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8

On the Role of System Understanding in the Slufter, Texel, the Netherlands

By Floortje d'Hont and Jill Slinger

8.1. Motivation for research approach

8.1.1. Location, type of coast

The Slufter is an estuary located within a nature reserve in the North Sea dunes of the island of Texel, the most westerly Wadden Sea island of the Netherlands (Figure 8.1). The Slufter comprises coastal dunes, an estuarine channel, a salt-marsh and an intertidal zone landwards of the coastal dunes. The entire Slufter area is about 1 km wide (from mouth to sand dike) and over 2 km long. The Slufter is a small system, with an intermittently closed mouth and seasonal freshwater inflow of unknown total volume. The dynamic intertidal zone is bounded by a sand dike and sandy dunes. Diversity in the substrates and a lack of disturbance mean the Slufter exhibits high species richness in its vegetation (Pedroli & Hoekstra, 1992). The Slufter area, including the sand dike, forms a component of the primary flood defence of Texel, and protects the hinterland from flooding from the North Sea.

Figure 8.1. Figure 8.1: The Slufter is situated along the North Sea coast of Texel, the Netherlands (Picture: Flying Focus)

8.1.2. Purpose of mouth management: Flood defence

According to Dutch law (Water Act, 2009), the water board Hollands Noorderkwartier (HHNK) is formally responsible for managing parts of the Dutch coast, including the Texel coast and ensuring that it adheres to the legally prescribed safety standards for flood defence (see Chapter 2). For the purpose of flood defence, HHNK's existing management policy for the Slufter is to excavate a straight mouth channel to the west of the existing mouth every four to six years. The aim is to maintain the integrity of the dune front to the northeast, and to reduce the penetration and potential erosive action of storm waves at the sand dike.

However, simulations from new storm wave models (van Rooijen & van Thiel de Vries, 2013) indicate that it may not be necessary to intervene in this way as the mouth dynamics have only a limited effect on flooding safety. Because of these indications, and because flooding safety is not the only issue at stake, HHNK is considering intervening less with the mouth of the estuary as part of their coastal policy and letting nature take its course in the Slufter in the future.

8.1.3. Additional societal and ecological value

Indeed, the Slufter is a tourist attraction, drawing nature lovers, particularly bird watchers, as well as hikers and cyclists to the island of Texel, and generating economic value for medium and small business enterprises. There are more slufters and slufter-like nature areas in the Netherlands, but the Slufter is the largest natural salt-marsh and the most stable one in the Netherlands (Pedroli & Hoekstra, 1992). As a protected nature area, the Slufter forms part of several ecological networks established and safeguarded by national and European legislation.

Other stakeholders include governmental authorities, environmental organisations, nature managers and the citizens of the island. However, the value of such an estuary is perceived differently by the different actors (Costanza et al., 1997; Farber et al., 2002), each of whom may have an interest in, some responsibility for, or be affected by decisions regarding the Slufter. The multi-actor environment and the formal and informal responsibilities of HHNK result in a playing field in which HHNK wants to enhance (collaborative) long-term decision making about the Slufter. For HHNK this means maintaining safety standards efficiently and effectively, while minimizing the negative effects on the ecosystem, and maintaining good relations with the stakeholders.

8.2. Research motivation and approach

As researchers at Delft University of Technology, this case study provided a unique opportunity to explore the role of system understanding in support of integrated management of a small estuary. The Slufter and similar small estuary systems are under-researched in the Netherlands. By gathering a wide range of knowledge from different sources and sharing new knowledge in a collaborative workshop setting, we aimed to deepen understanding of both the social and the ecological aspects of the small estuary system, with the end objective of including values besides flood defence in the policy making process. We investigated social-ecological knowledge via the design and application of an action research study that aimed to improve system understanding and influence policy in the long term. This study is extensively reported in D'Hont (2014) and D'Hont et al. (2014). Although there was no need for policy change purely from a flood defence perspective, there was an opportunity for more natural dynamics in the area and a resulting regime that is more in line with societal and ecological values. As such, the case study of the Slufter represents a small exemplar of the friction between ecological and safety values in Dutch coastal management, as well as signalling a larger scale trend of increasing integration and stakeholder consultation in coastal management. The undertaken approach is characterised by a combination of a stakeholder analysis and problem modelling, and requires the adoption of a dynamic, multi-actor, and social-ecological systems conceptual lens. In particular, the utility of combining information gathered through desk research, a simulation model study and stakeholder interviews for enhancing system understanding is explored. We designed and applied a knowledge intervention in the form of a workshop, where stakeholders were able to use this synthesised understanding of the dynamic system, as well as information from the stakeholder analysis, as starting points for discussions.

We view the Slufter as a social-ecological system (SES), where system knowledge among stakeholders is important. The structure of this book chapter follows the steps undertaken in the case study research. Following some theoretical background, a systems analysis was performed, so as to be able to assess the functioning of the Slufter with respect to ecological and social aspects. Values, interests, functions, system understanding and individual perspectives were elicited through stakeholder analysis and stakeholder interviews. In the interviews stakeholders were encouraged to explain their view of the system, revealing their own scale perspectives and preferences, and supplying information-rich insights and answers (Vreugdenhil et al., 2010). Desk research revealed a high degree of nestedness of the Slufter as hydro-morphological system (cf. Slinger 2017) and as multi-level governance system (Section 8.4). Accordingly, part of the research involved using a system dynamics modelling study to illustrate how the abiotic dynamic processes that occur within archetypical estuaries such as the Slufter, influence the biotic environment. The hydro-morphological (abiotic) processes are the main driver for the dynamic behaviour of the Slufter, particularly the Slufter mouth, as sediment disposition and erosion shape the landscape, enhancing freshwater-seawater

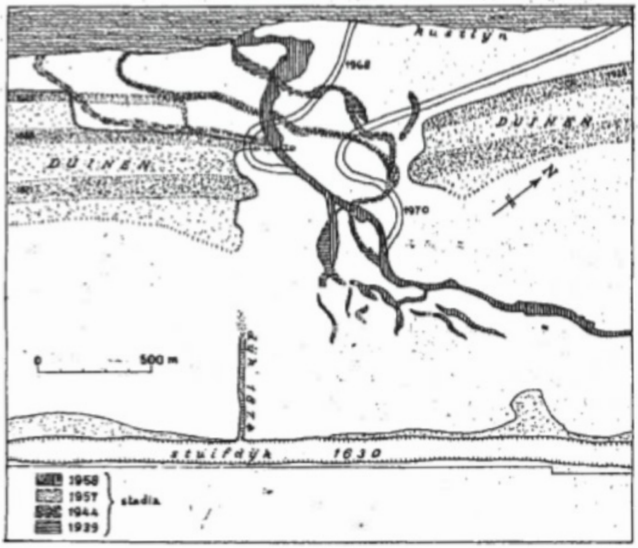

Figure 8.2. Dynamic behaviour of the Slufter channel and mouth from 1939 to 1958 (Rijkswaterstaat, n.d.)

gradients and contributing to the highly valued biodiversity (i.e., diversity in vegetation, invertebrates and birds). Then, we move on from describing the ecological system and its abiotic and biotic natural dynamics to consider the origination of the Slufter, and the role that humans interventions have played, and are playing, in the physical system and the social, governmental and institutional structures in Section 8.5.

Then the results from the first two analytical stages are synthesised and reported back to selected stakeholders, forming the knowledge intervention (Section 8.6). The knowledge intervention was designed with the aim of increasing the shared understanding and enhancing individual system understanding in a stakeholder setting. In D'Hont et al. (2014), we describe the design and application of the knowledge intervention within a potentially contentious situation, owing to the existing degree of discussion among stakeholders and the extent and variety of the values associated with the nature reserve, the Slufter. Clearly, the long-term influence of the knowledge intervention cannot be understood fully immediately after the workshop, nor can it be understood in isolation of other knowledge acquisition opportunities or events. Instead, this book chapter focuses on the shifting social values and perspectives regarding human interventions in the ecological and social aspects of the Slufter estuary.

8.3. Theoretical background

The choice for knowledge-sharing is grounded in scientific literature and policy practice. The field of integrated coastal management (ICM) has a substantive issue-based focus (e.g., coastal erosion issues, flood defence issues, and conservation issues). ICM is also characterised by extensive evaluation of issue-based pilot projects and their contribution to integrated management programmes (Olsen et al., 1997; Olsen, 2009), delivering insights at the national and regional level. Findings from these evaluations indicate that a participatory approach can have success in generating public acceptance for new national policies or programmes, e.g., the South African Coastal Policy (Department of Environmental Affairs, 2008) and the Dutch New Delta Programme (Delta Commission, 2016). We therefore research a knowledge-based, stakeholder-inclusive approach to coastal management aimed at deepening system understanding. For this, the case study of the Slufter is suitable, because the Netherlands has a strong tradition in collaborative governance. Activities to encourage inclusion and consultation of the public are increasingly favoured, although claims are made regarding success based primarily on the personal experience of the initiators or on the number of people informed (Newig & Fritsch, 2009; Reed, 2008). Accordingly, we aimed at an intervention in a collaborative and transdisciplinary setting, combining knowledge of local stakeholders and specialists of different backgrounds to think together on an area they all know, either personally or professionally, using a social-ecological perspective. We know that local actors perceive and value complex systems differently (Costanza et al., 1997; Farber et al., 2002; Mayer et al., 2004). Ostrom (Ostrom, 2009) famously argues that increased system understanding can lead to better long-term management supported by local stakeholders: "When users share common knowledge of relevant SES attributes, how their actions affect each other, and rules used in other SESs, they will perceive lower costs of organizing" (Ostrom, 2009). Acordingly, we choose to focus on increasing the system understanding of local stakeholders using a three stage analysis process, namely (i) system analysis, (ii) system dynamics simulation, and (iii) a knowledge intervention with stakeholders in the form of a workshop. The results of the system analysis and the knowledge intervention are described in Sections 8.4 and 8.5. respectively. The results of the system analysis were communicated to the stakeholders through an oral presentation and discussion during the workshop.

8.4. Natural dynamics of inlet

The Slufter has a highly dynamic character with a narrow and sinuous channel meandering through a dune valley. Pioneer plant species grow on the bare areas, succeeded by other species over time. The Slufter mouth is particularly dynamic, as sediment disposition and erosion shape the inlet and associated intertidal landscape, enhancing freshwater-seawater gradients and contributing to the highly valued biodiversity (i.e., diversity in vegetation, invertebrates and birds). Figure 8.2 provides a representation of the changing location of the Slufter mouth and the meandering behaviour of the Slufter channel in the early to mid 20th century (Rijkswaterstaat, n.d.).

8.4.1. Abiotic characteristics and dynamics

The Slufter is located in a coastal area with semidiurnal and spring-neap tidal variations, which are associated with high-low variations in water level on a 12 hour 40 minute and 28 day time scale respectively. The sill height increases when sediment is deposited in the mouth channel and decreases when erosion occurs in the mouth channel. The sediment is transported by the water flowing through the mouth on the ebb and flood flows. During the ebb, sediment is eroded from the mouth channel and transported out to sea. This erosion causes the sill height to decrease. During flood flows, the action of waves in the breaker zone means that the capacity of the seawater to transport sediment is enhanced. As the water floods into the estuary, it is no longer able to transport all the sediment that it is carrying in suspension. This excess sediment is deposited and causes the sill height to increase and the mouth cross-section to decrease. It is this mechanism which can cause the mouth to close and the tidal influence on the estuary to be cut off. This usually happens under high wave conditions, but not necessarily storm conditions. Communities and authorities can intervene in such a situation by choosing to breach the mouth.

Storms typically occur in the winter season between October and March. For the Slufter, the highest storm wave intensity near the sand dike (within the Slufter basin) would be caused by surges during spring tide with a North Westerly wind direction. High waves during storms can deposit sandy sediments deep within the Slufter area. For instance, the 'Sinterklaasstorm' of 5 December 2013 happened during the course of the case study research, elevating water levels to 2.54 m above NAP in the Slufter, and causing concern that the sand dike would burst (From: stakeholder interviews in D'Hont, 2014). This did not occur. Indeed, as mentioned before, the district water board HHNK maintains safety levels through intervening in the Slufter to reduce the storm wave intensity near the sand dike by maintaining the integrity of the dune front.

8.4.2. Biotic characteristics and dynamics

In the Slufter, the combination of wind- and water-driven sediment transport and the transition from fresh to salt water results in a high diversity of vegetation types in a relatively small area (Balke, 2013). There is valuable vegetation in the salt-fresh water transition areas near and in the Slufter channel, as well as in the brackish habitats (Balke, 2013, p. 13), for instance the Dutch-termed 'Fraaiduizendguldenkruid', 'Hertshoornweegbree', 'Zilte rus', 'Rood zwenkgras' en 'Engels gras' (Pranger, 1999). The Slufter area attracts a wide diversity of bird species. This is mainly due to the peace and quiet in the area and the wide diversity of biotopes (Durieux, 2004). The area is a birds habitat, as it is used

Figure 8.3. Texel (here spelled Teßel) and Eierland (here spelled Eyerland) on a northern fragment of a map of The Netherlands, published circa 1743. Sand embankments between Eierland and Texel later connected the two islands to form Texel as we know it today (Image: Wikipedia - Eierland, 2018)

for incubation by birds, such as eider ducks, the common shelduck, and the pied avocet. Other organisms that live in The Slufter channel are crabs, shrimps and flounder. Sheep and cattle graze the Slufter area (Nationaal Park Duinen van Texel, 2010).

The ecological situation in the Slufter was measured and mapped by Pranger and Tolman (Pranger & Tolman, 2011; Balke, 2013). The largest part of the salt-marsh is taken up by vegetation types from the middle salt-marsh. The pioneer zone is characterised by an abundance of species. The humid dune slacks and typical brackish salt-marsh vegetation indicate the presence of freshwater near the dune front. The vegetation and bird species are indicative of the presence or absence of abiotic factors such as wind, freshwater and seawater. The Slufter serves a foraging function; animals, such as geese, ducks, waders, gulls and other birds search for food resources and exploit them. These food resources include vegetation, insects and benthic organisms (Durieux, 2004, p. 28). Additionally the area serves a refuge function; water birds and waders seek refuge on the high dunes when the water rises high (Durieux, 2004, p. 28).

8.5. The role of human interventions on the Slufter

Aside from the ecological value of the Slufter area, the nature reserve is also socially valuable. First and foremost, the sand dike of the Slufter functions as a primary flood defence barrier and is an important link in Texel's flood defence infrastructure. Historically, the Slufter is arguably a remnant of a 'failed' land reclamation centuries ago. The area has a cultural-historical value, and is an area of pride to the islanders. Poems have been written about the area which is unique along the Dutch coast. Its dynamic (a) biotic richness attracts educational school excursions to teach children about different species and ecosystem dynamics. Lastly, associated with its rich vegetation and highly dynamic character, the Slufter attracted tourism and recreationists.

8.5.1. Origin of the Slufter

Present-day Texel and the Slufter have been shaped by consecutive geomorphological processes from the penultimate glacial period and by human interactions from the 17th century. Settlement on Texel has adapted to the elevation differences. The villages and older buildings are located on the higher areas, whereas agricultural lands are mostly located in the polders (Municipality of Texel, 2006).

Pleistocene

The Wadden Islands are the result of the effects of the tides, waves, wind and a rising sea level in the time period after the last glacial period, approximately 11 000 years ago. An increasingly warmer climate caused the North Sea to fill up with melted land ice. The irregular pleistocene landscape was flooded with sea water and waves and streams formed a beach ridge ('strandwallenreeks') along the Dutch coast from present day Belgium to the Elbe river mouth in Germany. New primary dunes were shaped from new, fresh sand on the beach areas and the beach ridge evolved into a island ridge with local openings. The area between the islands and the Dutch coast became an intertidal zone, comparable to the present day Wadden Sea (Rijkswaterstaat, 2013b).

Texel is the only Dutch Wadden Island that is positioned from southwest to northeast. This is mainly caused by the origin and geological structure of the island: Texel is the only

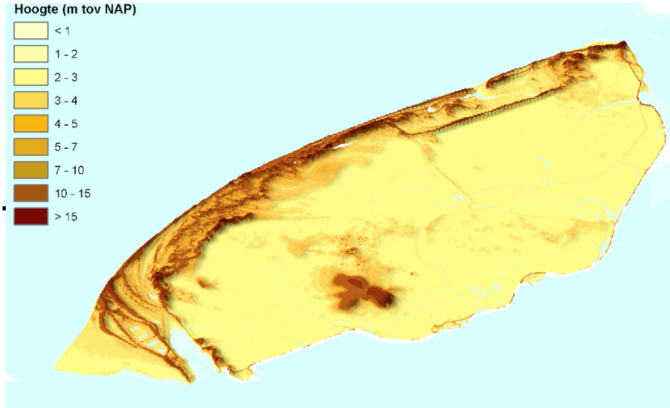

Figure 8.4. Elevation on Texel in metre above NAP (Hoogheemraadschap Hollands Noorderkwartier, 2013)

Wadden Island with boulder clay (keileem) close to the surface. Boulder clay bulges kept the West coast of Holland and Texel from moving towards the east, not following the movements of the other Wadden Islands. Another determining factor in the morphology of the present day Wadden Islands was the occurrence of storm surges in the 10th to 12th century A.C. that divided the beach ridge up into islands (Hoogheemraadschap Hollands Noorderkwartier, 2013).

Land reclamation attempts

Where present-day Texel is shaped through land reclamation and embankment constructions, the Slufter can be considered to be a remnant of a "failed" land reclamation. Centuries ago, the island consisted of two separate, smaller islands: Texel in the south and Eierland (or: Yerland) in the north, with washover systems in between the two. Around 1630, the Staten van Holland decided to connect Eierland to Texel by constructing a sand embankment (Figure 8.3. and Figure 8.4.), to prevent the development of a new inlet from the North Sea to the Zuiderzee (i.e., present-day Wadden Sea) (Rijkswaterstaat, n.d.). Through natural sediment accretion and human interventions (e.g., planting of marram grass), dunes on the North Sea side of the connecting sand dike were formed and, in line with the Dutch reclamation tradition of those times, attempts were made to empolder the area in 1855 (Water Act, 2009). However, the closing was unsuccessful and three tidal channels came into being: 'De Muy', the small Slufter and the large Slufter. The Dutch persisted in trying to close the North Sea dune ridge, aiming for a continuous sandy flood defence line. As such, the smaller 'De Muy' was closed relatively easily (Water Act, 2009). The large Slufter, located near the 'Krimduinen' on former Eierland, proved to be a bigger challenge, with failed enclosure attempts in 1886 and again 1888. Closing these tidal inlets affected the freshwater discharge in the others. After the large Slufter and the Muy were closed through dune and dam ridge construction, the small Slufter channel experienced rapid growth, because it had to process much more water than before. After the final attempt to close the small Slufter in 1925 failed, the State decided to leave the estuary open. The Slufter evolved into the nature area we know today – a highly dynamic nature reserve, by Dutch standards (Hoogheemraadschap Hollands Noorderkwartier, 2013).

The map in Figure 8.4 represents the range of elevation with respect to NAP; the vertical datum that approximately equals the Mean Sea Level along the Dutch coast (Ministry of Defence, 2013). The map shows the dunes and the sand dike forming the main coastal barrier on the island. The lower parts are most likely to flood in case of a dike break and high tide. The Slufter forms an inlet in the line of North Sea dunes. The sand dike behind the Slufter, which is the same sand dike that was built in the 17^{th} century, protects the polders behind the Slufter. The elevation of the lands behind the coastal barrier vary from 2 m below NAP in the polders to 23 m above NAP at the top of the dunes (Municipality of Texel, 2006). The Slufter area comprises approximately 700 hectare of land. The Slufter area has silted up during the past 50 years, caused by natural processes and by the addition of sediment to the coastal system through interventions such as shore-face nourishments or beach nourishments (Rijkswaterstaat, 2013a). However, the exact effect of human interventions in the North Sea on the Slufter nature reserve is unknown.

8.5.2. Institutional context

The nature reserve the Slufter is part of the primary water barrier, i.e., the part of the coast that protects the island of Texel from high water levels in the North Sea. The Delta Act (1958), Flood Defence Act (1996), and Water Act (2009) establish the safety standards against flooding in the Netherlands. Mulder et al. (Mulder et al., 2011) describe the institutionalisation of coastal erosion management (see section 2.4). The water board HHNK is one of 25 water boards in the Netherlands. These regional governmental authorities are amongst the oldest forms of government, the earliest ones known existed in the 13^{th} century, forming collectives of local people with an interest in water safety. Now the water boards lay down the conditions for achieving the strategic objectives of flood defence, they define concrete measures to achieve these objectives and they execute projects.

In addition to its function in flood defence, the Slufter's unique natural characteristic and location make it the object of environmental protection as well. The legislative context regarding the flood protection and environmental protection of the Slufter is complex, because it is not an isolated ecosystem, but embedded in a larger nature network. On the European level, the Slufter is part of the Natura 2000 area 'Duinen and Lage Land Texel', and is protected under both the Habitat Directive (92/43/EEC) and the Birds Directive (2009/147/EEC) (Rijkswaterstaat, 2013a). Natura 2000 forms the core of European Union nature and biodiversity policy. Further, the Ramsar Convention (an international convention on protection of wetlands) applies to the Slufter, and it is included in the broader objectives for the Wadden Sea and the North Sea as specified in the Fifth White Paper on Spatial Planning (Vijfde Nota Ruimtelijke Ordening [VIJNO], 2001). The Slufter forms part of a National Park that is in turn part of the Ecological Network (Ecologische Hoofdstructuur, EHS). Additionally, there are many institutionalised forms of cooperation between managers of nature reserves on the regional, national and international levels (e.g., Wetlands convention, EHS, National Park Dunes of Texel).

8.5.3. Current management practice

Within current management practices, the district water board HHNK is formally responsible for maintaining the sandy coast of Texel so that it adheres to the legally prescribed safety standards for flood defence. Most notably, HHNK intervenes in the physical system by straightening the channel near the opening every four to six years.

The interventions in the Slufter (periodical dredging of the mouth) to maintain the integrity of the flood defences have negative side-effects on the ecological system in the area. In line with the more dynamic approach to Dutch coastal management in the recent past, and new insights from flood risk models, the water board is considering a less drastic way of intervening in the system. This change is likely to have only limited effects on flooding safety and could potentially have substantial beneficial effects on the bio-geomorphological dynamics of the Slufter. The simulations from new storm wave models commissioned by HHNK (Rooijen & van Thiel de Vries, 2013) indicate that the sand dike is in principal strong enough to protect the hinterland from flooding even if the Slufter opening becomes larger. Their simulation study reveals that a wider Slufter channel at different locations will not create unsafe situations, and thus provides the district water board with a justification to review the current practice of channel straightening.

Although the current practice of HHNK includes stakeholder management in relation to flood management, HHNK is interested in discovering whether another type of stakeholder involvement could deliver deeper insights or enhanced engagement. Although environmental protection legislation is in place, water managers have the right and obligation to intervene if (water) safety is at stake, even when this affects a protected ecological system. However, HHNK aims to keep flood protection measures and water quality management aligned with nature preservation, and only wants to have to cross ecological boundaries when this is absolutely necessary. HHNK partners with other actors, such as governmental authorities, environmental organisations and nature managers on the island. These actors may hold different opinions. Besides water safety, broadly speaking, stakeholders of the Slufter are interested in other aspects, such as ecology, economy, tourism and recreation.

Owing to the natural dynamic nature of the Slufter, the vegetation growth in the Slufter can change significantly over the course of 6 years (Balke, 2013). Human interventions influence the natural dynamics too: the vegetation, and the proportions between bare sand, water, and pioneer vegetation differ from 2005 to 2011, because the Slufter channel was straightened in 2010.

8.6. The knowledge intervention – intervening in the social system

The synthesised understanding from the preceding system analysis was combined with simulation model outcomes and a stakeholder analysis and presented to a selection of participants in a workshop setting, forming the knowledge intervention. After some deliberation, we chose for a level of detail of supplied information that was thought to be appropriate for the participants with real-world understanding of the estuary, but limited specialised, disciplinary or abstracted conceptual knowledge. The participants group was a mixture of researchers familiar with modelling techniques and local actors from the island, all with individually different viewpoints and substantial, ready, real-world knowledge of the Slufter. An ex ante survey of what participants valued about the Slufter was conducted. Thereafter, we presented three archetypical estuary characteristics and estuary behaviour (Figure 8.5 and Figure 8.6), followed by discussion on estuary dynamics in relation to the Slufter. Participants were encouraged to consider the situation of normal weather conditions and ordinary tidal dynamics, as opposed to other meetings and workshops on the Slufter that commonly emphasised flood defence and consequently the situation of exceptional storm weather conditions. The aim in this regard was to increase dynamic system understanding of the participants by discussing known dynamic behaviour and system boundaries that related to the individual real-world experiences of the participants. As expected, the discussion quickly diverted from water safety, and participants were able to communicate regarding the potential consequences of dynamic estuary behaviour on vegetation and birds, based on the information supplied on the abiotic dynamics.

Next, information on stakeholder perceptions and values derived from the interviews were presented and discussed. Contrary to expectations that the discussion would focus on differences in the perceptions of stakeholders and what they could learn from each other, participants repeatedly came back to discussing the importance of wild nature versus human interference. They agreed that finding a balance between human interventions and wild nature remains difficult. Participants did communicate their individual values and exchanged some knowledge on the system, thereby creating some

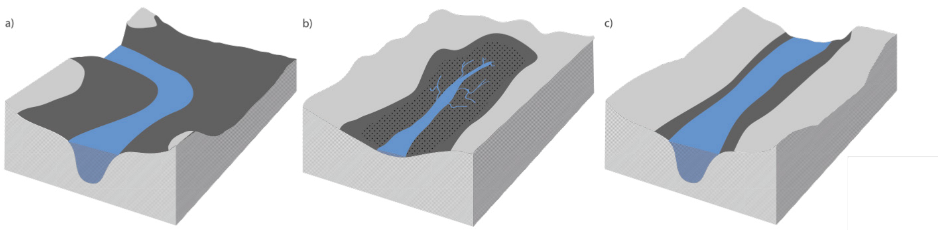

Figure 8.5. Archetypal estuary systems – a) small estuary with a shallower basin form and a higher sill height b) mudflat-like, perched, shallow formed basin c) long, deep estuary (from: D'Hont, 2014)

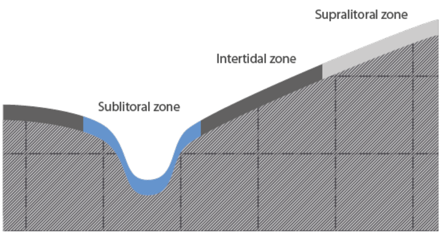

Figure 8.6. Archetypical estuary bathymetries were used in a stakeholder setting alongside summarised descriptions of estuary behaviour (from: D'Hont, 2014)

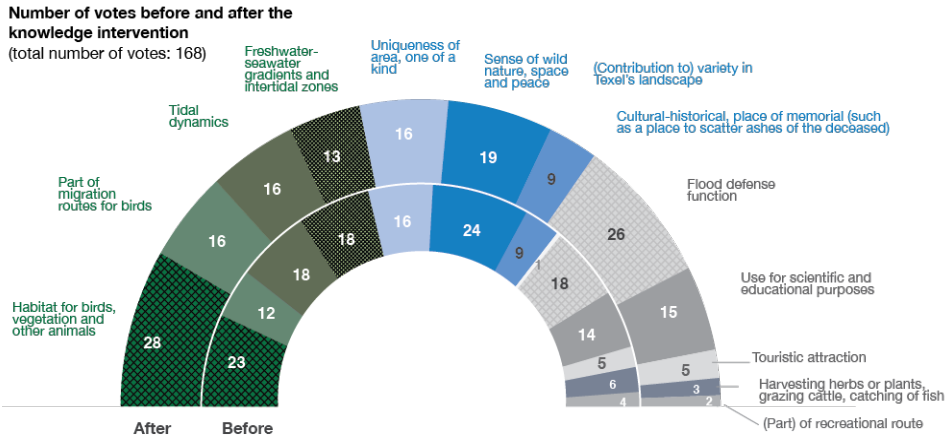

Figure 8.7. Participant voting before and after the knowledge intervention (Participants each had 12 votes to rank the qualities of the Slufter before and after the knowledge intervention) (from: D'Hont, 2014)

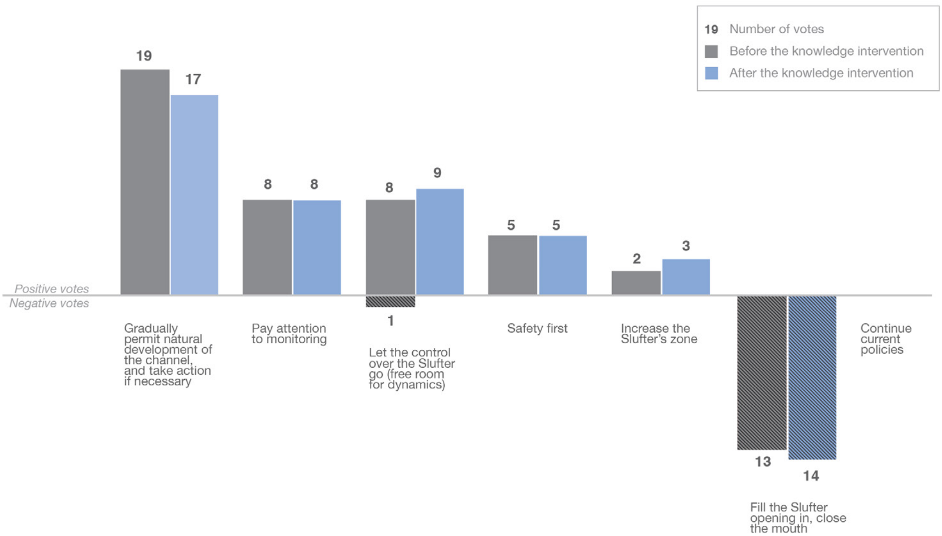

Figure 8.8. The ex-ante and post workshop voting distribution (Participants each had 3 positive votes and 1 negative vote to express how their preferences were to be translated to (hypothetical) policy options) (from: D'Hont, 2014)

common knowledge. For example the unknown volume and seasonal variability of the freshwater inflow to the Slufter estuary was discussed and whether the freshwater inflow should be considered significant was debated. An additional discussion was started regarding the values of a participant who emphasised the function of the Slufter as a bird habitat and a link in global migration routes. After a coffee break and a stroll outside during which the discussion and sharing continued, the participants voted again by sticking dots on the posters hanging in the room, which provided the same options as the ex-ante measure. As depicted in Figure 8.7, the greatest change in the participants' perceptions lay in the increased recognition of the nature reserve's function as a habitat and migration route for birds, vegetation and other animals, as well for the flood defence function of the Slufter. This change can be explained by the topics discussed during the session. In reacting to proposed policies, the participants agreed almost unanimously that the Slufter mouth should not be closed for the purpose of embankment (Figure 8.8). Figures 8.7 and 8.8 reveal that participants' opinions did not change radically, although the quality of the Slufter as a bird habitat or migration route was more valued than before the event. However, the knowledge intervention undertaken provides an indication that a shared understanding of the ecological and social functions of the Slufter estuary can be enhanced by an integration of a stakeholder approach and problem modelling.

8.7. Conclusions: system understanding and insights gained

This intervention brought new system knowledge on stakeholders' perceptions and estuary morphodynamics into a collaborative setting in which current practices in managing the inlet of the Slufter were under discussion. In this research, we used system knowledge in an experimental setting, with stakeholders within a potentially contentious situation. The system was understood in terms of its social-ecological system characteristics, the biophysical and social components, and their interactions. Participants were recognised as forming an integral part of this system. There was a high level of discussion ongoing amongst policy makers and stakeholders. The diversity and extent of the values that stakeholders associate with the island and the nature reserve the Slufter is such that it is an emotive issue. Despite this connection to the Slufter, there was a lack of urgency, which could also have affected the engagement of actors with the new knowledge (De Bruijn & Herder, 2009; Roeser, 2012). Additionally, the insights from the focussed knowledge intervention and its prior system analysis were later not fully adopted by the water board 'Hoogheemraadschap Hollands Noorderkwartier' (HHNK). HHNK initiated the research project, and also hosted, facilitated and controlled the intervention. Although HHNK gladly accepted this role, and strives for participation, they appear unaware that stakeholders would not necessarily perceive the activity as neutral. This could affect the efficacy of policy activities in the Netherlands (Deelstra et al., 2003; Kolb et al., 2008). The duality of the role of the water board (i.e., governance authority vs. stakeholder, task-oriented and stakeholder-engagement-oriented),and their habit of being in the driving seat are issues to consider when designing such activities. Different workshop participants (e.g., stakeholders with less connections to policy makers), small or one-on-one groups might be more effective conditions for knowledge interventions to improve system understanding and support ongoing coastal management (Andersen et al., 1997). Also, changing the way participants work with the supplied information, creating a more interactive approach or a comparison between different kinds of knowledge interventions could be implemented (Hommes et al., 2009; Reddel & Woolcock, 2004).

In conclusion, well-designed collaborative engagement interventions add local knowledge and stakeholder involvement in early design phases. This fits with the current practice of stakeholder management, especially for smaller projects that include interventions in coastal, ecological systems. The developed approach is useful to assess human values and use functions, in addition to biophysical qualities of these systems. The choice to conceptualise a dynamic coastal nature reserve as a social-ecological system allowed for the involvement of a wide range of stakeholders and accommodated dealing with the dynamic behaviour of the ecological system.

Today, the Integrated Coastal Management approach (ICM) aims to facilitate participation and conflict mediation, to ensure multi-sectoral planning and to balance conservation and development (Christie, 2005). The contextual nature of implementation means that site-specific knowledge is valued in the ICM field, and that articles describing the evolution of learning on, and about, ICM stress this notion (Cicin-Sain et al., 1998; Olsen et al., 1997). Engaging stakeholders to elicit knowledge, and other forms of participation, are becoming common practice (Reed, 2008) especially in water and coastal governance (Morinville & Harris, 2014; Taljaard et al., 2013).

As described in the previous sections, when discussing the flood defence in the Netherlands, we are mainly talking about interventions in the physical system. While safety levels are meeting basic levels of flood protection, there is room and recognition for societal values, such as ecosystem values, environmental protection, and other forms of (anthropocentric) human enjoyment of ecosystems. Consequently in more recent years, the focus on resolving flood defence issues has shifted from morphological solutions, to more inclusive interventions in the social system.

8.8. References

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