerge? Above all, what did the residents want to preserve for future generations?*

Is referenced at the start of the book.

3. *Local contacts are very important in these projects. You say this should be worked on intensively (not just one information evening). What do you think is the best means of engaging the public in this regard (contact evenings, open days, lectures, etc.)?*

One-on-one talks by a link person (was my role for 15 years) who can tap into large network.

4. *Not everyone could stay on the Overdiepse polder. Did this still elicit many reactions?*

Stayers, leavers and doubters soon emerged. Gradually it became clearer. There was no fuss.

5. *Were residents satisfied with the result? Did it match their expectations? What did farmers notice about the changes?*

Great appreciation in and around the polder. More than 10,000 visitors from home and abroad. Ideal solution for permanent farmers.

6. *In exceptional cases, the Overdiepse polder may be flooded. How will this possibility be made known to residents and travellers?*

If the water level in the Oude Maas rises extremely quickly, farmers will be asked to keep livestock on terpen. Then polder may be needed to cap water level in Meuse.

Peter de Ruyter's interview

Author of 'Vloeiend Landschap' and director of Bureau Peter de Ruyter.

1. *Hoe zou u It Lege Midden beschrijven? (interviewer)*

It Lege Midden is een groot veengebied. Het veen neemt het water op als een spons. Het gebied kent een daling van 1 tot 2 centimeter per jaar. Het gebied tussen Drachten en Joure bestaan uit diepe veenpolders. De lage veengebieden waren drooggemalen en worden de veenpolders genoemd. Dit gebied moet echter robuuster worden in zijn wateropvang. Het moet meer water kunnen vasthouden. Water stroomt namelijk naar de lage gebieden van het land. It Lege Midden bevindt zich tussen twee hogere gebieden westelijke kleigronden en de hoge Drentse zandgronden. Door snelle afvoer van water kan het leiden tot uitdroging in de hoge delen. Als de lage gebieden onderwater blijven staan kan dit zorgen dat de hoge plekken het waterniveau ook stijgt. In de Ryptsjerksterpolder valt het gebied in de zomer droog en in de winter staat het onderwater. In het verleden was het gebruikelijk dit seizoensgebonden waterbeheer. In de winter kon er geschaatst over worden en in de zomer konden de dieren weiden. Een robuuster watersysteem maakt dit gebied ook minder gevoelig voor weerextremen. Bij droog, nat of warm weer biedt deze nieuwe waterinfrastructuur veel nieuwe mogelijkheden. (Peter de Ruyter)

2. *Kent It Lege Midden verzilting?*

It Lege Midden kent verzilting, dit is echter sterk verbonden met het waterbeheer. Het zoete water van It Lege Midden is van goede kwaliteit en wordt gebruikt als drinkwater. Door het snel afvoeren van zoetwater treedt verzilting op. Dit wordt hier minder bepaald door interne verzilting. Zout water stroomt in It Lege Midden binnen door het lage waterniveau. Het water werkt als compensatie voor de lage waterstand. Hierom moeten we kijken naar een robuuster systeem om het zoete water vast te houden. Om het water meer vast te houden in plaats van zo snel mogelijk afvoeren.

3. *Wat vindt u van mijn terpen plan?*

Terpen kunnen worden gebouwd in de lage delen van It Lege Midden. In de zomer het land kan gebruikt worden voor veeteelt, terwijl in de winter de terp veiligheid biedt. Naast de lage gebieden kunnen ze ook aan de randen of bij de oevers van rivieren zitten. Het materiaal van de terpen is nog een interessant kwestie. Het veen gebruiken in dit gebied biedt waarschijnlijk geen sterke ondergrond. Bij de rivieren kunnen in de oevers gegraven worden om het sediment te gebruiken voor de constructie van de terpen. Aan de zijkanten vindt vaak al afkalving en afzetting van de rivieren plaats. Onder de veenlagen bevindt zich vaak zand of keileem. De keileem laag is in veel gevallen zeer hard door de druk van gletsjers in het Pleistoceen en is moeilijk te gebruiken voor het bouwen van terpen. Het zand en de lichtere grondsoorten zou in praktijk kunnen worden leeggezogen. Dit materiaal kan gebruikt worden voor terpconstructie.

4. *Wat kunt u mij vertellen historische terp in It Lege Midden?*

Er zijn verschillende types in Fryslân. Naast keileemterpen en zandterpen bestaan er ook veenterpen. Dit type heeft waarschijnlijk een rol gespeeld in It Lege Midden. It Lege Midden kent een

laagveenlandschap, wat verschilt van de terpen in de voormalige kwelders. De Rijksuniversiteit van Groningen heeft onderzoek gedaan naar deze terpen. Niet veel is bekend van dit type.

5. *Hoe kijkt u naar moderne terpvarianten in andere projecten (Overdiepse polder, baggerterpen, etc.)?*

De Overdiepse polder bevindt zich in een veel kleiner gebied vergeleken een mogelijk project in It Lege Midden. Dit project richt zich ook niet op seizoensgebonden waterbeheer, maar bood de rivier ruimte bij hoge waterstanden (1:25 jaar). De baggerterpen houden zich bezig met een opslag van baggerspecie en bieden hierbij een tijdelijke oplossing. In de bestrijding van eutrofiëring zijn middelen als oevervegetatie en waterplanten het meest succesvols. Deze kunnen het water van Fryske Boezem schoner maken.

6. *U heeft zelf aan verschillende projecten in Fryslân gewerkt (Natuerlik Fryslân 2050, Ruilverkaveling 2.0). Wat houden ze in?*

Met Natuerlik Fryslân 2050 werkte ik aan een kaart van de verschillende landschappen in Fryslân. Met Ruilverkaveling 2.0 keek ik hoe je naar het gebied anders kan inrichten. Waarbij de kwetsbare gebieden eerder in handen kwamen van boeren die zich focussen op biologische landbouw in plaats van intensieve. Hierdoor maken we het beleid landschapsgericht. Hiernaast heb ik ook het boek ‘Vloeiend landschap’ en het essay ‘Roepend landschap’ geschreven. Beide stukken houden zich bezig met de ruimtelijke inrichting en toekomst van Fryslân.

English version

1. *How would you describe It Lege Midden? (interviewer)*

It Lege Midden is a large peat bog. The peat absorbs water like a sponge. The area experiences a decrease of 1 to 2 centimetres per year. The area between Drachten and Joure consists of deep peat polders. The fen areas were drained and are called the peat polders. However, this area needs to become more robust in its water collection. It must be able to hold more water. In fact, water flows into the low areas of the country. It Lege Midden is located between two higher areas western clay soils and the high Drenthe sandy soils. Rapid drainage of water can lead to dehydration in the high areas. If the low areas remain flooded, it can cause the high spots to see the water level rise as well. In the Ryptsjerksterpolder, the area falls dry in summer and is flooded in winter. In the past, this seasonal water management was common. In winter it could be skated over and in summer animals could graze. A more robust water system also makes this area less susceptible to weather extremes. In dry, wet or hot weather, this new water infrastructure offers many new opportunities. (Peter de Ruyter)

2. *Does It Lege Midden suffer from salinization?*

It Lege Midden has salination; however, this is strongly linked to water management. The freshwater of It Lege Midden is of good quality and is used as drinking water. Salinization occurs due to the rapid discharge of freshwater. This is less determined by internal salinization here. Saltwater flows into It Lege Midden because of the low water level. The water acts as compensation for the low water level.

This is why we need to look at a more robust system to retain the fresh water. To hold the water more instead of draining it as fast as possible.

3. *What do you think of my terpen plan?*

Terpen can be built in the lower parts of It Lege Midden. In summer the land can be used for cattle breeding, while in winter the mound provides security. Besides the low areas, they can also sit on the edges or near the banks of rivers. The material of the terpen is another interesting issue. Using the peat in this area probably does not provide a strong foundation. Close by rivers, the banks may be dug into to use the sediment to construct the terpen. On the sides, calving and deposition of the rivers often already takes place. Beneath the peat layers there is often sand or boulder clay. The boulder clay layer is in many cases very hard due to the pressure of glaciers in the Pleistocene and is difficult to use for building terpen. The sand and lighter soil types could be drained in practice. This material could be used for mound construction.

4. *What can you tell me about the historic terpen in It Lege Midden?*

There are different types in Fryslân. Besides boulder clayterpen and sandterpen, peatterpen also exist. This type probably played a role in It Lege Midden. It Lege Midden has a low moorland landscape, which differs from the terpen in the former salt marshes. The University of Groningen has conducted research on these terpen. Not much is known about this type.

5. *How do you view modern terp variants in other projects (Overdiepse polder, dredged terpen, etc.)?*

The Overdiepse polder is in a much smaller area compared to a possible project in It Lege Midden. This project also does not focus on seasonal water management but provided space for the river at high water levels (1:25 years). The dredging terps are concerned with a storage of dredged material, offering a temporary solution. In combating eutrophication, agents such as riparian vegetation and aquatic plants are the most successful. These can make the water of Fryske Boezem cleaner.

6. *You have worked on various projects in Fryslân (Natuerlik Fryslân 2050, Ruilverkaveling 2.0). What do they involve?*

With Natuerlik Fryslân 2050, I worked on a map of the different landscapes in Fryslân. With Ruilverkaveling 2.0, I looked at how to rearrange the area. In which vulnerable areas were more likely to be owned by farmers who focus on organic farming instead of intensive ones. By doing so, we make policy landscape-oriented. Alongside this, I also wrote the book ‘Vloeiend Landschap’ and the essay ‘Roepend landschap’. Both pieces deal with the spatial planning and future of Fryslân.

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